Haldia Institute of Technology (Autonomous)

B. Tech in Computer Science & Engineering (Data Science)

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 modeling 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 team work: 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-DS-301	Principles of Communication Engineering	2	0	0	2
2		Engineering Science Course	ESC-DS-302	Digital Electronics	3	0	0	3
3		Engineering Science Course	ESC-DS-303	Statistics for Data Science	2	0	0	2
4		Professional Core Course	PCC-DS-301	Data Structure and Algorithms	3	0	0	3

5		Professional Core Course	PCC-DS-302	Discrete Mathematics	3	0	0	3
6		Basic Science Course	BSC-DS-301	Probability Theory	2	0	0	2
7		Mandatory Course	MC-DS-301	Environmental Sciences	2	0	0	0
8	Practical	Engineering Science Course	ESC-DS-391	Digital Electronics Lab	0	0	3	1.5
9		Engineering Science Course	ESC-DS-392	Statistics for Data Science Lab	0	0	3	1.5
10		Professional Core Course	PCC-DS-391	Data Structure and Algorithms Lab	0	0	3	1.5
Total Credits								19.5

Semester IV (Second year)								
Sl. No.		**Type of Course**	**Code**	**Course Title**	**Hours per week**			**Credits**
					L	T	P	
1	Theory	Basic Science Course	BSC-DS-401	Linear Algebra	3	0	0	3
2		Professional Core Course	PCC-DS-401	Computer Organization and Architecture	3	1	0	4
3		Professional Core Course	PCC-DS-402	Data Base Management System	3	0	0	3
4		Professional Core Course	PCC-DS-403	Design and Analysis of Algorithm	3	1	0	4
5		Humanities and Social Sciences including Management Courses	HSMC-DS-401	Economics for Engineers	2	0	0	2
6	Practical	Professional Core Course	PCC-DS-491	Computer Architecture Lab	0	0	3	1.5
7		Professional Core Course	PCC-DS-492	Data Base Management System Lab	0	0	3	1.5
8		Professional Core Course	PCC-DS-493	Design and Analysis of Algorithm Lab	0	0	3	1.5
9		Professional Core Course	PCC-DS-494	IT Workshop (Python) Lab	0	0	3	1.5
Total Credits								22

Semester V (Third year)								
Sl. No.		**Type of Course**	**Code**	**Course Title**	**Hours per week**			**Credits**
					L	T	P	
1	Theory	Professional Core Course	PCC-DS-501	Operating System	3	0	0	3
2		Professional Core Course	PCC-DS-502	Object Oriented Programming	3	0	0	3
3		Professional Core Course	PCC-DS-503	Artificial Intelligence	3	0	0	3
4		Professional Core Course	PCC-DS-504	Formal Language and Automata Theory	3	0	0	3
5		Professional Core	PCC-DS-505	Data Mining	3	0	0	3

		Course						
6		Humanities and Social Sciences including Management	HSMC-DS-501	Human Values and Professional Ethics	3	0	0	3
7	Practical	Professional Core Course	PCC-DS-591	Operating System Lab	0	0	3	1.5
8		Professional Core Course	PCC-DS-592	Object Oriented Programming Lab	0	0	3	1.5
9		Professional Core Course	PCC-DS-593	Artificial Intelligence Lab	0	0	3	1.5
Total Credits								22.5

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-DS-601	Data Analysis and Visualization	3	0	0	3
2		Professional Core Course	PCC-DS-602	Machine Learning	3	0	0	3
3		Professional Core Course	PCC-DS-603	Computer Networks	3	0	0	3
4		Professional Elective Course I	PEC-DS-601 (A/B/C/D)	Mobile Computing Information Security and Privacy Computer Graphics Cloud & Edge Computing	3	0	0	3
5		Professional Elective Course II	PEC-DS-602 (A/B/C/D)	Data Warehousing Big Data Analytics Soft Computing Software Engineering	3	0	0	3
6		Open Elective Course I	OEC-DS-601 (A/B/C/D)	Soft Skill and Interpersonal Communication Operation Research Human Resource Management Organizational Behaviour	3	0	0	3
7		Mandatory Course	MC-DS-601	Technical and Quantitative Aptitude	1	0	0	0
8	Practical	Professional Core Course	PCC-DS-691	Data Analysis and Visualization Lab	0	0	3	1.5
9		Professional Core Course	PCC-DS-692	Computer Networks Lab	0	0	3	1.5
Total Credits								21

Semester VII (Fourth year)								
Sl. No.		**Type of Course**	**Code**	**Course Title**	**Hours per week**			**Credits**
					L	T	P	
1	Theory	Professional Elective Course III	PEC-DS-701 (A/B/C/D)	Information Theory and Coding Advanced Computer Architecture	3	0	0	3

				Digital Image Processing Internet Technology				
2		Professional Elective Course IV	PEC-DS-702 (A/B/C/D)	Internet of Things Information Retrieval E-Commerce and ERP Block chain Technology	3	0	0	3
3		Open Elective Course II	OEC-DS-701 (A/B/C/D)	Bioinformatics Cyber Law and Cyber Security Optimization Technique Microprocessor and Microcontroller	3	0	0	3
4		Humanities and Social Sciences Including Management	HSMC-DS-701	Project Management and Entrepreneurship	3	0	0	3
5	Session	Project	PROJ-DS-781	Project I	0	0	10	5
6		Summer Internship	SI-DS-782	Internship I				3
Total Credits								20

Semester VIII (Fourth year)								
Sl. No.		**Type of Course**	**Code**	**Course Title**	**Hours per week**			**Credits**
					L	T	P	
1	Theory	Professional Elective Course V	PEC-DS-801 (A/B/C/D)	Artificial Neural Network Natural Language Processing Web Mining Quantum Computing	3	0	0	3
2		Open Elective Course III	OEC-DS-801 (A/B/C/D)	Embedded Systems Business Analytics Human Computer Interaction Cryptography and Network Security	3	0	0	3
3		Open Elective Course IV	OEC-DS-802 (A/B/C/D)	Economic Policies in India Compiler Design Research Methodology Remote Sensing and GIS	3	0	0	3
4	Session	Project	PROJ-DS-881	Project II	0	0	10	5
5		Winter Internship	WI-DS-882	Internship II				3
Total Credits								17

Semester III (Second year)

ESC-DS-301: Principles of Communication Engineering

Contacts: 2L per week Credits: 2

Course Outcomes (COs):

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

- Describe the basic principle of communication system.
- Analyze and design amplitude modulation systems at the sub-system level.

- Analyze and design angle modulation systems at the sub-system level.
- Analyze and design pulse modulation systems at the sub-system level.
- Demonstrate the basic methods of probability and random variables to signal-to-noise ratios.
- Apply the concepts to practical applications in telecommunication.

Prerequisites:
Basics of Electrical Engineering

Detailed Content:

Module	Content	Hours/ Module
1	**Elements of Communication system, Analog Modulation & Demodulation, Noise, SNR Analog-to-Digital Conversion**. (Basic ideas in brief) [Details: Introduction to Base Band transmission & Modulation (basic concept) **(1L);** Elements of Communication systems (mention of transmitter, receiver and channel); origin of noise and its effect, Importance of SNR in system design **(1L);** Basic principles of Linear Modulation (Amplitude Modulation) **(1L);** Basic principles of Non-linear modulation (Angle Modulation - FM, PM) **(1L);** Sampling theorem, Sampling rate, Impulse sampling, Reconstruction from samples, Aliasing **(1L);** Analog Pulse Modulation - PAM (Natural & flat topped sampling), PWM, PPM **(1L);** Basic concept of Pulse Code Modulation, Block diagram of PCM **(1L);** Multiplexing - TDM, FDM **(1L).**	8
2	**Digital Transmission:** [Details: Concept of Quantisation & Quantisation error, Uniform Quantiser **(1L);** Non-uniform Quantiser, A-law & μ-law companding (mention only) **(1L);** Encoding, Coding efficiency **(1L);** Line coding & properties, NRZ & RZ, AMI, Manchester coding PCM, DPCM **(1L);** Baseband Pulse Transmission, Matched filter (mention of its importance and basic concept only), Error rate due to noise **(2L);** ISI, Raised cosine function, Nyquist criterion for distortion-less base-band binary transmission, Eye pattern, Signal power in binary digital signals **(2L).**	8
3	**Digital Carrier Modulation & Demodulation Techniques:** [Details: Bit rate, Baud rate **(1L);** Information capacity, Shanon's limit **(1L);** M-ary encoding, Introduction to the different digital modulation techniques - ASK, FSK, PSK, BPSK, QPSK, mention of 8 BPSK, 16 BPSK **(2L);** Introduction to QAM, mention of 8QAM, 16 QAM without elaboration **(1L);** Delta modulation, Adaptive delta modulation (basic concept and importance only, no details **(1L);** introduction to the concept of DPCM, Delta Modulation, Adaptive Delta modulation and their relevance **(1L);** Spread Spectrum Modulation - concept only. **(1L)**	8

Text books and Reference books:

1. An Introduction to Analog and Digital Communications by Simon Haykin; Published by Wiley India.
2. Data Communication and Networking by Behrouz A. Forouzan, Published by Tata McGraw-Hill
3. Communication Systems 4th Edition by Simon Haykin; Published by Wiley India (Student Edition)
4. Principles and Analog and Digital Communication by Jerry D Gibson, Published by MacMillan.
5. Communication Systems by A. B. Carlson, Published by McGraw-Hill.
6. Understanding Signals and Systems by Jack Golten, Published by McGraw Hill.

ESC-CS-302: 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.

ESC-DS-303: Statistics for Data Science

Contacts: 2L per week Credits: 2

Course Outcomes (COs):

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

- Understand statistical concepts to include measurements of location and dispersion.
- Demonstrate probability, probability distributions.
- Analysis sampling and estimation.
- Dissect hypothesis testing and regression.
- Explain correlation analysis and multiple regressions
- Understand business/economic forecasting.

Prerequisite:

Basic Mathematics

Detailed Content:

Module	Content	Hours/ Module
1	Probability models, their properties, combinatorial principle, conditional probability, independence of events.	3
2	Random variable and distributions discrete and continuous distributions, cumulative distribution functions. One dimensional change of variable, joint distributions, joint probability functions, density functions. Conditional independence	5
3	Expectation: Discrete case & continuous case. Variance, covariance and correlation. Generating functions, Conditional expectation. Sampling distribution and limits. Convergence in probability and distribution. Monte Carlo approximations, Normal distribution.	8
4	Statistical inference. Models for inference. Data collection: finite population, simple random sampling, histograms, survey sampling. Some basic inferences. Likely hood inference. Maximum likely hood estimation, inference based on MLE. Bayesian Inference, prior and poster distributions, inference estimation, Baysian computations, optimal inference.	9
5	Model checking, sample model, residual probability plots, Chisquare test. Stochastic processes, distribution, Markov chains. Poisson processes.	7

Text book and Reference books:

1. Outline of statistics 1 and 2 by Goon-Gupta-Dasgupta
2. Fundamentals of mathematical statistics by Gupta and Kapoor
3. Complete Business Statistics Book By Amir Aczel
4. The Practice of Business Statistics, by Manish Sharma (Khanna)

PCC-DS-301: Data Structure and Algorithms

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

Course Outcomes (COs):

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

- **Create and Design** programs using a variety of data structures such as stacks, queues, hash tables, binary trees, heaps, graphs.
- **Evaluate** and choose appropriate data structures to represent data items in real world.
- **Analyze** the time and space complexities of algorithms.
- **Implement and apply** sorting algorithms for problem solving.
- **Understand** the concept of dynamic memory management.
- **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. BTree, 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-DS-302: Discrete Mathematics

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

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.	8
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.	6
4	Posets, Hasse Diagram and Lattices: Introduction, ordered set, Hasse diagram of partially, ordered set, isomorphic ordered set, well ordered set, properties of	6

	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.	
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.	5
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.	6
	Total	32

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

BSC-DS-301: Probability Theory

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

Course Outcomes (COs):

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

1. Calculate probabilities by applying probability laws and theoretical results.
2. Identify an appropriate probability distribution for a given discrete or continuous random variable and use its properties to calculate probabilities.
3. Calculate statistics such as the mean and variance of common probability distributions.
4. Calculate probabilities for joint distributions including marginal and conditional probabilities.
5. Determine whether random variables are independent and find their covariance and correlation.
6. Explain the role of probability in hypothesis testing and describe issues related to interpreting statistical significance.

Prerequisites

1. Knowledge of Basic Mathematics.

Detailed Content:

Module	Content	Hours/ Module
1	Probability: Introduction, random experiments, sample space, events and algebra of	5

	events. Definitions of Probability – classical, statistical, and axiomatic. Conditional Probability, laws of addition and multiplication, independent events, Theorem of total probability, Bayes' theorem and its applications.	
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 Jensen's Inequality, Cauchy Schwarz Inequality, Markov's inequality, Chebyshev's Inequality, Chernoff's Inequality, One Sided Chebyshev's Inequality.	10
3	Correlation and regression 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.	9
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

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)

MC-DS-301: 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	11

	converter, scrubber (ventury), Statement with brief reference). (1L)	
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: 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)	9
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

ESC-DS-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

ESC-DS-392: Statistics for Data Science Lab

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

Course Outcomes:

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

- List motivation for learning a programming language
- Access online resources for R and import new function packages into the R workspace
- Import, review, manipulate and summarize data-sets in R
- Explore data-sets to create testable hypotheses and identify appropriate statistical tests
- Perform appropriate statistical tests using R
- Create and edit visualizations with R

Prerequisites:

- Statistics
- Basics of any programming language

Detailed Content:

Module	Content	Hours/ Module
1	Introduction to R Programming: R and R Studio, Logical Arguments, Missing Values, Characters, Factors and Numeric, Help in R, Vector to Matrix, Matrix Access, Data Frames, Data Frame Access, Basic Data Manipulation Techniques, Usage of various apply functions – apply, lapply, sapply and tapply, Outliers treatment.	3
2	Descriptive Statistics: Types of Data, Nominal, Ordinal, Scale and Ratio, Measures of Central Tendency, Mean, Mode and Median, Bar Chart, Pie Chart and Box Plot, Measures of Variability, Range, Inter-QuartileRange, Standard Deviation, Skewness and Kurtosis, Histogram, Stem and Leaf Diagram, Standard Error of Mean and Confidence Intervals.	3
3	Probability, Probability& Sampling Distribution: Experiment, Sample Space and Events, Classical Probability, General Rules Of Addition, Conditional Probability, General Rules For Multiplication, Independent Events, Bayes' Theorem, Discrete Probability Distributions: Binomial, Poisson, Continuous Probability Distribution, Normal Distribution & t-distribution, Sampling Distribution and Central Limit Theorem.	3
4	Statistical Inference and Hypothesis Testing: Population and Sample, Null and Alternate Hypothesis, Level of Significance, Type I and Type II Errors, One Sample t Test, Confidence Intervals, One Sample Proportion Test, Paired Sample t Test, Independent Samples t Test, Two Sample Proportion Tests, One	3

	Way Analysis of Variance and Chi Square Test.	
5	Correlation and Regression: Analysis of Relationship, Positive and Negative Correlation, Perfect Correlation, Correlation Matrix, Scatter Plots, Simple Linear Regression, R Square, Adjusted R Square, Testing of Slope, Standard Error of Estimate, Overall Model Fitness, Assumptions of Linear Regression, Multiple Regression, Coefficients of Partial Determination, Durbin Watson Statistics, Variance Inflation Factor.	3

Text book and Reference books:

1. Sandip Rakshit, 2018, Statistics with R Programming, McGraw Hill.
2. Ken Black, 2013, Business Statistics, New Delhi, Wiley.
3. Lee, Cheng. et al., 2013, Statistics for Business and Financial Economics, New York: Heidelberg Dordrecht.
4. Anderson, David R., Thomas A. Williams and Dennis J. Sweeney, 2012, Statistics for Business and Economics, New Delhi: South Western.
5. Waller, Derek, 2008, Statistics for Business, London: BH Publications.
6. Levin, Richard I. and David S. Rubin, 1994, Statistics for Management, New Delhi: Prentice Hall.

PCC-DS-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:

- **Design and solve** programs using a variety of data structures such as stacks, queues, hash tables, binary trees, heaps, graphs.
- **Evaluate** and choose appropriate data structures to represent data items in real world.
- **Analyze** the time and space complexities of algorithms.
- **Implement** sorting and searching algorithms for problem solving.
- **Understand** the concept of dynamic memory management.
- **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.BPatel, Khanna Publishing House.

Semester IV (Second year)

BSC-DS-401: Linear Algebra

Contacts: 3L 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

PCC-DS-401: Computer Organization & Architecture

Contacts: 3L+1T per week Credits: 4

Course Outcomes:

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

- Demonstrate how Computer Systems work & the basic principles
- Understand Instruction Level Architecture and Instruction Execution
- Understand the current state of art in memory system design
- Demonstrate how I/O devices are accessed and its principles.
- Impart the knowledge on micro programming control unit
- Understand concepts of pipelining techniques.

Prerequisites:

- Number Systems
- 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. Throughput and speedup, pipeline hazards.	6
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

PCC-DS-402: Database Management Systems

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

Course Outcomes (COs):

On completion of the course students will be able to:

- **Describe** the fundamental elements of relational database management systems
- **Explain** the basic concepts of relational data model, entity-relationship model, relational database design, relational algebra and SQL.
- **Design** ER-models to represent simple database application scenarios
- **Convert** the ER-model to relational tables, populate relational database and formulate SQL queries on data.
- **Improve** the database design by normalization.
- **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 and object oriented data models, integrity constraints, data manipulation operations.	9
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	13

	forms, Dependency preservation, Lossless design. Query processing and optimization: Evaluation of relational algebra expressions, Query equivalence, Join strategies, Query optimization algorithms.	
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, HenryF. 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, NewDelhi (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-DS-403: Design and Analysis of Algorithm

Contacts: 3L+1T per week 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.	7

	Algorithm Design techniques Recursion- Definition, Use, Limitations, Examples: Hanoi problem. Tail Recursion	
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.M.Reingold, J.Nievergelt and N.Deo- "Combinational algorithms- Theory and Practice", Prentice Hall, 1997
8. A.Borodin and I.Munro, "The computational complexity of Algebraic and Numeric problems"

HSMC-DS-401: 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 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.	9
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)

PCC-DS-491: 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-DS-492: Database Management System Lab

Contacts: 3P per week 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. **Analyse** 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:

- Data Base Management Systems

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-DS-493: Design and Analysis of Algorithm Lab

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

Course Outcomes (COs):

After 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:

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

Text/ Reference 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-DS-494: IT Workshop (Python) Lab

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

Course Outcomes (COs):

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

- **Develop** algorithmic solutions to simple computational problems.
- **Identify** and repair coding errors in a program.
- **Demonstrate** programs using simple Python statements and expressions**.**
- **Explain** control flow and functions concept in Python for solving problems**.**
- **Use** Python data structures – lists, tuples & dictionaries for representing compound data.
- **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

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 V (Third year)

PCC-DS-501: 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	8

	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).	
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-DS-502: Object Oriented Programming

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

Course Outcomes (COs):

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

- **Create and explain** GUI and thread based application.
- **Evaluate** the complexity of procedural language by using the concept of polymorphism, inheritance, abstraction, and encapsulation.
- **Analyze** any real world problem with object oriented approach and formulate a solution for the same.
- **Implement and apply** object oriented approach to relate to real world problem.
- **Understand, describe** and illustrate the features of object oriented programming.
- **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, 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.	10
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 Buffered Reader & 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-DS-503: Artificial Intelligence

Contacts: 3L per week **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. Analyze 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 Structures
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 refencing, 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-GrawHill.
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.

PCC-DS-504: Formal Language & 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, Tata McGraw Hill., PEARSON.
6. Dr. R.B.Patel, Theory of Computation, Khanna Publishing House.

PCC-DS-505: Data Mining

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

Course Outcomes (COs):

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

1. Understand what Is Data Mining, what kinds of data can be mined, what kinds of patterns can be mined, and what kinds of applications are targeted.
2. Explain major Issues in data mining.
3. Apply machine learning, pattern recognition, statistics, visualization, algorithm, database technology and high-performance computing in data mining applications.
4. Identify what kinds of technologies are used for different application.
5. Manipulate data preprocessing, data Warehouse and OLAP technology, data cube technology; mining frequent patterns and association, classification, clustering, and outlier detection.
6. Discover interesting patterns from large amounts of data to analyze for predictions and classification.

Prerequisites:

- Basic understanding of DBMS
- Engineering Mathematics
- Data Structure and Algorithm

Detailed Content:

Module	***Content***	***Hours/ Module***
1	Introduction: Evolution and Importance of Data Mining-Types of Data and Patterns Mined-Technologies-Applications-Major Issues in Data Mining. Knowing about Data-Data Pre-processing: Cleaning– Integration–Reduction–PCA, Data Transformation and Discretization. Mining Frequent Patterns: Basic Concept – Frequent Item Set Mining Methods – Mining Association Rules – Association to Correlation Analysis.	8
2	Classification and Prediction: Issues – Decision Tree Induction – Bayesian Classification – Rule Based Classification – k-Nearest-Neighbor Classification – Linear SVM – Regression – Linear, Logistic – Accuracy and Error measures – Introduction to Ensemble methods	6
3	Clustering: Overview of Clustering – Types of Data in Cluster Analysis – Major Clustering Methods-Partitioning Methods- k-Means, k-Medoids. Hierarchical Methods-Agglomerative and Divisive hierarchical clustering. Density-Based Methods-DBSCAN, Graph-based clustering (CHAMELEON), Evaluation in Clustering	6
4	Mining Data Streams- Mining Time-Series Data- Mining Sequence Patterns in Biological Data- Graph Mining – Social network Analysis – Text Mining – Mining the World Wide Web, Applications and Trends in Data Mining Tools: Implementation of Data mining algorithms using Latest Open-Source Data mining	5

	Tools. TensorFlow, python, R	
5	Advanced techniques, Data Mining software and applications, Text mining: extracting attributes (keywords), structural approaches (parsing, soft parsing). Bayesian approach to classifying text, Web mining: classifying web pages, extracting knowledge from the web, Data Mining software and applications	5

Text book and Reference books:

1. Jiawei Han, Micheline Kamber and Jian Pei, "Data mining concepts and Techniques", Third Edition, Elsevier Publisher, 2006.
2. K.P.Soman, Shyam Diwakar and V.Ajay, "Insight into data mining Theory and Practice", Prentice Hall of India, 2006.
3. Yanchang Zhao, "R and Data Mining", Elsevier, 2013
4. Aurélien Géron, Hands-On Machine Learning with Scikit-Learn and TensorFlow, O'Reilly Media, 2017
5. Itay Lieder, Yehezkel Resheff, Tom Hope, Learning TensorFlow, O'Reilly Media, 2017

HSMC-DS-501: Human Values and Professional Ethics

Contacts: 3L per week Credits: 3

Course Outcomes:

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	8

	Technologists. Codes of professional ethics. Whistle blowing and beyond, Case studies.	
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 (2nd 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.

PCC-DS-591: 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

PCC-DS-592: 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:

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

Prerequisites:

- Programming for Problem Solving
- Object Oriented Programming

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, McGraw 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-DS-593: 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 VI (Third year)

PCC-DS-601: Data Analysis & Visualization

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

Course Outcomes (COs):

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

- **Understand** the basics of data visualization
- **Understand** the importance of data visualization and the design and use of many visual components.
- **Analyse** various visualization structures such as tables, spatial data, time-varying data, tree and network, etc.
- **Apply** basic algorithms in data visualization**.**
- **Understand** the types of transformation the data has undergone to improve the effectiveness of the visualization
- **Explain** characteristics and methods that are needed for the visualization of geospatial data

Prerequisites:

- Data Mining

Detailed Content:

Module	*Content*	*Hours/ Module*
1	Importance of analytics and visualization in the era of data abundance. Review of probability, statistics and random processes. Brief introduction to estimation theory.	4
2	Introduction to machine learning, supervised and unsupervised learning, gradient descent, over fitting, regularization.	3
3	Clustering techniques: K-means, Gaussian mixture models and expectation-maximization, agglomerative clustering, evaluation of clustering - Rand index, mutual information based scores, Fowlkes-Mallows index	5
4	Regression: Linear models, ordinary least squares, ridge regression, LASSO, Gaussian Processes regression.	5
5	Supervised classification methods: K-nearest neighbor, naive Bayes, logistic regression, decision tree, support vector machine.	5
6	Introduction to artificial neural networks (ANNs), deep NNs, convolutional neural network (CNN).	5
7	Data visualization: Basic principles, categorical and continuous variables.	3
8	Exploratory graphical analysis - Creating static graphs, animated visualizations - loops, GIFs and Videos. Data visualization in Python and R, examples.	4

Text book and Reference books:

1. Hastie, T., Tibshirani, R., Friedman, J. (2009). The elements of statistical learning: data mining, inference and prediction. Springer.
2. Richard O. Duda, Peter E. Hart, and David G. Stork. 2000. Pattern Classification (2nd Edition). Wiley-Interscience, New York, NY, USA.
3. Christopher M. Bishop. 2006. Pattern Recognition and Machine Learning (Information Science and Statistics). Springer-Verlag, Berlin, Heidelberg.

PCC-DS-602: Machine Learning

Contacts: 3L per week **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 Principal Component Analysis (PCA)	3
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:	3

	Hard Voting and Soft Voting.	
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 Dutta, 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.

PCC-DS-603: Computer Networks

Contacts: 3L per week **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.	4

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

PEC-DS-601A: Mobile Computing

Contacts: 3L per week **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	4

	Communication (GSM) system overview: GSM Architecture, Mobility management, Network signaling.	
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-DS-601B: Information Security and Privacy

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

Course Outcomes (COs):

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

- **Formulate** access control and application of defense against risks and threats.
- **Evaluate** the types of threats and vulnerabilities in context to the risks associated and their countermeasures.
- **Analyze** and compare attacks and their impact on information security.
- **Apply** available measures to confirm information reliability.
- **Remember** about malware, malicious code threats, its prevention and Detection.
- **Understand** requirements of security and its related terminology.

Prerequisites:

- Operating System
- Computer Networks

Detailed Content:

Module	*Content*	*Hours/ Module*
1	**Basics of Information systems security**: Information systems security, Seven domains of IT infrastructure, Weak links in security, IT security Policy Framework. **Overview of Security Parameters**: Confidentiality, integrity and availability- Security violation and threats-Security policy and procedure-Assumptions and Trust- Security Assurance, Implementation and Operational Issues- Security Life Cycle.	6
2	**Attacks Threats and Vulnerabilities**: Malicious attacks, Threats and Vulnerabilities, Attack tools, What is security breach, Malicious software, Countermeasures. Risk management, BIA, BCP and DRP, Assessing risk and Vulnerabilities, Compliance laws, confidentiality of data.	6
3	**Access Control Models**: Discretionary, mandatory, roll-based and task-based models, unified models, access control algebra, temporal and spatio-temporal models. **Security Policies**: Confidentiality policies, integrity policies, hybrid policies, noninterference and policy composition, international standards.	6
4	**Design**: Design principles, representing identity, control of access and information flow, confinement problem. **Assurance**: Building systems with assurance, formal methods, evaluating systems.	5
5	Risk management and information security, risk analysis, evaluating countermeasures, steps to disaster recovery. Types of backups. **Logic-based System:** Malicious logic, vulnerability analysis, auditing, intrusion detection.	5
6	**Applications**: Network security, operating system security, user security, program security. **Special Topics**: Data privacy, introduction to digital forensics, enterprise security specification.	4

Text book and Reference books:

1. Cryptography and Network Security: Principles and Practice; Fourth or Fifth Edition. By William Stallings, Prentice Hall.
2. Network Security Essentials: Applications and Standards by William Stallings. Prentice Hall.
3. John E. Canavan, Fundamentals of Network Security, Artech House, 2001.
4. Matt Bishop and Sathyanarayana S.Venkatramanayya, Introduction to Computer Security, Pearson Education.
5. Matt Bishop, Computer Security: Art and Science, Pearson Education.
6. Thomas R. Peltier, Information Security Risk Analysis, CRC Press LLC.
7. Dorothy E. Denning, Information Warfare and Security, Addison Wesley.
8. Ross Anderson, Security Engineering: A Guide to Building Dependable Distributed Systems, John Wiley and Sons.
9. M. Stamp: Information Security: Principles and Practice, John Wiley & Sons.
10. Cryptography and Network Security, V.K. Jain, Khanna Publishing House.
11. Information Security & Cyber Laws, Sarika Gupta, Khanna Publishing House.
12. Fundamentals of Information Systems Security, David Kim, Michael G. Solomon, 2nd Edition.
13. The Basics of Information Security: Understanding the fundamentals of InfoSec in theory and practice, Jason Andress.

PEC-DS-601C: 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 methods , fractal - geometry.	6
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-DS-601D: Cloud and Edge Computing

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

Course Outcomes (COs):

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

- Discuss the core concepts of cloud computing paradigm.
- Analyze services, systems, platforms, frameworks to support cloud computing.
- Assess virtualization technology services in open source cloud computing environment.
- Understand data centre technology and cloud security issues from industry centric perspective.
- Demonstrate the main concepts of edge computing.
- Gather knowledge of the different vendor platforms, software services, standard bodies and open source communities available for edge computing.

Prerequisites:

- Knowledge of Programming.
- Database Management System
- Basics of security and privacy.
- Operating System.

Detailed Content:

Module	Content	Hours/ Module
1	Introduction to Cloud Computing - Definition, Evolution of Cloud Computing, Characteristics, Components Cloud Computing Services - Cloud provider, SAAS, PAAS, IAAS and other Organizational scenarios of clouds.	7
2	Cloud Administration and Management - Administering & Monitoring cloud services, benefits and limitations, Lifecycle management of cloud services (six stages of lifecycle). Cloud Deployment - Deploy application over cloud. Comparison among SAAS, PAAS, IAAS.	7
3	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. Data Center Technology - Server Virtualization, Automation, Remote Operation and Management. Data Center virtualization: Computing, Storage, Network. Introduction to Open Source IoT Cloud Platforms - Introduction to IoT cloud platforms like Open Shift, Kaa etc.	6
4	Introduction to Edge Computing Scenario's and Use cases - Edge computing purpose and definition, Edge computing use cases, Edge computing hardware architectures, Edge platforms, Edge vs Fog Computing, Communication Models: Edge, Fog and M2M. IoT Architecture and Core IoT Modules - A connected ecosystem, IoT versus machine-to-machine versus, SCADA, The value of a network and Metcalfe's and Beckstrom's laws, IoT and edge architecture, Role of an architect, Understanding	8

	Implementations with examples-Example use case and deployment, Case study – Telemedicine palliative care, Requirements, Implementation, Use case retrospective.	
5	Implementation of Microcomputer RaspberryPi and device Interfacing, Edge to Cloud Protocols - Protocols, MQTT, MQTT publish-subscribe, MQTT architecture details, MQTT state transitions, MQTT packet structure, MQTT data types, MQTT communication formats, MQTT 3.1.1 working example. Edge computing with RaspberryPi, Industrial and Commercial IoT and Edge, Edge computing and solutions.	5

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
7. IoT and Edge Computing for Architects - Second Edition, by Perry Lea, Publisher: Packt Publishing, 2020, ISBN: 9781839214806
8. Raspberry Pi Cookbook, 3rd Edition, by Simon Monk, Publisher: O'Reilly Media, Inc., 2019, ISBN: 978149204322.
9. Fog and Edge Computing: Principles and Paradigms by Rajkumar Buyya, Satish Narayana Srirama, Wiley publication, 2019, ISBN: 9781119524984.
10. David Jensen, "Beginning Azure IoT Edge Computing: Extending the Cloud to the Intelligent Edge, MICROSOFT AZURE

PEC-DS-602A: Data Warehousing

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

Course Outcomes (COs):

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

1. Define the knowledge of mathematics and science on data warehouse, building blocks, Data Mart and recall in independent and life-long learning of data warehouse.
2. Classify Data warehouse Architecture in the areas of Data acquisition, Data storage and Information delivery and illustrate the engineering principles.
3. Make use of the architecture and infrastructure of Database Software and model appropriate tools for database software by applying the knowledge of software development by individual or team.
4. Analyze Metadata types by functional areas and assume effective reports on Business metadata by understanding of the engineering principles of metadata.
5. Justify effective reports on Data acquisition, Data storage, and Information delivery and evaluate the ability for life-long learning on data storage.

6. Discuss Knowledge Discovery Process, OLAP, Different techniques by building the knowledge of mathematics and engineering fundamentals on OLAP and develop applications in societal, health, safety, legal and cultural issues.

Prerequisites:

1. Knowledge of Programming skill.
2. Basic Statistics and mathematics.

Detailed Content:

Module	Content	Hours/ Module
1	Data Warehouse: Basic Concepts, Differences between Operational Database Systems and Data Warehouses- A Multitiered Architecture - Data Warehouse Models: Extraction, Transformation and Loading - Metadata Repository -Data Cube and OLAP -Data Warehouse Design and Usage – Data warehouse implementation.	7
2	Introduction To Data Mining: Introduction - The evolution of database system technology - Steps in knowledge discovery from database process - Architecture of a data mining systems - Data mining on different kinds of data - Different kinds of pattern - Technologies used - Applications - Major issues in data mining - Classification of data mining systems – Data mining task primitives - Integration of a data mining system with a database or data warehouse system.	8
3	Data Preprocessing: Data Objects and attribute types - Basic statistical description of data - Data visualization – Measuring data similarity and dissimilarity - Data cleaning - Integration - Data reduction – Data transformation and data discretization.	8
4	Association Rule Mining: Basic concepts - Frequent itemset mining methods - Apriori algorithm, APattern growth approach for mining frequent itemsets, Mining frequent itemsets using vertical data format, Mining closed and max patterns - Pattern mining in multilevel and multidimensional space – Constraint based Frequent pattern mining - Mining High-Dimensional Data and Colossal Patterns	8
5	Classification And Clustering: Classification: Basic concepts - Decision tree induction - Bayes classification methods-Rule Based Classification- Model Evaluation and Selection - Techniques to Improve Classification Accuracy - Bayesian Belief Networks - Classification by Back propagation - Cluster Analysis – Partitioning methods- Hierarchical methods.	9

Text and Reference books:

1. Jiawei Han, Micheline Kamber and Jian Pai, Data Mining: Concepts and Techniques, Morgan Kauffman, 2013
2. Alex Berson and Stephen J Smith, Data Warehousing, Data Mining, and OLAP, McGraw- Hill,2008
3. David Hand, Heikki Manila, Padhraic Symth, Principles of Data Mining, MIT Press, 2004
4. Margaret H. Dunham, Data Mining: Introductory and Advanced Topics, Pearson Education 2008

PEC-DS-602B: Big Data Analytics

Contacts: 3L per week **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. **Analyze** the optimization techniques in data bases.
5. **Analyze** 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 InfosphereBigInsights 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. **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	7
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 Pete Warden, Big Data Glossary, O'Reilly, 2011.
5. Big Data For Dummies, Judith Hurwitz, Alan Nugent, Fern Halper, Marcia Kaufman, Wiley 2013

PEC-DS-602C: Soft Computing

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

Course Outcomes (COs):

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

1. Characterize supervised and unsupervised learning neural networks based on its architecture, training and testing mechanism.
2. Apply the concept of fuzzification and defuzzification in fuzzy systems.
3. Classify the architecture and working principles of specialized neural networks.
4. Analyze the fundamental concepts of genetic algorithm and classify its types.
5. Design, implement and evaluate a system / computer-based system, process, component or program to meet desired needs.
6. Apply soft computing techniques to solve real time problems.

Prerequisites:

1. Mathematics
2. Data Structure & Algorithms
3. Programming and problem solving skills.

Detailed Content:

Module	Content	Hours/ Module
1	Introduction: Introduction to soft computing; introduction to fuzzy sets and fuzzy logic systems; introduction to biological and artificial neural network; introduction to Genetic Algorithm.	2
2	Fuzzy sets and Fuzzy logic systems: Classical Sets and Fuzzy Sets and Fuzzy relations: Operations on Classical sets, properties of classical sets, Fuzzy set operations, properties of fuzzy sets, cardinality, operations, and properties of fuzzy relations. Membership functions: Features of membership functions, standard forms and boundaries, different fuzzification methods. Fuzzy to Crisp conversions: Lambda Cuts for fuzzy sets, fuzzy Relations, Defuzzification methods. Classical Logic and Fuzzy Logic: Classical predicate logic, Fuzzy Logic, Approximate reasoning and Fuzzy Implication Fuzzy Rule based Systems: Linguistic Hedges, Fuzzy Rule based system – Aggregation of fuzzy Rules, Fuzzy Inference System- Mamdani Fuzzy Models – Sugeno Fuzzy Models. Applications of Fuzzy Logic: How Fuzzy Logic is applied in Home Appliances, General Fuzzy Logic controllers, Basic Medical Diagnostic systems and Weather forecasting	10
3	Neural Network	10

	Introduction to Neural Networks: Advent of Modern Neuroscience, Classical AI and Neural Networks, Biological Neurons and Artificial neural network; model of artificial neuron. Learning Methods: Hebbian, competitive, Boltzman etc., Neural Network models: Perceptron, Adaline and Madaline networks; single layer network; Back-propagation and multi layer networks. Competitive learning networks: Kohonen self organizing networks, Hebbian learning; Hopfield Networks. Neuo-Fuzzy modelling: Applications of Neural Networks: Pattern Recognition and classification	
4	Genetic Algorithms: Simple GA, crossover and mutation, Multi-objective Genetic Algorithm (MOGA). Applications of Genetic Algorithm: genetic algorithms in search and optimization, GA based clustering Algorithm, Image processing and pattern Recognition	10
5	Other Soft Computing techniques: Simulated Annealing, Tabu search, Ant colony optimization (ACO), Particle Swarm Optimization (PSO)	4
6	Applications of Soft Computing: Image Fusion - Neural network classification - Traveling salesman problem using Genetic algorithm - Genetic algorithm based Internet searching technique.	4

Text book and Reference books:

1. Fuzzy logic with engineering applications, Timothy J. Ross, John Wiley and Sons.
2. S. Rajasekaran and G.A.V.Pai, "Neural Networks, Fuzzy Logic and Genetic
1. Algorithms", PHI
2. Principles of Soft Computing , S N Sivanandam, S. Sumathi, John Wiley & Sons
3. Genetic Algorithms in search, Optimization & Machine Learning by David E. Goldberg
4. Neuro-Fuzzy and Soft computing, Jang, Sun, Mizutani, PHI
5. Neural Networks: A Classroom Approach,1/e by Kumar Satish, TMH,
6. Genetic Algorithms in search, Optimization & Machine Learning by David E. Goldberg, Pearson/PHI
7. A beginners approach to Soft Computing, Samir Roy & Udit Chakraborty, Pearson

PEC-DS-602D: Software Engineering

Contacts: 3L per week 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)

OEC-DS-601A: Soft Skill and Interpersonal Communication

Contacts: 3L per week **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-DS-601B: Operation Research

Contacts: 3L per week **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-DS-601C: Human Resource Management

Contacts: 3L per week **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. 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: Corporat 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-DS-601D: Organizational Behaviour

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

Course Outcomes (COs):

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

1. **Discuss** the development of the field of organizational behaviour and explain the micro and macro approaches
2. **Analyze** and compare different models used to explain individual behaviour related to motivation and rewards
3. **Identify** the processes used in developing communication and resolving conflicts
4. **Explain** group dynamics and demonstrate skills required for working in groups (team building)
5. **Evaluate** the various leadership styles and the role of leaders in a decision making process.
6. **Design** the implementation of organizational change

Prerequisites:

NIL

Detailed Content:

Module	Content	Hours/ Module
1	Definition, need and importance of organizational behaviour – Nature and scope – Frame work – Organizational behaviour models.	5
2	Individual Behaviour: Personality – types – Factors influencing personality – Theories – Learning – Types of learners – The learning process – Learning theories – Organizational behaviour modification. Misbehaviour – Types – Management Intervention. Emotions - Emotional Labour – Emotional Intelligence – Theories. Attitudes – Characteristics – Components – Formation – Measurement- Values. Perceptions – Importance – Factors influencing perception – Interpersonal perception- Impression Management. Motivation – importance – Types – Effects on work behavior.	8
3	Group Behaviour: Organization structure – Formation – Groups in organizations – Influence – Group dynamics – Emergence of informal leaders and working norms – Group decision making techniques –Team building- Interpersonal relations – Communication – Control.	7
4	Leadership and Power: Meaning – Importance – Leadership styles – Theories – Leaders Vs Managers – Sources of power – Power centers – Power and Politics.	5
5	Dynamics of Organizational Behaviour Organizational culture and climate – Factors affecting organizational climate – Importance. Job satisfaction – Determinants – Measurements – Influence on behavior. Organizational change – Importance – Stability Vs Change – Proactive Vs Reaction change – the change process – Resistance to change – Managing change. Stress – Work Stressors – Prevention and Management of stress – Balancing work and Life. Organizational development – Characteristics – objectives –. Organizational effectiveness.	5

Text book and Reference books:

1. P. Robins, Organisational Behavior, PHI Learning / Pearson Education,11th edition, 2008.
2. Fred Luthans, Organisational Behavior, McGraw Hill, 11th Edition, 2001.
3. Schermerhorn, Hunt and Osborn, Organisational behavior, John Wiley, 9th Edition, 2008.
4. Udai Pareek, Understanding Organisational Behaviour, 2nd Edition, Oxford Higher Education, 2004.
5. Mc Shane & Von Glinov, Organisational Behaviour, 4th Edition, Tata Mc Graw Hill, 2007.
6. Hellrigal, Slocum and Woodman, Organisational Behavior, Cengage Learning, 11th Edition 2007.
7. Ivancevich, Konopaske &Maheson, Oranisational Behaviour & Management, 7th edition, Tata McGraw Hill, 2008.

MC-DS-601: Technical and Quantitative Aptitude

Contacts:1L per week **Credits: 0**

Course Outcomes (COs):

On successful completion of the course the students will be able to:

- Understand the basic concepts of quantitative ability
- Understand the basic concepts of logical reasoning Skills
- Acquire satisfactory competency in use of reasoning
- Solve campus placements aptitude papers covering Quantitative Ability, Logical Reasoning Ability
- Compete in various competitive exams like CAT, CMAT, GATE, GRE, UPSC, GPSC etc.
- Learn professional ethics.

Prerequisites:

- Basic Mathematics
- Basic Physics

Detailed Content:

Module No	*Content*	*Hours / Module*
1	**UNIT - I** **1. Quantitative Ability** (**Basic Mathematics**) 1.1. Number Systems 1.2. LCM and HCF 1.3. Decimal Fractions 1.4. Simplification 1.5. Square Roots and Cube Roots 1.6. Average 1.7. Problems on Ages 1.8. Surds & Indices 1.9. Percentages 1.10 Problems on Numbers	4
2	**UNIT – II** **2. Quantitative Ability** (**Applied & Engineering Mathematics**) 2.1. Logarithm 2.2. Permutation and Combinations 2.3 Probability 2.4 Profit and Loss 2.5 Simple and Compound Interest 2.6. Time, Speed and Distance 2.7. Time & Work 2.8. Ratio and Proportion 2.9. Area 2.10 Mixtures and Allegation	4
3	**UNIT – III** **2. Data Interpretation** 3.1. Data Interpretation 3.2. Tables 3.3. Column Graphs 3.4. Bar Graphs 3.5. Line Charts 3.6. Pie Chart 3.7. Venn Diagrams	3

4	**UNIT – IV** **4. Logical Reasoning (Deductive Reasoning)** 4.1. Analogy 4.2. Blood Relation 4.3 Directional Sense 4.4. Number and Letter Series 4.5. Coding – Decoding 4.6. Calendars 4.7. Clocks 4.8. Venn Diagrams 4.9. Seating Arrangement 4.10. Syllogism 4.11. Mathematical Operations	4

Text/Reference Books:

1. A Modern Approach to Verbal & Non-Verbal Reasoning By R S Agarwal
2. Analytical and Logical reasoning By Sijwali B S
3. Quantitative aptitude for Competitive examination By R S Agarwal
4. Analytical and Logical reasoning for CAT and other management entrance test By Sijwali B S
5. Quantitative Aptitude by Competitive Examinations by Abhijit Guha 4th edition

PCC-DS-691: Data Analysis and Visualization Lab

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

Course Outcomes (COs):

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

- **Use** data analysis tools in the pandas library, Power BI and Tableau.
- **Assess** Load, clean, transform, merge and reshaping of data operation.
- **Apply** pre-processing method to multi-dimensional data, and manipulate time series data.
- **Understand** real world data analysis problems.
- **Design** and Analysis Hierarchical and Topographical Data.
- **Remember** Interactive data plots.

Prerequisites:

- Microsoft Excel
- Python

Detailed Content/ List of Experiments:

1: Visualization of Spread sheet Models in Python.
2: Oracle Database Connectivity using Python.
3: Visualization of Semi-Structured Data.
4: Introduction to Tableau/Power BI and Aggregation Methods in Tableau/Power BI.
5: Visual Encodings and Basic Dashboards in Tableau/Power BI.
6: Interactive Plots in Python.
7: Hierarchical and Topographical Data Visualizations in Tableau/Power BI.
8: Calendar Heat maps and Flow Data Visualizations in Python.
9: Time Series Data Visualization in Python.
10: Dashboards, Actions and Story Telling in Tableau/Power BI.

Text book and Reference books:

1. Andy Kirk, Data Visualization A Handbook for Data Driven Design, Sage Publications, 2016
2. Philipp K. Janert, Gnuplot in Action, Understanding Data with Graphs, Manning Publications, 2010.
3. Hastie, T., Tibshirani, R., Friedman, J. (2009). The elements of statistical learning: data mining, inference and prediction. Springer.
4. Richard O. Duda, Peter E. Hart, and David G. Stork. 2000. Pattern Classification (2nd Edition). Wiley-Interscience, New York, NY, USA.
5. Christopher M. Bishop. 2006. Pattern Recognition and Machine Learning (Information Science and Statistics). Springer-Verlag, Berlin, Heidelberg.

PCC-DS-692: Computer Networks Lab

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

Course Outcomes (COs):

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

- **Design** an application to execute command remotely using socket programming.
- **Evaluate** file transfer application using socket programming.
- **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.
- **Implement** error-control mechanism for data transmission.
- **Understand** the concepts of NIC installation and configuration.
- **Remember** to gather network information using socket programming.

Prerequisites

- Programming for Problem Solving
- Data Structure and Algorithms
- Object Oriented Programming & Java
- Computer 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:

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

Semester VII (Fourth year)

PEC-DS-701A: Information Theory and Coding

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

Course Outcomes (COs):

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

- Apply various source coding techniques.
- Design the channel performance using Information theory.
- Comprehend various error control code properties
- Apply linear block codes for error detection and correction
- Apply convolution codes for performance analysis & cyclic codes for error detection and correction.
- Design BCH & RS codes for channel performance improvement against burst errors.

Prerequisites:

- Basic Mathematics
- Probability and Statistics

Detailed Content:

Module 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.	6
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 Polynomials, division algorithm for polynomials, a method for generating cyclic codes, matrix description of cyclic codes, Golay codes.	5
6	BCH Codes Primitive elements, minimal polynomials, generator polynomials in terms of	5

	minimal polynomials, examples of BCH codes.	
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.	7
	Total	34

Text/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-DS-701B: 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 (ILP): 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	4

	architectures, systolic architectures.	
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-DS-701C: 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:

- 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

PEC-DS-701D: Internet Technology

Contacts: 3L per week **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

1. Knowledge of Programming Language.
2. 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:	8

	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.	
2	HTML: Introduction, Editors, Elements, Attributes, Heading, Paragraph. Formatting, Link, Head, Table, List, Block, Layout, CSS.Form, Iframe, Colors, Colorname, Colorvalue. Image Maps: 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.	10
3	PERL: Introduction, Variable, Condition, Loop, Array, Implementing data structure, Hash, String, Regular Expression, File handling, 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-DS-702A: Internet of Things

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

Course Outcomes (COs):
At the end of the course, the students will be able to:

- **Understand** the vision of IoT from a global context.
- **Determine** the Market perspective of IoT.
- **Design** Devices, Gateways and Data Management in IoT.
- **Building** state of the art architecture in IoT.
- **Apply** IoT in Industrial and Commercial Building Automation and Real-World Design
- **Evaluate** the performance of IoT devices

Prerequisites:

- Computer Networks
- Sensor Technology

Detailed Content:

Module	Content	Hours/ Module
1	M2M to IoT-The Vision-Introduction, From M2M to IoT, M2M towards IoT-the global context, A use case example, Differing Characteristics.	5
2	**Understand IoT Market perspective.** M2M to IoT – A Market Perspective– Introduction, Some Definitions, M2M Value Chains, IoT Value Chains, An emerging industrial structure for IoT, The international driven global value chain and global information monopolies. M2M to IoT- An Architectural Overview– Building an architecture, Main design principles and needed capabilities, An IoT architecture outline, standards considerations.	8
3	**Data and Knowledge Management and use of Devices in IoT Technology.** M2M and IoT Technology Fundamentals- Devices and gateways, Local and wide area networking, Data management, Business processes in IoT, Everything as a Service (XaaS), M2M and IoT Analytics, Knowledge Management. Understand State of the Art – IoT Architecture. IoT Architecture-State of the Art – Introduction, State of the art, Architecture Reference Model- Introduction, Reference Model and architecture, IoT reference Model.	8
4	**Real World IoT Design Constraints, Industrial Automation and Commercial Building Automation in IoT.** IoT Reference Architecture- Introduction, Functional View, Information View, Deployment and Operational View, Other Relevant architectural views. Real-World Design Constraints- Introduction, Technical Design constraints-hardware is popular again, Data representation and visualization, Interaction and remote control. Industrial Automation- Service-oriented architecture-based device integration, SOCRADES: realizing the enterprise integrated Web of Things, IMC-AESOP: from the Web of Things to the Cloud of Things, Commercial Building Automation – Introduction, Case study: phase one-commercial building automation today, Case study: phase two- commercial building automation in the future.	10

Text book and Reference books:

1. Jan Holler, Vlasios Tsiatsis, Catherine Mulligan, Stefan Avesand, Stamatis Karnouskos, David Boyle, "From Machine-to-Machine to the Internet of Things: Introduction to a New Age of Intelligence", 1st Edition, Academic Press, 2014.
2. Vijay Madisetti and Arshdeep Bahga, "Internet of Things (A Hands-on-Approach)", 1stEdition, VPT, 2014.
3. Francis daCosta, "Rethinking the Internet of Things: A Scalable Approach to Connecting Everything", 1st Edition, Apress Publications, 2013

PEC-DS-702B: Information Retrieval

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

Course Outcomes (COs)

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

1. **Describe** the objectives of information retrieval.
2. **Understand** relevance feedback in vector space model and probabilistic model.
3. **Understand** query, document and phrase.
4. **Ability** to apply IR principles to locate relevant information large collections of data.
5. **Ability** to design different document clustering algorithms
6. **Implement** retrieval systems for web search tasks.

Prerequisites

- Database Management System
- Design and Analysis of Algorithm

Detailed Content:

Module	***Content***	***Hours/ Module***
1	Introduction to Information Retrieval Systems: Definition of Information Retrieval System, Objectives of Information Retrieval Systems, Functional Overview, Relationship to Database Management Systems, Digital Libraries and Data Warehouses. Information Retrieval System Capabilities: Search Capabilities, Browse Capabilities, Miscellaneous Capabilities	4
2	Cataloging and Indexing: History and Objectives of Indexing, Indexing Process, Automatic Indexing, Information Extraction Data Structure: Introduction to Data Structure, Stemming Algorithms, Inverted File Structure, N-Gram Data Structures, PAT Data Structure, Signature File Structure, Hypertext and XML Data Structures, Hidden Markov Models.	7
3	Automatic Indexing: Classes of Automatic Indexing, Statistical Indexing, Natural Language, Concept Indexing, Hypertext Linkages. Document and Term Clustering: Introduction to Clustering, Thesaurus Generation, Item Clustering, Hierarchy of Clusters	7
4	User Search Techniques: Search Statements and Binding, Similarity Measures and Ranking, Relevance Feedback, Selective Dissemination of Information Search, Weighted Searches of Boolean Systems, Searching the INTERNET and Hypertext Information Visualization: Introduction to Information Visualization, Cognition and	7

	Perception, Information Visualization Technologies.	
5	Text Search Algorithms: Introduction to Text Search Techniques, Software Text Search Algorithms, Hardware Text Search Systems. Multimedia Information Retrieval: Spoken Language Audio Retrieval, Non-Speech Audio Retrieval, Graph Retrieval, Imagery Retrieval, Video Retrieval	6

Text book and Reference books:

a. C. Manning, P. Raghavan, and H. Schütze, "Introduction to Information Retrieval", Cambridge University Press, 2008.
b. R. Baeza-Yates and B. Ribeiro Neto, "Modern Information Retrieval: The Concepts and Technology behind Search", Second Edition, Addison Wesley, 2011.
c. David A. Grossman and Ophir Frieder "Information Retrieval: Algorithms and Heuristics", Second Edition, Springer 2004.
d. Gerald J Kowalski, Mark T Maybury Information Storage and Retrieval Systems: Theory and Implementation, Springer, 2004.

PEC-DS-702C: Ecommerce and ERP

Contacts: 3L per week **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 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.	6
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	6

	Network, Emerging Client Server Security Threats, firewalls & Network Security.	
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

PEC-DS-702D: Block chain Technology

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

Course Outcomes (COs)

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

1. Understand emerging abstract models for Block chain technology
2. Analyze the concept of bit coin and mathematical background behind it
3. Apply the tools for understanding the background of crypto currencies
4. Identify major research challenges and technical gaps existing between theory and practice in crypto currency domain
5. Understanding of latest advances and its applications in Block chain technology.
6. The course will enable an individual to learn, how these systems work and how to engineer secure software that interacts with the Bit coin network and other crypto currencies.

Prerequisites

1. Data Structures and algorithm
2. Cryptography

Detailed Content

Sl No	Content	Hours/ Module
1	**INTRODUCTION** Basic of Block chain Architecture – Challenges – Applications – Block chain Design Principles -The Block chain 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 -	5

	formal treatment of consistency, liveness and fairness - Proof of Stake (PoS) based Chains - Hybrid models (PoW + PoS).	
2	**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
3	**BITCOIN** Wallet - Blocks - Merkley Tree - hardness of mining - transaction verifiability - anonymity - forks - double spending - mathematical analysis of properties of Bit coin. Bitcoin block chain, the challenges, and solutions, proof of work, Proof of stake, alternatives to Bitcoin consensus, Bitcoin scripting language and their uses.	5
4	**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
5	**BLOCK CHAIN-RECENT TREND** Blockchain Implementation Challenges- Zero Knowledge proofs and protocols in Block chain - Succinct non interactive argument for Knowledge (SNARK) - pairing on Elliptic curves – Zcash - attacks on Block chains – such as Sybil attacks, selfish mining, 51% attacks - -advent of algorand, and Sharding based consensus algorithms	5

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; 1st edition, 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.

OEC-DS-701A: Bioinformatics

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

Course Outcomes (COs):

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

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

Prerequisites:

- Biological Science
- 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). Chemoinformatics in Drug Discovery, Volume 23. Wiley Online Library.

OEC-DS-701B: Cyber Law and Cyber Security

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

Course Outcomes (COs):

After studying this course, student will be able to:

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

Prerequisites:

- Computer Networks
- Cyber Security

Detailed Content:

Unit	Content	Hrs. / Unit
1.	**Introduction of Cybercrime:** What is cybercrime? Forgery, Hacking, Software Piracy, Computer Network intrusion. **Category Cybercrime:** of how criminals plan attacks, passive attack, Active attacks, cyberstalking.	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	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.	8
4.	**Phishing & Identity Theft**: Phishing methods, ID Theft; Online identity method. **Cybercrime & Cybersecurity**: Legal aspects, Indian laws, IT act, public key certificate.	8

Text book and Reference books:

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

OEC-DS-701C: Optimization Technique

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

Course Outcomes (COs):

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

- **Analyse** the real-life systems with limited constraints.
- **Depict** the systems in a mathematical model form.
- **Solve** the mathematical model manually as well as using soft resources/software under the given constraints.
- **Describe** the Concept of optimization and classification of optimization problems.
- **Understand** variety of real industrial problems such as resource allocation, production planning, assignment, transportation, travelling salesman etc. and solve these problems using linear programming approach using software.
- **Formulation** simplex methods variable with upper bounds.

Prerequisites:

- Linear algebra
- Probability and statistics
- Fundamentals of Computing and Programming

Detailed Content:

Unit	Content	Hrs/ Unit
1	Historical Development; Engineering applications of Optimization; Art of Modeling, Objective function; Constraints and Constraint surface; Formulation of design problems as mathematical programming problems. Classification of optimization problems, Optimization techniques –classical and advanced techniques. Introduction to Operation Research: Operation Research approach, scientific methods, introduction to models and modeling techniques, general methods for Operation Research models, methodology and advantages of Operation Research, history of Operation Research.	9
2	Linear Programming (LP): Introduction to LP and formulation of Linear Programming problems, Graphical solution method, alternative or multiple optimal solutions, Unbounded solutions, Infeasible solutions, Maximization – Simplex Algorithm, Minimization – Simplex Algorithm using Big-M method, Two phase method, Duality in linear programming, Integer linear programming.	7
3	Allocation problems and Game Theory: Introduction to Transportation problems, Transportation problem –Methods of basic feasible solution -Optimal solution–MODI Method. Assignment problem-Hungarian method Game theory: Two people-zero sum game-mixed stages -Dominance properties	8
4	Sequential optimization; Representation of multi stage decision process Types of multi stage decision problems; Concept of sub optimization and the principle of optimality. Recursive equations –Forward and backward recursions; Computational procedure in dynamic programming (DP), Discrete versus continuous dynamic programming; Multiple state variables; curse of dimensionality in DP; Problem formulation and application in Design of continuous beam and optimal geometric layout of atruss	8
5	Network Analysis: Network definition and Network diagram, probability in PERT analysis, project time cost trade off, introduction to resource smoothing and allocation Sequencing: Introduction, processing N jobs through two machines, processing N jobs through three machines, processing N jobs through m machines. Inventory Model: Introduction to inventory control, deterministic inventory model, EOQ model with quantity discount	8

Text Books/ References:

1. Hamdy A. Taha, Operations Research, Prentice Hall, Pearso.
2. J. S Arora, Introduction to optimum design, 2nd edition, Elsevier India Pvt. Ltd.,
3. S. S Rao, Optimization: theory and application, Wiley Eastern Ltd., New Delhi.
4. Wayne L. Winston - Operations Research - Applications and Algorithms-Duxbury Press (2003).
5. Ravindra K. Ahuja, Thomas L. Magnanti, and James B. Orlin, Network Flows: Theory, Algorithms, and Applications, Pearson.
6. J K Sharma, Operations Research Theory and Applications, MacMillan India Ltd.
7. N D Vohra, Quantitative Techniques in management, Tata McGraw Hill.
8. Payne T A, Quantitative Techniques for Management: A Practical Approach, Reston Publishing Co. Inc., Virginia.
9. Achille Messac, Optimization in practice with MATLAB, Cambridge University Press, 2015.

OEC-DS-701D: Microprocessor and Microcontrollers

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

Course Outcomes (COs):

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

- **Recall** and **apply** a basic concept of digital fundamentals to Microprocessor based personal computer system.
- **Identify** a detailed s/w & h/w structure of the Microprocessor.
- **Illustrate** how the different peripherals (8255, 8253 etc.) are interfaced with Microprocessor.
- **Distinguish** and analyse the properties of Microprocessors & Microcontrollers.
- **Analyse** the data transfer information through serial & parallel ports.
- **Train** their practical knowledge through laboratory experiments.

Prerequisites:

- Digital Electronics
- Computer Organization & Architecture

Detailed Content:

Unit	Content	Hrs/ Unit
1	Introduction to 8085A CPU architecture-register organization, addressing modes and their features. Software instruction set and Assembly Language Programming. Pin description and features.	8
2	Instruction cycle, machine cycle, Timing diagram.	3
3	Hardware Interfacing: Interfacing memory, peripheral chips (IO mapped IO & Memory mapped IO). Interrupts and DMA.	7
4	Peripherals: 8279, 8255, 8251, 8253, 8237, 8259, A/D and D/A converters and interfacing of the same. Typical applications of a microprocessor.	8
5	16-bit processors: 8086 and architecture, segmented memory has cycles, read/write cycle in min/max mode. Reset operation, wait state, Halt state, Hold state, Lock operation, interrupt processing. Addressing modes and their features. Software instruction set (including specific instructions like string instructions, repeat, segment override, lock prefizers and their use) and Assembly Language programming with the same.	9
6	Brief overview of some other microprocessors (e.g. 6800 Microprocessor).	3

Text Books and References:

1. Microprocessor architecture, programming and applications with 8085/8085A, Wiley eastern Ltd, 1989 by Ramesh S. Gaonkar.
2. Intel Corp: The 8085 / 8085A. Microprocessor Book – Intel marketing communication, Wiley inter science publications, 1980.
3. An introduction to micro-computers Vol. 2 – some real Microprocessor – Galgotia Book Source, New Delhi by Adam Osborne and J. Kane
4. Advanced Microprocessors by Ray and Bhurchandi - TMH
5. Intel Corp. Micro Controller Handbook – Intel Publications, 1994.
6. Microprocessors and Interfacing by Douglas V. Hall, McGraw Hill International Ed. 1992
7. Assembly Language Programming the IBM PC by Alan R. Miller, Subex Inc, 1987

8. The Intel Microprocessors: 8086/8088, 80186, 80286, 80386 & 80486, Bary B. Brey, Prentice Hall, India 1996.

HSMC-DS-701: Project Management and Entrepreneurship

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

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 [2L] 2. **Entrepreneurship – An Innovation:** Challenges of Innovation, Steps of Innovation Management, Idea Management System, Divergent v/s Convergent Thinking, Qualities of a prospective Entrepreneur [2L] 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 [4L] 4. **Entrepreneurial Motivation:** Design Thinking - Driven Innovation, TRIZ (Theory of Inventive Problem Solving), Achievement motivation theory of entrepreneurship – Theory of McClelland, Harvesting Strategies [2L] 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 [4L] 6. **Closing the Window:** Sustaining Competitiveness, Maintaining Competitive Advantage, the Changing Role of the Entrepreneur. [2L] 7. Applications and Project Reports Preparation [4L]	20
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 [4L] 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 [2L] 3. **Project Planning** – Importance of Project Planning, Steps of Project Planning, Project Scope, Work Breakdown Structure (WBS) and Organization Breakdown Structure (OBS),	20

	Phased Project Planning [2L] 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. [6L] 5**. Project Monitoring and Control** – Role of Project Manager, MIS in Project Monitoring, Project Audit [2L] 6. Case Studies with Hands-on Training on MS-Project [4L]	

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 (Fourth Year)

PEC-DS-801A: Artificial Neural Network

Contacts: 3L per week Credits: 3

Course Outcomes (COs):

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

1. **Analyze** synaptic connectivity as the basis of neural computation and learning
2. **Evaluate** the ideological basics of artificial neural networks
3. **Understand** the origins of artificial neural networks
4. **Know** some application of artificial neural networks
5. **Identify** the different structures of artificial neural networks.
6. **Learn** perceptron and dynamical theories of recurrent networks including amplifiers, attractors, and hybrid computation.

Prerequisites:

- Higher Engineering Mathematics e.g. linear algebra, multivariate calculus and Probability theory,
- Data Structure and Algorithms
- Fundamental knowledge of signals and systems along with types, Mathematical representation of signals and system modelling in time as well as frequency domain.

Detailed Content:

Module	***Content***	***Hours/ Module***
1	Introduction to ANN Features, structure and working of Biological Neural Network, Trends in Computing Comparison of BNN and ANN	7
2	Basics of Artificial Neural Networks: History of neural network research, characteristics of neural networks terminology, models of neuron Mc Culloch – Pitts model, Perceptron, Adaline model, Basic learning laws, Topology of neural network architecture	6
3	Backpropagation networks: (BPN)	6

	Architecture of feed forward network, single layer ANN, multilayer perceptron, back propagation learning, input - hidden and output layer computation, backpropagation algorithm, applications, selection of tuning parameters in BPN, Numbers of hidden nodes, learning.	
4	Activation & Synaptic Dynamics: Introduction, Activation Dynamics models, synaptic Dynamics models, stability and convergence, recall in neural networks.	5
5	Basic functional units of ANN for pattern recognition tasks: Basic feed forward, Basic feedback and basic competitive learning neural network.	6

Text book and Reference books:

1. B. Yegnanarayana - Artificial neural network PHI Publication.
2. S. Raj sekaran, Vijayalakshmi Pari - Neural networks, Fuzzy logic and Genetic Algorithms
3. Kevin L. Priddy, Paul E. Keller – Artificial neural networks: An Introduction - SPIE Press, 2005
4. Mohammad H. Hassoun – Fundamentals of artificial neural networks - MIT Press, 1995
5. Nelson Morgan – Artificial neural network: Electronic Implementations – IEEE Press, 1990
6. Journal of Artificial neural networks, Volume 1 – Ablex Publishing Corporation, 1994

PEC-DS-801B: 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 **Tokenization** [**5L**] Word Tokenization, Normalization, Sentence Segmentation, Named Entity Recognition,	11

	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

PEC-DS-801C: Web Mining

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

Course Outcomes (COs):

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

- **Implement** web search concepts and methods to return documents automatically based on user queries.
- **Design** and implement a crawler application to collect and index documents from the web.
- **Develop** computational methods to classify documents by topic.
- **Create** a system to collect and analyse streaming data.
- **Evaluate** the performance of web search systems.
- **Analyse** text to determine the reliability of the information including potential bias.

Prerequisites:

- Basic knowledge of algebra, discrete math and statistics.

- Knowledge of Data Mining, and Machine Learning for extracting knowledge from the web.

Detailed Content:

Unit	Content	Hrs/ Unit
1	Introduction to Web Data Mining and Data Mining Foundations, Introduction – World Wide Web (WWW), A Brief History of the Web and the Internet, Web Data Mining-Data Mining, Web Mining. Data Mining Foundations – Association Rules and Sequential Patterns – Basic Concepts of Association Rules, Apriori Algorithm- Frequent Itemset Generation, Association Rule Generation, Data Formats for Association Rule Mining, Mining with multiple minimum supports – Extended Model, Mining Algorithm, Rule Generation, Mining Class Association Rules, Basic Concepts of Sequential Patterns, Mining Sequential Patterns on GSP, Mining Sequential Patterns on PrefixSpan, Generating Rules from Sequential Patterns.	10
2	Information Retrieval and Web Search: Basic Concepts of Information Retrieval, Information Retrieval Methods – Boolean Model, Vector Space Model and Statistical Language Model, Relevance Feedback, Evaluation Measures, Text and Web Page Pre-processing – Stopword Removal, Stemming, Web Page Preprocessing, Duplicate Detection, Inverted Index and Its Compression – Inverted Index, Search using Inverted Index, Index Construction, Index Compression, Latent Semantic Indexing – Singular Value Decomposition, Query and Retrieval, Web Search, Meta Search, Web Spamming.	10
3	Link Analysis and Web Crawling: Link Analysis – Social Network Analysis, Co-Citation and Bibliographic Coupling, Page Rank Algorithm, HITS Algorithm, Community Discovery-Problem Definition, Bipartite Core Communities, Maximum Flow Communities, Email Communities. Web Crawling – A Basic Crawler Algorithm- Breadth First Crawlers, Preferential Crawlers, Implementation Issues – Fetching, Parsing, Stopword Removal, Link Extraction, Spider Traps, Page Repository, Universal Crawlers, Focused Crawlers, Topical Crawlers, Crawler Ethics and Conflicts.	10
4	Opinion Mining and Web Usage Mining Opinion Mining – Sentiment Classification – Classification based on Sentiment Phrases, Classification Using Text Classification Methods, Feature based Opinion Mining and Summarization – Problem Definition, Object feature extraction, Feature Extraction from Pros and Cons of Format1, Feature Extraction from Reviews of Format 2 and 3, Comparative Sentence and Relation Mining, Opinion Search and Opinion Spam. Web Usage Mining – Data Collection and Pre-processing- Sources and Types of Data, Key Elements of Web usage Data Pre-processing, Data Modeling for Web Usage Mining, Discovery and Analysis of Web usage Patterns -Session and Visitor Analysis, Cluster Analysis and Visitor Segmentation, Association and Correlation Analysis, Analysis of Sequential and Navigation Patterns.	10

Text Book / Reference Books:

1. Web Data Mining: Exploring Hyperlinks, Contents, and Usage Data by Bing Liu (Springer Publications)
2. Data Mining: Concepts and Techniques, Second Edition Jiawei Han, Micheline Kamber (Elsevier Publications)
3. Web Mining : Applications and Techniques by Anthony Scime
4. Mining the Web: Discovering Knowledge from Hypertext Data by Soumen Chakrabarti

PEC-DS-801D: Quantum Computing

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

Course Outcomes (COs):

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

- **Explain** the working of a Quantum Computing program, its architecture and program model**.**
- **Develop** quantum logic gate circuits.
- **Design** different mathematical foundation for quantum computing.
- **Develop** quantum computing algorithm.
- **Program** quantum algorithm on major toolkits.
- **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	14

	· 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)	
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 error correction Classical three-bit code Fault tolerance Quantum error correction Three- and nine-qubit quantum codes Fault-tolerant quantum computation	7

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.

OEC-DS-801A: Embedded Systems

Contacts: 3L per week **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	Contents	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-DS-801B: 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-DS-801C: Human Computer Interaction

Contacts: 3L per week Credits: 3

Course Outcomes (COs):

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

- **Explain** the capabilities of both humans and computers from the viewpoint of human information processing.
- **Describe** typical human–computer interaction (HCI) models, styles, and various historic HCI paradigms.
- **Apply** an interactive design process and universal design principles for designing HCI systems.
- **Analyze** and identify user models, user support, socio-organizational issues, and stakeholder requirements of HCI systems.
- **Apply** design and development principles in the construction of HCI systems
- **Use** current techniques, skills, and tools necessary for computing practice.

Prerequisites:

- Basics of programming
- Data Structure and Algorithms

Detailed Content:

Module	Content	Hours/ Module
1	Introduction to Human-Computer Interaction, Task-centered system design: task-centered process, development of task examples, evaluation of designs through a task-centered walk-through	6
2	User-centered design and prototyping: assumptions, participatory design, methods for involving the user, prototyping, low fidelity prototypes, medium fidelity	6
3	Methods for evaluation of interfaces with users: goals of evaluation, approaches, ethics, introspection, extracting the conceptual model, direct observation, constructive interaction, interviews and questionnaires, continuous evaluation via user feedback and field studies, choosing an evaluation method	8
4	Psychology of everyday things: psychopathology of everyday things, examples, concepts for designing everyday things, Beyond screen design: characteristics of good representations, information visualization, Tufte's guidelines, visual variables	5
5	Graphical screen design: graphical design concepts, Design principles and usability heuristics: design principles, principles to support usability, HCI design standards: process-oriented standards, product-oriented standards, Past and future of HCI: the past, present and future, perceptual interfaces, context-awareness and perception.	5

Text book and Reference books:

1. Dix A. et al., Human-Computer Interaction, Harlow, England, Prentice Hall, 2004, ISBN-10: 0130461091
2. Yvonne Rogers, Helen Sharp, Jenny Preece, Interaction Design: Beyond Human Computer Interaction, 3rd, Edition, Wiley, 2011, ISBN-10: 04706657693.

OEC-DS-801D: Cryptography and Network Security

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

Course Outcomes (COs):

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

- **Design** network application security schemes, such as PGP, S/MIME, SSL, HTTPS etc.
- **Evaluate** concepts of Firewall (including types of Firewall), DMZ Network and comparing between different Firewall Configurations.
- **Analyze** Biometric Authentication and differentiate between different types of Authentication tokens.
- **Implement and apply** numerical module based on DES and RSA illustrating the concept of SSL, PGP, Authentication token, Digital Signature, Message Digest and Hash function.
- **Understand** and classify different kinds of Substitution techniques and Transposition techniques and discuss the concepts of Symmetric key cryptography and Asymmetric key cryptography.
- **Define** the concepts of Network security and identifying different types of attack on Network security.

Prerequisites:

- Computer Networks
- Discrete Mathematics

Detailed Content:

Module	Content	Hours/ Module
1	**Network Security and Cryptography**: Concepts and Techniques, Need for Security, Security approaches, Principles of Security, Types of attack on security. Introduction to cryptography, Plaintext & Cipher text, Substitution Techniques, Transposition Techniques, Encryption & Decryption, Type of attacks on encrypted text, Symmetric & Asymmetric key Cryptography.	9
2	**Symmetric Key Algorithms:** Algorithm types & Modes, Overview of Symmetric Key Cryptography, Diffie-Hellman key exchange algorithm, Digital Envelope, DES (Data Encryption Standard) algorithm & its variant, IDEA(International Data Encryption Algorithm) algorithm, RC5 (Rivest Cipher 5) algorithm.	8
3	**Asymmetric Key Algorithms**: Digital Signature and User Authentication, Overview of Asymmetric key Cryptography, RSA algorithm, Digital Signature, Basic concepts of Message Digest and Hash Function (Algorithms on Message Digest and Hash function not required), HMAC algorithm. Authentication Basics, Password, Authentication Token, Certificate based Authentication and Biometric Authentication.	9
4	**Electronic mail security, SSL and Firewall**: Basics of mail security, PEM, PGP, S/MIME, Secure Socket Layer (SSL) protocol. Introduction to Firewall, Types of firewall, Firewall Configurations and DMZ Network.	6

Text book and Reference books:

1. Cryptography and Network Security, William Stallings, 2nd Edition, Pearson Education Asia
2. Network Security private communication in a public world, C. Kaufman, R. Perlman and M. Speciner, Pearson
3. Cryptography & Network Security: Atul Kahate, TMH.
4. Network Security Essentials: Applications and Standards by William Stallings, Pearson.
5. Designing Network Security, Merike Kaeo, 2nd Edition, Pearson Books.
6. Building Internet Firewalls, Elizabeth D. Zwicky, Simon Cooper, D. Brent Chapman, 2nd Edition, Oreilly.

7. Practical Unix & Internet Security, Simson Garfinkel, Gene Spafford, Alan Schwartz, 3rd Edition, Oreilly.

OEC-DS-802A: Economic Policies in India

Contacts: 3L per week 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.
7. Dantwala, M. L. (1996), Dilemmas of Growth: The Indian Experience, Sage Publications, New Delhi.
8. Datt, R. (Ed.) (2001), Second Generation Economic Reforms in India, Deep Publications, New Delhi.
9. Government of India, Economic Survey (Annual), Ministry of Finance, New Delhi.
10. Jain, a. K. (1986), Economic Planning in India, Ashish Publishing House, New Delhi.
11. Jalan, B. (1992), The Indian Economy – Problems and Prospects, Viking, New Delhi.

OEC-DS-802B: Compiler Design

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

Course Outcomes (COs):

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

- Describe the compilation phases, input and output of each phases, recognizing different possible errors detected by different phases..
- Design a DFA to recognize partial keywords of C programming language and lexical analyzer, automated lexical analyzer using LEX, and FLEX.
- Understand the role of a parser, syntax analysis phase, top-down parsing and bottom-up parsing techniques and automated parser generation tool: YACC.
- Realize and explain the role of semantic analysis phase with data type handling issues, associated actions with CFG rules using SDD and SDT.
- Understand different ways of intermediate code generation techniques and intermediate representation of any high-level language code segment, and run-time environment issues during compilation.
- Develop the knowledge of code optimization and code generation issues, construct flow graphs and DAG representation of basic blocks, and register allocation and assignment.

Prerequisites:

- Formal Language & Automata
- Knowledge of Programming Language

Detailed Content:

Module	***Content***	***Hours/ Module***
1	Introduction to Compiling Compilers, Analysis of the source program, The phases of the compiler, Cousins of the compiler.	2
2	Lexical Analysis The role of the lexical analyzer, Tokens, Patterns, Lexemes, Input buffering, Specifications of a token, Recognition of a tokens, Finite automata, From a regular expression to an NFA, From a regular expression to NFA, From a regular expression to DFA, Design of a lexical analyzer generator (Lex).	5
3	Syntax Analysis The role of a parser, Context free grammars, Writing a grammar, Top down Parsing,	8

	Non-recursive Predictive parsing (LL), Bottom up parsing, Handles, Viable prefixes, Operator precedence parsing, LR parsers (SLR, LALR), Parser generators (YACC). Error Recovery strategies for different parsing techniques.	
4	Syntax directed translation Syntax director definitions, Construction of syntax trees, Bottom-up evaluation of S attributed definitions, L attributed definitions, Bottom-up evaluation of inherited attributes.	4
5	Type checking Type systems, Specification of a simple type checker, Equivalence of type expressions, Type conversions.	3
6	Run time environments Source language issues (Activation trees, Control stack, scope of declaration, Binding of names), Storage organization (Subdivision of run-time memory, Activation records), Storage allocation strategies, Parameter passing (call by value, call by reference, copy restore, call by name), Symbol tables, dynamic storage allocation techniques.	5
7	Intermediate code generation Intermediate languages, Graphical representation, Three-address code, Implementation of three address statements (Quadruples, Triples, Indirect triples).	4
8	Code optimization Introduction, Basic blocks & flow graphs, Transformation of basic blocks, Dag representation of basic blocks, The principle sources of optimization, Loops in flow graph, Peephole optimization.	5
9	Code generations Issues in the design of code generator, a simple code generator, Register allocation & assignment	4

Text book and Reference books:

1. Aho, Sethi, Ullman - "Compiler Principles, Techniques and Tools" - Pearson Education.
2. Holub - "Compiler Design in C" - PHI.
3. John E. Hopcroft, Rajeev Motwani, Jeffrey D. Ullman, "Introduction to Automata Theory,Languages and Computation", 3rd Edition, Pearson Education, 2014
4. Alfred V. Aho, Monica S Lam, Ravi Sethi, Jeffery D Ullman, "Compilers: Principles, Techniques, and Tools", 2nd Edition, Pearson Education, 2015.
5. Michael Sipser, "Introduction to the Theory of Computation", 2nd Edition, Wadsworth Publishing Co Inc, 3rd Edition, 2012.

OEC-DS-802C: Research Methodology

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

Course Outcomes (COs):

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

- **Discuss** different methodologies and techniques used in research work.
- **Explain** basic computer skills necessary for the conduct of research.
- **Explain** key research concepts and issues.
- **Select** and define appropriate research problem and parameters.
- **Develop** the required numerical skills necessary to carry out research.
- **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 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. Coley, S.M. and Scheinberg, C. A., 1990, "Proposal Writing", Sage Publications.
8. Day, R.A., 1992.How to Write and Publish a Scientific Paper, Cambridge University Press.
9. Fink, A., 2009. Conducting Research Literature Reviews: From the Internet to Paper. Sage Publications
10. Leedy, P.D. and Ormrod, J.E., 2004 Practical Research: Planning and Design, Prentice Hall.
11. Satarkar, S.V., 2000. Intellectual property rights and Copy right. Ess Publications.

OEC-DS-802D: Remote Sensing and GIS

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

Course Outcomes (COs):

After studying this course, student will be able to:

- **Analyse** the principles and components of photo-grammetry and remote sensing.
- **Describe** the process of data acquisition of satellite images and their characteristics
- **Compute** an image visually and digitally with digital image processing techniques.
- **Explain** the concepts and fundamentals of GIS.
- **Design** by computation knowledge of remote sensing and GIS in different civil engineering applications.

Prerequisites:

To understand this course, the learner must have idea of:

- Internet Fundamental
- Data Base Concepts
- 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 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.	11
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	10

	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.	
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