Academic Hand Book

for

Bachelor of Technology Programme

in

Computer Science and Engineering

National Institute of Technology Goa

Farmagudi, Ponda, Goa - 403 401

Semester-wise Credit Distribution

Semester	Total Credits
I	22
II	21+1
III	21
IV	20+1
V	21+3
VI	21
VII	21
VIII	18
Total Credits	**170**

I Semester Details

Sl. No	Sub. Code	Subjects	L-T- P	Credits
1	MA100	Mathematics-I	4-0-0	4
2	PH100	Physics	3-0-0	3
3	ME100	Engineering Mechanics	3-0-0	3
4	CS100	Computer Programming and Problem Solving	2-0-3	4
5	HU100	Professional Communication	2-0-2	3
6	ME101	Engineering Drawing	1-0-3	3
7	PH101	Physics Laboratory	0-0-3	2
		Total Credits		**22**

II Semester Details

Sl. No	Sub. Code	Subjects	L-T- P	Credits
1	MA150	Mathematics-II	4-0-0	4
2	PH150	Material Science	3-0-0	3
3	CY150	Chemistry	3-0-0	3
4	ME150	Elements of Mechanical Engineering	2-0-0	2
5	EE151	Basic Electrical Science	3-0-0	3
6	ME151	Workshop Practices	0-0-3	2
7	CY151	Chemistry Laboratory	0-0-3	2
8	EE152	Basic Electrical Science Lab	0-0-3	2
9	PE150	Physical Education	1-0-0	1
		Total Credits		**22**

III Semester Details

Sl. No	Sub. Code	Subjects	L-T- P	Credits
1	CS200	Principles of Data Communications	3-1-0	4
2	CS201	Data Structures	3-1-0	4
3	CS202	Computer Organization and Architecture	3-1-0	4
4	CS203	Discrete Mathematics	3-1-0	4
5	MA200	Mathematics-III	3-0-0	3
6	CS206	Data Structures Laboratory	0-0-3	2
		Total Credits		**21**

Subject Code CS 200	**Principles of Data Communication(PDC)**	Credits: 4 (3-1-0) Total hours:56
Course Objectives	This course provides an introduction to the field of data communications. The course covers the principles of data communications, transmission fundamentals: Signals, media, encoding and modulation, multiplexing, devices, error detection and correction, data link control and protocols, data transmission over networks - switching techniques and Local Area Network.	
Module 1		**12 Hours**
Introduction to communication signals, message, data, signal, mathematical models for basic communication, Fourier series, Fourier transform and signals, information spectrum, energy type and power type signals, Parseval's theorem, basic of analog filters.		
Module 2		**12 Hours**
Introduction to modulation, types of modulation, channel and noise effects in time domain and frequency domain, signals and spectra in amplitude, phase and frequency modulation; basic block diagram and analysis of AM/FM/PM demodulation/detection system.		
Module 3		**10 Hours**
Introduction to Information Theory and concepts in Digital data representation, sampling, Nyquist sampling theorem, filtering, pass band need for quantization, aliasing, reconstruction filter, problem of quantization, quantizer design and noise.		
Module 4		**8 Hours**
Introduction to source coding, Shannon's first coding theorem, optimality of entropy based representation, Search for uniquely decodable code book and the kraft inequality, fixed vs. variable length codebook, Huffman coding, some other source coding algorithms - run length, Shannon-Fano, and introduction to Ziv–Lempel coding.		
Module 5		**10 Hours**
Errors in transmission/storage, need for forward error detection and control, need for feedback error detection and control, field, group and algebra of error control coding, minimum distance and distance distribution for error detection and correction, code word design using hamming algorithm, decoding and error detection - correction using syndrome, CRC and cyclic code.		
Module 6		**4 Hours**
Digital modulation concepts, architectures for receivers, communication network models, LAN, ethernet and IEEE 802.11 standards, resource allocation and performance issues in wired/wireless LAN.		
Reference books	(1) William Stallings, "Data and Computer Communications and Networking", 2nd Edition, TMH, 2002. (2) Behrouz A Forouzan, "Data Communications and Networking", 2nd edition, TMH, 2002. (3) Leon, Garcia and Widjaja , " Communication Networks", TMH, 2002.	

Subject Code CS 201	**Data Structures (DS)**	Credits: 4 (3-1-0) Total hours:56
Course Objectives	Following this course, students will be able to: 1) Assess how the choice of data structures and algorithm design methods impacts the performance of programs. 2) Choose the appropriate data structure and algorithm design method for a specified application. 3) Solve problems using data structures such as linear lists, stacks, queues, hash tables, binary trees, heaps, tournament trees, binary search trees, and graphs and writing programs for these solutions. 4) Solve problems using algorithm design methods such as the greedy method, divide and conquer, dynamic programming, backtracking, branch and bound and writing programs for these solutions.	
Module 1		**6 Hours**
Introduction to data structures and objectives, basic concepts Arrays: one dimensional, multi-dimensional, Elementary Operations.		
Module 2		**8 Hours**
Stacks: Representation, elementary operations and applications such as infix to postfix, postfix evaluation, parenthesis matching, Queues: Simple queue, circular queue, dequeue, elementary operations and applications.		
Module 3		**10 Hours**
Linked lists: Linear, circular and doubly linked lists, elementary operations and applications such as polynomial manipulation.		
Module 4		**12 Hours**
Trees: Binary tree representation, tree traversal, complete binary tree, heap, binary search tree, height balanced trees like AVL tree and 2-3 tree and other operations and applications of trees.		
Module 5		**20 Hours**
Graphs: Representation, adjacency list, graph traversal, path matrix, spanning tree; introduction to algorithm analysis and design techniques, algorithms on sorting: Selection sort, bubble sort, quick sort, merge sort, heap sort, searching, linear and binary search.		
Reference books	(1) Alfred V Aho, John E Hopcroft, Jeffrey D. Ullman, "Data structures & algorithms", Addison Wesley. 2003 (2) Ellis Horowitz, Sartaj Sahni and Dinesh Mehta, "Fundamentals of data structures and algorithms using C++", 2nd edition, Galgotia publications, 2006 (3) Michael T. Goodrich, Roberto Tamassia, "Data Structures and algorithms in Java", 4thEdition, John Wiley & Sons, Inc., 2010 (4) Thomas H. Cormen, Charles E. Leiserson, Ronald L.Rivest, Clifford Stein, "Introduction to algorithms", 2nd ed. MIT Press, 2003	

Subject Code CS 202	**Computer Organization and Architecture (COA)**	Credits: 4 (3-1-0) Total hours:56
Course Objectives	The course explores the hardware aspects of a computer system design.	
Module 1		**8 Hours**
Overview of Computer Architecture & Organization, contrast between computer architecture & organization, logical organization of computers; basic operational concepts, bus structures, performance, processor clock, basic performance equation, clock rate, performance measurement, Von Neumann machine, instruction format, execution cycle; instruction types and addressing modes.		
Module 2		**10 Hours**
Computer Arithmetic: representation of integers and real numbers, fixed point arithmetic, arithmetic and logical unit design, addition and subtraction of signed numbers, design of fast adders, multiplication of positive numbers, signed operand multiplication, fast multiplication, integer division, floating-point numbers and operations.		
Module 3		**8 Hours**
Basic Concepts of Memory System: Semiconductor RAM memories, ROM memories, speed, size, and cost, cache memories mapping functions, replacement algorithms, performance considerations, virtual memories, secondary storage.		
Module 4		**15 Hours**
Control Unit Design: Instruction sequencing, instruction interpretation, control memory, hardwired control, micro programmed control and micro programmed computers. I/O organization, bus control, Serial I/O (study of asynchronous and synchronous modes, USART & VART), parallel data transfer Program controlled: asynchronous, synchronous & interrupt driven modes, DMA mode, interrupt controller and DMA controller.		
Module 5		**15 Hours**
Organization of CPU: Single vs. multiple data path, ISA, control unit, instruction pipelining, trends in computer architecture, CISC, RISC, VLIW, introduction to ILP, pipeline hazards: structural, data and control, reducing the effects of hazards.		
Reference books	(1) Carl Hamacher, ZvonkoVranesic and SafwatZaky, "Computer organization", 5th Edition, Tata McGraw Hill, 2002. (2) J. P. Hayes, "Computer architecture and organization", 3rd Edition, McGraw Hill, 1998. (3) Patterson and Hennessy, "Computer architecture: A quantitative approach", Morgan Kaufmann, 2000. (4) Hwang and Briggs, "Computer architecture and parallel processing", McGraw Hill, 1985. (5) David A. Patterson& John L. Hennessy, "Computer organization and design", Morgan Kaufmann, 4th edition, 2012.	

Subject Code CS 203	**Discrete Mathematics (DM)**	Credits: 4 (3-1-0) Total hours:56
Course Objectives	This course introduces basic concepts of combinatory, notion of proofs, concept of generating functions, recurrence relations.	
Module 1		**15 Hours**
Sets and Subsets, set operations and the laws of set theory, counting and Venn diagrams, a first word on probability, countable and uncountable sets. Fundamentals of Logic: Basic Connectives and truth tables, logic equivalence, the laws of logic, logical implication, rules of inference, proportional and predicate calculus the use of quantifiers, quantifiers, definitions and the proofs of theorems, normal forms, applications to artificial intelligence.		
Module 2		**10 Hours**
Properties of the Integers: Mathematical Induction, the well ordering principle, recursive definition.		
Module 3		**15 Hours**
Relations and Functions: Cartesian Products and Relations, functions, plain and one-to-one, onto functions, sterling numbers of the second kind, special functions, the pigeon-hole principle, function composition and inverse functions, properties of relations, computer recognition zero, one matrices and directed graphs, partial orders, Hasse diagrams, equivalence relations and partitions.		
Module 4		**10 Hours**
Groups: Definitions, examples, elementary properties, costs, normal subgroups, permutation groups, homeomorphisms, isomorphism, and cyclic groups, cosets and Lagrange's Theorem. Burnside's Theorem and simple applications.		
Module 5		**6 Hours**
Introduction to graph theory, trees, planarity, connectivity, traversability, shortest path and spanning tree, algorithms.		
Reference books	(1) J.P. Tremblay & R. Manohar, "Discrete mathematical structures with applications to computer science", Tata McGraw Hill, 2008. (2) C.L.Liu, "Elements of Discrete mathematics", 3rd ed. McGraw Hill, 2008 (3) Kenneth Rosen, "Discrete mathematics and its applications", TMH, 2011. (4) Jean Gallier, "Discrete mathematics", Springer, 2011. (5) Ralph P. Grimaldi, "Discrete and combinatorial mathematics: An applied introduction", Pearson, 2003.	

Subject Code **MA 200**	**Mathematics-III**	**Credits: 3** **Total hours 42**
Course Prerequisites	Mathematics-I & II	
Objectives	This Mathematics course provides requisite and relevant background necessary to understand the other important engineering mathematics courses offered for Engineers and Scientists. Important topics of applied mathematics, namely complex analysis, power series solutions, Fourier series and transforms and partial differential equations.	
Module 1	**Complex Analysis**	18 hours
Complex Numbers, geometric representation, powers and roots of complex numbers, Functions of a complex variable, Analytic functions, Cauchy-Riemann equations; elementary functions, Conformal mapping (for linear transformation); Contours and contour integration, Cauchy's theorem, Cauchy integral formula; Power Series and properties, Taylor series, Laurent series, Zeros, singularities, poles, essential singularities, Residue theorem, Evaluation of real integrals and improper integrals.		
Module 2	**Power Series Solutions**	9 hours
Differential Equations Power Series Method - application to Legendre equation, Legendre Polynomials, Frobenious Method, Bessel equation, Properties of Bessel functions, Sturm- Liouville BVPs, Orthogonal functions.		
Module 3	**Partial Differential Equations**	15 hours
Introduction to PDE, basic concepts, second order PDE and classification, D'Alemberts formula and Duhamel's principle for one dimensional wave equation, Laplace's and Poisson's equations, Laplace, Wave, and Heat equations using separation of variables. Vibration of a circular membrane. Heat equation in the half space.		
Texts/References	1. E. Kreyszig, Advanced engineering mathematics (8th Edition), John Wiley (1999). 2. W. E. Boyce and R. DiPrima, Elementary Differential Equations (8th Edition), John Wiley (2005). 3. R. V. Churchill and J. W. Brown, Complex variables and applications (7th Edition), McGraw-Hill (2003).	

Subject Code CS 206	**Data Structures Laboratory**	Credits: 2 (0-0-3) Total hours: 42
Course Objectives	The course provides practical knowledge in implementing the standard data structures in C	

List of Experiments

(1) Implementation of array operations, Structures & Unions.
(2) Stacks, Queues, Circular Queues, Priority Queues, Multiple stacks and queues.
(3) Infix to postfix expression using stack
(4) Implementation of linked lists: stacks, queues, single linked lists.
(5) Implementation of polynomial operations. Doubly linked lists.
(6) Tree traversal: AVL tree implementation, application of trees.
(7) Implementation of Hash Table.
(8) Searching and sorting.
(9) Traversal of graph

Reference books

(1) Mark Allen Weiss, "Algorithms data structures and problem solving with C++", Addison Wesley, 1996.
(2) Seymour Lipschutz, G A VijayalalashmiPai, "Data structure", Schaum's outlines,TMH, 1986
(3) O.G. Kakde&P.S. Deshpandey, "Data structures and algorithms", ISTE/EXCEL books, 2004.
(4) Aho Alfred V., Hopperoft John E., UIlman Jeffrey D., "Data Structures and Algorithms",Addison Wesley, 1983.

IV Semester Details

Sl. No	Sub. Code	Subjects	L-T- P	Credits
1	CS250	Digital Systems Design	3-0-0	3
2	HU250	Economics	3-0-0	3
3	CS251	Systems Programming	3-1-0	4
4	CS252	Object Oriented Programming	3-0-0	3
5	MA250	Mathematics-IV	3-0-0	3
6	CS253	Object Oriented Programming Laboratory	0-0-3	2
7	CS254	Digital Systems Laboratory	0-0-3	2
8	VE200	Value Education	1-0-0	1
		Total Credits		**21**

Subject Code CS 250	**Digital Systems Design (DSD)**	Credits: 3 (3-0-0) Total hours:45
Course Objectives	To understand the working of digital systems. Hardware components of the computer can be studied in greater depth.	
Module 1		**10 Hours**
Number Systems And Boolean Algebra: Review of binary, octal & hexadecimal number systems, representation of signed numbers, floating point number representation BCD, ASCII, EBCDIC, excess 3 codes, gray code-error detecting & correcting codes. Boolean algebra: Postulates & theorems of boolean algebra, canonical forms, simplification of logic functions using Karnaugh map, Quine McCaskey method.		
Module 2		**8 Hours**
Combinational Logic Design: Logic gates, implementation of combinational logic functions, encoders & decoders, multiplexers &demultiplexers, code converters, comparator, half adder, full adder, parallel adder, binary adder, parity generator/checker, implementation of logical functions using multiplexers.		
Module 3		**11 Hours**
Sequential Logic Design-I : RS, JK, JK master, slave, D&T flip flops, level triggering and edge triggering, excitation tables, asynchronous & synchronous counters, modulus counters, shift register , Johnson counter, ring counter, timing waveforms, counter applications.		
Module 4		**8 Hours**
Sequential Logic Design-II: Basic models of sequential machines, concept of state table, state diagram, state reduction through partitioning & implementation of synchronous sequential circuits, Introduction to asynchronous sequential logic design.		
Module 5		**8 Hours**
Programmable Logic Devices: Semicustom design, introduction to PLD's, ROM, PAL, PLA, FPGA Architecture of PLD's: PAL 22V10, PLS 100/101, implementation of digital functions. Logic Families: RTL, DTL, TTL families, Schottky, clamped TTL, Emitter Coupled Logic (ECL), Integrated Injection Logic (IIL), MOS inverters, CMOS inverters, comparison of performance of various logic families.		
Reference books	(1) Alan B.Marcovitz, "Introduction to logic design", 3rd Edition, McGraw-Hill Professional, 2009. (2) Giovanni De Micheli, "Synthesis and optimization of digital circuits", Tata McGraw-Hill Education 2003. (3) Zvi Kohavi, Niraj K. Jha, "Switching and finite automata theory", 3rd Edition Cambridge University Press, 2011. (4) Douglas A. Pucknell &Kamran Shrayhian, "Basic VLSI design systems and circuits", Prentice Hall 2000. (5) ParagK.Lala, "Fault tolerant & fault testable hardware design", B.S publications, 2002.	

Subject Code HU250	**Economics**	Credits: 3 (3-0-0) Total hours:45
Course Prerequisites	Basic concept of macroeconomic & Indian Economy.	
Course Outcome	Develops the ability to understand and analyze the broad macroeconomic scenario and its dynamism	
Module 1	**Introduction to Economics**	**1 Hours**
Constructing a Model, Optimization and Equilibrium in market demand and supply, Comparative statistics and asset allocation.		
Module 2	**Budget Constraint and Consumer Preference**	**4 Hours**
Budget constraint in case of two goods, Shifting of budget line and impact of Taxes, Subsidies, and Rationing. Indifference curve, Marginal Rate of Substitution, Cardinal utility and utility function, Indifference curve from utility functions, Marginal Utility vs MRS.		
Module 3	**Choice and Demand**	**4 Hours**
Optimal Choice, Consumer demand, Implication of MRS conditions, Normal and Inferior Goods, Income Offer Curves and Engel Curves, The Price Offer Curve		
Module 4	**Technology**	**3 Hours**
From Individual to Market Demand, The Inverse Demand Function, The Extensive and the Intensive Margin, Elasticity, Elasticity and Demand, Market Supply, Market equilibrium, Inverse Demand and Supply Curves		
Module 6	**Profit Maximization**	**3 Hours**
Profits, The Organization of Firms, The Organization of Firms, Short-Run Profit Maximization, Profit Maximization in the Long Run, Profit Maximization and Returns to Scale.		
Module 7	**Cost Function**	**5 hours**
Cost Minimization , Revealed Cost Minimization , Returns to Scale and the Cost Function , Average Costs, Marginal Costs, Marginal Costs and Variable Costs.		
Module 8	**Markets**	5 hours
Monopoly, Maximizing Profits , Linear Demand Curve and Monopoly , Markup Pricing , Oligopoly and Choosing a Strategy, Price Leadership , Comparing Price Leadership and Quantity Leadership.		
Module 9	**National Income Accounting**	2 hours
National Income and Related concepts, Nominal or real GDP, Methods of measuring NI.		
Module 10	**Determinants of Equilibrium Output**	4 hours
Aggregate demand and Equilibrium output, Consumption function and aggregate demand, Multiplier, Govt. sector, Budget and Full employment		
Module 11	**Money, Interest and Income**	4 hours
The goods market and IS curve, The Asset market and LM Curve, Equilibrium in Goods band asset market and Adjustment towards equilibrium.		
Module 12	**Monetary and Fiscal Policy**	6 hours
Monetary policy, Fiscal Policy, crowding out, Composition of output and policy mix and implementation		
Reference books	(1) Varian, Hal R.: Intermediate Microeconomics, W.W. Norton & Co., New work (ISBN: 0393978303) (2) Koutsoyiannis, A.: Modern Microeconomics, 2nd ELBS/Palgrave Macmillan, London (ISBN: 0333778219) (3) Rudiger Dornbusch and Stanley Fisher: Macroeconomics, McGraw Hill (4) Barro Robert J. "Macroeconomics, New York, John Wiley.	

Subject Code CS 251	**Systems Programming (SP)**	Credits: 4 (3-1-0) Total hours:56
Course Objectives	To understand the relationship between system software and machine architecture to design and implement assemblers, linkers and loaders.	
Module 1		**10 Hours**
Components of a programming system: Assemblers, loaders, macros, compilers, machine Structure: Memory, registers, data, instructions. Machine language: Address modification using instructions as data, address modification using index registers, looping Assembly language.		
Module 2		**15Hours**
Assemblers: Basic assembler functions with an example assembler, assembler algorithm and data structures, machine dependent assembler features, machine independent assembler features, one-pass assemblers, multi-pass assemblers, implementation example. Table processing: Searching and sorting.		
Module 3		**15 Hours**
Loaders and Linkers: Basic loader functions, design of an absolute loader, a simple bootstrap loader, machine dependent loader features, program linking, algorithms and data structures for lining, machine independent loader features, automatic library search, loader design options, dynamic linking and an implementation example.		
Module 4		**10 Hours**
Macro processors: Basic macro processor functions, macro definition and expansion, macro processor data structures and algorithms, implementation example, discussion of ANSI C macro language.		
Module 5		**6 Hours**
System Software Tools: Text editors, overview of the editing process, user interface, editor structure, interactive debugging systems, debugging functions and capabilities, relationship with other parts of the system.		
Reference books	(1) John J. Donovan, "Systems Programming", Tata McGraw-Hill Edition, 2009. (2) Leland L. Beck, D. Manjula, "System software: An introduction to systems programming", Pearson education, 3rd ed, 2007. (3) D.M. Dhamdhere, "Introduction to system software", Tata McGraw Hill Publications, 2002. (4) John R. Levine, "Linkers & Loaders", Morgan Kaufmann Publishers, 2000.	

Subject Code CS 252	**Object Oriented Programming (OOP)**	Credits: 3 (3-0-0) Total hours:45
Course Objectives	This course focuses on principles of object oriented programming paradigm. The course also includes practice of writing programs in C++ and Java.	
Module 1		**10 Hours**
Principles of OOP: Programming paradigms, basic concepts, benefits of OOP, applications of OOP Introduction to C++: History of C++, structure of C++, basic data types, type casting, type modifiers, operators and control structures, input and output statements in C++. Classes and objects: class specification, member function specification, scope resolution operator, access qualifiers, instance creation .Functions: Function prototyping, function components, passing parameters, call by reference, return by reference, inline functions, default arguments, overloaded function. Pointers: Array of objects, pointers to objects, this pointer, dynamic allocation operators, dynamic objects.		
Module 2		**10Hours**
Constructors: Constructors, parameterized constructors, overloaded constructors, constructors with default arguments, copy constructors, static class members and static objects. Operator overloading: Overloading unary and binary operator, overloading the operator using friend function, stream operator overloading and data conversion.		
Module 3		**8 Hours**
Inheritance: Defining derived classes, single inheritance, protected data with private inheritance, multiple inheritance, multi-level inheritance, hierarchical inheritance, hybrid inheritance, multi path inheritance, constructors in derived and base class, abstract classes, virtual function and dynamic polymorphism, virtual destructor.		
Module 4		**7 Hours**
Exception Handling: Principle of Exception handling, exception handling mechanism, multiple catch, nested try, rethrowing the exception. Streams in C++: Stream classes, formatted and unformatted data, manipulators, user defined manipulators, file streams, file pointer manipulation, file open and close. Templates: Template functions and Template classes.		
Module 5		**10 Hours**
Object oriented programming using Java: Introduction to Java, bytecode, virtual machines, basic data types, operators, control structures, classes and objects, using Javadoc, packages, arrays, strings, inheritance, interfaces, exception handling, multithreaded programming, Java streams, developing user interfaces in Java.		
Reference books	(1) BJarne Stroustrup, "The C++ Programming Language", Addison Wesley, 2004. (2) Stanley B Lippman, "The C++ Primer", Addison Wesley, 2005. (3) Ira Pohl, "Object oriented programming using C++", 2nd ed, Pearson Education India, 2003. (4) Patrick Naughton and Herbert Schildt, "Java 2: The Complete Reference", Fourth ed, McGraw Hill Professional 2001. (5) Paul. Deitel, Harvey Deitel, "Java: How to program", 8thEdition, PHI private limited, 2010.	

Subject Code MA 250	**Mathematics-IV**	Credits: 3 (3-0-0) Total hours: 45
Course Objectives	This is a one semester course that covers elements of linear algebra from notion of vector spaces, norm, and basic topology and views the signal space model useful to model most real world observations. It aims at developing probabilistic models for Information processing and systems.	
Module 1		**15 Hours**
Signal Modeling: Review of vector spaces, linear data models, Eigen-decomposition & matrices, Fourier series and transforms, Some other transforms and applications to data representation.		
Module2		**10 Hours**
Motivating probability via measure theory and Borel-Field, Kolmogorov axioms, Bayes' theorem and applications, random variable, properties of CDF/PDF, inequalities & bounds, moment generating function & probability generating functions.		
Module 3		**10 Hours**
One function of one random variable, discrete and continuous random variables, Bernoulli, binomial, Poisson, geometric, uniform, exponential, Gaussian, statistical tests on surveys and sampling as experiments.		
Module 4		**10 Hours**
Computational models using randomness, information theory, pattern recognition, random sequences, random processes, measurements with random processes, types of random processes, detection and estimation (statistical inference models), Markov chains and discrete random processes, examples from communication networks		
Reference books	(1) Athanasios Papoulis, U. S. Unnikrishnan Pillai, "Probability, random variables and Stochastic processes", 4th ed, Tata McGraw-Hill Edition, 2002 (2) Vijay K. Rohatgi, A. K. Md. Ehsanes Saleh "An introduction to probability and statistics", 2nd edition, Wiley series in probability and statistics, 1976. (3) Gilbert Strang, "Introduction to linear algebra", 3rd edition, Wellesley-Cambridge Press, 2005. (4) Sheldon M. Ross, "Stochastic Processes", 2nd edition, Wiley India Pvt. Limited, 2008. (5) Thomas M. Cover, Joy A. Thomas, "Elements of information theory", 2nd edition, Wiley-Interscience, 2006.	

Subject Code CS 253	**Object Oriented Programming Laboratory**	Credits: 2 (0-0-3) Total hours: 42
Course Objectives	To understand the basic object oriented programming concepts (objects, classes and subclasses, methods) using C++ and Java.	

List of experiments

(1) Simple programs in C++
(2) Matrix multiplication in C++
(3) Operator overloading exercises
(4) Matrix manipulation using dynamic memory allocation
(5) Overloading dynamic memory allocation operators
(6) Practice on templates
(7) Implementation of linked list using templates
(8) Implementation of sorting algorithms using templates
(9) Implementation of stack and queue using exception handling
(10) Inheritance based exercise
(11) File handling using streams
(12) Practice of Java programming
(13) File handling using Java streams
(14) Multithreaded programming using Java
(15) Developing graphical user interfaces using Java

Reference books

(1) BJarne Stroustrup, "The C++ Programming Language", Addison Wesley, 2004.
(2) Stanley B Lippman, "The C++ Primer", Addison Wesley, 2005.
(3) Ira Pohl, "Object oriented programming using C++", 2nd ed., Pearson Education India, 2003
(4) John R.Hubbard, "Schaum's Outline of Programming with C++", McGraw Hill Professional, 2003
(5) K.R.Venugopal, RajKumar Buyya, T.Ravishankar, "Mastering C++", Tata McGraw-Hill Publishing Company Limited, 2006
(6) E. Balagurusamy, "Object Oriented Programming with C++", Tata McGraw-Hill, 4th ed., 2008
(7) Patrick Naughton and Herbert Schildt, "Java 2: The Complete Reference", 4th ed., McGraw Hill Professional 2001
(8) Paul.Deitel, Harvey Deitel, "Java: How to program", 8th ed., Prentice Hall of India private limited, 2010

Subject Code CS 254	**Digital Systems Laboratory**	Credits: 2 (0-0-3) Total hours: 42
Course Objectives	The course provides practical knowledge in designing the digital systems	

List of Experiments

(1) Simplification, realization of boolean expressions using logic gates/universal gates
(2) Realization of half/full adder & half/full subtractors using logic gates
(3) Realization of parallel adder/subtractors using 7483 chip, BCD to Excess-3code conversion & vice versa
(4) Realization of binary to gray code conversion & vice versa
(5) MUX/DEMUX – use of 74153,74139 for arithmetic circuits & code converter
(6) Realization of one/two bit comparator and study of 7485 magnitude comparator
(7) Use of a) Decoder chip to drive LED display & b) Priority encoder
(8) Truth table verification of flip-flops: i) JK Master Slave ii) T type iii) D type
(9) Realization of 3 bit counters as a sequential circuit & MOD-N counter design (7476,7490,74192,74193)
(10) Writing & testing of sequence generator

Reference books	(1) J. Bhasker, "A VHDL primer", 3rd edition, Addison Wesley Longmen, 1999. (2) Douglas Perry, "VHDL: Programming by example", 4th ed. McGraw Hill International, 2002. (3) Peter Ashenden, "The Designer Guide to VHDL",Morgan Kaufmann, 1998

Subject Code: VE200	**Value Education**	**Credits: 1 (1-0-0) Total hours: 14**
Course Prerequisite	General Awareness of the Society/ Environment we live in	
Course Objectives	It aims at Holistic Development	
Course Outcome	At the end, the students should be a complete human being in every respect	
Module 1	**Ethics in Engineering**	4 hours
Concepts of Values and Ethics, History and Purposes, Utilitarianism, Duties, Rights, Responsibility, Virtue, Honesty, Moral Autonomy, Obligations of Engineering Profession and moral Propriety		
Module 2	**Engineer's Moral responsibility**	3 hours
Engineer's Moral responsibility for Safety and Human Rights, Risk Assessment and Communication, Product Liability, Engineers-Employers Liaison, Whistle-Blowing and Its Moral Justification		
Module 3	**Computer Ethics**	3 hours
Social Impact of Computer, Gender-Issues and Privacy, Cyber Crime, Ethical use of Software		
Module 4	**Intellectual property**	4 hours
Definition, Types, Rights and Functions, Patents, Trademark, Grant of Patent in India, Surrender and Revocation of Patents, Compulsory Licensing, Acquisition of Inventions by the Government, Contents of draft application of Patents, WTO		
Texts:	1. Vinod V. Sople, *Managing Intellectual Property*: The Strategic Imperative, PHI,2006 2. Govindarajan, *Natarajan & Senthil Kumar, Engineering Ethics*, PHI 3. Robin Attfield, *A Theory of Value and Obligation, London*: Croomhelm, 1987 4. Jones and barlett, " *Cyber Ethics: Morality and Law in Cyber Space"*	
Reference	Case Studies from Newspapers	

V Semester Details

Sl. No	Sub. Code	Subjects	L-T- P	Credits
1	CS300	Operating Systems	3-1-0	4
2	CS301	Database Systems	3-1-0	4
3	CS302	Microprocessor and Microcontrollers	3-0-0	3
4	CS303	Theory of Computation	3-1-0	4
5	ES300	Environmental Studies	3-0-0	3
6	CS304	Operating Systems Laboratory	0-0-3	2
7	CS305	Database Systems Laboratory	0-0-3	2
8	CS306	Microprocessor and Microcontrollers Laboratory	0-0-3	2
		Total Credits		**24**

Subject Code CS 300	Operating Systems (OS)	Credits: 4 (3-1-0) Total hours: 56
Course Objectives	This course covers the objectives and functions of operating systems which include process management, memory management, disk scheduling, security and File Systems. At the end of the course student should be able to write application keeping concurrency and synchronization semaphores/monitors, shared memory, mutual exclusion Process scheduling services of an OS.	
Module 1		**10 Hours**
Introduction to OS, batch processing, multi-programming, interrupts, CPU scheduling, real time scheduling, concurrent processes, threads, multi-threading, inter process communication.		
Module 2		**10 Hours**
Mutual exclusion, Software solution, hardware solutions, atomic test and set, LL, swap instructions, monitors, deadlocks, avoidance, prevention and detection algorithms.		
Module 3		**14 Hours**
Memory management, fixed and variable paging, segmentation, virtual memory, virtual memory concept, demand paging, page replacement algorithms, trashing, and strategies to control trashing.		
Module 4		**12 Hours**
File Systems, disk scheduling algorithms, LOOK, C-LOOK, SCAN, C-SCAN, I/O Hardware, I/O buffering, RAID, performance evaluation.		
Module 5		**10 Hours**
Operating system security & protection, breaches, solutions, mechanisms, Inside attacks, outside attacks, case studies - the UNIX kernel and Microsoft Windows NT.		
Reference books	1) Peter B. Galvin, "Operating System Concepts", 8th Ed., TMH, 2012. 2) Andrew.S.Tanenbaum, "Modern Operating Systems", 3rd ed., PHI Learning, 2009. 3) Silberschartz& Galvin, Operating System Concepts, Addison Wesley, 5th ed., 1997. 4) MelinMilenkovic, "Operating Systems: Concepts and Design", McGraw Hill, New York, 2000.	

Subject Code CS 301	**Database Systems (DS)**	Credits: 4 (3-1-0) Total hours: 56
Course Objectives	This course covers the relational database systems RDBS - the predominant system for business, scientific and engineering applications at present. The topics are reinforced using tools such as Oracle server in labs. The course includes entity-relation model, normalization, relational model, relational algebra, and data access queries as well as an introduction to SQL.	

Module 1	**12 Hours**
Introduction: An overview of database management system, database system vs file system, database system concept and architecture, data model schema and instances, data independence and database language and interfaces,(DDL,DML,DCL), overall database structure, database users. Data modeling using the Entity Relationship model: ER model concepts, notation for ER diagram, mapping constraints, keys, specialization, generalization, aggregation, reduction of an ER diagrams totables, extended ER model, relationship of higher degree.	
Module 2	**14 Hours**
Relational data Model and Language: Relational data model concepts,integrity constraints, entity integrity, referential integrity, key constraints, domain constraints, relational algebra, relational calculus, tuple and domaincalculus.Introduction on SQL: Characteristics of SQL, advantage of SQL, SQL data type and literals, types of SQL commands, SQL operators and their procedure, tables, views and indexes, queries and sub queries, aggregate functions, insert, update and delete operations, joins, unions, intersection, minus, cursors, triggers, procedures in SQL/PL SQL.	
Module 3	**18 Hours**
Data Base Design & Normalization: Functional dependencies, primary key, foreign key, candidate key, super key, normal forms, first, second, third normalforms, BCNF, 4th Normal form,5th normal form, loss less join decompositions, canonical cover, redundant cover, synthesis the set of relation , MVD, and JDs,inclusion dependence, transaction processing concept, transaction system, testing ofserializability, serializability of schedules, conflict & view serializable schedule,recoverability, Recovery from transaction failures, log based recovery,deadlock handling.	
Module 4	**12 Hours**
Concurrency Control Techniques: Concurrency control, locking techniques for concurrency control, 2PL, time stamping protocols for concurrency control, validation based protocol, multiple granularity, multi version schemes and recovery with concurrent transaction. Storage: Introduction, secondary storage devices, tertiary storage, buffering of blocks, structure of files, file organization, indexing and hashing, types of single level ordered indexes, multilevel indexes, dynamics multilevel indexes using B-trees and B+- Trees, database security.	

Reference books	(1) Korth, Silberschatz, "Database System Concepts", 4th ed., TMH, 2003. (2) Elmsari and Navathe, "Fundamentals of Database Systems", 4th ed., A. Wesley, 2004 (3) Raghu Ramakrishnan , Johannes Gehrke, " Database Management Systems", 3rd Edition, McGraw- Hill, 2003. (4) J D Ullman, "Principles of database systems", Computer Science Press, 2001.

Subject Code CS302	**Microprocessors and Microcontrollers (MPMC)**	Credits: 3(3-0-0) Total hours:45
Course Objectives	To introduce the student with knowledge about architecture, interfacing and programming with 8086 microprocessors and 8051 microcontrollers. It gives a brief introduction to ARM 7 and ARM 9 micro controllers. After studying this subject, the student should be able to design microprocessor/controller based system.	
Module 1		**12 Hours**
Introduction: History of microprocessors, basics of computer architecture, computer languages, CISC and RISC, 8085 programming model, architecture.		
Module2		**10 Hours**
Software architecture of the 8086 microprocessors, address space, data organization, registers, memory segmentation and addressing, stack, I/O space, Assembly language programming and program development, 8086 microprocessor architecture, min/max mode, coprocessor and multiprocessor configuration , hardware organization of address space, control signals and I/O interfaces.		
Module 3		**10 Hours**
Programmable interfacing devices, 8255A programmable parallel interface, 8279 programmable keyboard/display interface, 8254 programmable interval timer, 8259A programmable interrupt controller, direct memory access (DMA), 8237 DMA controller, serial I/O and data communication, standards in serial I/Os, serial I/O lines, 8251A programmable communication interfacing.		
Module 4		**13 Hours**
Intel 8051 microcontroller, CPU operation, memory space, software overview, peripheral overview, interrupt, timers parallel port inputs and outputs, serial port, low power special modes of operation, introduction to ARM processors , features of ARM 7 and 9 processors.		
Reference books	(1) Hall D.V., "Microprocessors and Interfacing", McGraw Hill, 1974. (2) Triebal W A & Singh A., "The 8088 and 8086 microprocessors", McGraw Hill, 2007. (3) Muhammad Ali Mazidi, Janice Gillispie Mazidi and Rolin D Mckinlay,"The 8051 microcontroller and embedded systems", 2nd edition, Pearson education, 2009. (4) Ramesh Gaonkar, "Microprocessor architecture programming and applications with 8085", 5th edition, Penram International Publishing, 2002	

Subject Code CS 303	**Theory of Computation (TOC)**	Credits: 4 (3-1-0) Total hours: 56
Course Objectives	This course introduces models of computation: Regular languages models, Recursive and recursively enumerable sets models and context-free languages models.	
Module 1		**10 Hours**
Models of computation, classification, properties and equivalences, automata: Introduction to formal proof, additional forms of proof, inductive proofs, finite automata (FA), deterministic finite automata (DFA), non-deterministic finite automata (NFA) , Finite Automata with Epsilon transitions.		
Module 2		**10Hours**
Regular expression and languages: Introduction to regular expression, building regular expression, converting DFA to a regular expression, converting regular expression to DFA, pumping lemma and its applications to prove languages not to be regular, closure properties of regular languages, minimization of automata.		
Module 3		**15 Hours**
Context free grammars (CFG) and languages: Definition, derivations, parse trees, ambiguity in grammars and languages, pushdown automata (PDA): Definition, Graphical notation, deterministic and nondeterministic, instantaneous descriptions of PDAs, language acceptance by final states and by empty stack, equivalence of the CFG and PDAs, pumping lemma for CFLs, closure properties of CFLs, decision problems for CFLs.		
Module 4		**15 Hours**
Turing machines: Introduction to Turing machines, instantaneous descriptions, language acceptance by Turing machines, Turing machine transition diagrams, Church-Turing hypothesis, Chomsky hierarchy, recursively enumerable sets, existence of non-recursively enumerable notion of undecidable problems, universality of Turing machine, separation of recursive and recursively enumerable classes, notion of reduction, undecidable problems of Turing machines.		
Module 5		**6 Hours**
Intractability: Notion of tractability/feasibility, the classes NP and co-NP, polynomial time many-one reduction, completeness under this reduction, NP-completeness of propositional satisfiability, other variants of satisfiability, NP-complete problems from other domains: graphs (clique, vertex cover, independent sets, Hamiltonian cycle), number problem (partition), set cover.		
Reference books	(1) J.E. Hopcroft and J.D. Ullman. "Introduction to Automata Theory, Languages of Computations", Addison-Wesley, 1979. (2) C. Papadimitriou and C. L. Lewis. "Elements of Theory of Computation", Prentice-Hall, 1981. (3) John. C. Martin, "Introduction to languages and the theory of computation", 3rd edition, TMH, 2003. (4) Peter Linz, "An introduction to formal language and automata", 3rd edition, Narosa publishing house, 2002. (5) John E. Hopcroft, Rajeev Motwani and Jeffery D. Ullman "Automata Theory, Languages, and Computation", 3rd Edition, Pearson Education, 2008. (6) Michael Sipser, "Introduction to the Theory of Computation", Books/Cole Thomson Learning, 2001.	

Subject Code CS 304	**Operating Systems Laboratory**	Credits: 2 (0-0-3) Total hours: 42
Course Objectives	To understand the implementation of an operating system.	

List of experiments

(1) Linux based exercises to practice/simulate: scheduling, memory management algorithms.
(2) Implementation of various CPU scheduling algorithms (FCFS, SJF, Priority).
(3) Implementation of various page replacement algorithms (FIFO, Optimal, LRU).
(4) Concurrent programming; use of threads and processes, system calls (fork and v-fork).
(5) Implementation of Producer-Consumer problem, Bankers algorithm
(6) To simulate concept of semaphores.
(7) To simulate concept of inter process communication.
(8) Implementation of various memory allocation algorithms, (First fit, Best fit and Worst fit), Disk Scheduling algorithms (FCFS, SCAN, SSTF, C-SCAN)
(9) Kernel reconfiguration, devicone drivers and systems administration of different operating systems.
(10) Writing utilities and OS performance tuning.

Reference books

(1) Peter B. Galvin, "Operating System Concepts", 8th ed., TMH, 2012.
(2) Andrew.S.Tanenbaum, "Modern Operating Systems", 3rd ed., PHI Learning, 2009
(3) Silberschartz& Galvin, "Operating System Concepts", Addison Wesley, 5th ed., 1997.
(4) MelinMilenkovic, "Operating Systems: Concepts and Design", McGraw Hill, New York, 2000.

Subject Code CS 305	**Database Systems Laboratory**	Credits: 2 (0-0-3) Total hours:42
Course Objectives	To obtain working knowledge of a database management system and developing applications using the databases.	

List of experiments

(1) Defining schemas for applications.
(2) Creating tables, Renaming tables, Data constraints (Primary key, Foreign key, Not Null), Data insertion into a table.
(3) Grouping data, aggregate functions, Oracle functions (mathematical, character functions).
(4) Sub-queries, Set operations, Joins.
(5) Creation of databases, writing SQL and PL/SQL queries to retrieve information from the databases.
(6) Triggers & Cursors.
(7) Assignment in Design and Implementation of Database systems or packages for applications such as office automation, hotel management, hospital management;
(8) Deployment of Forms, Reports Normalization, Query Processing Algorithms in the above application project;
(9) Distributed data base Management, creating webpage interfaces for database applications using servlets.

Reference books	1) Ramez Elmasri, Shamkant B Navathe, "Fundamentals of database systems", 5th ed., 2003. 2) Avi Silberschatz, Henry korth and S. Sudarshan, "Database Systems Concepts", 5th Edition, TMH, 2005.

Subject Code CS 306	**Microprocessor and Microcontroller Laboratory**	Credits: 2 (0-0-3) Total hours: 42
Course Objectives	To practice writing programs using microprocessor.	

List of experiments

(1) 8085 and 8086 kit familiarization and basic experiments
(2) Arithmetic operation of 16 bit binary numbers
(3) Programming exercise : sorting ,searching and string
(4) Interfacing with A/D and D/A converters
(5) Interfacing with stepper motors
(6) keyboard interfacing to 8086
(7) 8255 interface to 8086
(8) Assembly language programming of 8051
(9) Timer programming of 8051,using interrupts
(10) LCD interfacing to 8051 –project

Reference books	(1) ROM-BIOS service summary- Programmer's Guide to the IBM PC.

Subject Code ES300	Environmental Studies	Credits: 3 (3-0-0) Total hours: 45
Course Objective	Understanding environment, its constituents, importance for living, ecosystem, human developmental activities vs environment, climate change, national and international environment related developments, need for public awareness, its protection and conservation activities.	

Module 1	Hours : 2
Multidisciplinary nature of environmental studies: Definition, scope and importance, Need for public awareness.	

Module 2	Hours : 8
Renewable and non-renewable Natural resources : Natural resources and associated problems; Forest resources : Use and over-exploitation, deforestation, case studies, Timber extraction, mining, dams and their effects on forest and tribal people; Water resources : Use and over-utilization of surface and ground water, floods, drought, conflicts over water, dams-benefits and problems; Mineral resources : Use and exploitation, environmental effects of extracting and using mineral resources, case studies; Food resources : World food problems, changes caused by agriculture and overgrazing, effects of modern agriculture, fertilizer-pesticide problems, water logging, salinity, case studies; Energy resources : Growing energy needs, renewable and non renewable energy sources, use of alternate energy sources, Case studies; Land resources : Land as a resource, land degradation, man induced landslides, soil erosion and desertification; Role of an individual in conservation of natural resources; Equitable use of resources for sustainable lifestyles.	

Module 3	Hours : 10
Ecosystems: Concept of an ecosystem, Structure and function of an ecosystem, Producers, consumers and decomposers, Energy flow in the ecosystem, Ecological succession, Food chains, food webs and ecological pyramids, Introduction, types, characteristic features, structure and function of the Following ecosystem, Forest ecosystem, Grassland ecosystem, Desert ecosystem, Aquatic ecosystems (ponds, streams, lakes, rivers, oceans, estuaries).	

Module 4	Hours : 12
Biodiversity and its conservation: Introduction – Definition : genetic, species and ecosystem diversity, Bio geographical classification of India, Value of biodiversity : consumptive use, productive use, social, ethical, aesthetic and option values, Biodiversity at global, National and local levels, India as a mega-diversity nation, Hot-sports of biodiversity, Threats to biodiversity : habitat loss, poaching of wildlife, man-wildlife conflicts, Endangered and endemic species of India, Conservation of biodiversity : In-situ and Ex-situ conservation of biodiversity, Eco-cultural heritage of India-various festivals related to Environment, Tradition of community conserved areas-Sacred forests, sacred tanks, sacred mountains, sacred rivers.	

Module 5	Hours : 12
National and International Environment related developments Environmental ethics : Issues and possible solutions, Climate change, global warming, acid rain, ozone layer depletion, nuclear, accidents and holocaust, Environment related Acts, Issues involved in enforcement of environmental legislation, Public awareness, Wasteland reclamation, Consumerism and waste products, UN Frame Convention Climate Change, Kyoto protocol, concept of carbon credits, latest CoP meet Agenda; Filed Work(equal to 5 lecture hours): Visit to a local area to document environmental assets river/forest/grassland/hill/mountain/sacred groves/sacred forests, Visit to a local polluted site-Urban/Rural/Industrial/Agricultural, Study of common plants, insects, birds, Study of simple ecosystems-pond, river, hill slopes, etc.	

Reference books	1. Textbook for Environmental Studies For Undergraduate Courses of all Branches of Higher Education (online book -UGC Website), Erach Bharucha,University Grants Commission , India. 2. Anil Agarwal, Dying Wisdom, Publisher: Centre for Science and Environment, Edi:1st,1997 ISBN-13 9788186906200; ISBN-10 8186906207 3. R. Rajagopalan, Environmental Studies from Crisis to Cure, Oxford IBH Pub., 2005. 4. Benny Joseph, Environmental Science and Engineering, Tata McGraw Hill, 2006. 5. Erach Bharucha, Text Book for Environmental Studies, Pub., Universities Press, 2005. 6. Masters, Gilbert M., Introduction to Environmental Engineering and Sciences, Prentice Hall India, 1991

VI Semester Details

Sl. No	Sub. Code	Subjects	L-T- P	Credits
1	CS350	Compiler Design	3-1-0	4
2	CS351	Design and Analysis of Algorithms	3-0-0	3
3	CS352	Software Engineering	3-0-0	3
4	CS353	Computer Networks	3-0-0	3
5	CS5**	Programme Specific Elective-I	3-0-0	3
6	CS354	Compiler Design Laboratory	0-0-3	2
7	CS355	Networks Laboratory	0-0-3	2
8	CS356	Mini Project/Industrial training	0-0-3	1
		Total Credits		**21**

Subject Code CS 350	**Compiler Design (CD)**	Credits: 4 (3-1-0) Total hours: 56
Course Objectives	Describe the steps and algorithms used by language translators, Recognize the underlying formal models such as finite state automata, push-down automata and their connection to language definition through regular expressions and grammars, Discuss the effectiveness of optimization.	
Module 1		**10 Hours**
Introduction to compiler design, Model of a Compilers, Translators, Interpreters, Assemblers, Languages, Computer Architecture vs Compiler Design, Lexical analyzer, Regular expressions and finite automata.		
Module2		**8 Hours**
Introduction to context free grammars, BNF notation, Syntax Analysis.		
Module 3		**14 Hours**
Parsing Techniques: Top-down parsing and Bottom-up parsing, general parsing strategies, brute force approach, recursive descent parser and algorithms, simple LL(1) grammar, bottom-up parsing-handle of a right sentential form, shift reduce parsers, operator precedence parsers, LR, SLR, Canonical LR, LALR grammar and parsers, error recover strategies for different parsing techniques.		
Module 4		**14 Hours**
Symbol table, syntax-directed translation schemes, intermediate code generation, translation schemes for programming language constructs, runtime storage allocation.		
Module 5		**10 Hours**
Code generation and instruction selection: Issues, basic blocks and flow graphs, register allocation, DAG representation of programs, code generation from DAG, peep hole optimization, code generator generators, specifications of machine. Code optimization, source of optimizations, optimization of basic blocks, loops, global dataflow analysis, solution to iterative dataflow equations.		
Reference books	1) Alfred V. Aho, Ravi Sethi & Jeffrey D. Ullman, "Compilers; Principles, Techniques & Tools", Addison- Wesley Publication, 2001. 2) William A. Barrett et.al, "Compiler Construction, Theory and Practice", Galgotia 2000 3) Holub A.I., "Compiler Design in C", Prentice Hall India.2000.	

Subject Code CS 351	**Design and Analysis of Algorithms (DAA)**	Credits: 3 (3-0-0) Total hours: 45
Course Objectives	To study paradigms and approaches used to analyze and design algorithms and to appreciate the impact of algorithm design in practice.	
Module 1		**10 Hours**
Models of computation, RAM model, big Oh, big Omega, asymptotic analysis, recurrence relations, probabilistic analysis, linearity of expectations, worst and average case analysis of sorting and searching algorithms, hashing algorithms, lower bound proofs for the above problems, amortized analysis, aggregate, accounting and potential methods, analysis of Knuth-Morris-Pratt algorithms, amortized weight balanced trees.		
Module2		**11 Hours**
Problem Solving, Divide & Conquer, Strassens algorithm, O(n)_ median finding algorithm, dynamic programming, combinatorial search, matrix chain multiplication, optimal binary search trees, Floyd Warshall algorithm, CYK algorithm, Greedy, set of intervals, Huffman coding, Knapsack, Kruskal& Prims algorithm for MST, back tracking, branch & bound, traveling salesman problem		
Module 3		**8 Hours**
Computing Algorithms, Simple Numerical algorithms, B trees, Fibonacci Heaps, Data Structure for disjoint sets.		
Module 4		**8 Hours**
Efficient Graph algorithms based on DFS, BFS, topological sort, pattern matching & string/ text algorithms, shortest path, flow, cuts. Efficient algorithms for matrix inversion and LUP decomposition, Modular arithmetic.		
Module 5		**8 Hours**
Complexity classes, P, NP, Co-NP, NP Hard & NP complete problems. Search / decision, SAT, Cooks theorem, NP Completeness for clique, vertex cover, TSP, set covering &subset sum, approximation algorithms.		
Reference books	(1) Aho, Hopcroft and Ullman "The design and analysis of Computer Algorithms", Addison Weseley. (2) Horowitz and Sahni, "Fundamentals of Computer Algorithms", Galgotia Publications, 2000. (3) Baase S., "Computer Algorithms: Introduction to Design and Analysis", Addison Wesley. 2000 (4) Donald E. Knuth, "Art of Computer Programming, Volume 1: Fundamental Algorithms", 3rd Edition, Addison Wesley, 2000 (5) Corman, Leiserson and Rivest " Introduction to Algorithm", Prentice Hall India, 3rd Edition, 2010 (6) AnanyLevtin, "Introduction to Design and Analysis of Algorithms", Pearson, 2003.	

Subject Code CS 352	**Software Engineering (SE)**	Credits: 3 (3-0-0) Total hours: 45
Course Objectives	Following this course, students will be able to: 1) Define software engineering and explain its importance, 2) Discuss the concepts of software products and software processes, 3) Explain the importance of process visibility, 4) Introduce the notion of professional responsibility. This course covers the basic concepts of software engineering, life cycle models and system engineering, concepts & principles of software coding, design and testing. Improvement in design languages & reusable code. Participatory design & debugging. Specification of interface & mock up to confirm specifications. To introduce ethical & Professional issues & to explain why they are of concern to software engineers & experience working in a team.	

Module 1	**6 Hours**
Introduction to software engineering and its objectives, S/W myths, generic view of process, S/W engineering paradigm, verification, validation.	
Module 2	**11 Hours**
Life cycle models, system engineering, requirements engineering, business process engineering, analysis concepts, design process and concepts, modular design, design heuristic, architectural design, data design, user interface designs, real time software design, data acquisition system, monitoring and control system.	
Module 3	**14 Hours**
Taxonomy of software testing, types of S/W test, black box testing, testing boundary conditions, structural testing, test coverage criteria based on data flow mechanisms, regression testing, unit testing, integration testing, validation testing, system testing and debugging.	
Module 4	**14 Hours**
Software implementation techniques measures and measurements, software cost estimation, function point models, COCOMO model, error tracking, software configuration management, program evolution dynamics, software maintenance, project planning, risk management, CASE tools.	

Reference books	(1) R.S. Pressman, "Software Engineering", McGraw-Hill, 2002 (2) PankajJalote, "An Integrated Approach to software Engineering", Narosa Pub., 2002. (3) Ian Sommerville, "Software Engineering", 5th ed., Addison-Wesley Publication House, 1997. (4) Bell Morry and Pugh. "Software Engineering Approach", Prentice Hall. 2001 (5) K. C. Shet, "Software Engineering & Quality Assurance", BPB Publications, New Delhi. (6) Waman S. Jawadekar, "Software Engineering, Principles and Practice", Tata McGraw Hill.

Subject Code CS 353	**Computer Networks (CN)**	Credits: 3 (3-0-0) Total hours: 45
Course Objectives	This course focuses on understanding the design of computer networks, assimilating hubs into a personal network.	
Module 1		**6 Hours**
Introduction to Computer Networks,Overview of OSI reference model. Topology design,Problems and protocols, Practical local area network design and implementation. IEEE LAN Standards, Logical Link Control protocols, HDLC, ALOHA, SLOTTED ALOHA, FDDI, Client Server model and related softwares. Computer Networks and Internet, Network edge, network core, Network Access, Delay and Loss.		
Module 2		**17 Hours**
Transport layer services, UDP, TCP, New transport layer protocols, congestion control and resource allocation, new versions of TCP, network layer services, routing, IP, routing in internet, router, IPV6, multicast routing.		
Module 3		**9 Hours**
Link layer services, error detection and correction, multiple access protocols, ARP, Ethernet, hubs, bridges, switches, wireless links, mobility, PPP, ATM, MPLS, VLAN.		
Module 4		**13 Hours**
Multimedia networking, streaming stored audio and video, real-time protocols, security, Cryptography, authentication, integrity, key distribution, network management, Firewalls, Brief functioning of upper layers, E-mail and other application.		
Reference books	(1) J. F. Kurose and K. W. Ross, "Computer Networking: A Top-Down Approach Featuring Internet", 3/e, Pearson Education, 2005. (2) Peterson L.L. & Davie B.S., "Computer Networks, A systems approach", 3/E, Harcourt Asia, 2003. (3) Andrew. S. Tanenbaum, "Computer Networks", Prentice Hall of India, 5th Edn, 2002. (4) Fred Halsall, "Data Communications, Computer networking on OSI", Addison Wesley Publishing Co., 2nd Edition, 2002. (5) William Stallings, "Data & Computer Communications", 2nd Edition, Maxwell, MacMillan International Edn. 2003. (6) Behrouz A. Forouzan, "Data Communications & Networks", third edition, Tata McGraw Hill.	

Subject Code CS 354	**Compiler Design Laboratory**	Credits: 2 (0-0-3) Total hours: 42
Course Objectives	To obtain the practice of writing compilers.	

List of experiments

(1) Introduction to Flex/Lex& Bison/Yacc tools, Lexing and tokenizing Programs
(2) Implementing an alternative grammars for infix expressions
(3) Parsing and parse trees
(4) Type checking
(5) Intermediate code generation
(6) Simple optimization (constant folding, etc.)
(7) Relations
(8) Control flow
(9) Functions
(10) Building a minicompiler (possibly subsets of Standard Compilers like PASCAL or other languages) and executing Simple problems to demonstrate the Compiler capabilities

Reference books

1) Holub A.I., "Compiler Design in C", Prentice Hall India.2000.
2) W. Appel, "Modern Compiler Implementation in C" , Cambridge University Press, 1998.
3) V. Aho, M. S. Lam, R. Sethi, J. D. Ullman, "Compilers- Principles, Techniques & Tools", 2/e, Pearson Education, 2007.

Subject Code CS 355	**Networks Laboratory**	Credits: 2 (0-0-3) Total hours: 42
Course Objectives	To provide students with a theoretical and practical base in computer networks issues.	

List of experiments

(1) Implementation of basic Client Server program using TCP and UDP Socket
(2) Exercises comprising simulation of various protocols and performance study
(3) TCP/IP Level Programming Problems
(4) Implementing fully concurrent application with a TCP server acting as a directory server and client programs allowing concurrent connection and message transfer (Eg. Chat sytem).
(5) Routing Algorithms and internetworking
(6) Experiments with open source firewall/proxy packages like iptables,ufw, squid etc
(7) Experiments with Emulator like Netkit, Emulabetc
(8) Experiments with Simulator like NS2, NCTU NS etc

Reference books	1) W. Richard Stevens, Bill Fenner and Andrew M. Rudoff, "UNIX Network Programming", PHI. 2) Kris Jamsa, Ken Cope, "Internet Programming", Galgotia 3) Elliotte Rusty Harold, "Java Network Programming", 3rd Edition, O'Reilly, 2004.

Subject Code CS 356	**Mini Project/Industrial Training**	Credits: (0-0-2)1
Course Objectives	Students are expected to undergo hands on training on a real problem under the guidance of a faculty/ an expert from industry. The problem domain should be relevant to Computer Science and Engineering applications.	

VII Semester Details

Sl. No	Sub. Code	Subjects	L-T- P	Credits
1	CS400	Foundations of cryptography	3-1-0	4
2	CS401	Introduction to Machine Learning	3-0-0	3
3	CS5**	Program Specific Elective-II	3-0-0	3
4	HU400	Management	3-0-0	3
5	CS402	Seminar	0-0-2	2
6	CS403	Security Laboratory	0-0-3	2
7	CS449	Major Project-I	0-0-4	4
		Total Credits		**21**

Subject Code CS 400	**Foundation of Cryptography (FC)**	Credits: 4 (3-1-0) Total hours: 56
Course Objectives	The purpose of the course is to familiarize the students to the arithmetic topics that have been at the centre of interest in applications of number theory, particularly in cryptography. It also includes familiarizing the students with cryptography, cryptographic protocols and the latest elliptic curve systems.	
Module 1		**13 Hours**
Mathematical preliminaries: Number theory and algebra, finite fields.		
Module 2		**9 Hours**
Symmetric key encryption: Stream ciphers and block ciphers.		
Module 3		**12 Hours**
Public key cryptography, digital signatures, attacks, hash functions, authentication schemes, key exchange algorithm, public key infrastructure.		
Module 4		**10 Hours**
Identification schemes, interactive proofs, commitment protocols, zero knowledge proofs, non-interactive proofs.		
Module 5		**12 Hours**
Secret sharing schemes, digital cash, electronic voting, elliptic curve, elliptic curve cryptosystems, identity based encryption.		
Reference books	(1)Neal Koblitz, "Number theory and cryptography", Springer, 2007. (2)Hans Delfs, Helmut Knebl, "Introduction to Cryptography: Principles and Applications", Springer. (3)Alfred J. Menezes, Paul C. van Oorschot, Scott A. Vanstone, "Handbook of Applied Cryptography", CRC Press, 1996. (4)Stinson Douglas R, "Cryptography Theory and Practice", CRC press, 2005. (5)Rudolf Lidl, Herald Niederreiter, "Introduction to Finite Fields and their Applications", Cambridge University Press. (6)Ivan Niven, Herbert S. Zukerman, Hugh L.Montgomery, "An Introduction to the Theory of Numbers", John Wiley, 1991. (7)Husten, "Topics in Algebra", John Wiley, 1975. (8)Lide and Niderriten, "Finite Fields", Cambridge University press, 1984. (9)Birchoff and Maclan, "Modern Algebra". (10) Relevant Research Papers	

Subject Code CS 401	**Introduction to Machine Learning (IML)**	Credits: 3 (3-0-0) Total hours: 45
Course Objectives	To develop framework for representation, classification and processing of information using various mathematical approaches with real architectures based in statistics, and modern algorithms [Genetic, Neural networks]	
Module 1		**8 Hours**
Basic test on Linear algebra and review of algorithms, Introduction to pattern classification, learning theory, Lloyd-max algorithm and quantization with Kraft inequality, entropy as minimum word length		
Module 2		**15 Hours**
Bayesian decision theory, classifiers, discriminant functions, decision surfaces. Error probabilities in statistical decision, non-parametric techniques in pattern classification, order statistics, windowing,		
Module 3		**15 Hours**
KNN, linear discriminants, non-metric methods, grammar based methods, dictionary and the Lempel-Ziv estimation, mixtures, clusters data description and clustering, component analysis – PCA, ICA, architectures and performance analysis of pattern classification		
Module 4		**7 Hours**
Database systems, search & complexity, distributed, parallel and randomized processing environments, selected topics and research papers from PAMI, PY, KBS, IFS, for seminar and assignments.		
Reference books	(1) Luciano Da Costa, Roberto Cesar Jr. – "Shape analysis and classification: theory and practice ", CRC Press, 2001 (2) T Hastie, R Tibshirani, J Friedman – "The elements of statistical learning: Data mining, Inference and Prediction", Springer-verlag, 2009 (3) K. Fukunaga – "Introduction to statistical pattern recognition", Academic press (4) Yu Xinjie, Mitsuo Gen – "Introduction to Evolutionary Algorithms", Springer (5) Richard O. Duda, Peter E. Hart and David G. Stork "Pattern Classification" , Wiley, 2007 (6) Christopher M. Bishop "Pattern Recognition and Machine Learning", Springer, 2006	

Subject Code HU 400	**Management**	Credits: 3
Course Prerequisites	Basic concept of monetary economic, financial concepts and Basic statistics.	
Course Outcome	Develops the ability to understand and analyze the broad aspect of management and its financial dynamism	
Module 1	**Principles of Accounting**	5 hours
Accounting Cycle, Assumptions, Classifications of Accounts- Journal, Cash Book, Ledger, Final Accounts- Manufacturing Account, Trading Account, P & L Account, Balance Sheet.		
Module 2	**Financial Statement Analysis**	5 hours
Balance sheet, Profit and Loss Account, Economic vs Accounting Profit, Changes in Financial Position, Funds flow and cash flow statement.		
Module 3	**Ratio Analysis**	6 hours
Nature of Ratio Analysis, Liquidity Ratio, Leverage Ratio, Activity Ratio, Profitability Ratio, DuPont Analysis, Comparative statement and Trend Analysis, Inter-firm Analysis.		
Module 4	**Working Capital**	6 hours
Concept of working Capital, Operating and Cash conversion Cycle, Permanent and Variable working Capital, Balance working capital position and Issues.		
Module 5	**Time Value of Money**	5 hours
Time preference for money, Future value, Annuity, Perpetuity, Sinking fund factor, Present value, Annuity, Perpetuity, capital recovery factor, Multiple period Compounding.		
Module 6	**Capital Budgeting**	8 hours
Nature and type of Investment decision, Net Present value, (NPV), Internal Rate of Return (IRR), Payback period, Profitability Index, Nature and Behavior of Cost, Breakeven point, multiple products analysis, decision points.		
Module 7	**Financial System**	6 hours
Introduction to Indian Financial System, Financial Institutions and Financial Markets.		
Module 8	**Industrial Engineering & Project Management**	4 hours
Work Study, Time Study, Industrial Psychology, Project Management (PERT, CPM)		
Text Books	1. I.M Pandey, *Financial Management*, 10th edition, Vikish Publication 2. Brealey Y Myers, *Principles of Corporate Finance*, McGraw-Hill 3. Rajiv and Anil: *Financial Management*, 2nd Edition, Oxford University Press 4. L.M Bhole: *Financial Institutions and Markets*, Tata McGrow-hill	

Subject Code CS 402	**Seminar**	**Credits: (0-0-2)2**
Course Objectives	Students will have to choose a topic in Computer Science and related areas, current trends or industry practices, prepare a write up, and present it along with a suitable demonstration.	

Subject Code CS 403	**Security Laboratory**	Credits: 2 (0-0-3) Total hours: 42
Course Objectives	To study the number-theoretic and cryptographic algorithms. To have practical hands on experience with the number theoretic algorithms and cryptographic algorithms. To learn the usage of the number theoretic library packages in supplement with the C programming language.	

List of experiments

1. Euclidean algorithm for finding the Greatest Common Divisor of two large integers.
2. Extended Euclidean algorithm for finding the GCD of two large integers.
3. Binary Euclidean algorithm to find the GCD of two large integers.
4. Computing the Multiplicative inverses in Z_n. Z_n is defined as *the integers modulo n.*$Z_n = \{0, 1,2,...,n-1\}$. Given a ϵ Z_n. Find the multiplicative inverse of a.
5. Write a program to find the modular inverse of the matrix if it exists.
6. Repeated square and multiply algorithm for modular exponentiation in Z_n.
7. Determining the order of a group element.
8. Finding a generator of a cyclic group.
9. Chinese remainder method
10. Pollard's rho algorithm for factoring integers.
11. Pollard's p-1 algorithm for factoring integers.
12. Fermat's factorization method
13. Congruence of squares. Finding a congruence of squares modulo n to factor n.
14. Fermat primality test
15. Solovay-Strassen probabilistic primality test
16. Miller-Rabin probabilistic primality test
17. Lucas-Lehmer primality test for Mersenne numbers
18. AKS primality test
19. DES Symmetric key algorithm
20. RSA public key algorithm, Elgamal Cryptosystem, Subset sum, Secret Sharing scheme.

Reference books	(1) Hand Book of Applied Cryptography by Alfred J. Menezes, Paul C. van Oorschot and Scott A. Vanstone (2) (It is freely available: One of the source links: http://www.cacr.math.uwaterloo.ca/hac/) (3) PARI C Library: http://pari.math.u-bordeaux.fr/ (4) The C Programming Language by Brian W. Kernighan, Dennis M. Ritchie (5) Any Library packages for multi-precision arithmetic.

VIII Semester Details

Sl. No	Sub. Code	Subjects	L-T- P	Credits
1	CS5**	Program Specific Elective-III	3-0-0	3
2	CS5**	Program Specific Elective- IV	3-0-0	3
3	CS5**	Program Specific Elective- V	3-0-0	3
4	CS5**	Program Specific Elective- VI	3-0-0	3
5	CS499	Major Project – II	0-0-6	6
		Total Credits		**18**

Subject Code CS 500	**Object Oriented Analysis and Design (OOAD)**	Credits: 3 (3-0-0) Total hours: 45
Course Objectives	To apply an iterative process such as the Unified Process & Analyze software requirements and document them using Use Cases. Perform software analysis and record the results using UML notation. Discuss how object oriented software development affects testing and quality.	
Module 1		**8 Hours**
An overview of object oriented systems development, object basics, object oriented systems development life cycle.		
Module 2		**13 Hours**
Rumbaugh methodology , Booch methodology , Jacobson methodology , patterns, frameworks, unified approach, unified modeling language , use case , class diagram , interactive diagram , package diagram , collaboration diagram , state diagram , activity diagram.		
Module 3		**12 Hours**
Identifying use cases, object analysis, classification, identifying object relationships, attributes and methods, design axioms, designing classes, access layer, object storage, and object interoperability.		
Module 4		**12 Hours**
Designing interface objects, software quality assurance, system usability, measuring, user satisfaction, mini project.		
Reference books	(1) Ali Bah rami, "Object Oriented Systems Development", Tata McGraw-Hill, 1999. (2) Martin Fowler, "UML Distilled", 2nd ed., PHI/Pearson Education, 2002. (3) Stephen R. Schach, "Introduction to Object Oriented Analysis and Design", Tata McGraw-Hill, 2003. (4) James Rumbaugh, Ivar Jacobson, Grady Booch "The Unified Modeling Language Reference Manual", Addison Wesley, 1999. (5) Hans-Erik Eriksson, Magnus Penker, Brain Lyons, David Fado, "UML Toolkit", OMG Press Wiley Publishing Inc., 2004.	

Subject Code CS 501	**Advanced Data Structures (ADS)**	Credits: 3 (3-0-0) Total hours: 45
Course Objectives	Advanced Data Structures is about using mathematical objects like trees and graphs to represent computational problems. It aims at the usage of some sophisticated algorithms and methods of analysis.	
Module 1		**9 Hours**
Introduction: Algorithms, algorithms as a technology, analyzing algorithms, designing algorithms, asymptotic notations, standard notations, common functions, recurrences, substitution method, master method. Sorting and order statistics: Merge sort, quick sort, heap sort, sorting in linear time, Median and order statistics.		
Module 2		**9 Hours**
Data structures: Elementary data structures, linked lists, stacks, queues, hash tables, direct address tables, hash tables, hash functions, open addressing, search trees , binary search trees, red-black Trees, splay trees. Advanced Data structures: B – Trees, binomial heaps, fibonacci heaps, data structures for disjoint sets. Suffix Trees-Tries-Text compression, text similarity testing-range trees, priority search trees, quad trees and k-d trees.		
Module 3		**9 Hours**
Graph Algorithms: Elementary graph algorithms, representation of graphs, BFS, DFS, topological sort, strongly connected components, minimum spanning trees, the algorithms of Kruskal and Prim's. Single-source shortest paths: Bellman-ford algorithm, single source shortest paths in DAG's, Dijkstra's algorithm, all-pair shortest paths, matrix multiplication, Floyd-Warshall algorithm. Maximum flow: Flow networks, the Ford-Fulkerson method, maximum bipartite matching.		
Module 4		**9 Hours**
Advanced design and analysis techniques: Greedy algorithms, an activity, selection problem, elements of greedy strategy, Huffman codes. Dynamic programming: Matrix chain multiplication, elements of dynamic programming, optimal binary search trees.		
Module 5		**9 Hours**
String Matching: The naïve string matching algorithm, Rabin-Karp algorithm, Knuth-Morris-Pratt algorithm. NP-Completeness: Polynomial time, Verification, NP-Completeness and reducibility, NP-Completeness proofs, NP-Complete problems.		
Reference books	(1) Thomas Cormen, Charles E Leiserson and Ronald D River, "Introduction to Algorithms", PHI, 2001. (2) Mark Allen Weiss, Algorithms, "Data Structures and Problem Solving with C++", Addison Wesley, 2002. (3) M.T.Goodrich and R.Tomassia,"Algorithm design: Foundations,analysis and internet examples", John Wiley and sons. (4) EllisHorowitz, Satraj Sahni and S.Rajasekaran, "Fundamentals of computer algorithms",Galgotia publications pvt. Ltd. (5) R.C.T.Lee, S.S.Tseng, R.C.Chang and T.Tsai, "Introduction to design and analysis of algorithms: A strategic approach", McGraw Hill.	

Subject Code CS 502	**Advanced Computer Architecture (ACA)**	Credits: 3 (3-0-0) Total hours: 45
Course Objectives	To understand concepts of parallel processing and design choices of implementing parallel execution within a single processor (pipeline, VLIW, and superscalar) and multiprocessor systems. To gain knowledge of the state of the art research topics on advanced computing systems	
Module 1		**9 Hours**
Parallel Computer Models: The state of computing, classification of parallel computers, multiprocessors and multicomputer, multi vector and SIMD computers. Program and network properties: Conditions of parallelism, data and resource dependences, hardware and software parallelism, program partitioning and scheduling, grain size and latency, program flow mechanisms, control flow versus inter connects, hierarchical bus systems, crossbar switch and multiport memory, multistage and combining network.		
Module 2		**9 Hours**
Advanced Processors: Advanced processor technology, instruction-set architectures, CISC scalar processors, RISC scalar processors, superscalar processors, VLIW architectures, vector and symbolic processors.		
Module 3		**9 Hours**
Pipelining: Linear pipeline processor, nonlinear pipeline processor, instruction pipeline design, mechanisms for instruction pipelining, dynamic instruction scheduling, branch handling techniques, branch prediction, arithmetic pipeline design, computer arithmetic principles, static arithmetic pipeline, multifunctional arithmetic pipelining		
Module 4		**9 Hours**
Multi Processors: Multiprocessor system interconnect, cache coherence and synchronization mechanisms, message-passing mechanism, scalable, multi-threaded and dataflow architectures: latency-hiding techniques, principles of multithreading, scalable and multithreaded architecture, dataflow and hybrid architectures.		
Module 5		**9 Hours**
Parallel Models, languages and compilers: Latency-Hiding techniques environment, synchronization and multiprocessing modes, shared variable program structures, message passing programming development		
Reference books	(1) Dezso Sima, Terence Fountain, Peter Kacsuk, "Advanced computer architectures: A design space approach" , Addison Wesley. (2) K.Hwang and F.A. Briggs, "Computer architecture and parallel processing", McGraw Hill Publications (3) K. Hwang, "Advanced computer architecture-parallelism, scalability, programmability" , McGraw Hill. (4) J. Hennesy and D. Patterson, "Computer architecture –A quantitative approach", Morgan Kaufmann, 200.3	

Subject Code CS503	**Advanced Microprocessors (AMP)**	Credits:3 (3-0-0) Total hours:45
Course Objectives	To thoroughly understand the internal operation, layout and underlying design principles of modern systems containing advanced microprocessors. Throughout the semester, the Intel family of microprocessors will be the baseline used to illustrate the particular concepts.	
Module 1		**9 Hours**
80186 Architecture, enhancements of 80186,80286 architecture, real and virtual addressing modes, 80386 architecture, special registers, memory management, memory paging mechanism, 80486 architecture, enhancements, cache memory, comparison of microprocessors (8086, 80186, 80286, 80386, 80486).		
Module 2		**10 Hours**
Pentium microprocessor architecture, special Pentium registers, Pentium memory management, new Pentium instructions, Pentium pro microprocessor architecture, special features, Pentium II microprocessor architecture, Pentium II microprocessor architecture, Pentium III architecture, Pentium IV architecture, comparison of Pentium processors.		
Module 3		**10 Hours**
PowerPC620, Instruction fetching, branch prediction, fetching, speculation, instruction dispatching dispatch stalls, instruction execution, issue stalls, execution parallelism, instruction completion, Basics of P6 micro architecture, Pipelining, out of order core pipeline, Memory subsystem.		
Module 4		**8 Hours**
Intel I960, Intel IA32, MIPS R8000, MIPS R10000 , Motorola 88110, Ultra SPARC processor-SPARC version 8 , SPARC version, DSP processors.		
Module 5		**8 Hours**
Functional Units & Interconnection, new generation mother boards 286 to Pentium 4bus interface-ISA- EISA- VESA- PCI- PCIX, peripheral interfaces and controller, memory and I/O port addresses.		
Reference books	(1) B.B.Brey, "The Intel Microprocessor 8086/8088 /80186/80188, 80286, 80386, 80486 Pentium, Pentium Pro, PII, PIII & IV Archietecture, Programming & Interfacing", Pearson Education , 2004. (2) John Paul Shen, Mikko H.Lipasti, "Modern Processor Design", Tata Mcgraw Hill,2006 (3) Douglas V.Hall, "Microprocessors and Interfacing", Tata McGraw Hill, IIEdition 2006 (4) Mohamed Rafiquzzaman, "Microprocessors and Microcomputer BasedSystem Design", II Edition, CRC Press, 2007	

Subject Code CS 504	**Principles of Programming Languages (PPL)**	Credits: 3 (3-0-0) Total hours:45
Course Objectives	The basic thrust of this course will be on learning the distinctive techniques in the different paradigms and what semantic and compiling issues come up in the various languages considered. The course introduces Imperative Languages, functional programming, declarative programming and semantics of object-oriented programming.	
Module 1		**12 Hours**
Imperative and object-oriented programming, role of types, static and dynamic type checking, scope rules, grouping data and operations, information hiding and abstract data types, objects, inheritance, polymorphism, templates.		
Module 2		**12 Hours**
Functional programming, expressions and lists, evaluation, types, type systems, values and operations, function declarations, lexical scope, lists and programming with lists, polymorphic functions, higher order and curried functions, abstract data types.		
Module 3		**12 Hours**
Logic programming, review of predicate logic, clausal-form logic, logic as a programming language, unification algorithm, abstract interpreter for logic programs, semantics of logic programs, programming in prolog.		
Module 4		**9 Hours**
Lambda calculus and semantic environment and rules.		
Reference books	(1) Kenneth C. Louden, "Programming Languages: Principles and Practice", 2nd ed., Thomson 2003. (2) Carlo Ghezzi, Mehdi Jazayeri, "Programming Language Concepts", 3rd ed., John Wiley & Sons, 1997. (3) Ravi Sethi, "Programming Languages: Concepts and Constructs", 2nd ed., Pearson Education Asia.	

Subject Code CS505	Data Warehousing and Data Mining (DWDM)	Credits: 3 (3-0-0) Total hours:45
Course Objectives	Following this course, students will be able to 1) Learn the concepts of database technology, 2) Understand data mining principles and techniques, 3) Discover interesting patterns from large amounts of data to analyze and extract patterns to solve problems, make predictions of outcomes. 4) Evaluate systematically supervised and unsupervised models and algorithms with respect to their accuracy, 5) Design and implement of a data-mining application using sample, realistic data sets and modern tools.	

Module 1	**9 Hours**
Introduction to data warehousing, building a data warehouse, mapping the data warehouse to a multiprocessor architecture, OLAP technology for data mining, data warehouse, multidimensional data model, data warehouse architecture, data warehouse implementation, OLAP guidelines, multidimensional versus multi relational OLAP, categories of tools, DBMS schemas for decision support data extraction, cleanup and transformation tools for metadata, development of data cube technology, from data warehousing to data mining, data generalization, efficient methods for data cube computation, further development of data cube and OLAP Technology, attribute-oriented induction.	
Module 2	**12 Hours**
Introduction to data mining tasks, objectives (classification, clustering, association rules, sequential patterns, regression, deviation detection).	
Module 3	**8 Hours**
Data and preprocessing (data cleaning, feature selection, dimensionality reduction).	
Module 4	**8 Hours**
Classification (decision-tree based approach, rule-based approach, instance-based classifiers, Bayesian Approach: Naive and Bayesian networks, classification model evaluation).	
Module 5	**8 Hours**
Clustering (partitional methods, hierarchical methods, graph-based methods, density-based methods, cluster validation methods), anomaly/outlier detection (introduction to various types of outliers, statistical-based, density-based and other methods for outlier detection).	

Reference books	**(1)** Jiawei Han and Micheline Kamber, "Data mining: Concepts and techniques", 2nd ed., Morgan Kaufmann publishers. (2) Raph Kimball," Data warehouse toolkit", John Wiley & Sons Publications (3) Michael. J. Berry, Gordon Linoff, "Data mining techniques: Marketing, sales, customer support", John Wiley & Sons.

Subject Code CS 506	**Advanced Database Systems (ADBS)**	Credits: 3 (3-0-0) Total hours: 45
Course Objectives	To develop an appreciation of emerging database trends as they apply to semi-structured data, the internet, and object-oriented databases. To explain the process of DB Query processing and evaluation.	
Module 1		**11 Hours**
Distributed database concepts, overview of client-server architecture and its relationship to distributed databases, concurrency control heterogeneity issues, persistent programming languages, object identity and its implementation, clustering, indexing, client server object bases, cache coherence.		
Module 2		**11 Hours**
Parallel databases: Parallel architectures, performance measures, shared nothing/shared disk/shared memory based architectures, data partitioning, intra-operator parallelism, pipelining, scheduling, load balancing, query processing- index based, query optimization: cost estimation, query optimization: algorithms, online query processing and optimization, XML, DTD, XPath, XML indexing, adaptive query processing.		
Module 3		**11 Hours**
Advanced transaction models: Save points, sagas, nested transactions, multi-level transactions, Recovery, multilevel recovery, shared disk systems, distributed systems 2PC, 3PC, replication and hot spares, data storage, security and privacy- multidimensional k- anonymity, data stream management.		
Module 4		**12 Hours**
Models of spatial data: Conceptual data models for spatial databases (e.g. pictogram enhanced ERDs), logical data models for spatial databases: raster model (map algebra), vector model, spatial query languages, need for spatial operators and relations, SQL3 and ADT. spatial operators, OGIS queries.		
Reference books	(1) AviSilberschatz, Henry Korth, and S. Sudarshan, " Database system concepts", 5th ed., McGraw Hill, 2005. (2) S. Shekhar and S. Chawla, "Spatial databases: A tour, Prentice Hall", 2003. (3) Ralf HartmutGuting, Markus Schneider, "Moving objects databases", Morgan Kaufman, 2005. (4) R. Elmasri and S. Navathe, "Fundamentals of database systems", Benjamin-Cummings,5th ed., 2007. (5) Raghu Ramakrishnan, "Database management systems", McGraw-Hill, 2000. (6) Ceri S and Pelagatti G, "Distributed databases principles and systems", 2nd ed., Mc-Graw Hill, 1999.	

Subject Code CS 507	E-Commerce (EC)	Credits: 3 (3-0-0) Total hours: 45
Course Objectives	To provide principles of e-commerce from a business perspective.	
Module 1		**12 Hours**
Infrastructure and tools for e-commerce, current trends in e-commerce applications development, the business of internet commerce, enterprise level e-commerce.		
Module 2		**12 Hours**
Security and encryption, electronic payment systems, search engines, intelligent agents in e-commerce, on-line auctions, data mining for e-commerce.		
Module 3		**12 Hours**
Web metrics, recommended systems, knowledge management, mobile e-commerce, legal, ethical and social issues.		
Module 4		**9 Hours**
Seminars and mini projects.		
Reference books	(1) Henry Chan et al., "E-Commerce-Fundamental and applications", John Wiley & Sons 2002.. (2) G. Winfield Treese and Lawrence C.S., "Designing Systems for Internet Commerce", Pearson Education, LPE, 2002 (3) Fensel, Dieter, Brodie M.L., "Ontologies: A Silver Bullet for Knowledge Management and ECommerce", Allied Publishers, 2004 (4) Zimmermann, Olaf Tomlinson, Mark R.: Peuser, Stefan, "Perspectives on Web Services", Allied Publilshers, 2004	

Subject Code CS 508	**Advanced Operating Systems (AOS)**	Credits: 3 (3-0-0) Total hours: 45
Course Objectives	To provide comprehensive and up-to-date coverage of the major developments in distributed operating system, multi-processor operating system and database operating system.	
Module 1		**9 Hours**
Architectures of distributed systems , system architecture types, issues in distributed OS, communication networks, primitives, theoretical foundations, inherent limitations of a distributed system, lamp ports logical clocks, vector clocks, casual ordering of messages, global state, cuts of a distributed computation, termination detection, distributed mutual exclusion.		
Module 2		**9 Hours**
Distributed deadlock detection, introduction, deadlock handling strategies in distributed systems, issues in deadlock detection and resolution, control organizations for distributed deadlock detection, centralized, distributed and hierarchical deadlock detection algorithms , agreement protocols.		
Module 3		**12Hours**
Distributed shared memory, architecture, algorithms for implementing DSM, memory coherence and protocols, design issues, distributed scheduling, issues in load distributing, components of a load distributing algorithm, stability, load distributing algorithm, performance comparison, selecting a suitable load sharing algorithm, requirements for load distributing, task migration and associated issues. Failure recovery and Fault tolerance: Introduction, basic concepts, classification of failures, backward and forward error recovery, recovery in concurrent systems, consistent set of check points, synchronous and asynchronous check pointing and recovery, check pointing for distributed database systems, recovery in replicated distributed databases.		
Module 4		**8 Hours**
Protection and security, preliminaries, the access matrix model and its implementations, safety in matrix model, advanced models of protection. Cryptography basics,multiple encryption and authentication in distributed systems.		
Module 5		**7 Hours**
Multiprocessor OS, database OS, database systems, a concurrency control model, problem, serializability theory, distributed database systems, concurrency control algorithms.		
Reference books	(1) MukeshSinghal Niranjan, Shivorothri G., "Advanced Concepts in Operating systems" (2) Andrew S. Tanenbaum, "Distributed Operating systems" (3) Doreen L. Galli, "Distributed operating systems - concepts and practice", Prentice-Hall 2000. (4) A Silberschatz, "Applied Operating systems Concepts", Wiley 2000 (5) Lubemir F. Bic& Alan C. Shaw, "Operating systems Principles", Pearson Education, 2003.	

Subject Code CS 509	Cyber Laws & Intellectual Property Right (CLIPR)	Credits: 3 (3-0-0) Total hours: 45
Course Objectives	To introduce the cyber world, intellectual property law and cyber law in general to explain about the various facets of cyber-crimes, to enhance the understanding of problems arising out of online transactions and provoke them to find solutions, to clarify the Intellectual Property issues in the cyber space and the growth and development of the law in this regard and to educate about the regulation of cyber space at national and international level.	
Module 1		**12 Hours**
Cyber laws and IT act; the rights the various parties have with respect to creating, modifying, using, and distribution, storing and copying digital data..		
Module 2		**12 Hours**
Concurrent responsibilities and potential liabilities, intellectual property issues connected with use and management of digital data, the similar act of other countries.		
Module 3		**12 Hours**
Computer crime, computer fraud, hacking.		
Module 4		**9 Hours**
Unauthorized modification of information, privacy, computer pornography harassment.		
Reference books	(1) D. Brainbridge, "Introduction to computer law", 5th ed., Pearson Education,2004. (2) P. Duggal, "Cyber law: the Indian perspective", 2005.	

Subject Code CS 510	**Information Theory (IT)**	Credits: 3 (3-0-0) Total hours: 45
Course Objectives	This course aims at developing contents from Information theory formulating its mathematical structure towards design, representation and performance limits associated with the problems in information systems.	
Module 1		**15 Hours**
Over view of probability theory & statistics, analysis and discrete mathematics, measure of information using probability, digitization and Shannon's model for information storage/transmission		
Module 2		**10 Hours**
Discrete entropy and the law of large numbers, bounds on typicality, properties of entropy – rate characterization, conditional, relative, joint entropy, mutual information, source coding theorem (loss less for DMS), existence of minimum information, entropy as divergence, entropy rates of various families, entropy rate of Markov sources, comments on complexity		
Module 3		**10 Hours**
Source coding for DMS: Existence of good source codes, optimality criterion, Huffman coding and competitive optimality, greedy algorithm via min-max constraint, Shannon-Fano coding, run length coding, rate-distortion function and data compression of speech or image (case study), dictionary and entropy rates		
Module 4		**10 Hours**
Entropy rate for reliability analysis, Burg's theorem and entropy maximization, error and information rates for unreliable communication, Shannon-McMillan-Brieman theorem, information theory and betting, stock market (the log-optimal portfolio), special topics : algorithms in database development, learning theory, distributed processing/source coding, information theory in machine learning		
Reference books	(1) T. Cover, J Thomas, "Elements of information theory", Wiley Press (2) R. G. Gallager, "Information theory and reliable communication", Cambridge Press (3) A Rohatgi, MdEhsanes Saleh, "Introduction to probability, statistics", Wiley (4) Relevant Literature pointed in the Class from IEEE Transactions Information Theory	

Subject Code CS511	**Optimization Techniques in Computing (OT)**	Credits: 3 (3-0-0) Total hours:45
Course Objectives	The main goal of this course is to provide the students with a background, foundation, and insight into the several dimensions of Optimization Techniques.	
Module 1		**15 Hours**
Basic OR techniques, requirements, networks, design, role and methods, unconstrained optimization methods- Newton like methods, conjugate direction methods.		
Module 2		**15 Hours**
Constrained optimization: Linear programming, theory of constrained optimization, Non-linear programming. Databases, compilers, optimization and performance in web computing, internet application.		
Module 3		**15 Hours**
Performance measurement tools, case studies, Implementation of an optimization technique for Computer Science applications		
Reference books	(1) K Kanth, "Introduction to computer system performance evaluation", McGraw Hill, 1992 (2) David K Smith, "Network optimization in practice", ellise, Horrwood publications, 1982 (3) R. Fletcher, "Practical methods of optimization", 2nd Edition, Wiley.2000.	

Subject Code CS 512	**Soft Computing (SC)**	Credits: 3 (3-0-0) Total hours: 45
Course Objectives	The course explores the soft computing approaches to consider uncertainty that is inherent in pattern analysis tasks.	
Module 1		**8 Hours**
Biological neuron, nerve structure and synapse, artificial neuron and its model, activation functions, Neural network architecture: single layer and multilayer feed forward networks, recurrent networks. Various learning techniques; perception and convergence rule, Auto-associative and hetro-associative memory.		
Module 2		**8 Hours**
Architecture: Perceptron model, solution, single layer artificial neural network, multilayer perception model; back propagation learning methods, effect of learning rule co-efficient, back propagation algorithm, factors affecting back propagation training, applications.		
Module 3		**10 Hours**
Basic concepts of fuzzy logic, fuzzy sets and crisp sets, fuzzy set theory and operations, properties of fuzzy sets, fuzzy and crisp relations, fuzzy to crisp conversion.		
Module 4		**9 Hours**
Membership functions, interference in fuzzy logic, fuzzy if-then rules, fuzzy implications and fuzzy algorithms, fuzzyfication and defuzzificataion, fuzzy controller, industrial applications		
Module 5		**10 Hours**
Genetic algorithm(GA):Basic concepts, working principle, procedures of GA, flow chart of GA, genetic representations(encoding), initialization and selection, genetic operators, mutation, generational cycle, applications.		
Reference books	(1) Satish Kumar, "Neural networks: A classroom approach" , III edition (2) J. S. R. Lang, C. T. Sun and E. Mizutaju "Neuro-Fuzzy and soft computing", Pearson Education (3) C. -T. Liu and C.S. George Lee "Neural fuzzy System: A neuro fuzzy synergism to intelligent system", PH 1996 (4) V. Kecman "Learning and soft computing" MIT press 2001 (5) A Ghosh, S. Dehuri and S. Ghosh(eds), "Multi-objective evolutionary algorithms for knowledge discovery from databases", Springer 2008 (6) S. Bandyopadhyay and S.K. Pal, "Classification and learning using genetic algorithms: applications in bioinformatics and web intelligence", , Springer-Verlag, 2007 (7) S. Rajsekaran& G.A. VijayalakshmiPai, "Neural networks, fuzzy logic and genetic algorithm:synthesis and applications" Prentice Hall of India, 2003	

Subject Code CS513	**Applied Algorithms (AA)**	Credits: 3 (3-0-0) Total hours: 45
Course Objectives	The course provides an overview of some of the essential numerical techniques which are commonly used in the scientific enterprise.	
Module 1		**15 Hours**
Sequential algorithms: Algorithm design techniques; stable marriage problem, stable matching problem analysis and representative problems. greedy algorithms, interval scheduling, scheduling with deadlines and profits, 1/2 approximation for knapsack. Data compression: Huffman code, (KT4.8) LZ77, gzip.		
Module 2		**11 Hours**
String Matching algorithms: Rabin-Karp algorithm, Knuth Morris pratt algorithm. Parallel algorithms: Designing parallel algorithms; combinatorial algorithms.		
Module 3		**10 Hours**
Network flows: Bellman ford algorithm. divide-and-conquer, closest points problem. external memory algorithms, online algorithms.		
Module 4		**9 Hours**
Graph Algorithms, internet algorithms and security- cryptography algorithms. basics of randomized algorithms. basics of approximation algorithms.		
Reference books	(1) Alfred V Aho, John E Hopcroft, Jeffery D Ullman, "Data structure and algorithms", Addison Wesley , 1993 (2) J. Kleinberg, E. Tardos, "Algorithm design". Pearson Education, Addison Wesley, 2006." (3) Michael Jay Quinn, "Designing efficient algorithms for parallel computers", McGraw Hill 1997. (4) Rajeev Motwani, PrabhakarRaghavan, "Randomized algorithms", Cambridge University Press,1995. (5) R. E. Tarjan, "Data structures and network algorithms", SIAM, 1983. (6) Vijay V. Vazirani, "Approximation algorithms", Springer, 2001.	

Subject Code CS514	Network Management(NM)	Credits: 3 (3-0-0) Total hours: 45
Course Objectives	To appreciate the need for interoperable network management, understand general concepts and architecture behind standards based network management. Understand advanced information processing techniques such as distributed object technologies, software agents and internet technologies used for network management	
Module 1		**11 Hours**
Data communications and network management overview: Goals, architecture and perspectives, review of information network and technology.		
Module 2		**11 Hours**
SNMP and network management- basic foundations: Standards, models and languages, network management organization and information models, communication and functional models.		
Module 3		**11 Hours**
Network Management tools, systems and engineering and applications, management of heterogeneous network with intelligent agents, network security management, internet management (IEEE communication May, Oct.03).		
Module 4		**12 Hours**
Broadband network management, wired and optical networks management, QoS in IP network, basic methods & theory for survivable network design & operation, network planning, network management standards.		
Reference books	(1) M. Subramanian, "Network management: principles and practice", Adison-Wesley, 2000. (2) James F. Kurose and Keith W. Rose, "Computer networking", Pearson Education, LPE, 2003 (3) J. Burke, "Network management concepts and practice, A Hands-on approach", Pearson Education, 2000. (4) Larry L. Peterson and Bruce S. Davie, "Computer networks, a system approach", 3rd edition, Elsevier.	

Subject Code CS515	Software Architecture (SA)	Credits: 3 (3-0-0) Total hours:45
Course Objectives	Complex software systems require abstraction and analysis at an architectural level of abstraction. In this course we study, typical software system structures.	
Module 1		**15 Hours**
Typical software system structures (architectural styles), techniques for designing and implementing these structures.		
Module 2		**10 Hours**
Models for characterizing and reasoning about architectures, and tools architectural modelling. Role of architecture in Software engineering;		
Module 3		**10 Hours**
Enterprise Architectures, Zachman's Framework; Architectural Styles, Design Patterns;		
Module 4		**10 Hours**
Architecture Description Languages; Product-line architectures; Component based development.		
Reference books	(1) Frank Buschmann, RegineMeunier, Hans Rohnert, Peter Sommerlad, MiachelStal, Douglas Schmidt, "Pattern oriented software architecture", Volumes 1 &2, Wiley (2) Len Bass, Paul Clements, Rick Katzman, Ken Bass, "Software architecture in practice".2nd ed. Addison-Wesley Professional 2003 (3) George T. Heineman, William T. Councill, "Component based software engineering", Addison-Wesley, 2001 (4) Kurt Wallnau, Scott Hissam and Robert Seacord, "Building systems from commercial components", Addison-Wesley 2002	

Subject Code CS 516	Cyber Laws & Security Standards(CLSS)	Credits: 3 (3-0-0) Total hours: 45
Course Objectives	To acquire critical understanding in cyber law, the emerging social & intellectual property issues explore legal & policy developments in various countries to regulate cyber space & to develop competencies for dealing fraud & deceptions using cyber space.	
Module 1		**15 Hours**
Perimeter barrier standards, cyber laws, cyber security issues, FGIB cyber security proposals.		
Module 2		**15 Hours**
NRIC cyber security recovery best practices, creation of new practices.		
Module 3		**15 Hours**
NRIC physical security practices.		
Reference books	(1) www. Bell-labs.com/user/krauscher/nric/#intraduction%20TO%20NRIC (2) Hacking exposed scambrey mcclure, kartz tata-mcgrawhill	

Subject Code CS 517	**Wireless Networks & Systems (WNS)**	Credits: 3 (3-0-0) Total hours: 45
Course Objectives	To provide students with the knowledge and skills necessary to securely design, deploy and manage enterprise-wide wireless local area networks and to test the security of wireless networks for weaknesses.	
Module 1		**11 Hours**
Introduction to network resilience problems and solutions, wireless beyond 3G, performance modeling of (wireless) networks and formal methods.		
Module 2		**11 Hours**
Network design algorithms & network design using network processors, wireless ad-hoc networks, security issues in control, management, routing and other areas of networks		
Module 3		**11 Hours**
Distributed control in (wireless) network and middleware, distributed mobile computing.		
Module 4		**12 Hours**
Embedded systems in mobile/wireless/network systems, hardware & software design/development issues, standardization in wireless/mobile network systems.		
Reference books	(1) Theodore S. Rappaport, "wireless communications – principles & practices",2nd ed, Pearson Education, 2002 (2) Boucher N., "Cellular radio handbook", Quantum Publishing, 1991 (3) Feng& Leonidas, "Wireless sensor networks", Elsevier India, 2005	

Subject Code CS 518	Web Engineering(WE)	Credits: 3 (3-0-0) Total hours: 45
Course Objectives	To apply the concepts, principles, and methods of Web engineering to Web applications development	
Module 1		**10 Hours**
Web Engineering Fundamentals: Requirements specification and analysis, web-based systems development methodologies and techniques, migration of legacy systems to web environments.		
Module 2		**10 Hours**
Web-application development: Web-based real-time applications development, testing, verification and validation, quality assessment, control and assurance, configuration and project management.		
Module 3		**10 Hours**
Web metrics: generating metrics for estimation of development efforts, performance specification and evaluation, update and maintenance.		
Module 4		**15 Hours**
User-centric development: Development models, teams, staffing, integration with legacy systems, human and cultural aspects, user-centric development, user modeling and user involvement and feedback, end-user application development.		
Reference books	(1)Journal of Web Engineering, Rinton Press, IEEE & ACM Publications (2) Cato and John, " User centered web design", Pearson Education, 2001	

Subject Code CS 519	**Software Project Management (SPM)**	Credits: 3 (3-0-0) Total hours: 45
Course Objectives	This course introduces project management as it relates to the software life cycle. Different software life cycle models and the project management activities in each phase of the life cycle are studied. Project planning activities are introduced, including effort estimation & the use of software metrics. Risk analysis and resource allocation and project scheduling. The course concludes with a project monitoring & control, project contracts & team organization.	
Module 1		**11 Hours**
Introduction, project definition, contract management, activities covered by software project management.		
Module 2		**11 Hours**
Overview of Project planning, stepwise project planning, life cycle phases, artifacts of the process, model based software architectures, workflows of the process, check points of the process.		
Module 3		**11 Hours**
Software management disciplines, iterative process planning, project organizations & responsibilities, process automation, project control & process instrumentation, tailoring the process.		
Module 4		**12Hours**
Modern project profiles, next generation software economics, modern process transitions, the state of practice in software project management, the COCOMO cost estimation model, change of metrics		
Reference books	(1) K. Conway, "Software project management: From concept to development", IDG Books, 2001. (2) I. Jacobson, G.Booch, J.Rumbaugh, "The unified software development" Process, Addison Wesley, 1999. (3) Stephan H.Kin, "Metric and models in software quality engineering", Addison Wesley 1995. (4) Walker Royce, "Software Project Management", Addison Wesley,1998. (5) Pankaj Jalote, "Software Project Management in Practice", Pearson Education Inc. Delhi, 2002	

Subject Code CS520	**Advanced Compilers (AC)**	Credits: 3 (3-0-0) Total hours:45
Course Objectives	Complex software systems require abstraction and analysis at an architectural level of abstraction. In this course we study, typical software system structures.	
Module 1		**10Hours**
Overview of compiler design, optimizing compilers, graph structures for control flow analysis of programs, data flow analysis of programs, static single assignment form, data dependence of program, program dependence graph.		
Module 2		**10 Hours**
Scalar optimization, loop optimizations,register allocation, instruction scheduling, local methods, graph colouring, code scheduling software pipelining, inter procedural dataflow analysis, optimizing for memory hierarchies.		
Module 3		**9Hours**
High performance systems, scalar, vector, multiprocessor, SIMD, message passing architectures. sequential and parallel loops, data dependence use-def chains.		
Module 4		**16Hours**
Dependence system, GCD test, Banerjee's Inequality, exact algorithm, vectorization, concurrentization, array region analysis, loop restructuring transformations		
Reference books	(1) Robert "Building an Optimizing Compiler Morgan",Digital Press, 1998. (2) M. Wolfe, "High Performance Compilers for Parallel Computing", Addison-Wesley, 1996. (3) Steven S. Muchnick, "Advanced Compiler Design and Implementation", Morgan Kaufmann Publishers, 1997. (4) R. Allen and K. Kennedy, "Optimizing Compilers for Modern Architectures", Morgan Kaufmann Publishers, 2003. (5) A. Appel,Press, "Modern Compiler Implementation in C", 1998. (6) A. Aho, M. Lam, R. Sethi and J. Ullman "Compilers: Principles, Techniques, and Tools", 2007. (7) Steven S. Muchnick, "Advanced Compiler Design and Implementation", Morgan Kaufmann, Elsevier Science, 2003 (8) Michael Wolfe, "High Performance Compilers for Parallel Computing", Addison Wesley, 1995.	

Subject Code CS 521	**Computer Vision (CV)**	Credits: 3 (3-0-0) Total hours: 45
Course Objectives	The objective of this course is to understand the basic issues in computer vision and major approaches that address them. Even though Computer Vision is being used for many practical applications today, it is still not a solved problem. Hence, definitive solutions are available only rarely.	
Module 1		**11 Hours**
Introduction and overview, pinhole cameras, radiometry terminology. Sources, shadows and shading: Local shading models- point, line and area sources; photometric stereo. Color: Physics of color; human color perception, Representing color; A model for image color; surface color from image color.		
Module 2		**12 Hours**
Linear filters: Linear filters and convolution; shift invariant linear systems- discrete convolution, continuous convolution, edge effects in discrete convolution; Spatial frequency and Fourier transforms; Sampling and aliasing; filters as templates; Normalized correlations and finding patterns. Edge detection: Noise; estimating derivatives; detecting edges. Texture: Representing texture; Analysis using oriented pyramid; Applications; Shape from texture. The geometry and views: Two views.		
Module 3		**11 Hours**
Stereopsis: Reconstruction; human stereo; Binocular fusion; using color camera.		
Module 4		**11 Hours**
Segmentation by clustering: Human vision, applications, segmentation by graph theoretic clustering. Segmentation by fitting a model, Hough transform; fitting lines, fitting curves;		
Reference books	(1) David A Forsynth and Jean Ponce, "Computer vision- A modern approach", Pearson education series, 2003. (2) Milan Sonka, Vaclav Hlavac and Roger Boyle , "Digital image processing and computer vision", Cengagelearning, 2008. (3) Schalkoff R. J., "Digital image processing and computer vision", John Wiley, 2004. (4) Sonka M., Hlavac V., Boyle R., "Image processing analysis and machine design". PWS Publishers (5) Ballard D., Brown C., "Computer vision", Prentice Hall	

Subject Code CS522	**Artificial Intelligence (AI)**	Credits: 3 (3-0-0) Total hours:45
Course Objectives	The course objective is to introduce problems in search, logic, and game playing, more complex problems in first-order predicate logic, inference, knowledge bases, planning, and reasoning systems.	
Module 1		**15 Hours**
Introduction to artificial intelligence,architecture of AI & KBCS systems, design issues and AI techniques; problem solving, knowledge based reasoning, logic, inference, knowledge based systems, reasoning with uncertain information; state space search, heuristic search.		
Module 2		**10 Hours**
Planning and making decisions, learning, distributed AI, communication, web based agents. introduction &design of expert systems, various applications;		
Module 3		**10 Hours**
Negotiating agents, artificial intelligence applications and programming. introduction to fuzzy logic systems, natural language processing;		
Module 4		**10 Hours**
Heuristic search techniques, knowledge based systems. problem solving by search; uninformed search, informed ("heuristic") search, constrained satisfaction problems, adversarial search,		
Reference books	(1) Nilson, "Artificial intelligence : A new synthesis", Morgan Kaufmann Publishers, 2001. (2) Charniak and Mcdermott, "Introduction to artificial intelligence", Addison-Wesley, 1985. (3) S. Russel and P. Norvig, "Artificial intelligence - A modern approach", Prentice Hall, 1995. (4) Deepak Khemani, "A first course in artificial intelligence", Tata McGraw Hill,2013. (5) Ginsburg, "Essentials of artificial intelligence", Morgan Kaufmann, 1993. (6) George F. Luger, "Artificial intelligence", Pearson Education, 2001. (7) Edwin wise, "Hands on AI with Java", McGraw Hill, 2004	

subject Code CS523	**Multimedia & Virtual Reality (MVR)**	**Credits: 3 (3-0-0)** **Total hours:45**
Course Objectives	To provide basic knowledge of multimedia and overview of the tools & taxonomy of multimedia authoring, including data representation for images, video & audio. To understand data compression & multimedia communication & retrieval	
Module 1		**11Hours**
Introduction to multimedia technology and its applications, multimedia hardware and software essentials. multimedia graphics fundamentals. multimedia audio - sound card fundamentals		
Module 2		**12Hours**
MIDI fundamentals: digital video production techniques, image processing - digital image fundamentals, digital image development and editing, computer animation techniques, animation software. multimedia file formats – growth pace of multimedia in IT industry.		
Module 3		**11Hours**
Concepts of virtual reality and its effectiveness in real time applications, virtual reality tools, introduction to scientific visualization and virtual reality, hardware requirements, sound, animation techniques, VR on flight simulation.		
Module 4		**11Hours**
VR on CAD / CAM processing : Virtual banks, compression and decompression techniques, CASE study of multimedia workstations		
Reference books	(1) The Winn L. Rosch "Multimedia Bibble", SAMS Publishing (2) D. P. Kothari & Anshu, "Hypermedia: From multimedia to V. R." , PHI, 2004.	

Subject Code CS524	Software Quality Assurance (SQA)	Credits: 3 (3-0-0) Total hours:45
Course Objectives	The course will introduce the basics of software quality assurance. Further, the issues, processes, and techniques in software quality assurance are discussed. The course will train the students to apply quality assurance techniques in different activities of software development and maintenance.	
Module 1		**15 Hours**
Introduction to software quality, software defects, reasons of poor quality, quality laggards, project management approaches, cost and economics of SQA, quality measurements, evaluation, role, maturity in development, life cycle, models, maintenance issues, specification.		
Module 2		**10 Hours**
Software requirements and SQA, requirements defects, writing quality requirements, quality attributes of requirements document, software design model and software design defects		
Module 3		**10 Hours**
Quality design concepts, programming and SQA, SQA reviews, software inspections, software testing: WBT techniques, BBT techniques, testing strategies, debugging, test planning, automated software testing, test cases, responsibilities of testers		
Module 4		**10 Hours**
SQA and SCM, SCM plan and SQA plan, process assurance, process management and improvement, introduction to quality metrics, a process model of software quality assurance.testing, mechanisms, verification and validation.cost estimation, tools, debugging, simulators, ISO 9000 standards, quality assurance.		
Reference books	(1) Capers Jones, "Software quality: Analysis and guidelines for success", International Thomson Computer Press. 1997. (2) Capers Jones, "Software assessments, benchmarks, and best practices", Addison-Wesley Professional, 2000. (3) Pankaj Jalote, "An integrated approach to software engineering", Narosa Publication, 1995. (4) John J Marciniack, (Ed), "Encyclopedia of software engineering", John Wiley and Sons,1994. (5) Isabel Evans, "Achieving software quality through team work", Allied Publishers, 2004. (6) Mordechai Ben, Menachem, Garry S. Marliss, "Software quality producing practical, consistent software", Thomson Learning. (7) James F. Peters, Witold Pedrycz, "Software engineering, an engineering approach" WSE, Wiley.	

Subject Code CS 525	**Protocol Engineering(PE)**	Credits: 3 (3-0-0) Total hours: 45
Course Objectives	Characterize protocol engineering. Compare and contrast various Internet protocols such as TCP/IP, DNS, DHCP, LDAP, and IPsec.	
Module 1		**11 Hours**
Review of Communication Network: Overview of computer network protocol, OSI reference model, Basic design concept: Protocol as a system, life cycle model, architectural design phase,top down approach ,bottom up approach ,separation of concern.		
Module 2		**11 Hours**
Requirement specification: service specification service data unit service elements, communication mode, Protocol architecture:Basic protocol concept, protocol layer, protocol entity, protocol element protocol data unit.		
Module 3		**11 Hours**
Protocol structuring, design and specification protocol structuring, the users of pdu service structuring, generic protocol function, five elements of protocol specification, rules of design, specification language, message sequence chart, petri net finite state machine		
Module 4		**12 Hours**
Protocol Data Format: Abstract Syntax format design principles, ASN.1, ASN.1 record structure ASN.1 encoding rule, XML Syntax, DTD and XML schemas example, Case of protocol data format customer information: XML-based customer information, ASN.1 binary-encoded based XML schema and ASN.1 cooperation.		
Reference books	(1) Web sites, IEEE, ISO and ITU-T sites. (2) P. Venkatram & S. S. Manavi, "Protocol Engineering", PHI, 2004.	

Subject Code CS 526	**Software Testing (ST)**	Credits: 3 (3-0-0) Total hours: 45
Course Objectives	To discuss the distinctions between validation tests and defect testing. To describe strategies for generating system test cases.To gain the techniques and skills on how to use modern software testing tools to support software testing projects.	
Module 1		**9 Hours**
Testing as an engineering activity, role of process in software quality, testing as aprocess, basic definitions, software testing principles, the tester's role in asoftware development organization, origins of defects, defect classes, the defectrepository and test design, defect examples, developer / tester support fordeveloping a defect repository.		
Module 2		**9 Hours**
Introduction to testing design strategies, the smarter tester, test case designstrategies, using black box approach to test case design, random testing, equivalence class partitioning, boundary value analysis, other black box testdesign approaches, black box testing and cots, using white box approach to testdesign, test adequacy criteria, coverage and control flow graphs, covering codelogic, paths, their role in white box based test design – additional white box test design approaches, evaluating test adequacy criteria.		
Module 3		**9 Hours**
The need for levels of testing, unit test, unit test planning, designing the unittests, the class as a testable unit, the test harness, running the unit tests andrecording results,integration tests, designing integration tests, integration testplanning, system test, the different types, regression testing, alpha, beta andacceptance tests.		
Module 4		**9 Hours**
Basic concepts, testing and debugging goals and policies, test planning, testplan components, test plan attachments, locating test items, reporting testresults, the role of three groups in test planning and policy development, processand the engineering disciplines, introducing the test specialist, skills needed by atest specialist, building a testing group.		
Module 5		**9 Hours**
Defining terms, measurements and milestones for controlling and monitoring, status meetings, reports and control issues, criteria for test completion, scm, types of reviews, developing a review program, components of review plans, reporting review results.		
Reference books	(1) Glenford J. Myers, "The art of software testing", John Wiley & Sons, 1979. (2) Boris Beizer, Black "Testing: Techniques for functional testing of software and systems", John Wiley & Sons, 1995. (3) William Perry, "Software testing: Effective methods for software testing", John Wiley, 1995. (4) Cem Kaner, Jack Falk, Hung Quoc Nguyen, "Testing computer software", 2nd Ed, Intl. Thomson Computer Press, 1993. (5) Ilene Burnstein, "Practical software testing", Springer International Edition,2003.	

Subject Code CS 527	**Mobile Communications (MC)**	**Credits: 3 (3-0-0)** **Total hours: 45**
Course Objectives	To understand the issues involved in mobile communication system design & analysis.	
Module 1		**8 Hours**
Introduction to cellular mobile systems: A basic cellular system, performance criteria, uniqueness of mobile radio environment, operation of cellular systems, planning and cellular systems, analog & digital cellular systems.		
Module 2		**8 Hours**
Elements of cellular radio system design:General description of the problem, concept of frequency channels, co-channel interference reduction factor, desired c/i from a normal case in an omnidirectional antenna system, cell splitting, consideration of the components of cellular systems.		
Module 3		**10 Hours**
Interference:Introduction to Co-channel interference, real time Co-channel interference, Co-channelmeasurement, design of antenna system, antenna parameters and their effects, diversity receiver, non Co-channel interference - different types.		
Module 4		**9 Hours**
Cell coverage for signal and traffic:General introduction, obtaining the mobile point- to - point model, propagation over water or flat open area, foliage loss, propagation in near in distance, long distance propagation, point - to - point predication model - characteristics, cell site, antenna heights and signal coverage cells, mobile - to - mobile propagation.		
Module 5		**10 Hours**
Mobile communications by satellite service systems in operation, INMARSAT, MSAT, LEO mobile satellite services		
Reference books	(1)Lee W.C.Y., "Mobile cellular telecommunications", McGraw Hill, 1995. (2) Mazda F., "Telecommunications engineering" Reference book, Butterworth, 1993. (3) Gibson J.D., "Mobile communication hand book", CRC press, U.S.A., 1996. (4)Macario R.C.V., "Cellular radio", Macmillan, 1993. (5) Bud Bates, "Wireless networked Communication", McGraw Hill, 1991. (6)Dr. KamiloFeher, “Wireless digital communication”, PHI.	

Subject Code CS528	Information Security(IS)	Credits: 3 (3-0-0)0 Total hours:45
Course Objectives	To provide extensive, detailed and critical understanding of the concepts, issues, principles and theories of computer network security. also the course focuses on application and operating system security , web security mobile application security.	
Module 1		**9Hours**
Security properties, threat models, examples; control hijacking attacks and defences.		
Module 2		**9 Hours**
Tools for robust code, exploitation techniques and fuzzing, dealing with legacy code, least privilege, access control		
Module 3		**9 Hours**
Operating system security, cryptography overview, basic web security model		
Module 4		**9 Hours**
Web application security; session management and user authentication, HTTPS: goals and pitfalls		
Module 5		**9 Hours**
Mobile platform security models: Android, iOS, mobile threats and malware, the trusted computing architecture		
Reference books	(1) Matt Bishop, "Computer security, arts & science", Pearson Education, 2003. (2) Pceprzyk et.al. "Fundamentals of computer security", Allied Publishers, 2004. (3) Derek Atkins and 9 others, "Internet security" Techmedia 2nd edition, 1997. (4) Michael Howard and David LeBlane, "Writing Secure Code, Microsoft, WP Publishers. (5) Dave Aitel, "How hackers look for bugs" (6) Charlie Miller, "Real world fuzzing"	

Subject Code CS529	Network Security(NS)	Credits: 3 (3-0-0) Total hours:45
Course Objectives	To provide extensive, detailed and critical understanding of the concepts, issues, principles and theories of network security.	
Module 1		**15 Hours**
Introduction to network security and associated techniques, Firewall design principles: Packet filtering, Gateways: Circuit-level gateways; application-level gateways,		
Module 2		**10 Hours**
Firewall Configurations, Intrusion Control: Detection; Anomaly-Based IDS Intrusion Recovery; Vulnerability Scanners; Login, Audit, and Sniffers,		
Module 3		**10 Hours**
Communication Security Network Access Layer;- Internet Layer - Transport Layer;		
Module 4		**10 Hours**
Application Layer - Message Security Risk Analysis, Policies, Procedures and Enforcement. Special Topics : DOS Mitigation ,VPNs Special Topics: Viruses, SPAM. Network protocols and vulnerabilities, Network defenses, Denial of service attacks, Malware,		
Reference books	(1) C. Kaufman, R. Perlman, M. Speciner, "Network security: Private communication in a public world", Prentice Hall, 2002. (2) William Stallings, "Network security essentials", 2/e, Pearson Education, 2003.	

Subject Code CS 530	**Parallel Algorithms (PA)**	Credits: 3 (3-0-0) Total hours: 45
Course Objectives	To introduce techniques for the design of efficient parallel algorithms and their implementation.	
Module 1		**10 Hours**
Parallel processing, parallel models, performance of parallel algorithms, complexity measure for parallel algorithms.		
Module 2		**11Hours**
Techniques for designing parallel algorithms, pointer jumping technique, divide and conquer, partitioning strategy, pipelining, accelerated cascading, symmetry breaking.		
Module 3		**12Hours**
Lists and trees, list ranking, Euler-tour technique, Tree contraction, computation of tree functions, merging, parallel sorting algorithms. parallel combinatorial algorithms: permutations with and without repetitions combinations, derangements. parallel searching algorithms: maximum/minimum, median, K-th largest/smallest element.		
Module 4		**12Hours**
Parallel graph algorithms, parallel graph search &, tree traversal algorithms, parallel algorithms for connectivity problems, parallel algorithms for path problems., Ear decomposition, Polynomial and matrix computations, General dense matrices.		
Reference books	(1) Jaja, J. "An introduction to parallel algorithms", Addison- Wesley, Reading, MA, 1992. (2) Gibbons A., W.Rytter, "Efficient parallel algorithms", Cambridge university Press; Cambridge, 1988 (3) H. Sparkias and A. Gibbon, "Lecture notes on parallel computation", Cambridge University Press, 1993. (4) K. Hwang and F. A. Briggs, "Computer architecture and parallel processing", McGraw Hill Inc., 1985. (5) S. Akl., "Design and analysis of parallel algorithms", Prentice Hall Inc, 1992.	

Subject Code CS531	**Distributed Algorithms(DA)**	Credits: 3 (3-0-0) Total hours:45
Course Objectives	To introduce the main algorithmic techniques in the framework of distributed models of computing; to define the most significant complexity parameters and the computational limits of parallelism and concurrency.	
Module 1		**9 Hours**
Distributed Algorithms: models and complexity measures. Modeling: Synchronous network model, asynchronous system model,asynchronous shared memory model, asynchronous network model. partially synchronous system model.		
Module 2		**9 Hours**
Leader election in synchronous ring: Basic algorithm, non-comparison based algorithm, timeslice and variablespeeds algorithm. Lower bounds on the algorithms. Leader election in a general network.		
Module 3		**9 Hours**
Distributed consensus with process failures: Algorithms for stopping failures, algorithms for byzantine failures. approximate agreement.		
Module 4		**9 Hours**
Consensus: Agreement using read/write shared memory. Basic asynchronous network algorithms: Leader election in a ring algorithms, leader election in arbitrary network.		
Module 5		**9 Hours**
Synchonizers, safe synchronizer implementations. algorithm tolerating process failures. adding logical time to asynchronous networks. applications. termination detection for diffusing algorithms. The chandylamport algorithms, mutual exclusion , general resource allocation algorithms .		
Reference books	1. Nancy & Lynch, Distributed Algorithms, Harcour Asia, 2001.	

Subject Code CS 532	**Web Services & Cloud Computing (WSCC)**	Credits: 3 (3-0-0) Total hours: 45
Course Objectives	To standardize a framework applications to communicate over the internet & to get a general idea about the models of web services. To understand the emerging area of "cloud computing" and how it relates to traditional models of computing. To understand how well-known algorithms such as Page Rank and inverted index construction can be expressed in the Map-Reduce framework. To gain competence in Ajax as a vehicle for delivering highly-interactive Web applications.	
Module 1		**11 Hours**
Basic concepts, enabling infrastructure, core functionality and standards.		
Module 2		**12 Hours**
Service semantics, web service composition, service development and recent research trends.		
Module 3		**11 Hours**
Introduction to cloud computing, cloud computing delivery models.		
Module 4		**11 Hours**
Open Source and Industry case Studies of cloud, Map Reduce, Apache VCL, Amazon, IBM and Eucalyptus, Hadoop, Security issues in cloud		
Reference books	(1) Rajkumar Buyya, Christian Vecchiola, and Thamarai Selvi, Mastering Cloud Computing, International Edition: Morgan Kaufmann, 2013. (2) AlonsoG.,Casati F., Kuno H., Machiraju V., "Web Services – Concepts, Architectures and Applications Series: Data- Centric Systems and Applications"PHI 2004. (3) SanjivaWeerawarana, Francisco Curbera, Frank Leymann et al, "Web Services Platform Architecture: SOAP, WSDL, WS-Policy, WS-Addressing, WS-BPEL, WS-Reliable Messaging and more", Prentice Hall Publication, 2005. (4) Thomas Erl, "Service oriented Architecture: Concepts, Technology and Design", Prentice Hall Publication, 2005. (5) R. Allen Wyke et-al, "XML Programming", WR Publishers, (6) Richard Monson-Haefel , "Web Services", , Pearson (LPE), 2005. (7) "Cloud Application Architectures" by George Reese, O'Reilly Publications, 2009. (8) "Cloud Security and Privacy", Tim Mather, SubraKumaraswamy, O'Reilly, 2009. (9) The Hadoop – Definitive Guide, Tom White, O'Reilly, 2009.	

Subject Code CS533	Computer Security Audit and Assurance (CSAA)	Credits: 3 (3-0-0) Total hours:45
Course Objectives	To introduce students to the concepts of Information Assurance and how to secure such information using appropriate systems and technologies, presenting introductory aspects on computer audit including auditing information systems auditing computerized systems, auditing applications etc. Also, to introduce students to the key management and Public Key Infrastructure.	
Module 1		**10 Hours**
Security policy frameworks;practices and procedures, business practice disclosures. Information Systems in Global Context · Threats to Information Systems · Security Considerations in Mobile and Wireless Computing · Information Security Management in Organizations · Building Blocks of Information Security · Information Security Risk Analysis · Overview of Physical Security for Information Systems · Perimeter Security for Physical Protection · Biometrics Controls for Security · Biometrics-based Security: Issues and Challenges · Network Security in Perspective.		
Module 2		**15 Hours**
·Networking and Digital Communication Fundamentals · Cryptography and Encryption · Intrusion Detection for Securing the Networks · Firewalls for Network Protection · Virtual Private Networks for Security · Security of Wireless Networks · Business Applications Security: An EAI Perspective · Security of Electronic Mail Systems · Security of Databases · Security of Operating Systems · Security Models, Frameworks, Standards and Methodologies · ISO 17799/ISO 27001 · Systems Security Engineering Capability Maturity Model - The SSE-CMM · COBIT, COSO-ERM and SAS 70.		
Module 3		**10 Hours**
· Information Security: Other Models and Methodologies · Laws and Legal Framework for Information Security · Security Metrics · Privacy - Fundamental Concepts and Principles · Privacy - Business Challenges · Privacy - Technological Impacts · Web Services and Privacy · Staffing the Security Function · Business Continuity and Disaster Recovery Planning. Policy authority and practices, information security practices, personal and physical security practices, operation management practices .		
Module 4		**10 Hours**
· Auditing for Security · Privacy Best Practices in Organizations · Asset Management · Ethical Issues and Intellectual Property Concerns for InfoSec Professionals. PKI's and key management schemes, key generation, key storage, backup, recovery and distribution. XML frameworks for security policy specification, certificate management life cycle.		
Reference books	(1) W K Brotby, Information security management metrics, CRC press 2009. (2) Nina Godbole, Information systems security: security management, metrics, frameworks and best practices, John Wiley and sons Ltd. 2009.	

Subject Code CS534	Big Data Analysis (BDA)	Credits: 3 (3-0-0) Total hours: 45
Course Objectives	This course covers the object oriented programming concepts using C++.	
Module 1		**15 Hours**
Overview of big data, stages of analytical evolution, state of the practice in analytics, the data scientist.		
Module 2		**10Hours**
Big data analytics in industry verticals, data analytics lifecycle, operationalizing basic data analytic methods using R, advanced analytics - analytics for unstructured data - map reduce and Hadoop, the Hadoop ecosystem, in-database analytics.		
Module 3		**10 Hours**
Data Visualization Techniques, Stream Computing Challenges, Systems architecture, Main memory data management techniques, energy-efficient data processing, benchmarking.		
Module 4		**10 Hours**
Security and Privacy, Failover and reliability.		
Reference books	(1) Bill Franks, Taming, "The big data tidal wave", 1st ed., Wiley, 2012 (2)Frank J. Ohlhorst, "Big data analytics", 1st ed., Wiley, 2012.	

Subject Code CS 535	**Business Intelligence (BI)**	Credits: 3 (3-0-0) Total hours:45
Course Objectives	Explore the concepts of business intelligence/business analytics through readings, creation of Wikis and Blogs relevant to the course. To develop and apply critical thinking, problem-solving and decision-making skills .	
Module 1		**15 Hours**
Overview of managerial, strategic and technical issues associated with business intelligence and data warehouse, analytics and DSS.		
Module 2		**15 Hours**
Design, implementation and utilization, data as the basis for decision making, business reporting and visualization.		
Module 3		**15 Hours**
Data warehouse architecture, OLAP, data cubes, Reporting tools, Balance Scorecard, dash board design, and implementation. Case studies.		
Reference books	(1) Efraim Turban, Ramesh Sharda, Jay Aronson, David King, "Decision support and business intelligence systems", 9th ed., Pearson Education, 2009. (2) David Loshin, "Business Intelligence - The Savy Manager's Guide Getting Onboard with Emerging IT", Morgan Kaufmann Publishers, 2009.	

Subject Code CS 536	Secure Software Engineering (SSE)	Credits: 3 (3-0-0) Total hours: 45
Course Objectives	This course focuses on secure software engineering process and details the secure programming and software security.	
Module 1		**15Hours**
Definition of software security, threats and vulnerabilities, risk management, security requirements.		
Module 2		**10Hours**
Principles of secure design and patterns, secure programming, validation of the data.		
Module 3		**10Hours**
Secure usage of cryptography, code reviews and static analysis.		
Module 4		**10Hours**
Secure testing, creating a software security programs.		
Reference books	(1) Julia H Allen, Sean J Barnum, Robert J Ellison, Gary McGraw, Nancy M Read, "Software Security Engineering: A Guide to Project Managers", Addison Wesley, 2008. (2) Ross J Anderson, "Security Engineering: A Guide to Building Dependable Distributed Systems", Wiley, 2008. (3) Howard M and LeBlanc D, "Writing Secure Code", Microsoft Press, 2003.	

Subject Code CS 537	**Computer Graphics (CG)**	Credits: 3 (3-0-0) Total hours: 45
Course Objectives	To have an introduction to computer graphics to develop abilities to comprehend contemporary issues and address them.	

Module 1	**6 Hours**
Introduction to graphics hardware devices, display devices, primitive operations, the display-file interpreter, display file structure, and graphics file formats. text mode graphics function, graphic mode graphics functions shapes, colors, co-ordinate systems, applications of computer graphics.	
Module 2	**11 Hours**
Basic concepts in line drawing, line drawing algorithms: DDAalgorithms, Bresenham's algorithm Circle generating algorithms: DDA circle drawing algorithm, Bresenham's circle drawing algorithm, midpoint circle algorithm, polygons, types of polygons, polygon representation, entering polygons, inside –outside test, polygon filling: Flood fill, scan-line algorithm.	
Module 3	**13 Hours**
2D transformation: scaling, Reflection, shearing, Rotation, Translation, Rotation about an arbitrary point. 3D Transformation: scaling, rotation, translation, rotation about arbitrary axis. Viewing transformation, normalization, transformation. Line clipping: Cohen-Sutherland, Line clipping algorithm, midpoint subdivision algorithm Polygon clipping: Sutherland–Hodgeman Polygon clipping algorithm.	
Module 4	**15 Hours**
Curve generation: arc generation using DDA algorithm. Interpolation, B-Spline, Bezier curves. Fractals: Hilbert's Curve, Koch curve, Fractal lines, Fractal Surfaces. Raster scan display, Random scan display Need for graphics standards, Graphics standards, Advantages of Graphics standards, Hazards of Graphics standards. Graphical user interface Open GL: What is Open GL, How OpenGL works, Open GL and animation, Graphical processors: GPUs.	

Reference books	(1) Ronald Hearn &MPauline Baker, "Computer graphics", 2nd ed., PES, 2003. (2) James D. Foley, Andrews van Dam, Steven K Feimer, John F Hughes, "Computer graphics principles and practice", 2nd ed., Addison Wesley, 1996. (3) William Newman and Robert Sproull, "Principles of Interactive Computer Graphics", Tata McGraw-Hill,1973.

Subject Code CS 538	**Graph Theory (GT)**	Credits: 3 (3-0-0) Total hours: 45
Course Objectives	This is an introductory course about properties and applications of graphs. It aims at the usage of graph theoretic methods for modeling problems and proofs in discrete mathematics.	

Module 1	**12 Hours**
Definitions, pictorial representation of a graph, isomorphic graphs, sub graphs, matrix representations of graphs, degree of a vertex, special graphs, complements, larger graphs from smaller graphs, connected graphs and shortest paths, walks, trails, paths, cycles, connected graphs, cut-vertices and cut-edges, blocks, connectivity, weighted graphs and shortest paths, weighted graphs, Dijkstra's shortest path algorithm, Floyd-Warshall shortest path algorithm.	
Module2	**12 Hours**
Trees, Definitions and characterizations, number of trees, Cayley's formula, minimum spanning trees, Kruskal's algorithm, Prim's algorithm, bipartite graphs, Eulerian graphs, Fleury's algorithm, Chinese Postman problem.	
Module 3	**12 Hours**
Hamilton Graphs, necessary conditions and sufficient conditions, independent sets, coverings and matchings, matchings in bipartite graphs, Hall's theorem, Konig's theorem, perfect matching's in graphs, vertex Colorings, basic definitions, cliques and chromatic number, greedy coloring algorithm.	
Module 4	**9 Hours**
Edge colorings, Gupta-Vizing theorem, class-1 and class-2 graphs, edge-coloring of bipartite, graphs, planar graphs, basic concepts, Euler's formula and its consequences, characterizations of planar graphs, 5-color-theorem, directed graphs, directed walks, paths and cycles, Eulerian and Hamilton digraphs.	

Reference books	(1) Adrian Bondy, U. S. R. Murty, "Graph Theory", Springer, 2008. (2) Reinhard Diestel, "Graph Theory", 3rd edition, Springer, 2000. (3) Douglas B. West, "Introduction to Graph Theory", Prentice Hall, 1996 (4) Jonathon L. Gross, "Combinatorial methods with computer applications", Chapman & Hall /CRC press, 2008

Subject Code CS 539	**Distributed Computing Systems (DCS)**	Credits: 3 (3-0-0) Total hours: 45
Course Objectives	This course covers abstractions and implementation techniques for the design of distributed systems. It focuses on server design, network programming, naming, storage systems, security, and fault tolerance.	
Module 1		**9 Hours**
Introduction Distributed Systems and applications, Distributed vs parallel systems, models of distributed systems, Message Passing mechanisms IPC and RPC.		
Module2		**11 Hours**
Clock synchronization, physical & logical clocks, vector clocks, verifying clock algorithms, mutual exclusion using time stamp, election algorithms, Distributed mutual exclusion using time stamps, token & quorums, centralized & distributed algorithms, proof of correctness & complexity, drinking philosophers problem, Implementation & performance evaluation of DME Algorithms.		
Module 3		**13 Hours**
Leader election algorithms, global states, global predicates, termination detection, Control of distributed computation, disjunctive predicates, performance evaluation of leader election algorithms on simulated environments.		
Module 4		**12 Hours**
Distributed File Systems and Services, Shared data, Synchronization Transaction and Concurrency Control. Distributed databases, Name service, Timing & Coordination, Replication, Security and Fault Tolerance.		
Reference books	(1) Vijay K Garg "Elements of Distributed Computing", Wiley & Sons, 2002 (2) Pradeep Sinha, "Distributed Operating Systems- Concepts and Design", PHI,2000 (3) A.S. Tanenbaum and M.V. Steen, "Distributed Systems – Principles and Paradigms", PHI.2003 (4) George Couloris, Jean Dollimore & Time Kindberg, "Distributed Systems: Concepts & Design", 2nd Edition, Addison Wesley 2003. (5) V. Rajaraman, C. Siva Ram Murthy, "Parallel, Computers Architecture & Programming", PHI. (6) Khemkalyani and Singal, "Distributed Computing" (7) Nancy Lynch , "Distributed Algorithm" (8) Singal and Shivaratri, "Ditributed OS"	

Subject Code: HU 401& HU 402	**Professional Communication-II and Language Lab**	**Credits: 4 (2-0-3) Total hours: 56**
Course Prerequisite	Knowledge of English	
Course Objectives	This course aims at Personality Development	
Course Outcome	At the end, the students should possess a Saleable Image with employability skills	
Module 1	**Principles of Soft Skills and Practice**	12 hours
Definition of Soft Skills and Personality, Attitude, Dress Code, Body Language, Individual and Group Behaviour, Personality Test, C.V Writing and the difference between CV & Resume		
Module 2	**Group Discussion, Extempore, JAM and Survey**	16 hours
Topics: Is Cloning Ethical, Shopping Mall vs Retailer, Should Animals be used for Drug-Test, Effects of Advertisement on Youth, Google vs Social Networking Sites, Newspaper is the thing of Past, Diversity in Indian Culture, Gender Discrimination, Who is Smarter: Human Beings or Computer and so on		
Module 3	**Interview**	14 hours
Types of Interview, Interview Ethics, Questions and Mock-Interview Sessions		
Module 4	**Business Presentation and Seminars**	14 hours
Business Presentation and Students' Seminar		
Texts:	1.W.B. Martin, *Ethics in Engineering* Tata McGraw Hill, India 2. Patnaik,Priyadarshi, *Group Discussion and Interview Skills*, New Delhi: CUP, (Video CD) 3..Downes, Colm, *Cambridge English for Job Hunting*,2009, New Delhi,CUP (2 Audio CDs)	
Reference	TV News (Headlines Today, ND TV and BBC), Chat-Shows on TV, Magazines like India Today, Outlook, The Week and English Dailies. Reader's Digest for Expressive Skill, English Films & English Comics	