[DRAFT]

Syllabus of Ph.D. Preparatory Course Work (PCW) in

Computer Science and Application

Under

Choice Based Credit System (CBCS)

Enlightenment to Perfection

Department of Computer Science and Application

University of North Bengal (N.B.U.)

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West Bengal, India, Pin-734013

(2017-18)
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1. A model Scheme of Instruction and Examination

<table>
<thead>
<tr>
<th>Name of the Course:</th>
<th>Ph.D. Preparatory Course Work (PCW) in Computer Science and Application</th>
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<tr>
<td>Course Duration:</td>
<td>One Semester</td>
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<tr>
<th>Paper Code</th>
<th>Papers Title</th>
<th>Type of Paper</th>
<th>Credit</th>
<th>Term End</th>
<th>Sessional</th>
<th>Total Marks</th>
<th>Lecture/Tutorial/Practical (hr/week)</th>
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<tbody>
<tr>
<td>PCWCSA 11</td>
<td>Research Methodology 1: Research Foundation</td>
<td>Theory</td>
<td>2</td>
<td>40</td>
<td>10</td>
<td>50</td>
<td>2 + 0 + 0</td>
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<tr>
<td>PCWCSA 12L</td>
<td>Research Methodology 2: Computer Applications in Research</td>
<td>Laboratory</td>
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<td>10</td>
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<tr>
<td>PCWCSA 13</td>
<td>Elective: Any one paper to be chosen from the list of electives based on the scholar's research area with the consent of the supervisor</td>
<td>Theory</td>
<td>4</td>
<td>80</td>
<td>20</td>
<td>100</td>
<td>2 + 4 + 0</td>
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</tbody>
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Total: 8 160 40 200 4 + 4 + 4

* L: Lecture; T: Tutorial; P: Practical/lab
** One Credit shall mean one teaching period of 1(one) hour per week for one semester (of 15 weeks) for theory courses and 2(two) practical / laboratory / field / demonstration hours / week for one semester.

2. Programme Syllabus

2.1. PCWCSA 11: Research Methodology 1: Research Foundation  [Credit Assign: 2, FM: 40+10, Teaching Period: 2hr/week]

**Introduction** - Meaning, purpose, objectives, characteristics, motivation, significance, types of research; approaches, process, methods and methodology used in research; criteria of good research; difference among research in social science, scientific and engineering domains; research methods in general and computer science, engineering, applications and IT in particular.

**The Research Problem** – Research problems and sub-problems identification, stating, defining, techniques involved in defining problem

**Research Planning and Design** - Research plan and its components, developing a research plan, meaning, importance and types of research design, characteristics of a good research design
Development of working hypothesis – Concepts, formulation and types of hypotheses, hypotheses testing methods/techniques, correlation and regression, chi-square test, analysis of variance and covariance etc.

Interpretation and Report Writing - Techniques of interpretation - significance, types, steps, checklist/precautions and characteristics of research documentation i.e. reviews, treatise, monographs, abstracts, articles, technical reports, white papers, research papers, thesis etc. - issues and techniques of writing project proposals, paper presentation and soft skills

Ethical issues and Professional Conduct Ethics in general, Professional Ethics, Ethical Issues and their significance those arise from Computer Technology, General Moral Imperatives, Concepts and issues related to plagiarism and Intellectual Property Rights

Quantitative Methods: Data collection and analysis techniques and tools; Sampling – concepts, types, steps and characteristics of sample, measurement and scaling techniques, types of data with sources; Statistics - Probability & Sampling distribution; Estimation, Hypothesis testing & application; Correlation & regression analysis

Literature Review - Importance of literature review in defining a problem, including literature in research proposal, critique, survey & peer review process, identifying gap areas from literature review; Major Research areas, Journals, Publication, Conferences and Status of Research in the field of Computer Science, engineering, Application and IT

References:

6. Conducting Research Literature Reviews: From the Internet to Paper by Fink, A., Sage Publications
9. Research Methodology by Dalip Kumar Bhattacharyya
10. Research Methodology by C.H. Chaudhary, RBSA Publication
11. Statistical Techniques by S.P. Gupta, Sultan Chand & Sons
13. WWW(Web Sources)

2.2. PCWCSA 12: Research Methodology 2: Computer Applications in Research
[Credit Assign: 2, FM: 40+10, Teaching Period: 2hr/week]

Introduction: Use of computer in research as a tool; introduction and use of internet and search engines with advanced search tools for data and information collection and repository; getting familiar and using e-resources i.e. open coursewire, online tutorials, eBooks,
eJournals etc., Libraries, INFLIBNET, Shodhganga, ShodhGangotri, N-LIST, UGC-INFONET Digital Library Consortium etc., different academic and research forums, bodies, societies etc.; concept of free and open source software (FOOS)

**Spreadsheets and Statistical tools:** Introduction to spread-sheet applications i.e. MS Excel, Open office and similar or other advanced tools, features & functions, using formulae & functions, data storing, features for statistical data analysis, generating charts/graphs & other features, GNU octave, ploticus, PSPP, R etc.

**Presentation tool:** Introduction to presentation tools i.e. MS Powerpoint, Open Office or any other tool, features & functions, creating presentations, customizing presentation.

**Thesis writing & Scientific editing tools:** Using different text editing and formatting tools i.e. LaTex, MS Office, Scientific Office, LibreOffice Writer, MS-Publisher, Idea Rover, Wunderlis, Mendely, Zotero, Docear, endnote, Evernote, Dropbox, Spotify, Citavi, Docear, ActiveScolar, FocusWriter, WriteMonkey, Celtx, Sigil, Scribus and others alike.

**References:**

1. LaTeX Beginner's Guide by Stefan Kottwitz
2. Getting Started with LaTeX by David R. Wilkins
3. Making TeX Work by Norman Walsh
4. A Gentle Introduction to TeX by Michael Doob
5. The Computer Science of TeX and LaTeX by Victor Eijkhout
7. LATEX Tutorials A PRIMER Indian TEX Users Group Trivandrum, India 2003 September Edited by E. Krishnan [Available at https://www.tug.org/twg/mactex/tutorials/ltxprimer-1.0.pdf]
8. LaTeX Wikibook [available at https://en.wikibooks.org/wiki/LaTeX]
9. WWW

**2.3. PCWCSA 13:** Elective – 1: Any one paper to be chosen from the list of following electives based on the research interest of the scholar and availability of suitable supervisor:

- E01: Adhoc and Sensor Networks
- E02: ANN and Pattern Recognition
- E03: Artificial Intelligence & Expert Systems
- E04: Big Data and Large-Scale Computing
- E05: Bioinformatics and Computational Biology
- E06: Computer Graphics and Animation
- E07: Computer Networks and Distributed Systems
- E08: Cloud and Grid Computing
- E09: Data Warehousing and Mining
- E10: Digital Image Processing
- E11: Digital Watermarking and Steganography
- E12: Education Technology
- E13: GIS and Remote Sensing
- E14: High Performance and Scientific Computing
- E15: Human-Computer Interaction (HCI)
E16: Information Security and Cyber Forensic
E17: Natural Language Processing
E18: Network Security and Cryptography
E19: Optimization Methods
E20: Soft Computing
E21: Software Engineering
E22: Systems Software and Compiler Optimization
E23: Theory of Computational Fundamentals

Detail Syllabus of the Elective Papers:

E01: Adhoc and Sensor Networks

Introduction to mobile and ad-hoc/sensor networks: Concepts; advantages, unique constraints and challenges; Driving Applications, Wireless Communications/Radio Characteristics, Ad-Hoc wireless networks, network simulators (OPNET, NS2, etc.)

Wireless LAN (WiFi): 802.11 specifications, Medium Access Control Protocol issues; power control, spatial reusability, and QoS.

Bluetooth: specifications, Piconet synchronization and master-slave switch, scatternet formations, interference issues, interoperability with WiFi.

Architecture: typical network architectures, data relaying strategies, aggregation, role of energy in routing decisions, single node architecture: hardware and software components of a sensor node, TinyOS operating system, nesC language.

Media Access Control (MAC) Protocols: MAC layer protocols, classifications of MAC protocols, MAC protocols, issues in designing MAC protocols, contention-based protocols, schedule-based protocols, 802.15.4 standard.

Routing: Cellular and Ad hoc wireless networks, Issues in designing routing protocols, Classification of routing protocols, Issues of MAC layer and Routing, Proactive, Reactive and Hybrid Routing protocols, Multicast Routing, Tree based and Mesh based protocols, Multicast with Quality of Service Provision, Routing protocols, Agent-based routing, random walk, trace routing; TCP over mobile ad hoc networks- IP address acquisition, effects of partitions on TCP, provisions for mobility and fairness.

Quality of Service: Real-time traffic support, Issues and challenges in providing QoS, Classification of QoS Solutions, MAC layer classifications, QoS Aware Routing Protocols, Ticket based and Predictive location based Qos Routing Protocols


Mesh Networks: Necessity for Mesh Networks, MAC enhancements, IEEE 802.11s Architecture, Opportunistic Routing, Self Configuration and Auto Configuration, Capacity Models, Fairness, Heterogeneous Mesh Networks, Vehicular Mesh Networks

Sensor Networks: Introduction, Unique features, Sensor Network architecture, Clock Synchronization- clustering for synchronization, sender-receiver and receiver-receiver synchronization, Error analysis, Node Localization- absolute and relative localization, triangulation, multi-hop localization and error analysis, anchoring, geographic localization, naming and addressing- addressing services, publish-subscribe topologies ; Data Dissemination, Data Gathering, MAC Protocols for sensor Networks, Deployment of ad-hoc/sensor network, Sensor tasking and control, Transport layer and security protocols,
Location discovery, Quality of Sensor Networks, Evolving Standards, Other Issues, Recent trends in Infrastructure less Networks

**Sensor Network Platforms and Tools:** Berkley Motes, Sensor network programming challenges, Embedded Operating System, Simulators

**Applications of Ad-Hoc/Sensor Network and Future Directions:** Ultra wide band radio communication, Wireless fidelity systems

**References:**
1. C. Siva Ram Murthy And B.S.Manoj, Ad Hoc Wireless Networks – Architectures And Protocols, Pearson Education, 2004

**E02: ANN and Pattern Recognition**

**Fundamentals of AI:** Definitions, foundations of AI, Brief History of Artificial Intelligence, solving Problems by Searching, Informed Search and Exploration, constraint Satisfaction Problems, Adversarial Search, Knowledge Representation, different branches and application domains of AI

**Introduction to ANN :** Introduction- Features, structure and working of Biological Neural Network, Trends in Computing Comparison of BNN and ANN; Basics of Artificial Neural Networks- History of neural network research, characteristics of neural networks terminology, models of neuron Mc Culloch – Pitts model, Perceptron, Adaline model, Basic learning laws, Topology of neural network architecture; Backpropagation networks (BPN) - Architecture of feed forward network, single layer ANN, multilayer perceptron, back propagation learning, input - hidden and output layer computation, backpropagation algorithm, applications, selection of tuning parameters in BPN, Numbers of hidden nodes, learning; Activation & Synaptic Dynamics - Introduction, Activation Dynamics models, synaptic Dynamics models, stability and convergence, recall in neural networks; Neural Network Classifier - Single and Multilayer Perceptron, Back Propagation Learning , Hopfield Network, Fuzzy Neural Network; Unsupervised Classification- Clustering, Hierarchical , clustering , Graph Based Method , Sum of Squared Error Technique, Iterative Optimization

**Pattern Recognition:** Feature extraction and Pattern Representation , Concept of Supervised and Unsupervised Classification , Application Areas; Statistical Pattern Recognition - Bayes Decision Theory , Minimum Error and Minimum Risk Classifiers; Discriminant Function and Decision Boundary, Normal Density, Discriminant Function for Discrete Features, Parameter Estimation; Dimensionality Problem- Dimension and accuracy , Computational Complexity , Dimensionality Reduction ,Fisher Linear Discriminant , Multiple Discriminant
Analysis; Nonparametric Pattern Classification - Density Estimation, Nearest Neighbour Rule, Fuzzy Classification; Linear Discriminant Functions- Separability, Two Category and Multi Category Classification, Linear Discriminators, Perceptron Criterion, Relaxation Procedure, Minimum Square Error Criterion, Widrow-Hoff Procedure, Ho-Kashyap Procedure, Kesler’s Construction; Time Varying Pattern Recognition - First Order Hidden Markov Model, Evaluation, Decoding, Learning

**Basic functional units of ANN for pattern recognition tasks:** Basic feed forward, Basic feedback and basic competitive learning neural network, Pattern association, pattern classification and pattern mapping tasks; Feedforward neural networks – Linear responsibility X-OR problem and solution. - Analysis of pattern mapping networks summary of basic gradient search methods; Feed back neural networks Pattern storage networks, stochastic networks and simulated annealing, Boltzmann machine and Boltzmann learning

**Competitive learning neural networks:** Components of CL network pattern clustering and feature mapping network, ART networks, Features of ART models, character recognition using ART network.


**References:**

3. Introduction to Artificial Intelligence by D. W. Patterson, ( Prentice Hall, 1990)
4. B. Yegnanarayana - Artificial neural network PHI Publication
5. S. Raj sekaran, Vijayalakshmi Pari - Neural networks, Fuzzy logic and Genetic Algorithms

**E03: Artificial Intelligence & Expert Systems**

**Scope of AI:** Games, theorem proving, natural language processing, vision and speech processing, robotics, expert systems, AI techniques-search knowledge, abstraction.

**Problem solving:** State space search- Production systems; Search space control-Depth first search, breadth first search, heuristic search – Hill climbing, best first search, branch and bound; Minimax search- Alpha-Beta cutoffs.

**Knowledge Representation:** Predicate Logic- Skolemizing queries, Unification, Modus ponens. Resolution, dependency directed backtracking.

**Rule Based Systems-** Forward reasoning, Conflict resolution, Backward reasoning- Use of no backtrack.

**Structured Knowledge Representations:** Semantic Net: slots, Frames.
Handling uncertainty: Probabilistic reasoning, Use of certainty factors, Fuzzy logic.


Expert Systems: Need and justification for expert systems, Knowledge acquisition
Case studies: MYCIN, RI.

References:

E04: Big Data and Large-Scale Computing

Introduction: Introduction to Big Data with applications, Technologies for handling big data, Hadoop overview- MapReduce and HDFS, Hadoop ecosystem- Mahout, Giraph, Pig, Hive, HBase, Sqoop, Spark; Apache Spark overview

Hadoop Fundamentals: Hadoop architecture and HDFS – Hadoop Distributed File System, The MapReduce paradigm, Anatomy of a MapReduce program, Working with (key, value) pairs, Streaming in Hadoop

Data Storage, Importing and Exporting Data: ingress and egress, Understanding HDFS and HBase, Sqoop to import/export from/to MySQL; Importing/Exporting data between HDFS and MongoDB; ingress/egrees between HBase and HDFS; Data serialization

Working with Hive and Pig: Hive basics and Hive query language (HiveQL), Data analytics with Hive, Working with user-defined functions (UDFs), Combining Pig with scripts, Combining (sorted and skewed) data with Pig, Sorting data with Pig

Hadoop Use Cases: How Hadoop is used in the real world, Recognizing Hadoop problems, Example use-cases in search, ad targeting, churn analysis, etc.

Big Data ML with Mahout – Classification: Mahout’s machine learning themes, Classification, Data as vector, Choosing an algorithm, Classifier evaluation API, Deploying a classifier in large systems, Case study I: Click prediction, Case study II: Spam classifier

Big Data ML with Mahout- Clustering and Recommenders: Clustering algorithms in Mahout o k-means, fuzzy k-means, Topic modeling by LDA, Clustering on a Hadoop cluster, Case studies, Recommenders, User, item, and content-based recommendations, Recommendations with Hadoop

Apache Spark Fundamentals: Stack: Spark Core, SQL, Streaming, GraphX, MLlib, Programming with Resilient Distributed Datasets (RDDs), Spark SQL, Introduction to data analysis with Scala and Spark

Temporal, Geospatial, Text Data Analysis with Spark: Spark Streaming, Working with temporal and geospatial data in Spark, Parsing text, TF-IDF, SVD, querying and scoring, relevance

Analyzing Networks with GraphX: Constructing co-occurrence network, Understanding network structure, Computing graph statistics

Big Data ML with MLlib: k-means Clustering, Decision Trees and Random Forests, Recommenders
Spark MLlib Use Cases: Recommending music, Predicting forest cover, Network traffic anomaly detection

References:

1. Hadoop in Practice, Manning Publications Co. Alex Holmes
2. Hadoop in Action, Manning Publications Co. Chuck Lam
4. Learning Spark, O’Reilly Holden Karau, Andy Konwinski, Patrick Wendell, and Matei Zaharia
5. Advanced Analytics with Spark, O’Reilly Sandy Ryza, Uri Laserson, Sean Owen & Josh Wills

E05: Bioinformatics and Computational Biology

Introduction and Basics: basics of molecular biology, DNA, RNA, proteins; transcription, translation, regulation; genome organization; cellular organization, metabolism, regulatory pathways; tree of life, phylogeny; cloning, DNA and protein sequencing, genome mapping, PCR, mutagenesis; in-vivo / in-vitro / in-silico; biological models and formalisms; phylogenetic trees

Bioinformatics Basics: introduction, issues and problems, physical mapping of genome, genome structure, interpreting genomic sequence data: sequence alignment, gene finding, structure prediction (RNA and proteins), pattern discovery, regulatory pathways and networks, simulations, computational models of evolution, simulations; DNA computing, bioinformatics tools vs. synergistic research; molecular biology tools, genomic information content, major databases in bioinformatics information search and data retrieval- tools for web search, data retrieval tools, data mining of biological databases; genome analysis, genome mapping, physical maps, cloning the entire genome, genome sequencing, Human Genome Project (HGP)

Alignment of Pairs of Sequences - Methods of Sequence Alignments, scoring- intro, basics, details; global vs. local sa; Using Scoring Matrices, Measuring Sequence Detection Efficiency, Methods of Multiple Sequence Alignment, Evaluating Multiple Alignments, Phylogenetic Analysis, Tree Evaluation Tools for Similarity Search and Sequence Alignment – Working with FASTA, BLAST, FASTA and BLAST Algorithms Comparison

RNA and Protein Structure: RNA secondary structure prediction, comparative sequence analysis, equilibrium partition function for secondary structure; prediction of pseudoknots in RNA secondary structure; basics; primary, secondary, tertiary, quartary protein structure; forces that stabilise structure; tertiary structure prediction approaches, energy minimisation with genetic algorithms; secondary structure prediction: simple statistical methods, chou-fasman rules, computational problems; neural network approaches

Gene Finding and Motif Discovery: gene finding- basic problem; why is it interesting? why is it hard?, open reading frames (watson method), simple pattern search, weight matrix methods (WAM, etc.), signal detection and integration, HMM-based methods, HMM gene identification and prediction – Basis of Gene Prediction, Pattern Recognition, technologies for gene expression analysis (microarrays, SAGE), clustering gene expression data, Gene Expression and Microarrays – Working with DNA Microarrays, Clustering Gene Expression Profiles, Data Sources and Tools for Microarray Analysis, state-of-the-art gene finders (HMMGene, GenScen), Applications of Microarray Technology; evaluating gene finding
algorithms; probabilistic scores, benchmark collections, combining gene finders, inference of regulatory relationships from gene expression data; motif discovery and characterization

**Biomolecular Computing:** Adleman's experiment; "classical" models for DNA computing, Self-assembly models for DNA computing; Winfree's work, combinatorial and algorithmic problems arising in biomolecular, computation: inverse RNA folding, theory of self-assembly and resource bounded tiling

**Protein Classification, Structure Visualization and Proteomics** - Protein Structure Visualization, Protein Structure Databases, Protein Structure Alignment, Domain Architecture Databases, Protein Classification Approaches, Protein Identification and Characterization, Primary and Secondary Structure Analysis and Prediction, measures of prediction accuracy, statistical technique (CF and GOR algorithm), neural network (PHD) nearest neighbor method (PREDATOR and NNSSP), consensus methods (JPRED and NPS), Protein tertiary structure prediction: homology modeling, threading and Abs Initio structure prediction, Other issues: CASP, Levinthol paradox and protein folding; Patterns and Fingerprints Search, Methods of 2D Structure Prediction, Protein Prediction from a DNA Sequence, Tools and Techniques in Proteomics, Protein-Protein Interactions, Methods of Gene Family Identification

**Computational Methods for Pathways and Systems Biology** – Analysis of Pathways, Metabolic Control Analysis, Simulation of Cellular Activities, Biological Markup Languages

**Phylogenetic Analysis:** Graphs and trees: phylogenetics trees and cladogram, Building phylogenetic trees: similarity and distance table, distance matrix methods, maximum parsimony methods, limitations of phylogenetic algorithms, phylogenetic software, reliability of phylogenetic trees, Evolution of macromolecular sequences: molecular phylogeny, choice of macromolecular sequence, rapidly evolving macromolecular sequences.

**References**


**E06: Computer Graphics and Animation**


**2D Transformations:** Transformations and Matrices, Transformation Conventions, 2D Transformations, Homogeneous Coordinates and Matrix Representation of 2D Transformations, Translations and Homogeneous Coordinates, Rotation, Reflection, Scaling, Combined Transformation, Transformation of Points, Transformation of The Unit Square, Solid Body Transformations, Rotation About an Arbitrary Point, Reflection through an Arbitrary Line, A Geometric Interpretation of Homogeneous Coordinates, The Window-to-Viewport Transformations


**Viewing in 3D:** Stages in 3D viewing, Canonical View Volume (CVV), specifying an Arbitrary 3D View, Examples of 3D Viewing, The Mathematics of Planar Geometric Projections, Combined transformation matrices for projections and viewing, Coordinate Systems and matrices, camera model and viewing pyramid, Scan conversion-Lines, circles and Ellipses; Filling polygons and clipping algorithms, Scan Converting Lines, Mid-point criteria, Problems of Aliasing, end-point ordering and clipping lines, Scan Converting Circles, Scan Converting Ellipses, Filling Polygons, edge data structure, Clipping Lines algorithms Cyrus-Beck, Cohen Sutherland and Liang-Barsky, Clipping Polygons, problem with multiple components.
**Solid Modeling:** Representing Solids, Regularized Boolean Set Operations, Primitive Instancing, Sweep Representations, Spatial-Partitioning Representations, Octree representation, B-Reps, Constructive Solid Geometry, Comparison of Representations

**Visible-Surface Determination:** Techniques for efficient Visible-Surface Algorithms, Categories of algorithms, Back face removal, The Z-Buffer Algorithm, Scan-line method, Painters algorithms (depth sorting), Area sub-division method, BSP trees, Visible-Surface Ray Tracing, comparison of the methods

**Illumination and Shading:** Illumination and Shading Models for Polygons, Reflectance properties of surfaces, Ambient, Specular and Diffuse reflections, Atmospheric attenuation, Phongs model, Gouraud shading, some examples.

**Plane Curves and Surfaces:** Curve Representation, Nonparametric Curves, Parametric Curves, Parametric Representation of a Circle, Parametric Representation of an Ellipse, Parametric Representation of a Parabola, Parametric Representation of a Hyperbola, A Procedure for using Conic Sections, The General Conic Equation; Representation of Space Curves, Cubic Splines, B-spline Curves, B-spline Curve Fit, B-spline Curve Subdivision, Parametric Cubic Curves, Quadratic Surfaces. Bézier Surfaces

**Graphics Programming using OpenGL:** Why OpenGL, Features in OpenGL, OpenGL operations, Abstractions in OpenGL GL, GLU & GLUT, 3D viewing pipeline, viewing matrix specifications, a few examples and demos of OpenGL programs.

**Miscellaneous topics:** Why Realism? Aliasing and Anti-aliasing, texture bump mapping, Animation concept and methods, methods of controlling animation, soft modeling of objects, image based rendering, Fundamental Difficulties, animation tools

**References:**

**E07: Computer Networks and Distributed Systems**


Distributed Systems: Introduction, Communication mechanisms, Processes and mobile code, Naming, Synchronization, Scalability, Consistency, replication, and caching, Fault tolerance, Security and access controls

References:
5. An Engineering Approach to Computer Networking, S. Keshav, Pearson Education.
8. The Internet and Its Protocols, A. Farrel, Elsevier.

E08: Cloud and Grid Computing

Management: Grid Application Description Languages, Application Partitioning, Metascheduling, Mapping, Monitoring; Web Services, Grid Portals,

**Cloud Computing Overview:** What is a cloud, Definition of cloud, Characteristics of cloud, Why use clouds, How clouds are changing, Driving factors towards cloud, Comparing grid with cloud, Public clouds (commercial), Cloud Computing and SOA, Enterprise Cloud drivers and adoption trends, Typical Cloud Enterprise workloads, Cloud service models/types, Cloud deployment models, Cloud ROI models, Cloud reference architectures, Cloud standards, Technology providers vs. Cloud providers vs. Cloud vendors, Planning Cloud transformations

**Cloud service delivery:** Cloud service, Cloud service model architectures, Infrastructure as a service (IaaS) architecture, Platform as a service (PaaS) architecture, Platform as a service (PaaS), Software as a service (SaaS) architecture, Examples of SaaS applications, Business Process as a Service (BPaaS) Architecture, Trade-off in cost to install versus, Common cloud management platform reference architecture: Architecture overview diagram, Common cloud management platform.

**Cloud deployment scenarios:** Cloud deployment models, Public clouds, Hybrid clouds, Community, Virtual private clouds, Vertical and special purpose, Migration paths for cloud, Selection criteria for cloud deployment, Case study example: IBM Smart Cloud

**Security in cloud computing:** Cloud security, Cloud security reference model, How security gets integrated, Cloud security challenges, Understanding security risks, Cloud security approaches: encryption, Digital signature, tokenization/obfuscation, cloud security alliance standards, cloud security models and related patterns; Virtualization and multitenancy, Internal security breaches, Data corruption or loss, User account and service hijacking, Steps to reduce cloud security breaches, Identity detection, forensics and management, What is SSL? Cloud security in mainstream vendor solutions; Mainstream Cloud security offerings: security assessment, secure Cloud architecture design; Design a secure Cloud architecture to support the deployment of a secure version of the course project application.

**References:**

**E09: Data Warehousing and Mining**

**Introduction to Data Mining:** Definition of data mining, Data Mining functionalities, Classification of data mining systems, Data Mining Applications, Architectures of data mining systems, Data mining class comparison.

**Data Mining Algorithms:** Concept Description: Definition, Data Generalization and Summarization –Based Characterization, Mining Descriptive Statistical Measures in Large Databases; Mining Association Rules: Association Rule Mining, Market Basket Analysis, Association Rule Classification, The Apriori Algorithm, Mining Multilevel Association Rules, Constraint-Based Association Mining, Sequential mining
Classification and Prediction: What is Classification and Prediction? Data Classification Process, Issues Regarding Classification and Prediction, Classification by Decision Tree Induction, Bayesian Classification, Classification Based on Association Rule Mining, Other Classification Methods Cluster Analysis: What is Cluster Analysis? Types of Data in Cluster Analysis, Categorization of Clustering Methods, Partitioning methods

Introduction to Data Warehousing: Introduction to Decision Support System: DSS Definition, History of DSS, Ingredients of DSS, Data and Model Management, DSS Knowledge base, User Interfaces, The DSS Users, Categories and Classes of DSSs Need for data warehousing, Operational & informational data, Data Warehouse Definition and characteristics, Operational Data Stores

Data warehouse Components: Architectural components, Data Preprocessing: Why Preprocess Data? Data Cleaning Techniques, Data Integration and Transformation, Data Reduction Techniques, Discretization and Concept Hierarchy, Generation for numeric and categorical data, Significant role of metadata, Building a Data warehouse, Benefits of Data Warehousing.


References:
2. Introduction to Data Mining – Pang-Ning Tan, Michael Steinbach and Vipin Kumar, Pearson education.
5. The Data Warehouse Life cycle Tool kit – Ralph Kimball Wiley student edition
7. Data Mining Introductory and advanced topics –Margaret H Dunham, Pearson education

E10: Digital Image Processing

Fundamentals of Image Processing: Image Acquisition, Image Model, Sampling, Quantization, Relationship between pixels and distance measurement, connectivity, Image Geometry, Photographic film, Light, Brightness adaption and discrimination, Perspective Projection, Spatial Domain Filtering, Grayscale and Color fundamentals, color models (RGB, CMY, HIS), formulation, color complements, color slicing, tone and color corrections, image file formats

Image Filtering: Spatial Domain Filtering- Intensity transformations, contrast stretching, histogram equalization, Correlation and convolution, Smoothing filters, sharpening filters, gradient and Laplacian; Frequency domain Filtering- Hotelling Transform, Fourier Transforms and properties, FFT, Convolution, Correlation, 2-D sampling, Discrete Cosine Transform, Frequency domain filtering, Inverse filtering, Least squares filtering, Recursive filtering
**Image Compression:** Encoder-Decoder model, Types of redundancies, Lossy and Lossless compression, Entropy of an information source, Shannon's 1st Theorem, Huffman Coding, Arithmetic Coding, Golomb Coding, LZW coding, Transform Coding, Sub-image size selection, blocking artifacts, DCT implementation using FFT, Run length coding, FAX compression (CCITT Group-3 and Group-4), Symbol-based coding, JBIG-2, Bit-plane encoding, Bit-allocation, Zonal Coding, Threshold Coding, JPEG, Lossy predictive coding, Lossy predictive coding, Motion Compensation; Wavelet based Image Compression-Expansion of functions, Multi-resolution analysis, Scaling functions, MRA refinement equation, Wavelet series expansion, Discrete Wavelet Transform (DWT), Continuous Wavelet Transform, Fast Wavelet Transform, 2-D wavelet Transform, JPEG-2000 encoding, Digital Image Watermarking; Fidelity criterion- MSE, PSNR, Compression ratio,


**Morphological Image Processing:** Basics, SE, Erosion, Dilation, Opening, Closing, Hit-or-Miss Transform, Boundary Detection, Hole filling, Connected components, convex hull, thinning, thickening, skeletons, pruning, Geodesic Dilation, Erosion, Reconstruction by dilation and erosion.

**Image Segmentation:** Definition, Detection of Discontinuities, Point, line detection, Edge detection, Edge linking, local processing, regional processing, Hough transform, Iterative and Multivariable thresholding, Otsu's method, Moving averages, Boundary detection based techniques; Characteristics of segmentation, Pixel based, Region based and histogram based segmentation methods, segmentation by sub region aggregation, split and merge technique, Watershed segmentation, Use of motion in segmentation (spatial domain technique only),

**Image Enhancement:** Spatial Domain Methods- Arithmetic and Analytical operations, pixel or point operations, size operations) Smoothing filters Mean, Median, Mode filters. Low pass filters, high pass filters, sharpening filters; Frequency Domain Method- Design of Low Pass, High Pass, Edge enhancement, Sharpening filters in frequency domain, Bufier Worth Filter, Homomorphic filters in frequency domain and spatial domain.

**Application:** Different application domains of digital image processing i.e. steganography, medical image processing, GIS etc.

**References:**
2. Anil K Jain; Fundamentals of Digital Image Processing
3. Rafael C Gonzalez, Richard E Woods; Digital Image Processing, Pearson Education
5. B Chanda & D Dutta Majumder; Digital Image Processing and Analysis, PHI

**E11: Digital Watermarking and Steganography**

**Fundamentals of Image Processing:** Basics of image Acquisition and Model, Sampling and Quantization, Image Geometry; Light, Brightness adaption and discrimination, Perspective Projection, Grayscale and Color fundamentals, models and formulation, color issues, image file formats; Image Filtering-Spatial Domain and Frequency domain Filtering; Image Compression- Encoder-Decoder model, Types of redundancies, Lossy and Lossless compression, different types of Image Compression techniques; Image Restoration- Basic
Framework, models and techniques; Morphological Image Processing- Introduction, different morphological operations on image; Image Segmentation- Introduction, detection of discontinuities; point, line, edge and boundary detection; Edge linking, characteristics of segmentation, different segmentation approaches; Image Enhancement- Spatial and Frequency Domain Methods


**References:**

1. Rafael C Gonzalez, Richard E Woods, Eddins; Digital Image Processing using MATLAB, Pearson Education

E12: Education Technology

Technology in Education: Meaning, Evolution, issues and development
E-Learning: Conceptual Frame Work- Pedagogy, Managerial Perspectives, Online Learning, Media Interactivity, E-Learning Framework; Technologies and Applications - Social Networking, Really Simple Syndication, Concept Maps in e-Learning, Learning Management Systems
Traditional Educational Technology/Materials: Cone of Experiences: Direct and Purposeful (Games & Experiments), Contrived Experiences (Three Dimensional, Mock up, Diorama), Dramatized Experiences(Pageant, Socio-Drama), Demonstration Boards (chalkboard, peg board etc.), Field Trips, Exhibits, Still Pictures(drawings, graphs, cartoon, etc.)
ICT in Education: Computer, Internet, Multimedia/Hypermedia
Educational Technology in Instructional Planning: Multiple Intelligence, Learning Styles, Blooms Taxonomy
Technology and Student Assessment: Rubrics, Checklist, Blogs, Miscellaneous Special Topics related to topics of Research

References:

E13: GIS and Remote Sensing

Introduction to GIS: GIS definition, key components, scope and functions of GIS, benefits, relationship with other disciplines, issues, application areas.
Functional requirements of GIS: GIS components; Cartography –GIS interface; Recent trends and applications of GIS; Open source GIS;
Geographic data: Spatial and non spatial; Data models: Raster and vector; Database Management System (DBMS); Data Structures: Relational, hierarchical and network; Data input: Digitization of maps and imageries; Coordinate transformation; Attribute data generation; Spatial Data Structures - Quad-tree, R-tree- searching, insertions, deletion algorithms, Topology and topological models- 9 Intersection model
Spatial data base fundamentals: Extended ER diagram for spatial entities. Spatial data model, object relational mode, ex. Oracle spatial data model
Spatial data models: ISO 19101 data model, geometry classes, basic element types, SDO-GEOMETRY structure and operations
**Spatial Indexing and analysis:** Spatial indexing - principles, benefits, index types, implementation in Oracle; Spatial overlay operations, network analysis and proximity analysis; 3D models; TIN, DEM, DTM Query in GIS; 

**Spatial SQL:** (operators and functions) terminology, principles, set based operations, topological operations. Spatial joins. Spatial functions. 

**Network modelling:** motivation, general network concepts, Network data model and metadata, spatial indexes on NM, shortest path and other functions. Directed and undirected networks, Traveling salesperson problem, reachability analysis, spanning tree spatial data infrastructure and 

**OpenGIS:** introduction, components of SDI, Standards 

**Principles of Remote Sensing:** Definition, types and scope of remote sensing; Stages in remote sensing data acquisition; Electromagnetic radiation and electromagnetic spectrum; Black body radiation and radiation laws; Interaction of EMR with atmosphere and Earth’s surface features. 

**Platforms, Sensors and Data Products:** Remote sensing platforms; Types & characteristics of sensors: IRS, LANDSAT, SPOT, IKONOS, Quick Bird; Remote sensing data products. 

**Thermal & Microwave Remote Sensing:** Thermal Remote Sensing; Thermal properties of materials: emissivity of materials; thermal inertia of Earth surface features; Thermal data sets: LANDSAT and ASTER; Concept and Principles of microwave remote sensing; Microwave data sets SLAR, LIDAR and SAR; Application of Thermal and Microwave data 

**Remote Sensing Applications:** Remote Sensing Applications in Human Settlement and Urban Analysis, Geosciences, Agriculture, Forestry and Soil, Hydrology & Water Resources Management 

**References:**

1. Geographic Information Systems and Science, Longley, Goodchild, Rhind, Wiley & Sons 
2. The Design and Analysis of Spatial Data Structures by Hanan Samet, Addison Wesley 
11. Slater,PN,1980,Remote Sensing: Optics and Optical System, Addison-Wesley, Reading
**E14: High Performance and Scientific Computing**


**Introduction to Parallel Computing:** Motivation, What is Parallel Computing and Why to Use? Concurrent, Parallel, Distributed computing, interacting with hardware- Composite Capabilities, How Do Languages and Environments Assist with These Tasks? Applications of Parallel Computing, RAM and PRAM model, PRAM pseudo code, Data vs. Task parallelism.

**Parallel Computers Architectures:** Overview of parallel system organization, Modifications to the Von-Neumann Model, Memory Barriers, Memory Hierarchy and organization, Different types of memory access-UMA and NUMA, Shared memory, distributed memory and distributed shared memory architectures, Cache Coherence and Memory Consistency, classification of parallel computers, Flynn's Classical Taxonomy, ILP, Multi-threaded architectures and TLP, Pipeline Parallelism, I/O Operations; Overheads-Hardware System Architecture, Costs of Operations; Parallel Architecture Design Tradeoffs and Future Directions, SIMD Processors, Systolic Processors, Cluster Computing, Grid and Cloud Computing, Multicore Systems, GPU computing, Synchronization and Mutual Exclusion; Scalability and Load Balance,

**Interconnection Networks:** Introduction, Communication between Parallel Processors, Classification of Interconnection Networks by Logical Topologies, Interconnection Network Switch Architecture, Routing Mechanisms for Interconnection Networks,

**Performance Analysis and Tuning:** Measuring Benefits of Parallel Computing, Performance, Performance Metric, Scalability and Scalability Metric, Speed up, Amdahl”s law, Gustafson–Barsis”s Law, efficiency, Scalability, Granularity, Latency, Bandwidth, Throughput, Cache, false sharing, Performance Analysis Tools- Tau.


**Coding and scripting for HPC:** Embarrassingly parallel problems, introduction to *nix, shells, make, C/C++, Fortran, to message passing and MPI programming , A brief history of HPC & Numerical and HPC libraries,

**References:**
2. Michael J. Quinn. Parallel Programming in C with MPI and OpenMP. TMH, 2004
4. M. Sasi Kumar, Dinesh Shikhare P. Raviprakash, Introduction to Parallel Processing, PHI
5. V. Rajaraman And C. Siva Ram Murthy, Parallel Computers – Architecture and Programming
6. Peter S. Pancheo, An Introduction to Parallel Programming, 2011

**E15: Human-Computer Interaction**

**Introduction:** Introduction to HCI, Humans, Information Process, Computer, Information Process, Differences and Similarities, Need for Interaction, Models, Ergonomics, Style, Context, Paradigms

**Design Process:** Designing of Interactive Systems, Usability, Paradigm shift, Interaction Design Basics, Design Process, Scenarios, Users Need, Complexity of Design


**References:**
1. Alan Dix, Janet Finlay, Gregory Abowd, Russell Beale, Human Computer Interaction, 3rd Ed., PHI, 2004

E16: Information Security and Cyber Forensic


Network Defense tools: Firewalls and Packet Filters: Firewall Basics, Packet Filter Vs Firewall, How a Firewall Protects a Network, Packet Characteristic to Filter, Stateless Vs Stateful Firewalls, Network Address Translation (NAT) and Port Forwarding, the basic of Virtual Private Networks, Linux Firewall, Windows Firewall, Snort: Introduction Detection System

Web Application Tools: Scanning for web vulnerabilities tools: Nikto, W3af, HTTP utilities, Curl, OpenSSL and Stunnel, Application Inspection tools, Zed Attack Proxy, Sqlmap. DVWA, Webgoat, Password Cracking and Brute-Force Tools, John the Ripper, L0htcrack, Pwdump, HTC-Hydra


Cyber Forensics: Firewalls and Packet Filters, password Cracking, Keyloggers and Spyware, Virus and Warms, Trojan and backdoors, Steganography, DOS and DDOS attack, SQL injection, Buffer Overflow, Attack on wireless Networks


References:
5. Mike Shema, Anti-Hacker Tool Kit (Indian Edition), TMH
10. Bernadette H Schell, Clemens Martin, Cybercrime, ABC – CLIO Inc, California, 2004
11. Understanding Forensics in IT, NIIT Ltd, 2005

E17: Natural Language Processing

Introduction: Introduction, Machine Learning and NLP, ArgMax Computation,
Probabilistic parsing: Training issues, Arguments and Adjuncts, Probabilistic parsing; inside-outside probabilities.
Speech : Phonetics, Hidden Markov Model, Morphology, Graphical Models for Sequence Labelling in NLP, Consonants (place and manner of articulation) and Vowels.
**Phonology:** ASR, Speech Synthesis, Hidden Markov Model and Viterbi, Precision, Recall, F-score, Map, Semantic Relations; UNL; Towards Dependency Parsing.

**Universal Networking Language:** Introduction, Semantic Role Extraction, Baum Welch Algorithm; HMM training.

**References:**
1. Alexander Clark, Chris Fox, and Shalom Lappin (Editors): The Handbook of Computational Linguistics and Natural Language Processing (Blackwell Handbooks in Linguistics).

**E18: Network Security and Cryptography**

**Introduction to Classical Cryptosystems:** Introduction, Need and importance of Cryptography, Classical Cryptosystems, Introduction to symmetric and asymmetric cryptography, Cryptanalysis of Classical Cryptosystems, Shannons Theory

**Mathematical Foundations:** Number Theory, Number Theoretic Results, Factorization-Factoring Algorithms, Quadratic Sieve Factoring Algorithm, Pollard-Rho Method; Modular Arithmetic- Groups, Solving Modular Linear Equations, Chinese Remainder Theorem, Modular Exponetiation, Discrete Logarithm Problem; GCD Computation- Euclids Algorithm, Extended Euclids Algorithm, Probability and Information Theory, The Discrete Logarithm Problem (DLP), Computation of Generators of Primes; Stream Ciphers, Pseudorandom functions.

**Symmetric Key Ciphers and Cryptanalysis:** Introduction, Symmetric Key Ciphers, Modern Block Ciphers- DES, AES; Linear Cryptanalysis, Differential Cryptanalysis, Other Cryptanalytic Techniques, Overview on S-Box Design Principles, Modes of operation of Block Ciphers, NIST recommendations.

**Hash Functions and MACs:** Hash functions, The Merkle Damgard Construction, Message Authentication Codes (MACs)

**Asymmetric Key Ciphers and Cryptanalysis:** Construction and Cryptanalysis, RSA Cryptosystem, Different Attacks & Remedies on RSA, Semantic Security of RSA, The Discrete Logarithm Problem (DLP), Diffie Hellman Key Exchange algorithm, The ElGamal Encryption Algorithm, Massey-Omura; Construction and Cryptanalysis, Cryptanalysis of DLP

**Modern Trends in Asymmetric Key Cryptography:** Overview of Modern Cryptography, Elliptic curve theory and Elliptic Curves based cryptography, Security of Elliptic Curves Cryptography, Elliptic Curve Factorization.

**Digital Signatures:** Introduction, Signature schemes, Authentication Protocols, Digital Signature Standards (DSS), Proxy Signatures
Network Security: Secret Sharing Schemes, Network Protocols, Kerberos, Pretty Good Privacy (PGP), Secure Socket Layer (SSL), Intruders and Viruses, Firewalls

Primality Testing: Primality Testing, Quadratic Residues, Randomized Primality Test & Deterministic Polynomial Time Algorithm

References:
7. Wenbo Mao, Modern Cryptography, Theory & Practice, Pearson Education.
10. A. Joux, Algorithmic Cryptanalysis, CRC Press
11. S. G. Telang, Number Theory, TMH

E19: Optimization Methods

Introduction and Basic Concepts: Historical Development; Engineering applications of Optimization; Art of Modeling; Objective function; Constraints and Constraint surface; Formulation of design problems as mathematical programming problems, Classification of optimization problems, Optimization techniques – classical and advanced techniques

Optimization using Calculus: Stationary points; Functions of single and two variables; Global Optimum, Convexity and concavity of functions of one and two variables; Optimization of function of one variable and multiple variables; Gradient vectors; Examples; Optimization of function of multiple variables subject to equality constraints; Lagrangian function; Optimization of function of multiple variables subject to equality constraints; Hessian matrix formulation; Eigen values; Kuhn-Tucker Conditions; Examples

Linear Programming and Applications: Standard form of linear programming (LP) problem; Canonical form of LP problem; Assumptions in LP Models; Elementary operations; Graphical method for two variable optimization problem; Examples; Motivation of simplex method, Simplex algorithm and construction of simplex tableau; Simplex criterion; Minimization versus maximization problems; Revised simplex method; Duality in LP;Primaldual relations; Dual Simplex method; Sensitivity or post optimality analysis; Other algorithms for solving LP problems – Karmarkar’s projective scaling method; Applications- Use of software for solving linear optimization problems using graphical and simplex methods; Examples for transportation, assignment, water resources, structural and other optimization problems

Geometric programming: Problems with positive coefficients up to one degree of difficulty, Generalized method for the positive and negative coefficients

Dynamic Programming and Applications: Sequential optimization; Representation of multistage decision process; Types of multistage decision problems; Concept of sub optimization and the principle of optimality; Recursive equations – Forward and backward recursions Computational procedure in dynamic programming (DP); Discrete versus continuous dynamic programming; Multiple state variables; curse of dimensionality in DP; Applications- Problem formulation and application in Design of continuous beam and Optimal geometric layout of a truss; Water allocation as a sequential process; Capacity expansion and Reservoir operation

Integer Programming: Integer linear programming; Concept of cutting plane method; Mixed integer programming; Solution algorithms; Examples

Advanced Topics in Optimization: Piecewise linear approximation of a nonlinear function; Multi objective optimization – Weighted and constrained methods; Multi level optimization; Direct and indirect search methods; Evolutionary algorithms for optimization and search; Applications in computer science

References:

E20: Soft Computing

Soft Computing: Introduction of soft computing, soft computing vs. hard computing, various types of soft computing techniques, applications of soft computing; Artificial Intelligence : Introduction, Various types of production systems, characteristics of production systems, breadth first search, depth first search techniques, other Search Techniques like hill Climbing, Best first Search, A* algorithm, AO* Algorithms and various types of control strategies; Knowledge representation issues, Prepositional and predicate logic, monotonic and non monotonic reasoning, forward Reasoning, backward reasoning, Weak & Strong Slot & filler structures, NLP.

**Artificial Neural Networks:** 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 hetero-associative memory; Propagation Networks - Introduction, Counter propagation network, architecture, functioning & its characteristics, Back Propagation Networks - Architecture: perceptron model, solution, single layer artificial neural network, multilayer perceptron model; back propagation learning methods, effect of learning rule co-efficient; back propagation algorithm, factors affecting backpropagation training, applications; Hopfield/ Recurrent network, configuration, stability constraints, associative memory, and characteristics, limitations and applications; Hopfield v/s Boltzman machine; Adaptive Resonance Theory: Architecture, classifications, Implementation and training; Associative Memory.

**Fuzzy Logic:** Basic concepts of crisp and fuzzy logic, Fuzzy sets and Crisp sets, Fuzzy set theory and operations, Properties of fuzzy sets, Fuzzy and Crisp relations, Fuzzy to Crisp conversion; Fuzzy rule base system - Membership functions, features of membership functions, fuzzy reasoning, interference in fuzzy logic, fuzzy decision making, fuzzy propositions, formation, decomposition & aggregation of fuzzy rules, fuzzy if-then rules, Fuzzy implications and Fuzzy algorithms, Fuzzyfication & Defuzzification, Fuzzy Controller, Applications of fuzzy logic, Industrial applications.

**Genetic Algorithm (GA):** Basic concepts, working principle, procedures of GA, flow chart of GA, Genetic representations, (encoding) Initialization and selection, fitness function, reproduction, Genetic modeling: Genetic operators, Inheritance operator, cross over, inversion & deletion, mutation operator, Bitwise operator; Generational Cycle, Convergence of GA, Applications & advances in GA, Differences & similarities between GA & other traditional method.

**Hybrid Systems:** Integration of neural networks, fuzzy logic and genetic algorithms.

**References:**
2. Siman Haykin, Neural Networks, PHI
4. Kumar Satish, Neural Networks, TMH
5. J. Yen and R. Langari., Fuzzy Logic, Intelligence, Control and Information, Pearson Education

**E21: Software Engineering**

**Introduction:** Introduction to software engineering, Fundamentals of software engineering principles and practices.

**Software Engineering:** A Preview, history of Software Engineering, Software Engineer’s Role, Software Lifecycle

**Software Lifecycles:** Lifecycle Models, Phases and Activities

**Software Requirements:** Functional and Non-Functional Requirements, IEEE Standard for Software Requirements document

**UML 2.0 and the Unified Process:** Overview of UML 2.0, The Unified Process

**Inception:** Use cases, Supplementary specification, Glossary and Vision
Domain Model: System Sequence Diagrams, Domain Model, Contracts for System Operations
Design Patterns: Design patterns
Design Model: Use Case Realization, Class Diagram
Implementation Model: Mapping design to code, Package structures
Project Planning and Management: Project Planning activities, Manager’s responsibilities, IEEE standard for Software Project Management Plans
Formal Specifications: Specification Qualities, Classification of Specification Styles, Descriptive Specifications- Logic and Algebraic Specifications, Operational Specifications-DFD, FSM, Petri Nets, Introduction to Z
Agile software engineering: Agile principles; Key concepts: sprint, backlog, product owner; Agile methods: SCRUM, Lean, Kanban, Agile project management, Documentation
Advance Topics: Real-time embedded software, adaptive software, reliability and dependability, real time JAVA, real time UML, formal methods, verification and validation, extreme programming, management issues in software development, software quality assurance, metrics, Aspect-oriented programming, web service and service-oriented architecture (SOA), Model driven Architecture (MDA), software security, software engineering education

References:

5. F. Brooks, "The Mythical Man-Month, 2nd ed.", Addison-Wesley, 1995
7. Agile estimating and planning - Cohn, Mike, Prentice Hall Professional Technical Reference
8. User stories applied : for agile software development - Cohn, Mike, Addison-Wesley , cop. 2004
E22: System Software and Compiler Optimization

**System Software:** Introduction, Definition, Role and Functions, characteristics, types

**Assembler:** Introduction, functions, features, design of one pass and two pass assemblers;

**Macroprocessors:** Introduction, functions, features and design;

**Loader and Linkers:** Basic Concepts of Linkers and Loader Functions, Boot Loaders, Linking Loaders, Linkage Editors, Dynamic Linking

**Compiler:** Introduction to Compiler, Different phases and passes of compiler, Compiler Structure, Analysis-synthesis model of compilation, various phases of a compiler, tool based approach to compiler construction.

**Lexical Analysis:** Role of Lexical Analyzer, Interface with input, parser and symbol table, Input Buffering, Specification of Tokens, lexeme and patterns; difficulties in lexical analysis; error reporting; Finite state machines and regular expressions and their applications to lexical analysis, regular definition, transition diagrams, Lex., Review of regular languages, design and implementation of a lexical analyzer,

**Syntax Analysis:** Role of the parser, Formal and context free grammars(CFGs) and their application to syntax analysis, ambiguity, associatively, precedence, Derivation and parse trees, Top Down parsing, LL(1) grammars, recursive descent parsing, transformation on the grammars, predictive parsing, bottom up parsing, Shift Reduce Parsing, LR(0) grammars, operator precedence grammars, LR parsing algorithms and LR parsers, Yacc.

**Syntax directed translation and Definitions:** Syntax directed definitions, Construction of syntax trees, Top down and bottom up approaches, dependency graph, data types, mixed mode expression; subscripted variables, evaluation order and sequencing statement, Inherited and synthesized attributes, bottom up and top down evaluation of attributes, L- and S- attributed definitions.

**Type Checking:** Type system, type expressions, structural and name equivalence of types, type conversion.

**Run Time System Environments:** Source Language issues, Storage organization, Storage Allocation strategies, activation tree, activation record, parameter passing, symbol table, dynamic storage allocation, Access to non-local names, Parameter passing mechanism

**Intermediate Code Generation:** Intermediate languages, Intermediate Graphical representations, Three address code, Implementation of three address statements (Quadruples, Triples, Indirect triples), translation of declarations, assignments, control flow, Boolean expressions and procedure calls, implementational issues.

**Code Optimization and generation:** Introduction and Issues, Basic blocks and flow graphs, Transformation of basic blocks, DAG representation of basic blocks, code generation from dags, Loops in flow graph, Principle sources of optimization, Peephole optimization, machine dependent and machine independent optimization techniques, Issues in the design of code generator, Register allocation and assignment, code generation, specifications of machine.

**Subroutines and functions:** parameters called by address, by name and by value, subroutines with side effects.

**References:**

4. S. Chattopadhyay, Compiler Design, PHI, 2005
8. C. N. Fischer and R. J. LeBlanc, Crafting a compiler with C, Pearson Education.  
12. D. M. Dhamdhere, Systems Programming and Operating Systems, TMH  

E23: Theory of Computational Fundamentals

Theory of Computations: Finite automata and regular languages, context-free languages, turing machines and algorithms, decidability and reducibility, time Complexity and NP-completeness.

Combinatorial algorithms: Set cover, Steiner tree and TSP, Multiway cut, Knapsack, Minimum makespan scheduling, Huffman coding

NP-completeness: Review, Basic NP-complete problems, Novel approaches to NP-complete problems

LP and SDP-based approximation algorithms: Fundamentals of approximation algorithms, LP Duality, Set cover via dual fitting, LP rounding techniques, Sparsest cut, Facility location, Semidefinite programming, Max-cut

Additional topics: Hardness of approximation, Approximation Algorithms based on Algorithmic Game Theory, Heuristic algorithms

Open problems

1. Introduction to Theory of Computation by Michael Sipser  
2. Computers and Intractability by M. R. Garey and D. S. Johnson  
3. Approximation algorithms by Vijay Vazirani.  
4. Introduction to Automata Theory, Languages, and Computation by J. E. Hopcroft, R. Motwani, and J. D. Ullman  
5. Introduction to Algorithms, by Cormen, Leiserson, Rivest, and Stein  
6. Algorithm Design, by Kleinberg and Tardos  
In Computer Science and related discipline. Hence, the syllabus for JEST Theoretical Computer Science Exam majorly focuses on the mathematical aspect of computer science. Elements of Discrete Mathematics. Introduction to Algorithms. An Introduction to Data Structures with Applications. Discrete Mathematical Structures with Applications to Computer Science. Compilers: Principles, Techniques, and Tools. The question paper of Theoretical Computer Science will have questions of both types – some requiring short answers and some involving detailed problem-solving. Physics and Mathematics question paper will be based on objective type questions. For Part A: 3 marks will be rewarded for every correct answer and 1 mark will be deducted for every wrong answer. Computer Science, Ph.D.: The doctoral degree in computer science prepares students to undertake fundamental and applied research in computer science, preparing them to apply their studies in the world of academia, governmental policy and/or the industrial sector. The Ph.D. in computer science is available for students of high ability who seek to develop and implement their own research studies. This degree features advanced course work and a strong emphasis on student research. The M.S. program provides numerous opportunities for interdisciplinary study. Within this degree, students can concentrate their studies in the following areas: arts, media and engineering, and cybersecurity. Computer Science, MS Catalog Program. Home » Courses » Electrical Engineering and Computer Science » Introduction to Computer Science and Programming » Syllabus. Syllabus. Help students (who may or may not intend to major in computer science) to feel justifiably confident of their ability to write small programs. Map scientific problems into computational frameworks. Position students so that they can compete for jobs by providing competence and confidence in computational problem solving. Introduction to Computation and Programming Using Python: With Application to Understanding Data. MIT Press, 2016. ISBN: 9780262529624.