IIT-JU

Course Curriculum of Doctor of Philosophy (Ph.D) in Information Technology

Institute of Information Technology

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PhD Program

The Degree of Doctor of Philosophy (hereinafter called the Ph.D. degree) in Information Technology shall be awarded by the University in recognition of the successful completion by a candidate of a program of advanced study and research and acceptance by the Academic Council of the thesis submitted by the candidate after a period of at least two years of registration at the University for the Ph.D. degree.

COURSE CURRICULUM FOR PH.D IN INFORMATION TECHNOLOGY

ICT 7001 Advanced Database Systems

ICT 7002 Advanced Artificial Intelligence

ICT 7003 Code Optimization

ICT 7004 Data Science

ICT 7005 Digital Image Processing

ICT 7006 Distributed Computing

ICT 7007 Distributed Databases

ICT 7008 Distributed Operating System

ICT 7009 Advanced Neuroinformatics

ICT 7010 Information Retrieval

ICT 7011 MultiMedia Application Development

ICT 7012 Network Security

ICT 7013 Object Oriented Software Engineering

ICT 7014 Soft Computing

ICT 7015 Advanced Computer Architecture

ICT 7016 Advanced Data Structures and Algorithms

ICT 7017 Advanced Unix Programming

ICT 7018 Advances in Computing

ICT 7019 Bioinformatics

ICT 7020 Computational Geometry

ICT 7021 Computer Communication

ICT 7022 Fault Tolerant Systems

ICT 7023 Advanced Machine Learning

ICT 7024 Advanced Mobile Computing

ICT 7025 Parallel Computing and Algorithms

ICT 7026 Pattern Recognition

ICT 7027 Scalable Parallel Computing Architectures

ICT 7028 Secured Data Base Application Development

ICT 7029 Wireless Networks and Mobile Computing

ICT 7030 Biophysics

ICT 7031 Biomechanics

ICT 7032 Biomedical Instrumentation

ICT 7033 Biomedical Signal Processing

ICT 7034 Advances in Neural Engineering

ICT 7035 Multimedia Communication Systems

ICT 7036 Satellite Communication

ICT 7037 Cellular Network Planning

ICT 7038 Fiber Optic Communication

ICT 7039 Switching Systems

ICT 7040 Wireless Networks

COURSE CURRICULUM FOR PH.D IN INFORMATION TECHNOLOGY (cont.)

ICT 7040 Wireless Networks

ICT 7041 Advanced Digital Communication

ICT 7042 Modeling of Data Networks

ICT 7043 Telecommunication Network Management

ICT 7044 Advanced Digital Signal Processing

ICT 7045 Error control Coding Techniques in Communications

ICT 7046 Stochastic Signals and Systems

ICT 7047 Signal Processing for Wireless Systems

ICT 7048 Advanced Mathematical Modeling for Biological Systems

ICT 7049 Mathematical Modeling for Finance

PROPOSED NEW COURSES IN THE CURRICULUM FOR PH.D IN INFORMATION TECHNOLOGY

ICT 7050 Intelligent Systems and Robotics

ICT 7051 Machine learning and Data Mining

ICT 7052 Human Language Understanding and Text Processing

ICT 7053 Computer Game Development

ICT 7054 Cloud and Web Technologies

ICT 7055 Computer Security

ICT 7056 Evolutionary Computation

ICT 7057 Graph Databases and Graph Theory

ICT 7058 Advanced Computer Networks

ICT 7059 Compilers

ICT 7060 Advanced Algorithms for Graph and Combinatorial Optimization Problems

ICT 7061 Advanced Operating Systems

ICT 7062 Computer Vision

ICT 7063 Computational Algebra

ICT 7064 Information and Coding Theory

ICT 7065 Pattern Recognition and Image Processing/Advanced Image Processing

ICT 7066 Research Design and Techniques

ICT 7067 Mathematical Models in Health Care

ICT 7068 Health Informatics

ICT 7069 Advanced Satellite Communication

ICT 7070 Information Systems and Securities

ICT 7071 Advanced Wireless and Cellular Communications

ICT 7072 Big Data Analytics

ICT 7073 Internet of Things

ICT 7074 Applied Cryptography

ICT 7075 Management Information System

ICT 7076 High Speed Computer Networks

ICT 7077 Applied Cyber Security and Cryptocurrency

ICT 7078 Digital Integrated Systems Design

ICT 7079 Project Management and Quality Assurance

ICT 7080 Leadership and Human Resources Management

ICT 7081 Geographical Information Systems

ICT 7082 Natural Language Processing

ICT 7083 Recent Trends in ICT

DETAIL SYLLABUS

ICT 7001 ADVANCED DATABASE SYSTEMS

Introduction: Distributed Data Processing, Distributed Databases System, promises of DDBS, Problem areas. Overview of Relational DBMS: Relational Databases Concepts, Normalization, Integrity rules, Relational data languages.

Distributed DBMS Architecture: Architectural Models for Distributed DBMS, DDMBS Architecture.

Distributed Database Design: Alternative Design Strategies, Distribution Design issues, Fragmentation, Allocation.

Query Processing and Decomposition: Query processing Objectives, Characterization of query processors, layers of query of query processing, query decomposition, Localization of distributed data. Distributed query Optimization: Query optimization, centralized query optimization, Distributed query optimization algorithms. Transaction Management: Definition, properties of transaction, types of transactions. Distributed concurrency control. Serialization, concurrency control Mechanism & Algorithms. Time stamped and Optimistic concurrency control Algorithms, Dead lock Management. Distributed DBMS Reliability: Reliability concepts and Measures, fault-tolerance in Distributed systems, failures in Distributed DBMS, local & Distributed Reliability Protocols, site failures and Network partitioning. Parallel Database Systems: Database Series, Parallel Architecture, Parallel DBMS Techniques, Parallel exception problems, Parallel Execution for Hierarchical architecture. Distributed object Database Management Systems: Fundamental object concepts and Models, Object Distributed Design, Architectural Issues, Object Management, Distributed Object storage, Object query Processing.

Object Oriented Data Model: Inheritance, object identity, persistent programming languages, persistence of objects, comparing ODDBMS and ORDBMS.

TEXT & REFERENCE BOOKS

1. Principles of Distributed Database Systems, 2/e; OZSU, Valduriez, Sridhar, Pearson.
2. Distributed Databases, Stefan Seri, Pelagatti Willipse, TMH
3. Database System Concepts, 5/e, Korth, Silberschatz, Sudershan, TMH
4. Database Management Systems, 3/e, Raghuramakrishnan, Johhanes Gehrke, TMH
5. Data Base Principles, Programming, and Performance, 2/e, P O' Neil, E O'Neil, Elsevier.

ICT 7002 ADVANCED ARTIFICIAL INTELLIGENCE

Introduction: AI problems, AI technique, Problem as state space search, problem characteristics, production systems, types of production systems, Design of Search programs Heuristic search techniques: Generate and test, Hill climbing, Best first search, Problem reduction, Constraint satisfaction, Means-Ends Analysis.

Game Playing: Minimax search procedure, adding alpha-beta cutoffs, additional refinements, Iterative deepening, Statistical Reasoning: Probability and Bayes theorem, Certainty factors and Rules based systems, Bayesian Networks, Dempster Shafer theorem UNIT III :Knowledge Representation: Theorem proving using Predicate logic, Resolution, Natural Deduction, Knowledge representation using Rules, Forward versus Backward Reasoning, Matching, Control Artificial Knowledge Structures: Semantic Networks, Frames, Conceptual Dependency diagrams, Scripts

Planning: Components of planning system, goal stack planning, nonlinear planning using constraint posting, Hierarchical planning, Reactive systems Natural Language Processing: Steps in NLP, Syntactic processing, Semantic analysis, Discourse and Pragmatic processing, Statistical NLP, Spell checking.

Learning: Rote learning, learning by taking advice, learning in problem solving, Learning from examples, Explanation based learning, Discovery, Analogy, Formal learning theory, NN learning and Genetic learning. Genetic Algorithms: survival of the fittest principle in Biology, Genetic Algorithms, Significance of Genetic operators, termination parameters, Evolving Neural nets, Ant Algorithms.

Fuzzy Set Theory: Classical & Fuzzy set theory, Interval Arithmetics, Operations on Fuzzy sets Fuzzy Logic Theory: Classical logic theory, Boolean Logic, Multivalued Logics.

Applications of Fuzzy Logic: PQE – Decision Making Investment – Examples Fuzzy Rule base and Fuzzy Modeling: If-Then Rules, Fuzzy Modeling: System modeling, Static fuzzy systems, Parameter Identification.

Fuzzy Control Systems: PLC, closed loop, fuzzy controllers, examples, Fuzzy PID controllers – type 1 and type 2.

TEXT & REFERENCE BOOKS

1. Intelligence, 3/e, E.Rich, K.Knight, TMH.
2. Introduction to Fuzzy Systems, G Chen, Trung Tat Pham, Chapman & Hall/CRC, 2009.
3. Artificial Intelligence, A Modern Approach, 2/e, Stuart Russel, Peter Norvig, PHI/PEA.
4. Artificial Intelligence and Expert Systems, Patterson, PHI.
5. Artificial Intelligence, A Systems Approach, Tim Jones, Infinity Science Press.

ICT 7003 ADVANCED CODE OPTIMIZATION

Compiler Internal Representations and Run time support: Intermediate Representations: Issues in Designing an Intermediate Language, High-Level Intermediate Languages, Medium-Level Intermediate Languages, Low-Level Intermediate Languages, Multi-Level Intermediate Languages, Our Intermediate Languages: MIR, HIR, and LIR, Representing MIR, HIR, and LIR in ICAN, ICAN Naming of Data Structures and Routines that Manipulate Intermediate Code, Other Intermediate-Language Forms Run-Time Support: Data Representations and Instructions, Register Usage, The Local Stack Frame, The Run-Time Stack, Parameter-Passing Disciplines, Procedure Prologues, Epilogues, Calls, and Returns, Code Sharing and Position-Independent Code, Symbolic and Polymorphic Language Support.

Control Flow Analysis: Approaches to Control-Flow Analysis, Depth-First Search, Preorder Traversal, Postorder Traversal, and Breadth-First Search, Dominators, Loops and Strongly Connected Components, Reducibility, Interval Analysis and Control Trees, Structural Analysis.

Data-Flow Analysis: Reaching Definitions, Basic Concepts: Lattices, Flow Functions, and Fixed Points, Taxonomy of Data-Flow Problems and Solution Methods, Iterative Data-Flow Analysis, Lattices of Flow Functions, Control-Tree-Based Data-Flow Analysis, Structural Analysis, Interval Analysis, Other Approaches, Du-Chains, Ud-Chains, and Webs, Static Single-Assignment (SSA) Form, Dealing with Arrays, Structures, and Pointers, Automating Construction of Data-Flow Analyzers.

Dependence Analysis and Optimization: Dependence Analysis and Dependence Graph: Dependence Relations, Basic-Block Dependence DAGs, Dependences in Loops, Dependence Testing, Program-Dependence Graphs Introduction to Optimization: Flow Sensitivity and May vs. Must Information, Importance of Individual Optimizations, Order and Repetition of Optimizations.

Early Optimizations: Constant-Expression Evaluation, Scalar Replacement of Aggregates, Algebraic Simplifications and Reassociation, Value Numbering, Copy Propagation, Sparse Conditional Constant Propagation.

Register Allocation: Register Allocation and Assignment, Local Methods, Graph Coloring, Priority-Based Graph Coloring, Other Approaches to Register Allocation.

Control-Flow and Low-Level Optimizations: Unreachable-Code Elimination, Straightening, If Simplifications, Loop Simplifications, Loop Inversion, Unswitching, Branch Optimizations, Dead-Code Elimination, Branch Prediction.

Procedural/Inter-procedural Analysis and Optimizations Tail-Call Optimization and Tail-Recursion Elimination, Procedure Integration, In-Line Expansion, Leaf-Routine Optimization and Shrink Wrapping Interprocedural Control-Flow Analysis: The Call Graph, Interprocedural Data-Flow Analysis, Interprocedural Constant Propagation, Interprocedural Alias Analysis, Interprocedural Optimizations, Interprocedural Register Allocation.

TEXT & REFERENCE BOOKS

1. Advanced Compiler Design and Implementation; Muchnick, Elsevier, 2008.
2. Engineering a Compiler, Keith D Cooper, Linda Torczon, Elsevier.
3. Compiler Design in C, Allen Holub, PHI, 1990.
4. Compilers Principles, Techniques and Tools, Aho, Sethi, Ullman, PEA, 2006.
5. Crafting a compiler with C, Charles N. Fischer, Richard J. Leblanc, Benjamin Cummings, Wesley.

ICT 7004 DATA MINING AND KNOWLEDGE DISCOVERY

Introduction to Data Mining: Types of Data, Data Quality, Data Processing, Measures of Similarity and Dissimilarity, Exploring Data: Data Set, Summary Statistics, Visualization, OLAP and multi-dimensional data Analysis.

Classification: Basic Concepts, Decision Trees, and model evaluation: General approach for solving a classification problem, Decision Tree induction, Model over fitting: Due to presence of noise, due to lack of representation samples, Evaluating the performance of classifier.

Classification-Alternative techniques: Nearest Neighborhood classifier, Bayesian Classifier, Support Vector Machines: Linear SVM, Separable and Non Separable case.

Association Analysis: Problem Definition, Frequent Item-set generation, Rule generation, compact representation of frequent item sets, FP-Growth Algorithms.

Handling categorical, continuous attributes, concept hierarchy, sequential, sub-graph patterns

Clustering: Overview, K-means, Agglomerative Hierarchical clustering, DBSCAN.

Cluster Evaluation: Overview, Unsupervised Cluster evaluation using cohesion and separation, using the proximity matrix, Scalable clustering algorithms.

Web Data mining: Introduction, Web terminology and characteristics, web content mining, web usage mining, web structure mining, Search Engines: Characteristics, Functionality, Architecture, Ranking of web pages, Enterprise search.

TEXT & REFERENCE BOOKS

1. Introduction to Data Mining, Pang-Ning Tan, Michael Steinbach, Vipin Kumar, PEA.
2. Introduction to Data Mining with Case Studies, GK Gupta , Prentice Hall.
3. Data Mining: Introductory and Advanced Topics, Margaret H Dunham, PEA, 2008.
4. Fundamentals of data warehouses, 2/e, Jarke, Lenzerini, Vassiliou, Vassiliadis, Springer.
5. Data Mining Theory and Practice, Soman, Diwakar, Ajay, PHI, 2006.
6. Data Mining, Concepts and Techniques, 2/e, Jiawei Han , Micheline Kamber , Elsevier, 2006.

ICT 7005 DIGITAL IMAGE PROCESSING

Digital Image fundaments: Introduction, An image model, sampling & quantization, basic relationships between Pixels, imaging geometry. Image Transforms: Properties of 2 – D Fourier transform, FFT algorithm and other separable image transforms. Walsh transforms. Hadamard, Cosine, Haar, Slant transforms, KL transforms and their properties.

Image Enhancement: Background, enhancement by point processing, histogram processing, spatial filtering and enhancement in frequency domain, color image processing.

Image filtering and restoration: Degradation model, diagnolisation of circulant and block circulate matrices, Algebraic approach to restoration, inverse filtering, least mean squares and interactive restoration, geometric transformations.

Image compression: Fundamentals, image compression modes, error free compression, lossy compression, image compression standards. Image segmentation: Detection of discontinuities, edge linking and boundary detection thresholding, region – oriented segmentation, use of motion in segmentation.

Representation and description: Various schemes for representation, boundary descriptors, and regional descriptors.

Image Reconstruction: Image reconstruction from Projections, Radon Transforms; Convolution/Filter back – Project Algorithms.

TEXT & REFERENCE BOOKS

1. Fundamentals of Digital Image Processing, A.K.JAIN, PHI
2. Fundamentals of Digital Image Processing, Anna durai, shanmuga lakshmi, Pearson
3. Introduction to Digital Image Processing, Alasdair, McAndrew, Cengage
4. Digital Image Processing, 3/e, GONZALEX, WOODS, Addison Wesley
5. Digital Image Processing, Castleman, Pearson
6. Digital Image Processing, S Jayaraman, SEsakkirajan, T Veerakumar,TMH

ICT 7006 DISTRIBUTED COMPUTING

Introduction to distributed programming: Anatomy of a Distributed Application, Requirements for Developing Distributed Applications, What Does Java Provide? Introduction to sockets programming: Sockets and Streams, URLs, URL Connections, and Content Handlers, The Class Loader.

Distributing Objects: Why Distribute Objects?, What's So Tough About Distributing Objects?, Features of Distributed Object Systems, Distributed Object Schemes for Java, CORBA, Java RMI, RMI vs. CORBA Threads: Thread and Runnable, Making a Thread, Managing Threads at Runtime, Networked Threads.

Security: Security Issues and Concerns, The java.security Package, Identities and Access Control, Keys: Public, Private, and Secret, Digital Signatures, Data Encryption, Choosing a Cryptographic Algorithm.

Message-Passing Systems: Messages Defined, Why Do We Need Messages?, Message Processing, Fixed Protocols, Adaptable Protocols, Message Passing with Java Events, Using Remote Objects Databases: An Overview of JDBC, Remote Database Applications, Multi-Database Applications.

RMI: The Basic Structure of RMI, The Architecture Diagram Revisited, Implementing the Basic Objects, The Rest of the Server, The Client Application The RMI Registry: Why Use a Naming Service? The RMI Registry, The RMI Registry Is an RMI Server, Examining the Registry, Limitations of the RMI Registry, Security Issues.

Naming Services: Basic Design, Terminology, and Requirements, Requirements for Our Naming Service, Federation and Threading, The Context Interface, The Value Objects, ContextImpl, Switching Between Naming Services, The Java Naming and Directory Interface (JNDI) The RMI Runtime: Reviewing the Mechanics of a Remote Method Call, Distributed Garbage Collection, RMI's Logging Facilities, Other JVM Parameters.

Service Oriented Architecture: Introduction, Defining a Service, Defining SOA, Identifying Service Candidates, Identifying Different Kinds of Services, Modeling Services, Making a Service Composable, Supporting Your SOA Efforts, Selecting a Pilot Project, Establishing Governance.

Introduction to Web Services: Introduction, Using Publicly Available Web Services to Test Against, Installing Metro, Installing Oracle WebLogic, Creating and Deploying the Simplest Web Service, Creating and Deploying a Service to WebLogic, Setting Up a Maven 2 Service and Client Project, Understanding WSDL, Using References in NetBeans to Generate Web Service Clients, Monitoring SOAP Traffic with Metro, Monitoring SOAP Traffic with TCPMon.

TEXT & REFERENCE BOOKS

1. Java Distributed Computing, Jim Farley, O'Reilly.·
2. Java RMI Designing and Building,The Basics of RMI Applications, William Grosso, O'Reilly.
3. Java SOA Cookbook SOA Implementation Recipes, Tips, Techniques, Eben Hewitt, O'Reilly, 2009.
4. Service Oriented Architecture With Java, Malhar Barai, Vincenzo Caselli, Binildas A. Christudas, Packt Publishing, 2008.
5. Distributed Programming with Java, Qusay H. Mahmoud, Manning Publisher 2000.
6. Java in Distributed Systems, Concurrency, Distribution and Persistence, Marko Boger, 2001.
7. Developing Distributed and E-commerce Applications, Darrel Ince, 2/e, Wesly, 2004.
8. Java Message Service (O'Reilly Java Series), Richard Monson-Haefel, David Chappell.
9. Sun SL 301 Distributed Programming with Java.
10. Java Tutorial, http://java.sun.com/docs/books/tutorial/index.html.

ICT 7007 DISTRIBUTED DATABASES

Introduction: Features of distributed databases, features of Centralized databases, level of distributed transparency Reference Architecture, types of Data Fragmentation, distribution Transparency, Access primitives, and Integrity constraints.

Distributed Database Design: A frame work, the design of database fragmentation, the allocation of fragments.

Query Processing: Translation of global queries into fragment queries, query optimization.

Distributed Transaction Management: A framework, transaction atomicity, 2-phase commit.

Concurrency control: Foundations, distributed deadlocks, timestamps.

Reliability: Basic concepts, commit protocols, consistent view of Network, Detection and Resolution of Inconsistencies, check points and cold restart.

Commercial Systems: Tranclem's ENCOMPASS Distributed database systems, IBM's Inter system communication, feature of distributed ingress and Oracle.

Heterogeneous databases: General problems – brief study of multi base.

TEXT & REFERENCE BOOKS

1. Distributed Database systems Principles and Systems, Ceri S. Pelagatti. G, MGH.
2. Principles of Distributed Database Systems, 2/e, M. Tamer Ozsu, Sridhar, PEA.
3. Database system Concepts, 5/e,Silberschatz, F.Korth, Sundrashan,MGH,2006.
4. Modern database Management, 7/e, Hoffer, Prescott, McFadden, PEA, 2007.

ICT 7008 DISTRIBUTED OPERATING SYSTEMS

Processes Threads: Introduction to Threads, Threads in Distributed Systems.

Clients: User Interfaces, Client-Side Software for Distribution Transparency.

Servers: General Design Issues, Object Servers.

Code Migration: Approaches to Code Migration, Migration and Local Resources, Migration in Heterogeneous Systems, Example: D'Agents.

Software Agents: Software Agents in Distributed Systems, Agent Technology.

Naming Entities: Names, Identifiers, and Addresses, Name Resolution, The Implementation of a Name Space, Example: DNS, X.500.

Locating Mobile Entities: Naming versus Locating Entities, Simple Solutions, Home-Based Approaches, Hierarchical Approaches.

Removing Unreferenced Entities: The Problem of Unreferenced Objects, Reference Counting, Reference Listing, Identifying Unreachable Entities.

Synchronization: Clock synchronization, logical clocks, global state, election algorithms, mutual exclusion, distributed transactions.

Consistency and Replication: Introduction, Data-Centric Consistency Models, Client-Centric Consistency Models, Distribution Protocols, Consistency Protocols, Examples: Orca and Causally-Consistent Lazy Replication.

Fault Tolerance: Introduction to Fault Tolerance, Process Resilience, Reliable Client-Server Communication, Reliable Group Communication, Distributed Commit, Recovery.

Distributed Object-Based Systems: CORBA, Distributed Com, Globe and Comparison of CORBA, DCOM, and Globe.

Distributed File Systems: Sun Network File System, Coda File System, Plan 9, XFS and SFS, Scalable Security, Comparison of Distributed File Systems.

Distributed Document-Based Systems and Coordination-Based Systems: Distributed Document-Based Systems: The World Wide Web, Lotus Notes, Comparison of WWW and Lotus Notes.

Distributed Coordination-Based Systems: Introduction to Coordination Models, TIB/Rendezvous, JINI, Comparison of TIB/Rendezvous and JINI.

TEXT & REFERENCE BOOKS

1. Distributed Systems, Principles and Paradigms, 2/e, Tanenbaum, M Van Steen, PHI.
2. Advanced concepts in Operating Systems, Mukesh Singhal, Niranjan G. Shivaratri, TMH, 2005.
3. Distributed Operating Systems and Algorithm Analysis, Chow, Johnson, PEA.
4. Distributed Systems Concepts and Design, 4/e, George Coulouris, Dollimore, Kindberg, PEA.
5. Distributed Operating Systems, Pradeep K. Sinha, PHI, 2009.
6. Operating Systems, Internals & Design Principles, 6/e, William Stallings, PEA.
7. Distributed Systems Computing over Networks, Joel M.Crichlow, PHI.

ICT 7009 ADVANCED NEUROINFORMATICS

Cell and Molecular Biology of the Neuron, Issues of Neuroinformatics, Modeling and Simulation, Neuronal Encoding and Decoding, Neuroelectronics, Single Neuron Modeling, Conductance Based Neuronal Modeling, Modeling Neuronal Network, Neuronal Plasticity and Learning, Processing and Analysis of Neuronal Time Series, Visualization of Atlas Based Time Series. Data Management and Summary Databases, The Neuroinformatics Workbench.

TEXT & REFERENCE BOOKS

1. Eric R. Kandel, James H. Schwartz, and Thomas M. Jessel, Principles of Neural Science, 4th Ed., New York: McGraw-Hill, 2000.
2. Michael A. Arbib, and Jeffrey S. Grethe, Computing the Brain: A Guide to Neuroinformatics, San Diego: Academic Press, 2001.
3. Peter Dayan, and L F Abbott, Theoretical Neuroscience: Computational and Mathematical Modeling of Neural Systems, Cambridge: MIT Press, 2001.
4. Eugene M. Izhikevich, Dynamical systems in Neuroscience: The Geometry of Excitability and Bursting, Cambridge: MIT Press, 2007.
5. Chris Eliasmith, and Charles H. Anderson, Neural Engineering: Computation, Representation, and Dynamics in Neurobiological Systems, Cambridge: MIT Press, 2003.
6. Bertil Hille, Ionic Channels of Excitable Membranes, 2nd Ed., Sunderland: Sinauer Associates Inc., 1992.
7. Stephen H. Koslow, Michael F. Huerta, Neuroinformatics: An Overview of the Human Brain Project, New Jersey: Lawrence Erlbaum Associates Inc., 1997.

ICT 7010 INFORMATION RETRIEVAL

Introduction to Information storage and retrieval systems: Domain Analysis of IR systems, IR and other types of Information Systems, IR System Evaluation Introduction to Data structures and algorithms related to Information Retrieval: Basic Concepts, Data structures, Algorithms.

Inverted Files: Introduction, Structures used in Inverted Files, Building an Inverted file using a sorted array, Modifications to the Basic Techniques.

Signature Files: Introduction, Concepts of Signature files, Compression, Vertical Partitioning, Horizontal Partitioning.

New Indices for Text: PAT Trees and PAT Arrays: Introduction, PAT Tree structure, Algorithms on the PAT Trees, Building PAT Trees as PATRICA Trees, PAT representation as Arrays.

Lexical Analysis and Stoplists: Introduction, Lexical Analysis, Stoplists.

Stemming Algorithms: Introduction, Types of Stemming algorithms, Experimental Evaluations of Stemming, Stemming to Compress Inverted Files.

Thesaurus Construction: Introduction, Features of Thesauri, Thesaurus Construction, Thesaurus construction from Texts, Merging existing Thesauri.

String Searching Algorithms: Introduction, Preliminaries, The Naive Algorithm, The Knutt – Morris - Pratt Algorithm, The Boyer-Moore Algorithm, The Shift-Or Algorithm, The Karp-Rabin Algorithm.

TEXT & REFERENCE BOOKS

1. Modern Information Retrieval,Ricardo Baeza-Yates, Neto, PEA,2007.
2. Information Storage and Retrieval Systems: Theory and Implementation, Kowalski, Gerald, Mark Academic Press, 2000.

3. Information Retrieval: Algorithms and Heuristics, Grossman, Ophir Frieder, 2/e, Springer, 2004.
4. Information Retrieval Data Structures and Algorithms, Frakes, Ricardo Baeza-Yates, PEA.
5. Information Storage and Retieval, Robert Korfhage, John Wiley & Sons.
6. Introduction to Information Retrieval, Manning, Raghavan, Cambridge University Press.

ICT 7011 MULTIMEDIA AND APPLICATION DEVELOPMENT

Fundamental concepts in Text and Image: Multimedia and hypermedia, world wide web, overview of multimedia software tools. Graphics and image data representation graphics/image data types, file formats.

Color in image and video: color science, color models in images, color models in video.

Fundamental Concepts in Cideo and Digital Audio: Types of video signals, analog video, digital video, digitization of sound, MIDI, quantization and transmission of audio.

Action Script I: ActionScript Features, Object-Oriented ActionScript, Datatypes and Type Checking, Classes, Authoring an ActionScript Class.

Action Script II: Inheritance, Authoring an ActionScript 2.0 Subclass, Interfaces, Packages, Exceptions.

Application Development: An OOP Application Frame work, Using Components with ActionScript MovieClip Subclasses.

Multimedia Data Compression: Lossless compression algorithm: Run-Length Coding, Variable Length Coding, Dictionary Based Coding, Arithmetic Coding, Lossless Image Compression, Lossy compression algorithm: Quantization, Transform Coding, Wavelet-Based Coding, Embedded Zerotree of Wavelet Coefficients Set Partitioning in Hierarchical Trees (SPIHT).

Basic Video Compression Techniques: Introduction to video compression, video compression based on motion compensation, search for motion vectors, MPEG, Basic Audio Compression Techniques.

Multimedia Networks: Basics of Multimedia Networks, Multimedia Network Communications and Applications: Quality of Multimedia Data Transmission, Multimedia over IP, Multimedia over ATM Networks, Transport of MPEG-4, Media-on-Demand (MOD).

TEXT & REFERENCE BOOKS

1. Fundamentals of Multimedia , Ze-Nian Li , Mark S. Drew, PHI/PEA.
2. Essentials ActionScript 2.0, Colin Moock, SPD O,REILLY.
3. Digital Multimedia, Nigel chapman & jenny chapman, Wiley-Dreamtech.
4. Macromedia Flash MX Professional 2004 Unleashed, PEA.
5. Multimedia & Communications Technology, Steve Heath, Elsevier (Focal Press).
6. Multimedia Applications, Steinmetz, Nahrstedt, Springer.
7. Multimedia Basics, Weixel Thomson.
8. Multimedia Technology & Applications, David Hilman , Galgotia.
9. Multimedia Technologies, Banerji, Mohan Ghosh, MGH.

ICT 7012 NETWORK SECURITY

Introduction to Network Security: Attacks, services, Security. A model of Inter network Security, Steganography, One time PADS.

Basic and ESOTERIC Cryptographic Protocols: Key Exchange, Authentication, Formal Analysis of Authentication and key Exchange Protocols, Multiple & Public Key Cryptography, Secret Splitting & Sharing Secure elections, Secure multiparty, Communication, Digital Cash.

Crypto Graphic Algorithms (Block Cipher): RC2, GOST, CAST, BLOW FISH, SAFEER, RC5, NEWDES, CRAB, Theory of Block Cipher design.

Key Management: Key lengths, Generating Keys, Transferring, Verification, Updating, Storing, Backup, Compromised, Lifetime of, Destroying Keys, Public key Management.

Digital Signature Algorithms: Digital Signature, DSA, DSA variants, Gost, Discrete Lagorithm, One – Schnorr – Shamir digital Signatures, Esign, Cellular Automata.

Mails: Electronic Mail & IO Security good Privacy, SIMIME, IP Security Architecture, Authentication Header, Encapsulating Security, Pay load Key Management Issues.

Security: Web Security Web Security requirements, Secure Sockets Layer and Transport Layer Security, Secure Electronic Transaction.

Viruses and Threats: Intruders, Viruses, Worms and Firewalls Intruders, Viruses and Related Threats, Firewall Design Principles, Trusted Systems.

TEXT & REFERENCE BOOKS

1. Applied Cryptography, 7/e, Bruce SCHNEIER John Wiley & Sons Inc.
2. Cryptography and Network Security, William Stallings, PHI.
3. Introduction to cryptography with coding Theory, 7/e, Wade Trappe, C. Washington, PEA.
4. Cryptography and Information Security, V.K. Pachghare, PHI.
5. Cryptography and Network Security, Forouzan, TMH, 2007.
6. Cryptography and Network Security, 2/e, Kahate , TMH.
7. Modern Cryptography, Wenbo Mao, PEA

ICT 7013 OBJECT ORIENTED SOFTWARE ENGINEERING

Introduction to Classical Software Engineering: Historical, Economic and Maintenance aspects. Introduction to OO Paradigm. Different phases in structured paradigm and OO Paradigm. Software Process and different life cycle models and corresponding strengths and weaknesses.

Planning and Estimation: Estimation of Duration and Cost – COCOMO components of software. Project Management plan – one case Study. Tools for Step-wised Refinement: Cost -Benefit analysis, Introduction to software metrics and CASE tools. Taxonomy and scope of CASE tools. Introduction to testing, with focus on Utility, Reliability, Robustness, Performance, Correctness. Modules to Objects: Cohesion and Coupling, Data Encapsulation and Information hiding aspects of Objects. Inheritance, polymorphism and Dynamic Binding aspects. Cohesion and coupling of objects. Reusability, Portability and Interoperability aspects. Requirement Phase: Rapid Prototyping method, Specification phase -Specification Document-Formal methods of developing specification document-Examples of other semi - formal methods of using Finite-State-Machines, Petri nets and E-Language.

Analysis phase: Use case Modeling -Class Modeling -Dynamic Modeling, Testing during OO Analysis.

Design phase: Data oriented design – Object Oriented design – Formal techniques for detailed design. One case study. Challenges in design phase.

IIM Phases: Implementation , Integration and maintenance phases-OOSE aspects in these phases.

TEXT & REFERENCE BOOKS

1. Object oriented and Classical Software Engineering, 7/e, Stephen R. Schach, TMH
2. Object oriented and classical software Engineering, Timothy Lethbridge, Robert Laganiere, TMH
3. Object-Oriented Software Engineering-A Use-Case Driven Approach, Ivar Jacobson, Addison Wesley.

ICT 7014 SOFT COMPUTING

Introduction: Uncertainty and Evidence, Shafer Dumpster belief and possibility Theory, Random sets and mass assignments, Dumpsters Rule, Fuzzy Measures and aggregation operators, Bayesian Networks. Graphical methods.

Automated Learning-1: Supervise vs unsupervised learning, Decision Tree induction, rule induction algorithms.

Automated Learning-2: Bayesian network learning algorithms, Evolutionary algorithms.

Fuzzy Methods: Fuzzy set theory, fuzzy control (including model based control), Fuzzy Decision trees.

Neural Networks: Adaptive Networks, Supervised Learning NN, Reinforcement Learning, Unsupervised Learning.

Hybrid systems: Neuro Fuzzy Systems, Backpropagation Network supported by Fuzzy, GA based weight determination applications. Genetic Algorithms: Encoding, Fitness functions, reproduction,Fuzzy Genetic Algorithms.

Applications: Practical Examples from areas such as Medical, Management, and control, GA in fuzzy logic controller design.

TEXT & REFERENCE BOOKS

1. Neuro Fuzzy and Soft Computing, A Computational approach to learning and Machine, Jyh-Shing Roger Jang, Cuen Tsai Sun, Eiji Mizurani, PEA.
2. Machine Learning, Tom Mitchell, MGH, 1997.
3. Soft Computing Techniques and Applications, Robert John, R. Birkenhead, Ralph Birkenhead.
4. Neural Networks, Fuzzy logic and genetic algorithms, S Rakasekharan, GA Vijayalakshmi, PHI.
5. Principles of Soft Computing, Sivanandam, Deepa, Wiley India, 2008.
6. Soft Computing and Intelligent Systems Design, Karry, De Silva, PEA, 2004

ICT 7015 ADVANCED COMPUTER ARCHITECTURE

Parallel Computer Models, Program and Network Properties: Parallel Computer Models: Multiprocessors and Multicomputers, Multivector and SIMD Computers, PRAM and VLSI Models, Architectural Development Tracks Program and Network Properties: Conditions of Parallelism, Program Partitioning and Scheduling, Program Flow Mechanisms, System Interconnect Architectures.

Principles of Scalable Performance: Performance Metrics and Measures, Parallel Processing Applications, Speedup Performance Laws, Scalability Analysis and Approaches. Processors and Memory Hierarchy: Advanced Processor Technology, Superscalar and Vector Processors, Memory Hierarchy Technology, Virtual Memory Technology.

Bus, Cache, and Shared Memory: Backplane Bus Systems, Cache Memory Organizations, Shared-Memory Organizations, Sequential and Weak Consistency Models.

Pipelining and Superscalar Techniques: Linear Pipeline Processors, Nonlinear Pipeline Processors, Instruction Pipeline Design, Arithmetic Pipeline Design, Superscalar and Super pipeline Design. Multiprocessors and Multicomputers: Multiprocessor System Interconnects, Cache Coherence and Synchronization Mechanisms, Three Generations of Multicomputers, Message-Passing Mechanisms.

Multivector and SIMD Computers: Vector Processing Principles, Multivector Multiprocessors, Compound Vector Processing, SIMD Computer Organizations: BSP and CM2 Architectures, The Connection Machine CM-5: CM5 Architecture and Inter process communication.

Parallel Models, Languages, and Compilers: Parallel Programming Models, Parallel Languages and Compilers, Dependence Analysis of Data Arrays, Code Optimization and Scheduling, Loop Parallelization and Pipelining.

TEXT & REFERENCE BOOKS

1. Kai Hwang, Advanced computer Architecture: Parallelism, Scalability, Programmability, TMH, 2000.
2. Computer Architecture – A quantitative approach, 4/e, John L. Hennessey, David A. Patterson, Morgan Kaufmann / Elsevier, 2007.
3. Parallel Computing Architecture: A hardware/ software approach, David E. Culler, Jaswinder Pal Singh, Morgan Kaufmann / Elsevier, 1997.
4. Computer Organization and Architecture – Designing for Performance, 7/e, William Stallings, PEa, 2006.
5. Computer Organization and Design, 4/e, Patterson, Elsevier, 2008.
6. Computer Architecture & Parallel Processing, Kai Hwang, Faye A. Briggs, TMH

ICT 7016 ADVANCED DATA STRUCTURES AND ALGORITHMS

Lists, Stacks, Queues and Trees: Lists, Stacks and Queues: Abstract Data Types (ADTs), The List ADT, vector and list in the STL, Implementation of vector, Implementation of list, The Stack ADT, The Queue ADT. Trees: The Search Tree ADT -Binary Search Trees, AVL Trees, Splay Trees, B-Trees.

Hashing and Priority Queues: Hashing: General Idea, Hash Function, Separate Chaining, Hash Tables Without Linked Lists, Rehashing, Extendible Hashing.

Priority Queues: Implementations, Binary Heap, Applications of Priority Queues, d-Heaps, Leftist Heaps, Skew Heaps, Binomial Queues.

Sorting: Simple Sorting Algorithms, Shellsort, Heapsort, Mergesort, Quicksort, Indirect Sorting, A General Lower Bound for Sorting, Bucket Sort, External Sorting.

The Disjoint Set Class: Equivalence Relations, the Dynamic Equivalence Problem, Basic Data Structure, Smart Union Algorithms, Path Compression, Worst Case for Union-by-Rank and Path Compression, an Application.

Graph Algorithms: Definitions, Topological Sort, Shortest-Path Algorithms, Network Flow Problems, Minimum Spanning Tree, Applications of Depth-First Search, Introduction to NP-Completeness.

Algorithm Design Techniques: Greedy Algorithms, Divide and Conquer, Dynamic Programming, Randomized Algorithms, Backtracking Algorithms. Amortized Analysis: An Unrelated Puzzle, Binomial Queues, Skew Heaps, Fibonacci Heaps, Splay Trees.

Advanced Data Structures and Implementation: Top-Down Splay Trees, Red-Black Trees, Deterministic Skip Lists, AA-Trees, Treaps, k-d Trees, Pairing Heaps.

TEXT & REFERENCE BOOKS

1. C & Data structures, N.B. Venkateswarulu, EV Prasad, S.Chand.
2. Data Structures and Algorithm Analysis in C++, 3/e, Mark Allen Weiss, PEA , 2007.
3. Data Structures Algorithms and Applications, 2/e, Sartaj Sahni, Universities Press, 2007.
4. Fundamentals of computer Algorithms, 2/e, Ellis Horowitz, Sartaj Sahni, Rajasekharan, Universities Press, 2008.
5. Data Structures and Algorithms, Aho, Ullman, PEA.
6. Data Structures and Algorithms in JAVA, Adam drozdek, Cengage .
7. Data Structures with JAVATM, Hubbard, Huray, PHI,2009.

8. Data Structures, Gilberg, Forouzan, Thomson.
9. Fundamentals of Data structures algorithms and application, Sahni, University Press.

ICT 7017 ADVANCED UNIX PROGRAMMING

Review of Unix Utilities and Shell Programming: File handling utilities, security by file permissions, process utilities, disk utilities, networking commands, backup utilities, text processing utilities, Working with the Bourne shell, What is a shell, shell responsibilities, pipes and input redirection, output redirection, here documents, the shell as a programming language, shell meta characters, shell variables, shell commands, the environment, control structures, shell script examples.

Unix Files: Unix file structure, directories, files and devices, System calls, library functions, low level file access, usage of open, creat, read, write, close, lseek, stat, fstat, octl, umask, dup, dup2. The standard I/O (fopen, fclose, fflush, fseek, fgetc, getc, getchar, fputc, putc, putchar, fgets, gets), formatted I/O, stream errors, streams and file descriptors, file and directory maintenance (chmod, chown, unlink, link, symlink, mkdir, rmdir, chdir, getcwd), Directory handling system calls (opendir, readdir, closedir, rewinddir, seekdir, telldir).

Unix Process: Threads and Signals: What is process, process structure, starting new process, waiting for a process, zombie process, process control, process identifiers, system call interface for process management, fork, vfork, exit, wait, waitpid, exec, system, Threads, Thread creation, waiting for a thread to terminate, thread synchronization, condition variables, cancelling a thread, threads vs. processes, Signal functions, unreliable signals, interrupted system calls, kill, raise functions, alarm, pause functions, abort, sleep functions.

Data Management: Management Memory (simple memory allocation, freeing memory) file and record locking (creating lock files, locking regions, use of read/ write locking, competing locks, other commands, deadlocks). Interprocess Communication: Introduction to IPC, IPC between processes on a single computer system, IPC between processes on different systems, pipes, FIFOs, streams and messages, namespaces, introduction to three types of IPC (systemV) message queues, semaphores and shared memory.

Message Queues: IPC, permission issues, Access permission modes, message structure, working message queues, Unix systemV messages, Unix kernel support for messages, Unix APIs for messages, client/server example.

Semaphores: Unix systemV semaphores, Unix kernel support for semaphores, Unix APIs for semaphores, file locking with semaphores. Shared Memory: Unix systemV shared memory, working with a shared memory segment, Unix kernel support for shared memory, Unix APIs for shared memory, semaphore and shared memory example.

Sockets: Berkeley sockets, socket system calls for connection oriented protocol and connectionless protocol, example client/server program, advanced socket system calls, socket options. Remote Procedure Calls: RPC Model, transparency issues, sun RPC: Sun's portmap/rpcbind, RPC Authentication, Secure RPC: Secure RPC Authentication, Setting Up Secure RPC with NIS, Using Secure RPC, Limitations of RPC.

TEXT & REFERENCE BOOKS

1. Advanced Programming in the UNIX Environment, Stevens, PEA/PHI.
2. Unix Network Programming, Stevens PEA/PHI.
3. Advanced Unix programming, N.B. Venkateswarlu, BSP.
4. Unix Concepts and Applications, 3/e, Sumitabha Das, TMH.
5. Practical UNIX and Internet Security, 2/e, Simson Garfinkel, Gene Spafford, O'Reilly.

ICT 7018 ADVANCES IN COMPUTING

Grid Computing: Data & Computational Grids, Grid Architectures and its relations to various Distributed Technologies, Autonomic Computing, Examples of the Grid Computing Efforts (IBM).

Cluster Computing: Cluster setup & its Administration, Performance Models & Simulations; Networking, Protocols & I/O, Lightweight Messaging systems, Active Messages. Distributed shared memory, parallel I/O Clusters, Jib and Resource management system, scheduling parallel jobs on clusters. Load sharing and Fault tolerance manager, parallel programming scheduling techniques, Dynamic load balancing Example Cluster System – Beowlf, COMPaS and NanOS.

Pervasive Computing: Pervasive Computing concepts & Scenarios, Hardware & Software, Human -machine interface Device connectivity, Java for Pervasive devices, Application examples.

Cloud Computing: History, Working of cloud computers, pros and cons of cloud computing, developing cloud services, cloud computer web based applications.

Quantum Computing: Introduction to Quantum Computing, QUbits, Quantum Mechanics, Quantum gates, Applications of quantum computing.

TEXT & REFERENCE BOOKS

1. J. Joseph & C. Fellenstein, Grid Computing, PEA*:*
2. Raj Kumar Buyya, High performance cluster computing, PEA.
3. J.Burkhardt et .al, Pervasive computing, PEA.
4. Vishal Sahni, Quantum computing, TMH.
5. Marivesar, Approaching quantum computing, PEA.
6. Neilsen & Chung L, Quantum computing and Quantum Information, Cambridge University Press.
7. A networking approach to Grid Computing , Minoli, Wiley.

ICT 7019 BIOINFORMATICS

Introduction: The Central Dogma, The Killer Application, Parallel Universes – Watson's Definition – Top Down Versus Bottom up – Information Flow, Convergence Databases, Data Management, Data Life Cycle, Database Technology, Interfaces, Implementation.

Network: Networks, Geographical Scope, Communication Models, Transmissions Technology, Protocols, Bandwidth, Topology, Hardware, Contents, Security, Ownership, Implementation, Management. Search Engines: The search process, Search Engine Technology, Searching and Information Theory, Computational methods, Search Engines and Knowledge Management.

Data Visualization: Data Visualization, sequence visualization, structure visualization, user Interface, Animation Versus simulation, General Purpose Technologies.

Statistics: Statistical concepts, Microarrays, Imperfect Data, Randomness, Variability, Approximation, Interface Noise, Assumptions, Sampling and Distributions, Hypothesis Testing, Quantifying Randomness, Data Analysis, Tool selection statistics of Alignment.

Data Mining: Clustering and Classification, Data Mining, Methods, Selection and Sampling, Preprocessing and Cleaning, Transformation and Reduction, Data Mining Methods, Evaluation, Visualization, Designing new queries, Pattern Recognition and Discovery, Machine Learning, Text Mining, Tools.

Pattern Matching: Pairwise sequence alignment, Local versus global alignment, Multiple sequence alignment, Computational methods, Dot Matrix analysis, Substitution matrices, Dynamic Programming, Word methods, Bayesian methods, Multiple sequence alignment, Dynamic Programming, Progressive strategies, Iterative strategies, Tools, Nucleotide Pattern Matching, Polypeptide pattern matching, Utilities, Sequence Databases.

Modeling and Simulation: Drug Discovery, components, process, Perspectives, Numeric considerations, Algorithms, Hardware, Issues, Protein structure, AbInitio Methods, Heuristic methods, Systems Biology, Tools, Collaboration and Communications, standards, Issues, Security, Intellectual property.

TEXT & REFERENCE BOOKS

1. Bio Informatics Computing, Bryan Bergeron, PHI, 2003.
2. Introduction to Bio Informatics, Attwood, Smith, Longman, 1999.
3. Bio Informatics Computing, Bergeron, PHI
4. Bio Informatics, Managing scientific Data, Lacroix, Terence Critchlow, Elsevier
5. Bio Informatics Methods and Applications, Rastogi, Mendiratta, Rastogi, PHI

ICT 7020 COMPUTATIONAL GEOMETRY

Basic Geometric Concepts: Points, lines, polygons; subdivisions; arrangements; polytopes; cell complexes.

Projective Geometry: Projective Geometry-geometric transformations. Geometric Searching: Fractional cascading; segment tree; interval tree, range tree; priority search tree. Non-orthogonal range searching, k-d trees –applications.

Point Location: Slab method; trapezoid method; chain method; bridged chain method.

Plane-Sweep Algorithms: Intersection of segments; intersection of rectangles; trapezoidation.

Proximity: Closest pair; furthest pair; Voronoi diagrams; triangulations. Voronoi diagrams and Delaunay Triangulations -Constructing voronoi diagram-Applications.

Graph Drawing: Planar drawings; straight-line drawings; orthogonal drawings; polyline drawings; upward drawings; hierarchical drawings; visibility representations.

Convex hulls: Preliminaries, algorithms for convex hulls-grahams scan-Jarvis march, quick hull techniques, divide and conquer methods, dynamic convex hull algorithms, convex hulls in multi-dimensions, applications Applications of computational geometry in web applications.

TEXT & REFERENCE BOOKS

1. Computational Geometry, an Introduction", 2/e, Franco P. Preparata, Michael Ian Shamos, Springer-Verlag 1988 (ISBN: 0-387-96131-3)
2. Computational Geometry Algorithms and Applications, 2/e., de Berg, van Kreveld, Overmars, and Schwarzkopf (Springer-Verlag, 2000).
3. Graph Drawing, Algorithms for the Visualization of Graphs, Giuseppe Di Battista, Peter Eades, Roberto Tamassia, Ioannis G. Tollis, Prentice-Hall 1999 (ISBN: 0-13-301615-3)
4. Computational Geometry in C , 2/e, Joseph O'Rourke, Cambridge University Press

ICT 7021 COMPUTER COMMUNICATIONS

Introduction: Network Hardware reference model – Transmission media – Narrowband ISDN – Broad band ISDN – ATM.

Data Link Layer: The data Link layer – Design Issues – Error detection and correction – Elementary Data Link Protocols – Sliding window protocols – Data link layer in HDLC, Internet and ATM.

Channel Allocation Methods and Standards: Channel allocation methods – TDM, FDM, ALOHA, Carrier sense Multiple access protocols, Collision Free protocols – IEEE standard BO2 for LANS – Ethernet, Token Bus, Token ring – Bridges.

Network Layer: NETWORK LAYER Routing Algorithms – Shortest path, Flooding, Flow based Distance vector, Link state, Hierarchical, Broadcast routing, Congestion Control algorithms-General principles of congestion control, Congestion prevention polices, Choke packets and Load shedding.

Internetworking : Tunneling, internetworking, Fragmentation, network layer in the internet – IP protocols, IP address, Subnets, Internet control protocols, DSPF, BOP, Internet multicasting, Mobile IP.

Network layer in the ATM Networks – cell formats, connection setup, routing and switching, service categories, and quality of service, ATM LANs.

Transport Layer: The Transport Layer Elements of transport protocols – addressing, establishing a connection, releasing connection, flow control and buffering and crash recovery, end to end protocols – UDP, reliable Byte Stream (TCP) end to end format, segment format, connection establishment and termination, sliding window revisited, adaptive retransmission, TCP extension, Remote Procedure Call – BLAST, CHAN, SELECT, DCE.

Application Layer: Application Layer – Network Security – Cryptographic Algorithms – DES, RSA. Security Mechanisms – Authentication Protocols, Firewalls, Name service (DNS), Domains Hierarchy, Name servers, Traditional Applications – SMTP, MIME, World Wide Web – HTTP, Network Management – SNMP.

TEXT & REFERENCE BOOKS

1. Computer Networks, Andrew Tanenbaum, 3/e, PHI.
2. Computer Networks –A System Approach, Larry L. Peterson, Bruce S. Davie, 2/e, Harcourt Asia PTE LTD.
3. Data Communication and Networking, 4/e, Forouzan, TMH
4. Data and Computer Communications, 8/e, Stallings, PHI
5. Computer communication and networking technologies, Gallo, Hancock, Cengage
6. Understanding data communications, 7/e, Held, PEA
7. Communication Networks, 2/e, Leon-Garcia, TMH

ICT 7022 FAULT TOLERANT SYSTEMS

Preliminaries: Fault Classification, Types of Redundancy, Basic Measures of Fault Tolerance, Hardware Fault Tolerance, The Rate of Hardware Failures, Failure Rate, Reliability, and Mean Time to Failure, Canonical and Resilient Structures , Other Reliability Evaluation Techniques.

Information Redundancy: Information Redundancy, Coding, Resilient Disk Systems, Data Replication, Voting: Hierarchical Organization, Primary-Backup Approach, Algorithm-Based Fault Tolerance.

Fault-Tolerant Networks: Measures of Resilience, Common Network Topologies and Their Resilience, Fault-Tolerant Routing.

Software Fault Tolerance: Acceptance Tests, Single-Version Fault Tolerance, N-Version Programming, Recovery Block Approach, Preconditions, Postconditions, and Assertions, Exception-Handling, Software Reliability Models, Fault-Tolerant Remote Procedure Calls.

Checkpointing: What is Checkpointing? , Checkpoint Level, Optimal Checkpointing-An Analytical Model, Cache-Aided Rollback Error Recovery (CARER), Checkpointing in Distributed Systems, Checkpointing in Shared-Memory Systems, Checkpointing in Real-Time Systems.

Case Studies: NonStop Systems, Stratus Systems, Cassini Command and Data Subsystem, IBM G5, IBM Sysplex, Itanium.

Fault Detection in Cryptographic Systems: Overview of Ciphers, Security Attacks Through Fault Injection, Countermeasures.

Simulation Techniques: Writing a Simulation Program, Parameter Estimation, Variance Reduction Methods, Random Number Generation, Fault Injection.

TEXT & REFERENCE BOOKS

1. Fault Tolerant Systems, Israel koren, Mani Krishna, Elsevier, 2007
2. Reliablity of Computer systems and networks(Fault Tolerance, analysis and Design), Martin L Shooman, Willey
3. FaultTolerant computer system Design, DK Pradhan(Ed), PHI, 1996
4. Software Fault tolerance Techniques and implementation, LL Pullam, Architect House
5. Reliable computer systems: Design and evaluation, siewiorek, swarz,AK Peters
6. Probability and statistics with reliability queuing and computer science applications, John wiley.
7. An Introduction to reliability and maintainability Engineering, Ebeling, MGH

ICT 7023 ADVANCED MACHINE LEARNING

Introduction: Well-posed learning problems, Designing a learning system, Perspectives and issues in machine learning Concept learning and the general to specific ordering – Introduction, A concept learning task, Concept learning as search, Find-S: finding a maximally specific hypothesis, Version spaces and the candidate elimination algorithm, Remarks on version spaces and candidate elimination, Inductive bias.

Decision Tree learning: Introduction, Decision tree representation, Appropriate problems for decision tree learning, The basic decision tree learning algorithm, Hypothesis space search in decision tree learning, Inductive bias in decision tree learning, Issues in decision tree learning.

Artificial Neural Networks: Introduction, Neural network representation, Appropriate problems for neural network learning, Perceptions, Multilayer networks and the back propagation algorithm, Remarks on the back propagation algorithm, An illustrative example face recognition Advanced topics in artificial neural networks Evaluation Hypotheses : Motivation, Estimation hypothesis accuracy, Basics of sampling theory, A general approach for deriving confidence intervals, Difference in error of two hypotheses, Comparing learning algorithms.

Bayesian learning: Introduction, Bayes theorem, Bayes theorem and concept learning, Maximum likelihood and least squared error hypotheses, Maximum likelihood hypotheses for predicting probabilities, Minimum description length principle, Bayes optimal classifier, Gibs algorithm, Naïve bayes classifier, An example learning to classify text, Bayesian belief networks The EM algorithm.

Computational learning theory: Introduction, Probability learning an approximately correct hypothesis, Sample complexity for Finite Hypothesis Space, Sample Complexity for infinite Hypothesis Spaces, The mistake bound model of learning -Instance-Based Learning-Introduction, k -Nearest Neighbor Learning, Locally Weighted Regression, Radial Basis Functions, Case-Based Reasoning, Remarks on Lazy and Eager Learning.

Genetic Algorithms: Motivation, Genetic Algorithms, An Illustrative Example, Hypothesis Space Search, Genetic Programming, Models of Evolution and Learning, Parallelizing Genetic Algorithms. Learning Sets of Rules: Introduction, Sequential Covering Algorithms, Learning Rule Sets: Summary, Learning First Order Rules, Learning Sets of First Order Rules: FOIL, Induction as Inverted Deduction, Inverting Resolution.

Analytical Learning: Introduction, Learning with Perfect Domain Theories: Prolog-EBG Remarks on Explanation-Based Learning, Explanation-Based Learning of Search Control Knowledge.

Combining Inductive and Analytical Learning: Motivation, Inductive-Analytical Approaches to Learning, Using Prior Knowledge to Initialize the Hypothesis, Using Prior Knowledge to Alter the Search Objective, Using Prior Knowledge to Augment Search Operators, Reinforcement Learning: Introduction, The Learning Task, Q Learning, Non-Deterministic, Rewards and Actions, Temporal Difference Learning, Generalizing from Examples, Relationship to Dynamic Programming.

TEXT & REFERENCE BOOKS

1. Machine Learning ,Tom M. Mitchell, MGH
2. Machine Learning, An Algorithmic Perspective, Stephen Marsland, Taylor & Francis(CRC)
3. Introduction to Machine Learning, Ethem Alpaydin, PHI, 2004

ICT 7024 ADVANCED MOBILE COMPUTING

Introduction to Mobile Communications and Computing: Mobile Computing (MC): Introduction to MC, novel applications, limitations, and architecture GSM: Mobile services, System architecture, Radio interface, Protocols, Localization and calling, Handover, Security, and New data services.

(Wireless) Medium Access Control: Motivation for a specialized MAC (Hidden and exposed terminals, Near and far terminals), SDMA, FDMA, TDMA, CDMA.

Mobile Network Layer: Mobile IP (Goals, assumptions, entities and terminology, IP packet delivery, agent advertisement and discovery, registration, tunneling and encapsulation, optimizations), Dynamic Host Configuration Protocol (DHCP).

Mobile Transport Layer: Traditional TCP, Indirect TCP, Snooping TCP, Mobile TCP, Fast retransmit/fast recovery, Transmission /time-out freezing, Selective retransmission, Transaction oriented TCP. Database Issues: Hoarding techniques, caching invalidation mechanisms, client server computing with adaptation, power-aware and context-aware computing, transactional models, query processing, recovery, and quality of service issues.

Data Dissemination: Communications asymmetry, classification of new data delivery mechanisms, push-based mechanisms, pull-based mechanisms, hybrid mechanisms, selective tuning (indexing) techniques.

Mobile Ad hoc Networks (MANETs): Overview, Properties of a MANET, spectrum of MANET applications, routing and various routing algorithms, security in MANETs.

Protocols and Tools: Wireless Application Protocol-WAP.

(Introduction, protocol architecture, and treatment of protocols of all layers), Bluetooth (User scenarios, physical layer, MAC layer, networking, security, link management) and J2ME.

TEXT & REFERENCE BOOKS

1. Mobile Communications, 2/e, Jochen Schiller, 2004, Addison-Wesley.
2. Handbook of Wireless Networks and Mobile Computing, Stojmenovic, Cacute, Wiley.
3. Mobile Computing Principles, Designing and Developing Mobile Applications with UML and XML, Reza Behravanfar, Cambridge, University Press, 2004.
4. Fundamentals of Mobile and Pervasive Computing, Adelstein, Frank, Gupta, Sandeep KS. Richard Golden, Schwiebert, Loren, TMH, 2005.
5. Principles of Mobile Computing, 2/e, Hansmann, Merk, Nicklous, et al., Springer, 2003.
6. Mobile and Wireless Design Essentials, Martyn Mallick, Wiley DreamTech, 2003
7. Mobile Computing, Rajkamal, Oxford, 2008
8. Adhoc Wireless Networks, 2/e, Sivaram murthy, manoj, PEA, 2009

ICT 7025 PARALLEL COMPUTING & ALGORITHMS

Introduction: Computational demand in various application areas, advent of parallel processing, terminology, pipelining, Data parallelism and control parallelism-Amdahl's law. Basic parallel random access Machine Algorithms-definitions of P, NP and NP-Hard, NP-complete classes of sequential algorithms-NC–class for parallel algorithms.

Organizational features of Processor Arrays, Multi processors and multicomputers. Mapping and scheduling aspects of algorithms. Mapping into meshes and hyper cubes-Load balancing-List scheduling algorithm Coffman-graham scheduling algorithm for parallel processors.

Elementary Parallel algorithms on SIMD and MIMD machines, Analysis of these algorithms. Matrix Multiplication algorithms on SIMD and MIMD models.

Fast Fourier Transform algorithms. Implementation on Hyper cube architectures. Solving linear file system of equations, parallelizing aspects of sequential methods back substitution and Tri diagonal. Parallel sorting methods—Odd-even transposition Sorting on processor arrays. Biotonic –merge sort on shuffle –exchange ID –Array processor, 2D-Mesh processor and Hypercube Processor Array.

Parallel Quick-sort on Multi processors. Hyper Quick sort on hypercube multi computers. Parallel search operations. Ellis algorithm and Manber and ladner's Algorithms for dictionary operations.

Parallel algorithms for Graph searching - All shortest paths and minimum cost spanning tree.

Parallelization aspects of combinatorial search algorithms with Focus on Branch and Bound Methods and Alpha-beta Search methods.

TEXT & REFERENCE BOOKS

1. Parallel computing theory and practice, MICHAEL J.QUINN
2. Programming Parallel Algorithms, Guy E. Blelloch, Communications of the ACM
3. Algorithms for Parallel processing, Michael T Heath, Abhiram Ranade, Schreiber(Ed), Springer.
4. Handbook of Parallel Computing Models, algorithms and applications, Samgithevar Rajasekharan, John Reif(Ed), Taylor and Franics group.
5. Parallel Processing and Parallel Algorithms: Theory and Computation, Seyed H. Roosta, Springer

ICT 7026 PATTERN RECOGNITION

Introduction: Basic concepts, Applications, Fundamental problems in pattern Recognition system design, Design concepts and methodologies, Examples of Automatic Pattern recognition systems, Simple pattern recognition model.

Decisions and Distance Functions: Linear and generalized decision functions, Pattern space and weight space, Geometrical properties, implementations of decision functions, Minimum-distance pattern classifications.

Probability -Probability of events: Random variables, Joint distributions and densities, Movements of random variables, Estimation of parameter from samples.

Decision Making: Introduction, Baye's theorem, Multiple features, Conditionally independent features, Decision boundaries, Unequal cost of error, estimation of error rates, the leaving-one-out-techniques, characteristic curves, estimating the composition of populations. Baye's classifier for normal patterns.

Non Parametric Decision Making: Introduction, histogram, kernel and window estimation, nearest neighbour classification techniques.

Adaptive decision boundaries, adaptive discriminant functions, Minimum squared error discriminant functions, choosing a decision making techniques.

Clustering and Partitioning: Hierarchical Clustering: Introduction, agglomerative clustering algorithm, the single-linkage, complete-linkage and average-linkage algorithm. Ward's method Partition clustering-Forg's algorithm, K-means's algorithm, Isodata algorithm.

Pattern Preprocessing and Feature selection: Introduction, distance measures, clustering transformation and feature ordering, clustering in feature selection through entropy minimization, features selection through orthogonal expansion, binary feature selection.

Syntactic Pattern Recognition and Application of Pattern Recognition: Concepts from formal language theory, formulation of syntactic pattern recognition problem, syntactic pattern description, recognition grammars, automata as pattern recognizers, Application of pattern recognition techniques in bio-metric, facial recognition, IRIS scon, Finger prints, etc.

TEXT & REFERENCE BOOKS

1. Pattern recognition and Image Analysis, Gose. Johnsonbaugh Jost, PHI.
2. Pattern Recognition Principle, Tou. Rafael. Gonzalez, Pea.
3. Pattern Classification, Richard duda, Hart., David Strok, Wiley.

ICT 7027 SCALABLE PARALLEL COMPUTING ARCHITECTURES

Parallel Computer Models, Program and Network Properties: Parallel Computer Models: Multiprocessors and Multicomputers, Multivector and SIMD Computers, PRAM and VLSI Models, Architectural Development Tracks Program and Network Properties: Conditions of Parallelism, Program Partitioning and Scheduling, Program Flow Mechanisms, System Interconnect Architectures.

Principles of Scalable Performance: Performance Metrics and Measures, Parallel Processing Applications, Speedup Performance Laws, Scalability Analysis and Approaches.

Processors and Memory Hierarchy: Advanced Processor Technology, Superscalar and Vector Processors, Memory Hierarchy Technology, Virtual Memory Technology.

Bus, Cache, and Shared Memory: Backplane Bus Systems, Cache Memory Organizations, Shared-Memory Organizations, Sequential and Weak Consistency Models.

Pipelining and Superscalar Techniques: Linear Pipeline Processors, Nonlinear Pipeline Processors, Instruction Pipeline Design, Arithmetic Pipeline Design Superscalar and Superpipeline Design Multiprocessors and Multicomputers: Multiprocessor System Interconnects, Cache Coherence and Synchronization Mechanisms, Three Generations of Multicomputers, Message-Passing Mechanisms. Multivector and SIMD Computers: Vector Processing Principles, Multivector Multiprocessors, Compound Vector Processing, SIMD.

Computer Organizations: BSP and CM2 Architectures, The Connection Machine CM-5: CM5 Architecture and Inter process communication.

Parallel Models, Languages, and Compilers: Parallel Programming Models, Parallel Languages and Compilers, Dependence Analysis of Data Arrays, Code Optimization and Scheduling, Loop Parallelization and Pipelining.

TEXT & REFERENCE BOOKS

1. Advanced computer Architecture,Parallelism, Scalability, Programmability. Kai Hwang, TMH

2. Computer Architecture,A quantitative approach, 4/e, John L. Hennessey , David A. Patterson, Morgan Kaufmann / Elsevier, 2007.
3. Computer Organization and Architecture, Designing for Performance, 7/e, William Stallings, Pearson, 2006.
4. Computer Organization and Design, 4/e, Patterson, Hennessy Elsevier India, 2008.
5. Computer Architecture & Parallel Processing, Kai Hwang, Faye A. Briggs, TMH.

ICT 7028 SECURED DATABASE APPLICATIONS DEVELOPMENT

Security Architecture: Introduction, Security, Information Systems, Database management systems, Information security, Information security Architecture, database security, Asset types and their value, Security methods.

Operating System Security Fundamentals: Introduction, operating systems overview, security environment, components, Authentication methods, user administration, password policies, Vulnerabilities of operating systems, E-Mail security.

Administration of Users: Introduction, user authentication, operating system authentication, creating/removing/modifying users, default/remote users, Database links, Linked servers, remote servers.

Profiles, Password Policies, Privileges, and Roles: Introduction, Defining and using profiles, Designing and implementing password policies, Granting and revoking user privileges, creating, Assigning and revoking user roles.

Database Application Security Models: Introduction, Types of users, security models, application types, application security models and Data encryption.

Virtual Private Databases (VPD): Introduction, Overview, implementing a VPD using views and application context.

Implementing oracle VPD, Viewing VPD policies and application context using: data dictionary, policy manager, implementing row and column level security with SQL server.

Database Auditing Models, Application Data Auditing: Database Auditing Models: Introduction, Auditing overview, environment, process, objectives, classification and types, benefits and side effects of auditing. Application Data Auditing: Introduction, DML auction auditing architecture. Triggers, fine grained auditing, DML statement audit trail and auditing application errors with Oracle.

Auditing Database Activities, Security and Auditing Project Cases: Auditing Database Activities: Introduction, usage of database activities, creating DLL triggers, auditing database activities with oracle Security and Auditing project cases: Introduction, case study for developing an online database, taking care of payroll, tracking database changes and developing a secured authentication repository.

TEXT & REFERENCE BOOKS

1. Database Security and Auditing, Hassan Afyouni, Cengage Learning, 2007
2. Database Security, Castano, M. Fugini, G. Martella, P. Samarati, Addison-Wesley, 1994.
3. Implementing Database Security and Auditing, RonBen Natan: Elsevier, 2006.
4. Principles of Distributed Database Systems, M.Tamer Özsu, Patrick Valdureiz, Springer.
5. Database Security, Castano, Fugini, Addison Wesley.
6. The security Audit and control of Databases, Clark, Holloway, List, UK:Ashgate.
7. Security and Audit of Database System, Douglas, Blackwell (UK)
8. Database security and Integrity, Fernandez, Summers, Wood, Addison Wesley

ICT 7029 WIRELESS NETWORKS AND MOBILE COMPUTING

Introduction to Mobile and Wireless Landscape: Definition of Mobile and Wireless, Components of Wireless Environment, Challenges, Overview of Wireless Networks, Categories of Wireless Networks, Wireless LAN: Infrared Vs radio transmission, Infrastructure and Ad-hoc Network, IEEE 802.11, HIPERLAN, Bluetooth.

Global System for Mobile Communications (GSM): GSM Architecture, GSM Entities, Call Routing in GSM, PLMN Interfaces, GSM Addresses and Identifiers, Network Aspects in GSM, GSM Frequency Allocation, Authentication and Security.

Mobile Network Layer: Mobile IP (Goals, assumptions, entities and terminology, IP packet delivery, agent advertisement and discovery, registration, tunneling and encapsulation, optimizations), Dynamic Host Configuration Protocol (DHCP), Mobile Ad-hoc networks: Routing, destination Sequence Distance Vector, Dynamic Source Routing.

Mobile Transport Layer: Traditional TCP, Indirect TCP, Snooping TCP, Mobile TCP, Fast retransmit/fast recovery, Transmission/time-out freezing, Selective retransmission, Transaction oriented TCP.

Broadcast Systems: Overview, Cyclical repetition of data, Digital audio broadcasting: Multimedia object transfer protocol, Digital video broadcasting: DVB data broadcasting, DVB for high-speed internet access, Convergence of broadcasting and mobile communications.

Protocols and Tools: Wireless Application Protocol-WAP.

(Introduction, protocol architecture, and treatment of protocols of all layers), Bluetooth (User scenarios, physical layer, MAC layer, networking, security, link management) and J2ME.

Wireless Language and Content – Generation Technologies: Wireless Content Types, Markup Languages: HDML, WML, HTML, cHTML, XHTML, VoiceXML. Content-Generation Technologies: CGI with Perl, Java Servlets, Java Server Pages, Active Server Pages, XML with XSL Stylesheets, XML Document, XSL Stylesheet.

Mobile and Wireless Security Mobile and Wireless Security: Creating a Secure Environment, Security Threats, Security Technologies, Other Security Measures, WAP Security, Smart Client Security

TEXT & REFERENCE BOOKS

1. Mobile Communications, 2/e, Jochen Schiller, PEA, 2008.
2. Mobile and Wireless Design Essentials, Martyn Mallick, Wiley, 2008.
3. Mobile Computing, Asoke K Talukder, et al,, MGH, 2008.
4. Mobile Computing,Raj Kamal,Oxford .
5. Wireless Communications & Networks, 2/e, William Stallings, PEA, 2007.
6. Fundamentals of Mobile and Pervasive Computing, Frank Adelstein et al, TMH, 2005.
7. Wireless Networks first-step, Jim Geier, PEA, 2005.
8. Handbook of Wireless Networks and Mobile Computing, Ivan Stojmenovic, Wiley, 2007.
9. 802.11 Wireless Networks,2/e, Matthew S.Gast, O'Reilly, 2006.

ICT 7030 BIOPHYSICS

Body fluid: Properties of body fluid, determination of conduction of body fluid, measurement of EMF of cells, temperature and reaction rates: Arrhenius equation. Photochemical reaction, the law of photochemistry, fluorescence and phosphorescence, Principles of colorimeter, Beer-Lambert's law, biometrics.

Biophysical activity of heart: electrical activity of the heart, monophonic and biphasic recordings, original and propagation of excitation & contraction, refractoriness, regular and ectopic pace makers, electrocardiography, waveform and measurement, ECG in diagnosis, arrhythmia's, flutter, fibrillation, vulnerable period, phonocardiography, ballistocardiography.

Biophysical activity of brain and other organs: electrical activity of brain, waveforms & measurements, electrogastrography, electroneurography, nerve conduction studies, electroretinography, electrooccculography, recording electrodes, interfaces, skin contact impedance, biological transducers, receptor potentials.

Introduction to electrical simulation: impedance & current distribution, dielectric properties of biological materials, skin impedance, total body impedance, impedances at high frequencies, high voltage & transient properties, patient safety, electrical shocks and hazards, leakage currents, types & measurements, protection against shock, burn & explosion hazards.

Radioactivity: Radio emission, radioisotopes, law of radioactive decay, half life period, production of radio isotopes for medical use, electromagnetic radiation, interaction of radiation with matter, exponential attenuation, half value thickness, photo electric, Compton and pair production process and their significance in radiology, radiation units, detection and measurements of radiation.

Introduction of ultrasonic wave: Ultrasonic wave motion, wave characteristics, intensity, and ultrasound properties in body (velocity, attenuation, reflection, refraction and absorption). Use of ultrasound in biological field.

Introduction of magnetic field: Optical activity and magnetic rotation of substances, dipole moments, magnetic properties of substances. Useful and harmful effects of magnetic fields, radio waves, micro waves, ultra violet radiation and infrared radiation on human beings - Applications.

Effect of hypothermia and hyperthermia. Production of ultra low and low temperature for medical use.

Standards: BIS standards, ISO regulations, Electrical safety and regulation to keep the hospital environment safe, medical ethics.

TEXT & REFERENCE BOOKS

1. Medical Imaging Physics (4/eds), W.R.Hendee & E.R.Ritenour, Wiley.
2. Medical Physics, Massey and Meredeth.
3. Principles of Biomedical Engineering, David Cooney
4. Bio Physical Principles of Structure and functions, F Snell et al., 1965.

ICT 7031 BIOMECHANICS

Use of statics, kinetics – rigid and non rigid bodies – Forces and motion – Newtons laws – Moment of force – Static equillibrum – Centre of gravity – Stability of equilibrium - Steps in analyzing a biomechanical problem – Graphical methods – contact forces – resolution of forces.

Bone structure & composition mechanical properties of bone, cortical and cancellous bones - Electrical properties of bone, fracture mechanism and crack propagation in bones, fracture fixators, repairing of bones. Pseudo elasticity, nonlinear stress-strain relationship, viscoelasticity, structure, function and mechanical properties of skin, ligaments and tendons.

Skeletal joints, skeletal muscles, basic considerations, basic assumption and limitations, forces and stresses in human joints, mechanics of the elbow, shoulder, spinal column, hip, knee and ankle. Human locomotion, gait analysis and goniometry, Ergonomics, Foot Pressure measurements – Pedobarograph, Force platform, mechanics of foot. Total Hip Prosthesis: requirements, different types of components, Stress analysis & instrumentation, Knee Prosthesis.

Alveoli mechanics, interaction of blood and lung, P-V curve of lung, breathing mechanism, airway resistance, physics of lung diseases.

Mechanical properties of blood vessels – arteries, arterioles, capillaries, veins, physics of cardio vascular diseases, prosthetic heart valves and replacement. Fluids – density – pressure – blood pressure and gravity – buoyancy – moments of force and stability – movement in water - Rheological properties of blood, laminar flow, Couette flow and Hagen-poiseuille equation, turbulent flow.

TEXT & REFERENCE BOOKS

1. Frank Bell, Principles of Mechanics and Biomechanics, Stanley Thorne (Publishers) Ltd., 1998
2. Donald R. Peterson and Joseph D. Bronzino, Biomechanics Principles and applications, CRC press, Taylor & Francis Group, LLC, 2008
3. Duane Knudson, Fundamentals of Biomechanics, Second Edition, Springer publication , 2007

ICT 7032 BIOMEDICAL INSTRUMENTATION

Analytical equipments used in clinical environment - Beer-Lambert's Law in spectrometry. UV, visible and infra-red spectrophotometers.

Blood cell counters- methods - Coulter Counters- automatic recognition and differential counting- audiometers – Automated Biochemical Analyzer – components – sampler control units – Sampling mechanisms – Flow injection analysis technique.

ECG Machines . Holter monitoring. Exercise systems. Measurement and application of average auditory evoked potential, visual evoked potential - magneto encephalogram - principles and measurements - Myoelectric control - Clinical applications of electrotherapy, short wave diathermy, ultrasonic diathermy, microwave diathermy, surgical diathermy unit, IR lamps, UV lamps.

X-Ray – Fluoroscopy - Computed tomography - Principles of sectional imaging - scanner configuration - data acquisition system - image formation principles - 2D image reconstruction techniques. Radio isotope imaging - Rectilinear scanners, linear scanners - SPECT - PET - Gamma Camera Radio nuclides for imaging, Emission Computed Tomography.

Physics of Ultrasound – Ultrasound Instrumentation – Doppler, Magnetic Resonance Imaging - Principles of MRI – pulse sequence- image acquisition and reconstruction techniques – MRI instrumentation – Functional MRI - Application of MRI. Introduction to Fusion imaging.

Physiological effects of electrical currents, macroshock and microshock, preventive measures to reduce shock hazards, Leakage current, isolation of patient circuits, safety of electrically susceptible patients, radiation hazards and safety, shielding, open ground problem and earthing methods.

TEXT & REFERENCE BOOKS

1. R. S. Khandpur, Biomedical Instrumentation Technology and Applications, McGraw-Hill Professional, 2004
2. Raja Rao, C; Guha, S.K, Principles of Medical Electronics and Biomedical Instrumentation, Orient Longman Publishers (2000)

ICT 7033 BIOMEDICAL SIGNAL PROCESSING

Simple signal conversion systems – conversion requirement for biomedical signals – signal conversion circuits. Discrete Fourier Transform (DFT) – Properties – circular and sectioned convolution – Filtering long duration sequences - FFT computation using DIT and DIF algorithms.

FIR design: Windowing techniques – Need and choice of Windows – Linear phase characteristics. IIR design: Analog filter design – Butterworth and Chebyshev approximations; digital design using impulse invariant and bilinear transformation – Warping, prewarping – Frequency transformation.

Adaptive filters – Principle noise canceller model – 50 Hz adaptive cancelling using a sine wave model – Maternal ECG cancellation in fetal electrocardiography – ECG cancellation in EMG recording – High frequency noise cancellation in Electro surgery. Signal averaging – Basics and limitations.

EEG signal characteristics – EEG analysis - time and frequency domain methods – Parametric model – Phenomenological model – linear prediction theory – Autoregressive method.

ECG QRS detection Techniques – Estimation of R-R interval – Estimation of ST segment inclination – Arrhythmia analysis monitoring – Long term ECG recording – Basics of ECG data reduction techniques.

Extracellular signal analysis – LFP Event detection, Latency calculation, single LFP classification.

TEXT & REFERENCE BOOKS

1. DC Reddy, Biomedical Signal Processing – Principles and Techniques, Tata McGraw Hill Publishing company Ltd., 2005
2. P.Ramesh Babu, "Digital Signal Processing", Second Edition, Scitech publications, Chennai, 2003
3. Willis J.Tompkins, Biomedical Digital signal processing, Prentice Hall of India Pvt. Litd., 2000
4. Biomedical Signal Analysis A case study approach by Rangaraj M.Rangayyan, John Wiley publications.

ICT 7034 ADVANCES IN NEURAL ENGINEERING

Introduction, Fundamentals of Neurophysiology, Neuron, membrane, Broad definition of a neural prosthesis: development; market; history, Design criteria for a prosthetic device: bottlenecks.

Brainstorming with students: why "Neural Engineering". Charge passage to and from the brain. Metals for use in implants.

Fundamentals of data analysis for implanted materials (electrochemistry and histology). Applications: cochlear implant.

Interfacing electronics to the body. High pass and low pass electrodes. Drug delivery and neurochemical analysis. Fabrication methods for implantable prosthesis. Sieve probes, shank probes, brain slice applications (non implantable). Brain-machine interfaces. Practical implementations and modeling. Neurorobotics. Electrical Stimulation of neurons. Effects of electric fields on transmembrane potentials. Neural signal processing. Learning, Plasticity. Artificial neural networks. Modeling neurons. Hodgkin Huxley. Timestamps. Firing rates. Neuronal system identification, Seizure prediction. Neural implant examples: retinal and cochlear.

TEXT & REFERENCE BOOKS

1. Neural Engineering, ed. Bin He, Bioelectric Engineering Series, vol. 3, 2005. ISBN 0-306-48609-1.
2. Kandel, E.R., Principles of Neural Science, McGraw-Hill, 2000, ISBN 0838577016.
3. Purves, D, Augustine, G.J, et al. (eds), Neuroscience, Sinauer Assoc., 1997 (or newer edition). ISBN 0878937471.
4. Khandpur, R.S., Biomedical Instrumentation, McGraw-Hill, 2005. ISBN 0071447849.

ICT 7035 MULTIMEDIA COMMUNICATION SYSTEMS

Definition of Multimedia: General Description and Standards, Transmission and Switching, System Technology, Services offered by Multimedia Communications.

Multimedia Support in Shared Media LAN and MAN: The original IEEE 802 Local Area Networks, ANSI Fiber Distributed Data Interface. Quality of Service: Generalized QoS Framework, QoS Principles and Specifications, QoS in Networked Multimedia System.

Video and Audio Coding Techniques and Standards: Discrete Cosine Transform (DCT), Coding of Still Images (JPEG, JPEG2000), Coding of Moving Pictures (MPEG 1, MPEG 2, MPEG 4, MPEG21).

Multimedia Operations, Administration, Management and Services: Network Element and Network-Level OA&M, OA&M System Technologies.

TEXT & REFERENCE BOOKS

1. K. R. Rao, Z. S. Bojkovic, Dragorad A. Milovanović, Multimedia communication systems: techniques, standards, and networks, Prentice Hall PTR, 2002
2. JR Ohm, Multimedia Communication Technology: Representation, Transmission and Identification of Multimedia Signals, Springer, 2004
3. Jerry D. Gibson, Multimedia communications: directions and innovations, Academic Press, 2001
4. Atul Puri, Tsuhan Chen, Multimedia systems, standards, and networks, CRC Press, 2000

ICT 7036 SATELLITE COMMUNICATION

Radio Wave Propagation: Introduction, Ground wave propagation, free space propagation, ground reflection, surface wave, diffraction.

Troposphere Wave Propagation: Troposcopic scatter, Ionosphere propagation, electrical properties of the ionosphere, effects of earth's magnetic field.

Over view of Satellite Systems: Introduction, frequency allocation, INTEL Sat.

Orbits: Introduction, Kepler laws, definitions, orbital element, apogee and perigee heights, orbit perturbations, inclined orbits, calendars, universal time, sidereal time, orbital plane, local mean time and sun synchronous orbits, Geostationary orbit: Introduction, antenna, look angles, polar mix antenna, limits of visibility, earth eclipse of satellite, sun transit outage, leandiag orbits. Propagation impairments and space link: Introduction, atmospheric loss, ionospheric effects, rain attenuation, other impairments.Space link: Introduction, EIRP, transmission losses, link power budget, system noise, CNR, uplink, down link, effects of rain, combined CNR.

Space Segment: Introduction, power supply units, altitude control, station keeping, thermal control, TT&C, transponders, antenna subsystem.

Earth Segemnt: Introduction, receive only home TV system, out door unit, indoor unit, MATV, CATV, Tx – Rx earth station.

Interference and Satellite access: Introduction, interference between satellite circuits, satellite access, single access, pre-assigned FDMA, SCPC (spade system), TDMA, pre-assigned TDMA, demand assigned TDMA, down link analysis, comparison of uplink power requirements for TDMA & FDMA, on board signal processing satellite switched TDMA.

TEXT & REFERENCE BOOKS

1. Satellite Communications – Dennis Roddy, 4th Edition, McGraw-Hill International edition, 2006.

2. Satellite Communications – Timothy Pratt, Charles Bostian and Jeremy Allnutt, , 2nd Edition, John Wiley & Sons, 2003.
3. Satellite Communication Systems engineering – W.L. Pitchand, H.L. Suyderhoud, R.A. Nelson, 2nd Ed., Pearson Education., 2007.

ICT 7037 CELLULAR NETWORK PLANNING

Introduction: Objectives of Radio Network Planning, The Impact of User Environment, Cellular Network Planning Approaches, Starting Points for The Planning Procedure: Desired Grade of Service, System Specification, Equipment Specifications, Available Frequency Band, Service Area Topography, Traffic Distribution, Existing Infrastructure, Phases of The Planning Procedure.

Radio Network Definition including Capacity planning: Starting Points and Objectives, Frequency Reuse, Prediction of Offered Traffic, Capacity Planning Example.

Propagation Analysis and Coverage Planning: Starting Points and Goals of Coverage Planning, Multipath Propagation: Path Loss, Hata Model, Walfish-Ikegami Model, Path Loss Corrections, Slow and Fast Fading, Connection Between Coverage and Quality of Service, Radio Link Power Budget: Antenna Feeder Loss, Antenna Gain, Application Example.

Frequency Allocation: Starting Points and Objectives, Regular Frequency Reuse Patterns, Methods Applied in Frequency Planning: Interference Levels, Minimum Reuse Distances, Allocation of Frequencies, Adjacent Channel Interference Avoidance, Application Example: Simple Frequency Planning Method Using Regular Reuse Patterns, Advanced Frequency Planning Method Using Pairwise Interference Analysis.

Cellular Network Planning Tools: Digital Maps, Capacity Planning in Radio Network Definition, Propagation Analysis and Coverage Planning: Hata Model and Walfish-Ikegami Model, Morphography, Antenna Height and Topography Corrections, Frequency Allocation, Route Calculations: Comparison of Predicted and Measured Data, Simulation of Calls Along Routes, Cellular Network Measurement: NMS/X, TIM and SAM of Nemo Technologies.

TEXT & REFERENCE BOOKS

1. Ajay R. Mishra, Fundamentals of Cellular Network Planning and Optimisation: 2G/2.5G/3G... Evolution to 4G, Wiley, 2004
2. Ajay R. Mishra, Advanced Cellular Network Planning and Optimisation: 2G/2.5G/3G...Evolution to 4G, John Wiley, 2007

ICT 7038 FIBER – OPTIC COMMUNICATION

Overview of Optical Fiber Communication: Introduction, Historical development, general system, advantages, disadvantages, and applications of optical fiber communication, optical fiber waveguides, Ray theory, cylindrical fiber (no derivations in article 2.4.4), single mode fiber, cutoff wave length, mode filed diameter. Optical Fibers: fiber materials, photonic crystal, fiber optic cables specialty fibers.

Transmission characteristics of optical FIBERS: Introduction, Attenuation, absorption, scattering losses, bending loss, dispersion, Intra modal dispersion, Inter modal dispersion.

Optical Sources and Detectors: Introduction, LED's, LASER diodes, Photo detectors, Photo detector noise, Response time, double hetero junction structure, Photo diodes, comparison of photo detectors.

Fiber Couplers and Connectors: Introduction, fiber alignment and joint loss, single mode fiber joints, fiber splices, fiber connectors and fiber couplers.

Optical Receiver: Introduction, Optical Receiver Operation, receiver sensitivity, quantum limit, eye diagrams, coherent detection, burst mode receiver operation, Analog receivers.

Analog and Digital Links: Analog links – Introduction, overview of analog links, CNR, multichannel transmission techniques, RF over fiber, key link parameters, Radio over fiber links, microwave photonics.

Digital links – Introduction, point–to–point links, System considerations, link power budget, resistive budget, short wave length band, transmission distance for single mode fibers, Power penalties, nodal noise and chirping.

WDM Concepts and Components: WDM concepts, overview of WDM operation principles, WDM standards, Mach-Zehender interferometer, multiplexer, Isolators and circulators, direct thin film filters, active optical components, MEMS technology, variable optical attenuators, tunable optical fibers, dynamic gain equalizers, optical drop multiplexers, polarization controllers, chromatic dispersion compensators, tunable light sources.

Optical Amplifiers and NETWORKS: optical amplifiers, basic applications and types, semiconductor optical amplifiers, EDFA. Optical Networks: Introduction, SONET / SDH, Optical Interfaces, SONET/SDH rings, High – speed light – waveguides.

TEXT & REFERENCE BOOKS

1. Optical Fiber Communication – Gerd Keiser, 4th Ed., MGH, 2008.
2. Optical Fiber Communications– John M. Senior, Pearson Education. 3rd Ed., 2007.
3. Fiber optic communication – Joseph C Palais: 4th Edition, Pearson Education.

ICT 7039 SWITCHING SYSTEMS

Evolution of Switching Systems: The Role of Switching Systems in Telecommunication Networks, Step By Step and Crossbar, Stored Program Control (SPC), Digital Switching, ATM Switching.

Switching System Architecture: Subscriber and Line Interface, Switching Network: Matrix and Channel Graph Representations, Blocking, Non-Blocking , and Rearrangeable Networks, Control Unit, Operation and Maintenance, Switching Process: Call Detecting, Number Analysis, Call Routing, Supervision, and Metering.

Hardware and Software Structure of the Digital Switch: Time Switches and Space Switches, Path Searching, Processor Systems Architecture and Functions, Reliability and Fault Recovery, Man Machine Interface, Examples of the Present Digital Switching Systems.

ATM Switching Architectures and Performance: ATM Switch Architectures, Full-and Partial-Connection Multistage Networks, Self –Routing Networks, ATM Switching Structures: Minimum-Depth Blocking Networks, Non-Blocking Single-, and Multiple-Queuing Networks, Arbitrary-Depth Blocking Networks, Fault-Tolerant ATM Switching Architectures.

New Trends in Switching: Photonic Switching, IP Switching.

TEXT & REFERENCE BOOKS

1. Telecommunication and Switching, Traffic and Networks - J E Flood: Pearson Education, 2002.
2. Digital Switching Systems, Syed R. Ali, TMH Ed 2002.
3. Digital Telephony - John C Bellamy: Wiley India 3rd Ed, 2000.

ICT 7040 WIRELESS NETWORKS

PCS Architecture, Cellular telephony, Cordless telephony and low tier PCS, Third and Fourth generation wireless systems; Mobility management, handoff, roaming management for SS& and CT2, handoff Detection, strategies for handoff detection, channel assignment, link transfer types, hard Handoff soft handoff; IS-41 signaling, IS-41 handoff and authentication, CDPD architecture, CDPD air Interface, radio resource allocation.; GSM architecture, location tracking, data services, HSCPD, GPRS, OSM network signaling, GSM mobility management, GSM short message service, International Roaming for GSM, VoIP for GSM networks.; GPRS functional groups, architecture, network nodes, interfaces, procedures, billing, evolving from GSM to GPRS,WAP protocols, W-CDMA and cdma 2000, QOS in 3G, paging network architectures, wireless local loop architectures, Bluetooth core Protocols; Introduction to wireless LANS, 802.11 WLANs, physical and MAC layers, Wireless ATM and HIPERLAN, 802.15 WPAN, Bluetooth, interference between Bluetooth and 802.11, wireless geolocation system architecture, standards, performance measures, introduction other wireless LAN standards 802.lle, 802.16, 802.17, 802.19, 802.20

TEXT & REFERENCE BOOKS

1. Yi-Bing Lin, Imrich Chlamtac, Wireless and mobile network architectures, John Wiley, 2001
2. Kaveh Pablavan, P. Krishnamurthy, Principles of wireless networks, Pearson education, 2002
3. P. Venkataram, S. S. Manvi, B. P. Vijaykumar, WLANs: Architectures, Protocols and Applications, Pearson education (In Press), 2005
4. Marlyn Mallick, Mobile and wireless design essentials, Wiley, 2003

ICT 7041 ADVANCED DIGITAL COMMUNICATION

Digital Modulation Techniques: QPSK, DPSK, FQPSK, QAM, M-QAM, OFDM, Optimum Receiver for Signals Corrupted by AWGN, Performance of the Optimum Receiver for Memory-less Modulation, Optimum Receiver for CPM Signals, Optimum Receiver for Signals with Random Phase in AWGN Channel.

Coding Techniques: Convolutional Codes, Hamming Distance Measures for Convolutional Codes; Various Good Codes, Maximum Likelihood Decoding of Convolutional codes, Error Probability with Maximum Likelihood Decoding of Convolutional Codes, Sequential Decoding and Feedback Decoding, Trellis Coding with Expanded Signal Sets for Band-limited Channels, Viterbi decoding.

Communication through band limited linear filter channels: Optimum receiver for channels with ISI and AWGN, Linear equalization, Decision-feedback equalization, reduced complexity ML detectors, Iterative equalization and decoding-Turbo equalization.

Adaptive equalization: Adaptive linear equalizer, adaptive decision feedback equalizer, adaptive equalization of Trellis- coded signals, Recursive least squares algorithms for adaptive equalization, self recovering (blind) equalization.

Spread Spectrum Signals for Digital Communication: Model of Spread Spectrum Digital Communication System, Direct Sequence Spread Spectrum Signals, Frequency-Hopped Spread Spectrum Signals, CDMA, time-hopping SS, Synchronization of SS systems.

Digital Communication through fading multi-path channels: Characterization of fading multi-path channels, the effect of signal characteristics on the choice of a channel model, frequency-Nonselective, slowly fading channel, diversity techniques for fading multi-path channels, Digital signal over a frequency-selective, slowly fading channel, coded wave forms for fading channels, multiple antenna systems.

TEXT & REFERENCE BOOKS

1. John G. Proakis, “Digital Communications," 4th edition, McGraw Hill, 2001.
2. Stephen G. Wilson, “Digital Modulation and Coding,” Pearson Education (Asia) Pte. Ltd, 2003.

3. Kamilo Feher," Wireless Digital Communications: Modulation and Spread Spectrum Applications," Prentice-Hall of India, 2004.
4. Andrew J. Viterbi, CDMA: Principles of Spread Spectrum Communications, Prentice Hall, USA, 1995.

ICT 7042 MODELING OF DATA NETWORKS

Delay Models in Data Networks: Queuing Models, M/M/1, M/M/m, M/M/, M/M/m/m and other Markov System, M/G/1 System, Networks of Transmission Lines, Time Reversibility, Networks of Queues. Multi-access Communication: Slotted Multi-access and the Aloha System, Splitting Algorithms, Carrier Sensing, Multi-access Reservations, Packet Radio Networks. Routing in Data Networks: Introduction, Network Algorithms and Shortest Path Routing, Broadcasting. Routing Information: Coping with Link Failures, Flow models, Optimal Routing, and Topological Design, Characterization of Optimal Routing, Feasible Direction Methods for Optimal Routing, Projection Methods for Optimum Routing, Routing in the Codex Network. Flow Control: Introduction, Window Flow Control, Rate Control Schemes, Overview of Flow Control in Practice, Rate Adjustment Algorithms.

TEXT & REFERENCE BOOKS

1. Dimitri Bertsekas and Robert Gallager, "Data Networks," 2nd edition, Prentice Hall of India, 2003.
2. William Stallings, "High-Speed Networks and Internets," Pearson Education (Asia) Pte. Ltd, 2004.
3. J. Walrand and P. Varaya,"High Performance Communication Networks," 2nd edition, Harcourt India Pte. Ltd. & Morgan Kaufman, 2000.

ICT 7043 TELECOMMUNICATION NETWORK MANAGEMENT

Introduction: Network management standards, network management model, organization model, information model abstract syntax notation 1 (ASN.1), encoding structure, macros, functional model.

Network management application functional requirements: Configuration management, fault management, performance management, Error correlation technology, security management, accounting management, common management, report management, polity based management, service level management, management service, community definitions, capturing the requirements, simple and formal approaches, semi formal and formal notations.

Telecommunication management network (TMN) architecture: Terminology, functional architecture, information architecture, physical architecture, TNN cube, TMN and OSI .

Common management information service element (CMISE): CMISE model, service definitions, errors, scooping and filtering features, synchronization, functional units, association services, common management information protocol (CMIP) specification.

Information Modeling for TMN: Rationale for information modeling, management information model, object oriented modeling paradigm, structure of management information, managed object class definition, management information base (MIB).

Simple network management protocol (SNMP): SNMPv1: managed networks, SNMP models, organization model, information model, SNMPv2 communication model, functional model, major changes in SNMPv2, structure of management information (SMI), MIB, SNMPv2 protocol, compatibility with SNMPv1, SNMPv3, architecture, applications, MIB security, remote monitoring (RMON) SMI and MIB, RMQN1 and RMON2; Network management examples: ATM integrated local management interface, ATM MIB. M1, M2,M3, M4, interfaces, ATM digital exchange interface management, digita1 subscriber loop (DSL) and asymmetric DSL (ADSL) technologies, ADSL configuration management, performance management.

Network management tools: Network statistics management, network management system, management platform case studies: OPENVIEW, ALMAP.

TEXT & REFERENCE BOOKS

1. Network Management: Principles and Practice - Mani Subramanian, Addison Wesley, Pearson Education Asia publication.
2. Fundamentals of Telecommunication Network Management - Lakshmi Raman IEEE Communication Society.
3. Telecommunication Network Management: Technologies and Implementations - Airdarous Salah, Plevyak Thomas. Prentice Hall
4. Telecommunication Network Management - Haojin Wang, Mc- Graw Hill Professional Publication.

ICT 7044 ADVANCED DIGITAL SIGNAL PROCESSING

Parametric Methods For Power Spectrum Estimation: Relationship between the auto correlation and the model parameters – The Yule – Walker method for the AR Model Parameters – The Burg Method for the AR Model parameters – unconstrained least-squares method for the AR Model parameters – sequential estimation methods for the AR Model parameters – selection of AR Model order.

Adaptive Signal Processing: FIR adaptive filters – steepest descent adaptive filter – LMS algorithm – convergence of LMS algorithms – Application: noise cancellation – channel equalization – adaptive recursive filters – recursive least squares.

Multirate Signal Processing: Decimation by a factor D – Interpolation by a factor I – Filter Design and implementation for sampling rate conversion: Direct form FIR filter structures – Polyphase filter structure.

Speech Signal Processing: Digital models for speech signal : Mechanism of speech production – model for vocal tract, radiation and excitation – complete model – time domain processing of speech signal:- Pitch period estimation – using autocorrelation function – Linear predictive Coding: Basic Principles – autocorrelation method – Durbin recursive solution.

Wavelet Transforms: Fourier Transform : Its power and Limitations – Short Time Fourier Transform – The Gabor Transform - Discrete Time Fourier Transform and filter banks – Continuous Wavelet Transform – Wavelet Transform Ideal Case – Perfect Reconstruction Filter Banks and wavelets – Recursive multi-resolution decomposition – Haar Wavelet – Daubechies Wavelet.

TEXT & REFERENCE BOOKS

1. John G.Proakis, Dimitris G.Manobakis, Digital Signal Processing, Principles, Algorithms and Applications, PHI.
2. Monson H.Hayes – Statistical Digital Signal Processing and Modeling, Wiley, 2002.
3. Roberto Crist, Modern Digital Signal Processing, Thomson Brooks/Cole (2004)
4. Raghuveer. M. Rao, Ajit S.Bopardikar, Wavelet Transforms, Introduction to Theory and applications, Pearson Education, Asia, 2000.

ICT 7045 ERROR CONTROL CODING TECHNIQUES IN COMMUNICATIONS

Introduction; The channel coding problem; Vector spaces; Groups, rings and fields; Primitive and irreducible polynomials; Hamming Codes and the Hamming bound; Code bounds; Polynomial rings and cyclic codes; Encoding and decoding of cyclic codes; BCH and Reed-Solomon codes; Decoding BCH and Reed-Solomon codes; Convolutional codes; Decoding convolutional codes; the Viterbi algorithm.

TEXT & REFERENCE BOOKS

1. Error Control Systems for Digital Communication and Storage, Stephen B. Wicker, Prentice-Hall, 1995.
2. Error Control Coding: An Introduction, P. Sweeney, Prentice-Hall, Englewood Cliffs, NJ, 1991.
3. Error-Correcting Codes and Finite Fields, O. Pretzel, Oxford University Press, Oxford, 1992.
4. Introduction to the Theory of Error-Correcting Codes V. Pless, 3rd Ed., Wiley, 1998.

ICT 7046 STOCHASTIC SIGNALS AND SYSTEMS

Probability space, sigma fields; probability axioms, conditional probability, random variables; Probability distributions and density functions; independent and conditional random variables; Two or more random variables; functions of random variables expectations, moments; characteristic functions; Correlation; covariance; parameter estimation; multivariate normal variables random sequences and stochastic convergence; Central Limit Theorem; Stochastic processes; Gaussian, exponential, random phase sinusoids in continuous and discrete time; Strict and wide-sense stationary processes; correlation functions and expected values; Linear transformations on random variables; linear system response to stochastic processes; ergodicity; power spectral density.

TEXT & REFERENCE BOOKS

1. Probability, random variables, and stochastic processes, by A. Papoulis and S. Unnikrishna Pillai. McGraw Hill, New York, 2002
2. Probability and Random Processes with Applications to Signal Processing, by H. Stark & J.W.Woods. Prentice Hall, 2001

ICT 7047 SIGNAL PROCESSING FOR WIRELESS SYSTEMS

Wireless Topics: Introduction, Wireless Standards Overview, Reasons behind Convergence of Wireless Services, Stochastic and Signal Processing Review, Representing Band Pass Signals and Subsystems, Receiver Sensitivity Definitions.

Modulation Theory: Modulation Impairments, Modulation Scheme Migration, Modulation Scheme Comparisons.

Wireless Multipath Channel: Additive White Gaussian Noise, Rayleigh Multipath Fading Phenomenon, Rician Multipath Fading Phenomenon, Frequency Selective Fading, Man-Made System Interference, Propagation Path Loss, Shadowing Discussion, Multipath Fading Simulation Models, Multipath Birth / Death Discussion.

Modulation Detection Techniques: Difference between Practice and Theory, Coherent Detection, Noncoherent Detection of DQPSK, Noncoherent Detection of MSK.

Performance Improvement Techniques: Forward Error Correction Codes, Receive Spatial Antenna Diversity Combining Techniques, Transmit Spatial Antenna Diversity Techniques, Link Budget Discussion. Receiver Digital Signal Processing: Temporal Equalization (EQ), Space-Time Equalization (STE), Frequency Domain Equalization, Symbol Timing Recovery, Channel Quality Estimation (CQE), Automatic Frequency Control, Overall Receiver Block Diagram.

3G Wideband CDMA: Introduction, Rake Receiver Principle, 2G IS-95 CDMA Discussion, Rake Finger Architecture and Performance, PN Code Properties, WCDMA Physical Layer Overview, High Speed Downlink Packet Access (HSDPA) Overview, High Speed Uplink Packet Access (HSUPA), Capacity Improvement in a Multipath Environment.

Computer Simulation Estimation Techniques: Introduction to Simulation, Monte Carlo Method, Modified Monte Carlo or Importance Sampling Method, Improved Importance Sampling Method, Tail Extrapolation Method (TEM), Semi-Analytic Method, General Discussion.

3G and Beyond Discussion: Introduction, Multimedia and Mobile TV Services, Some Sampled 3G Terminal (UE) Statistics, High Speed Packet Access Evolution, MIMO Techniques.

TEXT & REFERENCE BOOKS

1. Signal Processing for Wireless Communication, by - Joseph Boccuzzi, McGraw Hill.
2. Wireless Communications: Signal Processing Perspectives, by - Vincent Poor, Gregory W. Wornell, Prentice Hall Signal Processing Series

ICT 7048 ADVANCED MATHEMATICAL MODELING FOR BIOLOGICAL SYSTEMS

Introduction to Modeling : modeling process, overview of different kinds of models, Qualitative Modeling with Functions, Modeling with Dimensional Analysis, Modeling with Differential Equations: overview of basic concepts concerning matrices, eigenvalues and eigenvectors; fixed points, stability and iterative processes; Modeling with Ordinary Differential Equations: overview of basic concepts in ODE and stability of solutions: existence and uniqueness for 1st order IVPs, Picard iteration, numerical methods, higher order IVPs; linear operators, coupled linear systems, phase plane, stability analysis; some applications: growth of cells, market growth, enzyme reactions, examples in mechanics and electric circuits; Empirical Modeling with Data Fitting: error function, least squares method; fitting data with polynomials and splines; Modeling with Partial Differential Equations: overview of the key properties of some particular kinds of PDEs: advection, diffusion, advection-diffusion; separation of variables, equilibrium solutions, stability and linear stability; travelling waves, spatially periodic solutions (patterns); some applications: stripes on the skin of the Marine Angelfish, analysis of temperature from the Greenland Ice Sheet .

Introduction: Why Model?; discrete time models for population dynamics; Introduction to nonlinear discrete dynamical systems: graphical analysis, fixed points, linear stability analysis, bifurcation, chaotic dynamics, systems of difference equations, Applications of nonlinear difference equations; density-dependent population models; Introduction to continuous time models: logistic equation for single species population dynamics, Some techniques for ordinary differential equations: equilibrium points, stability, linearization; Introduction to continuous dynamical systems: geometric (phase plane) analysis of 2-dim systems, linear systems; Nonlinear systems, periodic solutions; Continuous time models for single species population dynamics: harvesting, metapopulations (patchy environments); Interacting populations: predator and prey models, competition, infectious disease models, Biochemical kinetics; Hodgkin-Huxley model for nerve conduction; Poincaré-Bendixon theory, oscillations in simplified nerve models (FitzHugh-Nagumo equations); Hopf bifurcations; cable equation; Introduction to partial differential equations and diffusion; Introduction to reaction-diffusion equations, traveling wave solutions; Spatial patterns.

TEXT & REFERENCE BOOKS

1. A First Course in Mathematical Modeling, by F. R. Giordano, M.D. Weir and W.P. Fox, Brooks/Cole.
2. Mathematical Models in Biology, by Edelstein-Keshet, L. SIAM.

ICT 7049 MATHEMATICAL MODELING FOR FINANCE

Introduction to Modeling : modeling process, overview of different kinds of models, Qualitative Modeling with Functions, Modeling with Dimensional Analysis, Modeling with Differential Equations: overview of basic concepts concerning matrices, eigenvalues and eigenvectors; fixed points, stability and iterative processes; Modeling with Ordinary Differential Equations: overview of basic concepts in ODE and stability of solutions: existence and uniqueness for 1st order IVPs, Picard iteration, numerical methods, higher order IVPs; linear operators, coupled linear systems, phase plane, stability analysis; some applications: growth of cells, market growth, enzyme reactions, examples in mechanics and electric circuits; Empirical Modeling with Data Fitting: error function, least squares method; fitting data with polynomials and splines; Modeling with Partial Differential Equations: overview of the key properties of some particular kinds of PDEs: advection, diffusion, advection-diffusion; separation of variables, equilibrium solutions, stability and linear stability; travelling waves, spatially periodic solutions (patterns); some applications: stripes on the skin of the Marine Angelfish, analysis of temperature from the Greenland Ice Sheet .

Introduction to mathematical modeling, Disciplines and their historical development, Models and their applications in economy; Operational research, Definition, Mathematical programming - review of disciplines; Linear programming, Basic terms, Typical linear programming applications and model formulations; Graphical solution of linear programming problem, interpretation of results, Special cases of linear programming models; Special linear programming applications, distribution problems; Methods and software products used for solving linear programming problems; Network models. Basic terminology and typical optimization applications; Shortest path problem, minimal spanning tree, maximal flow problem; Project management; Basic terminology, Critical path method; Inventory models, Basic terminology, Deterministic inventory model - economic order quantity model; Waiting lines models, Basic terminology, Classification of waitng line models (Kendall); Standard single-server exponential model; Principle of computer simulation; Decision theory, Basic terminology, Classification of problems, Multicriteria decision making models, Discrete multicriteria decision making models, Weighted sum method, Econometrics, Basic terminology, Standard linear regression model, Least squares method, Time series, production function.

TEXT & REFERENCE BOOKS

1. 1. A First Course in Mathematical Modeling, by F. R. Giordano, M.D. Weir and W.P. Fox, Brooks/Cole.
2. Introduction to Operations Research, by Frederick S. Hillier, Gerald J. Lieberman, McGraw Hill.

ICT 7050 Intelligent Systems and Robotics

Brief history of robotics, types of robots, Robot challenges (RoboCup, DARPA Grand Challenge), Potential applications of intelligent systems and robotics, Sensors and Actuators, Sonar, laser scanner, optical encoders, DC motors, Control, Feedback control, Fuzzy controllers. Localisation and mapping: Triangulation, Kalman filter, Behaviour based programming, Robot behaviours, Potential field approach, Behaviour based architecture.

TEXT & REFERENCE BOOKS

1. Uncertain Rule-based Fuzzy Systems: Mendel, J.M. (2017)Introduction and New Directions, 2nd edn. Springer.
2. Introduction to AI Robotics, Murphy, R.R. (2000) . London, UK: MIT Press.
3. Introduction to AI Robotics, Murphy, R.R. (2019), 2nd edn. London, UK: The MIT Press.

ICT 7051 Machine Learning and Data Mining

Introduction to Machine Learning and Data Mining Introduction to modern data analysis. Machine Learning. Data Mining and Knowledge Discovery in Data Bases. Course structure. Basic tasks and examples. Clustering and its basic techniques The task of clusterization. K-means and its modifications (k-medoids and fuzzy cmeans clustering). Density-based methods: DB-scan and Mean Shift. Hierarchical clustering. Criteria of quality.

Classification and its basic techniques The task of classification. 1-Rules. K-Nearest Neighbours approach. Naïve Bayes. Decision Trees. Logistic Regression. Quality assessment: precision, recall, F - measure, loss-function, confusion-matrix, cross- validation and learning curves (ROC, lift etc.). Multi-class and multi-label classification.

Frequent Itemset Mining and Association Rules Frequent itemsets. Apriori and FP-growth algorithms. Association rules. Interestingness measures: support and confidence. Closed itemsets. Connection with Lattice Theory and Formal Concept Analysis. Applications.

Feature Selection and Dimensionality Reduction. Outlier detection Feature selection versus feature extraction and generation. Singular Value Decomposition, Latent Semantic Analysis and Principal Component Analysis. Boolean Matrix Factorization. Outlier and novelty detection techniques.

Recommender Systems and Algorithms Collaborative filtering. User-based and item-based methods. Slope one. Association rules based and bicluster-based techniques. Quality assessment: MAE, precision and recall. SVD-based approaches: pureSVD, SVD++ and time-SVD. Factorization machines.

Ensemble Clustering and Classification Ensemble methods of clusterization for k-means partitions' aggregation. Ensemble methods of classification: Bagging, Boosting, and Random Forest.

Multimodal relational clustering Biclustering. Spectral co-clustering. Triclustering. Two-mode networks. Folksonomies and resource-sharing systems. Multimodal approaches. Applications: Community detection in Socail Network Analysis and gene expression analysis.

Artificial Neural Methods and Stochastic Optimization. Elements of Statistical Learning Artificial Neural Networks. Basic ideas of Deep Learning. (Stochastic) gradient descent. Statistical (Bayesian) view on Machine learning.

Machine Learning Tools and Big Data Orange, Weka, and Scikit-learn. Machine Learning for Big Data: Apache Spark.

TEXT & REFERENCE BOOKS

1. Data Mining and Machine Learning: Fundamental Concepts and Algorithms, Second Edition, Mohammed J. Zaki and Wagner Meira, Jr
2. Introduction to Algorithms for Data Mining and Machine Learning, Xin-She Yang, Elsevier Science
3. Machine Learning for Data Mining-Improve Your Data Mining Capabilities with Advanced Predictive Modeling, Jesus Salcedo
4. Alpaydin E., Introduction to Machine Learning, PHI.
5. https://online.stat.psu.edu/stat508/

ICT 7052 Human Language Understanding and Text Processing

UNIT – A // Introduction to NLP: Definition, History, Applications, Goals. Regular Expressions and Automata, Non-Deterministic FSAs. Transducers, English Morphology, Finite-State Morphological Parsing, Tokenization, Detection and Correction of Spelling Errors, N-grams, Part-of-Speech Tagging, English Word Classes, Tagsets, Rule-Based - HMM -Transformation-Based Tagging Evaluation and Error Analysis. Hidden Markov and Maximum Entropy Models. // UNIT-B // Syntax: Word Classes and Part-of Speech Tagging, Context Free Grammars for English, Parsing with Context- Free Grammars. Word Sense Disambiguation: Selection Restriction Based Disambiguation, Robust WSD: Machine Learning, Supervised Learning Approaches, Bootstrapping Approaches, Unsupervised Methods, Dictionary Based Approaches. // UNIT – C //15 Hours Speech Processing: Phonetics, Articulatory Phonetics, Phonological Categories, Acoustic Phonetics and Signals, Speech Synthesis, Text Normalization, Phonetic and Acoustic Analysis, Diphone Waveform synthesis, Evaluation-Automatic Speech Recognition, Architecture, Hidden Markov Model to Speech, MFCC vectors, Acoustic Likelihood Computation, Evaluation. Triphones, Discriminative Training, Modeling Variation. Computational Phonology, Finite-State Phonology, Computational Optimality Theory, Syllabification, Learning Phonology and Morphology// UNIT – D// Introduction to various machine learning techniques used in NLP: Machine Learning in the Context of Natural Language Processing, Supervised Machine Learning for NLP, Unsupervised Machine Learning for NLP, ML vs. NLP and Using Machine Learning on Natural Language Sentences, Hybrid Machine Learning Systems for NLP.

TEXT & REFERENCE BOOKS

1. Grosz, B.J., Sparck Jones, K. & Webber, B.L., Readings in natural language processing, Los Altos, CA. Morgan Kaufmann.
2. Allen, J., Natural Language Understanding, Redwood City, CA: Benjamin/Cummings.
3. Bharti, Akshar,Chaitanya Vineet, Sangal Rajeev, Natural Language Processing, Prentice Hall.
4. Jurafsky, D. & J. Martin, Speech and Language Processing: An Introduction to Natural Language Processing Computational Linguistics, and Speech Recognition, Prentice Hall.
5. Alpaydin E., Introduction to Machine Learning, PHI.

ICT 7053 Computer Game Development

Unity Game Development: Learn how to design beautiful games from the team at Unity A Primer to the Third Dimension:Coming around to 3D-Coordinates Systems- Local Space versus World Space; Vectors; Cameras; Faces, Edges, Vertices, and Meshes; Materials, Textures, and Shaders; Rigid Body Physics; Collision Detection; Essential Unity Concepts- Assets; Scenes; Game Objects; Components; Scripts; Prefabs; Packages; Unity Interface- Scene View and Hierarchy; Inspector;Project Window; Game View; Package Manager; Summary-Third Dimension; Unity Concepts; Unity Interface Design and Prototype: Game Design Fundamentals-Game Design Document; Deliberate Decisions; Iterative Production; Concepting; Your First Unity Project - Choosing a Version;Choosing a Template; Scriptable Render Pipeline; Built-in Rendering; Universal Rendering; High-Definition Rendering; Prototyping - Wireframing or Paper Creation; Greyboxing; Proof of Concept (POC); Minimum Viable Product (MVP); Vertical Slice Summary-Game Design Fundamentals; Your First Unity Project; Prototyping; Programming: Environment-Unity Environment; Fundamentals: Variables, Data Types, Logic or Flow, Functions Feedback

TEXT & REFERENCE BOOKS

1. Unity Game Development- Learn how to design beautiful games from the team at Unity, Anthony M Davis, Rusell Craig, Packt
2. Unity in Action: Multiplatform game development in C#, Joseph Hocking, Manning Publications
3. 3d Game Development With Unity, Franz Lanzinger, CRC Pr I Llc
4. Advanced Unity Game Development: Build Professional Games with Unity, C#, and Visual Studio, Victor G Brusca, Apress

ICT 7054 Cloud and Web Technologies

Concept and Evolution of Cloud Computing, Service Models and Architecture of Cloud Computing, Management Issues in Cloud, Security Issues in Cloud, Exposures to Some Open Source and Commercial Clouds, Exposure to the Research Issues in Cloud Computing, Distributed System Models: Parallel Computing, Virtualization, Cloud Platform Architectures, Amazon AWS, Microsoft Azure, Google App Engine, Google MapReduce, Yahoo Hadoop, Eucalyptus, Nimbus, OpenStack, Service-Oriented Architectures, Cloud Programming, Grid Computing, Peer-to-Peer Computing.

Client/Server Computing: DBMS concept and architecture, Single system image, Client Server architecture, mainframe-centric client server computing, downsizing and client server computing, preserving mainframe applications investment through porting, client server development tools, advantages of client server computing. Components of Client/Server application: The client: services, request for services, RPC, windows services, fax, print services, remote boot services, other remote services, Utility Services & Other Services, Dynamic Data Exchange (DDE), Object Linking and Embedding (OLE), Common Object Request Broker Architecture (CORBA). The server: Detailed server functionality, the network operating system, available platforms, the network operating system, available platform, the server operating system. Client/Server Network: connectivity, communication interface technology, Interposes communication, wide area network technologies, network topologies (Token Ring, Ethernet, FDDI, CDDI) network management. Client-server system development: Software, Client–Server System Hardware: Network Acquisition, PC-level processing unit, Macintosh, notebooks, pen, UNIX workstation, x-terminals, server hardware. Data Storage: magnetic disk, magnetic tape, CD-ROM, WORM, Optical disk, mirrored disk, fault tolerance, RAID, RAID-Disk network interface cards, Network protection devices, Power Protection Devices, UPS, Surge protectors. Client Server Systems Development: Services and Support, system administration, Availability, Reliability, Serviceability, Software Distribution, Performance, Network management, Help Disk, Remote Systems Management Security, LAN and Network Management issues. Client/Server System Development: Training, Training advantages of GUI Application, System Administrator training, Database Administrator training, End-user training. The future of client server Computing: Enabling Technologies, The transformational system.

TEXT & REFERENCE BOOKS

1. Client / Server Computing - Patrick Smith & Steave Guengerich,
2. Client/Server Computing - Dawna Travis Dewire
3. Database management System - Majumdar & Bhattacharya
4. Distributed and Cloud Computing: Clusters, Grids, Clouds, and the Future Internet - Kai Hwang, Jack Dongarra & Geoffrey C. Fox
5. Cloud Computing: Concepts, Technology, Security, and Architecture, Second Edition, Thomas Erl, Eric Barcelo, Pearson

ICT 7055 Computer Security

Introduction to computer security: Overview of Computer Security Concepts and Foundations o Threats, Attacks, and Assets

Computer Security Technology and Principles : User Identification and Authentication, Access Control, Database and Cloud Security, Malicious Software, Denial-of-Service Attacks, Intrusion Detection, Firewalls and Intrusion Prevention Systems

Software Security and Trusted Systems: Buffer Overflow, Software Security, Operating System Security, Database Security, Trusted Computing and Multilevel Security

Management Issues: Security Management and Risk Assessment, Human Resources Security, Legal and Ethical Aspects

Cryptographic Algorithms: Symmetric Encryption and Message Confidentiality, Public-Key Cryptography and Message Authentication

Networking and Distributed System Security: Internet Security Protocols and Standards, Network and Web Security, Distributed System Components and Security

TEXT & REFERENCE BOOKS

1. Dieter Gollman, “Computer Security”, 3rd edition, 2011
2. William Stallings, Lawrie Brown, "Computer Security: Principles and Practice", Prentice Hall, 3rd edition
3. The Essential Guide to Home Computer Security, Rowlingson R.

ICT 7056 Evolutionary Computation

Introduction: The main evolutionary computing metaphor, Brief history, The inspiration from biology, Evolutionary computing- Why?

What is an evolutionary algorithm? : Components of Evolutionary algorithms, Example applications, Working of an Evolutionary algorithm, Evolutionary Computing and Global optimization

Genetic algorithms: Introductory Examples, Representation of Individuals, Mutation,Recombination, Population Models, Parent Selection, Survivor Selection, Example applications

Evolutionary Strategies: Introductory Example, Representation, Mutation, Recombination, Parent Selection, Survivor Selection, Self-Adaptation, Example applications

Evolutionary Programming: Introductory Example, Recombination, Parent Selection, Survivor Selection, Example applications

Genetic Programming: Introductory Example, Representation, Mutation, Recombination, Parent Selection, Survivor Selection, Initialisation, Example applications, Bloat in Genetic Programming, Problems Involving "Physical Environments", Example applications

Learning Classifier Systems: Introductory Example, General Background, ZCS, XCS, Example applications

Parameter Control in Evolutionary Algorithms: Introduction, Examples of changing parameters, classification of control techniques, Examples of varying EA parameters

TEXT & REFERENCE BOOKS

1. Introduction to Evolutionary Computing, Agoston E. Eiben, J.E. Smith, Springer
2. Swarm Intelligence and Evolutionary Computation: Theory, Advances and Applications in Machine Learning and Deep Learning, Georgios Kouziokas, CRC Press
3. Evolutionary Computation with Intelligent Systems: A Multidisciplinary Approach to Society 5.0, R. S. Chauhan (editor), Kavita Taneja (editor), Rajiv Khanduja (editor), Vishal Kamra (editor), Rahul Rattan (editor), CRC Pr I Llc
4. Theory of Evolutionary Computation: Recent Developments in Discrete Optimization, Benjamin Doerr, Frank Neumann
5. Evolutionary Computation and Complex Networks, Jing Liu, Hussein A. Abbass, Kay Chen Tan, Springer

ICT 7057 Graph Databases and Graph Theory

Graph Databases

Introduction to graphs: What is a graph?, What is a graph database, Is my problem a graph problem? //Graph data modeling: The data modeling process, Understand the problem, Developing the whiteboard model, Constructing the logical data model, Checking our model

Running basic and recursive traversals: Setting up your environment, Traversing a graph, Recursive traversals

Pathfinding traversals and mutating graphs: Mutating a graph, Paths, Traversing and filtering edges, Formatting results, Review of values steps, Organizing our results, Combining steps into complex traversals

Developing an application: Starting the project, Connecting to our database, Retrieving data, Adding, modifying, and deleting data, Translating our list and path traversals

Advanced data modeling techniques: Reviewing our current data model, Extending our logical data model, Translating entities to vertices, Extending our data model for personalization, Comparing the results.

Graph Theory

Fundamental concepts of graphs- Basic definitions of graphs and multigraphs; adjacency matrices, isomorphism, girth, decompositions, independent sets and cliques, graph complements, vertex coloring, chromatic number, important graph like cubes and the Petersen graph; Paths, cycles, and trails; Eulerian circuits ; Vertex degrees and counting; large bipartite subgraphs, the handshake lemma, Havel-Hakimi Theorem; Directed graphs: weak connectivity, connectivity, strong components; Induction and other fundamental proof techniques;

Trees - Basics: equivalent characterizations of trees, forests; Spanning trees and 2-switches; Distance and center; Optimization: Kruskal's Theorem and Dijkstra's Theorem;

Matching and covering; Bipartite matching, vertex cover, edge cover, independent set, M-alternating path, Hall's Theorem, König-Egeváry Theorem, Gallai's Theorem

Connectivity- Vertex cuts, separating sets, bonds; vertex and edge connectivity, block-cutpoint tree; Menger's Theorem: undirected vertex and edge versions

Network flow - Ford-Fulkerson Labeling algorithm, flow integrality, Max-flow/Min-cut Theorem, proof of Menger's Theorem

Coloring- Chromatic number: lower bounds from clique number and maximum independent set, upper bounds from greedy coloring (& Welsh-Powell), Szekeres-Wilf, and Brooks' Theorem, Also k-critical graphs, cartesian product of graphs, and interval graphs, k-Chromatic graphs: Mycielski's construction, Turán's Theorem, Edge coloring, line graphs, Vizing's Theorem

Planarity - Embeddings, dual graphs, Euler's formula; Kuratowski's Theorem; Coloring, including the 5-color theorem

Student projects on applications of graph theory

TEXT & REFERENCE BOOKS

1. Graph Databases in Action, Dave Bechberger, Manning
2. Graph Databases: New Opportunities for Connected Data, Ian Robinson, Jim Webber, Emil Eifrem, Graph Databases: New Opportunities for Connected Data, Ian Robinson, Jim Webber, Emil Eifrem
3. Combinatorics, Graph Theory and Computing: SEICCGTC 2020, Boca Raton, USA, March 9–13, Frederick Hoffman, Springer

4. Graph Theory: An Introduction to Proofs, Algorithms, and Applications, Karin R Saoub, Chapman and Hall/CRC

ICT 7058 Advanced Computer Networks

Overview of data communication model – Internet Multicasting, NAT, VPN – Routing Algorithms – BGP, RIP, OSPF – Differentiated and Integrated Services – SONET, ATM – MPLS -Next generation Internet architectures, Green Communication Networks, and Data Center Networking.

Analysis of Network congestion Mechanism, Routing algorithms, ARQ protocols Multimedia Networking; Implementation of multi-threaded Web Server/Web Proxy with Caching/Filtering features, Sliding Window protocol implementation, performance study of various TCP/IP variants.

Software Defined Network - Comparison between SDN and traditional networks -SDN controller, Switch design, SDN Controller-Switch Protocols, Open Flow Protocol, Control Overhead & Handoff algorithms. Network Function Virtualization -NFV Architecture, Use cases, NFV Orchestration and NFV for 5G.

TEXT & REFERENCE BOOKS

1. Tanenbaum AS, Wetherall DJ. Computer Networks. Fifth edition, Pearson Education, Inc. 2011.
2. Stallings W. Data and Computer Communications. Pearson Education India; 2006.
3. Douglas E Comer. Internet Working with TCP/IP Volume -1, Sixth Edition, Addison-Wesley Professional;2013.
4. Goransson P, Black C, Culver T. Software Defined Networks: a Comprehensive Approach. Morgan Kaufmann; 2014.
5. Chayapathi R, Hassan SF, Shah P. Network Functions Virtualization (NFV) with a Touch of SDN Netw Fun Vir, Addison-Wesley Professional; 2016 Nov 14.
6. Marschke D, Doyle J, Moyer P. Software Defined Networking (SDN) Anatomy of OpenFlow Volume 1. 2015.

ICT 7059 Compilers

Introduction: Introduction, Assembly

Lexical analysis: crafting a scanner by hand, regular expressions, NFA and DFA, scanner generator (e.g.,, lex and JLex)

Context-free grammars: parsing, derivations, parse trees, abstract syntax trees (ASTs)

Syntactic analysis : recursive-descent parsing and LL(k) parsing, bottom-up parsing and LR(k) parsing, parser generators (e.g., yacc, JavaCC and JavaCUP)

Semantic analysis: attribute grammars, symbol table, identification (i.e., binding), type checking

Code generation : syntax-directed translation, Jasmin assembly language, Java Virtual Machine (JVM), Java byte code generation

Optimization and analysis: Functional programming optimizations, Type checking, Local optimization, Local optimization, Control flow graph and data flow analysis

TEXT & REFERENCE BOOKS

1. Compilers: Principles, Techniques, and Tools, Alfred V. Aho, Monica S. Lam, Ravi Sethi, and Jeffrey D. Ullman, Pearson Education, Inc

2. Modern Compiler Design, Dick Grune, Henri E. Bal, Ceriel J.H. Jacobs and Koen G. Langendoen, John Wiley & Sons, Ltd., 2000. ISBN 0471-976970
3. Compiler Design, Reinhard Wilhelm and Dieter Maurer, Addison-Wesley, 1995.
4. Modern Compiler Implementation in Java, Andew W. Appel, Cambridge University Press, 1998.
5. Theory of Parsing, Translation and Compiling, Afred V. Aho and Jeffrey D. Ullman, Addison-Wesley, 1986.
6. Crafting a Compiler with C, C. N. Fisher and R. J. LeBlanc, Jr., Benjamin/Cummings, 1991.
7. Introduction to Compiler Construction, Thomas. W. Parsons, W. H. Freeman and Company, 1992.
8. Compiler Construction, N. Wirth, Addison-Wesley, 1996.

ICT 7060 Advanced Algorithms for Graph and Combinatorial Optimization Problems

Graph theory fundamentals;

Algorithms on graphs: Graph connectivity and traversals, Matching, Shortest path, Isomorphism, Testing membership on families of graphs - Bipartite, Planar, Of bounded tree-width

Some NP-complete and hard problems on graphs: Colourability, Independent sets, Vertex cover, Clique, Cook's Theorem, Proving NP-Completeness, Approximation Algorithms, Local Search Methods

Approximation algorithms for some graph theoretic problems

Resource scheduling problems

Greedy algorithms and scheduling problems: Dynamic programming algorithm for scheduling of weighted intervals

The maximum flow problem and the Ford-Fulkerson algorithm: Maximum flow and minimum cuts, The preflow-push maximum-flow algorithm

Applications of network flow

TEXT & REFERENCE BOOKS

1. Gems of Combinatorial Optimization and Graph Algorithms, Andreas S. Schulz, Martin Skutella, Sebastian Stiller, Dorothea Wagner, Springer
2. Handbook of Graph Theory, Combinatorial Optimization, and Algorithms: 34 (Chapman & Hall/CRC Computer and Information Science Series), Andreas Brandstadt (Editor), Krishnaiyan "KT" Thulasiraman (Editor), CRC Press
3. Combinatorial Optimization and Graph Algorithms, Takuro Fukunaga, Ken-ichi Kawarabayashi, Springer

ICT 7061 Advanced Operating Systems

Abstractions: The Princple of Abstraction * Hardware Resources, OS FunctionalityManaging the CPU and Memory

OS Structure: OS Structure Overview, The SPIN Approach, The Exokernel Approach, The L3 Micro-Kernel Approach

Virtualization: Intro to Virtualization, Memory Virtualization, CPU and Device Virtualization

Parallelism: Shared Memory Machines, Synchronization, Communication, Lightweight RPC, Scheduling, A Shared-Memory Multiprocessor OS

Distributed Systems : Definitions, Lamport Clocks, Latency limits, Active networks, Systems from Components

Distributed Object Technology : Spring Operating System, Java RMI, Enterprise Java Beans

Design and Implementation of Distributed Services: Global Memory System, Distributed Shared Memory, Distributed File System

System Recovery: Lightweight Recoverable Virtual Memory, Rio Vista, Quicksilver

Internet Scale Computing : Giant Scale Services, MapReduce, Content Delivery Networks

Real-Time and Multimedia : Time sensitive Linux, Persistent temporal streams

Security : Principles of Information Security Security, The Andrew System

TEXT & REFERENCE BOOKS

1. ADVANCED CONCEPTS IN OPERATING SYSTEMS, by Mukesh Singhal, Niranjan Shivaratri, McGraw Hill Education
2. Robert Love: Linux Kernel Development , 3rd edition
3. A. Tanenbaum, A. Woodhull: Operating Systems: Design and Implementation, 2 nd ed. 1997, Prentice Hall.
4. UNIX Systems for Modern Architectures, 1994, Curt Schimmel, Addison Wesley.
5. Linux Kernel Internals, M. Beck, H. Böhme, M. Dziadzka, U. Kunitz, R. Magnus, and D. Verworner, 1997, Addison Wesley.
6. Marshall K. McKusick, Keith Bostic, Michael J. Karels, John S. Quarterman: The Design and Implementation of the 4.4BSD Operating System, 1996, Addison Wesley.
7. Helen Custer: Inside the Windows NT File System, 1994, Microsoft Press.
8. Scott Maxwell: Linux Core Kernel Commentary, 1999, CoriolisOpen Press.
9. John Lions: Commentary on UNIX 6 th edition with source code, 1996, Peer-to-Peer Communications. (The famous Lions Book, identical to the 1977 UNSW TR.)

ICT 7062 Computer Vision

Digital Image Processing : Image Formation, Image Filtering Edge Detection, Principal Component Analysis, Corner Detection SIFT, Applications: Large Scale Image Search

Geometric Techniques in Computer Vision : Image Tranformations, Camera Projections, Camera Calibration, Depth from Stereo, Two View Structure from Motion, Object Tracking

Machine Learning for Computer Vision : Introduction to Machine Learning, Image Classification, Object Detection, Semantic Segmentation

TEXT & REFERENCE BOOKS

1. "Computer Vision: A Modern Approach", Forsyth and Ponce,
2. Multiple View Geometry in Computer Vision", Hartley and isserma
3. Computer Vision and Machine Intelligence Paradigms for SDGs: Select Proceedings of ICRTAC-CVMIP 2021, R. Jagadeesh Kannan, Sabu M. Thampi, Shyh-Hau Wang, Springer
4. 3-D Computer Vision: Principles, Algorithms and Applications, Yu-Jin Zhang, Springer
5. Computer Vision and Graphics: Proceedings of the International Conference on Computer Vision and Graphics ICCVG 2022, Leszek J. Chmielewski, Arkadiusz Orłowski, Springer

ICT 7063 Computational Algebra

Axiom: general design principles, user facilities, data structures, domains, etc.

Brief comparison of systems.

Algebraic structures: overview, basic concepts and algorithms. Arbitrary precision operations on integers, rationals, reals, polynomials and rational expressions.

Importance of greatest common divisors and their efficient computation for integers and univariate polynomials (using modular methods).

Multivariate polynomial systems: solution of sets of equations over the complex numbers; construction and use of Groebner bases; relevant algebraic structures and results.

Reliable solution of systems of polynomial equations in one variable; Sturm sequences, continued fractions method.

Relevant QAA Computing Curriculum Sections: Data Structures and Algorithms, Simulation and Modelling, Theoretical Computing

TEXT & REFERENCE BOOKS

1. Computational Algebra, Willem de Graaf
2. Ideals, Varieties, and Algorithms: An Introduction to Computational Algebraic Geometry and Commutative Algebra, David A. Cox, John Little, Donal O'Shea, Springer
3. Introduction to computational linear algebra, Erhel, Jocelyne; Nassif, Nabil; Philippe, Bernard, Chapman & Hall/CRC

ICT 7064 Information and Coding Theory

Introduction to Probability – Random Variables, Random variable, Sample space, Conditional probability, Joint probability. Modeling of Information Sources – Self Information, Entropy, Mutual Information. Source Coding Theory and algorithms – Kraft inequality, Huffman algorithm, Arithmetic coding, Lempel Ziv coding. Modeling of Communication channels – Binary symmetric channel, Binary Erasure channel, Channel coding theorem.

Error Correction Codes – Introduction to Galois fields, polynomial arithmetic, linear block codes for error correction – Generator matrix, Encoding, Parity Check matrix, Decoding – Standard array decoding and Syndrome decoding. Cyclic Codes – Generation of codes, encoding and syndrome decoding.

BCH Codes – Minimal polynomial encoding and decoding. Convolutional encoder – Introduction to Convolutional codes, distance properties – Trellis codes, Viterbi decoder. Numerical problems and MATLAB based problem solving on selected topics of the course.

TEXT & REFERENCE BOOKS

1. Ranjan Bose, "Information Theory, Coding and Cryptography", Tata McGraw Hill, 2nd edition.
2. P.S. Satyanarayana, "Concepts of Information Theory and Coding", Dynaram Publication, 2005
3. Richard B. Wells, "Applied Coding and Information Theory for Engineers" Pearson Education, LPE 2004.
4. Shu Lin and Daniel Castello, "Error Control Coding – Fundamentals and Applications", second edition 2004
5. Thomas M Cover, Joy Thomas, "Elements of Information Theory", MGH 2006.

ICT 7065 Pattern Recognition and Image Processing/Advanced Image Processing

Introduction to digital image processing: Digital image representation, Digital image processing- Problems and applications, Elements of visual perception, Sampling and quantization, relationships between pixels

Two-dimensional systems: Fourier transform and Fast Fourier Transform, Other image transforms and their properties - Cosine transform, Sine transform, Hadamard transform, Haar transform

Image enhancement and restoration : Point operations, contrast stretching, clipping and thresholding, digital negative, intensity level slicing, bit extraction; Histogram modeling- Equalization, Modification, Specification; Spatial operations - Averaging, directional smoothing, median, filtering, spatial low pass, high pass and band pass filtering, magnification by replication and interpolation

Image coding and compression: Pixel coding - run length, bit plane coding, Huffman coding; Predictive and inter-frame coding

Introduction to pattern recognition in images Recognition and classification: Recognition and classification; Feature extraction; Models; Division of sample space

Grey level features edges and lines: Similarity and correlation, Template matching; Edge detection using templates;Edge detection using gradient models; model fitting; Line detection, problems with feature detectors

Segmentation : Segmentation by thresholding; Regions based Segmentation, edges, line and curve Detection

Frequency approach and transform domain

Advanced Topics : Neural networks and their application to pattern Recognition ; Hopfield nets; Hamming nets; perceptron

TEXT & REFERENCE BOOKS

1. “Digital Image Processing”, R. C. Gonzalez and·P. Wintz, Second Edition, Addison-Wesley Publishing, 1987.
2. “Digital Image Processing”, K. Castlemann. Prentice Hall of India Ltd., 1996.
3. “Fundamentals of Digital Image Processing”, A. K. Jain, Prentice Hall of India Pvt. Ltd., 1995.
4. “Pattern Recognition and Image Processing”, Sing Tze Bow, M. Dekker, 1992
5. “Pattern Recognition”, M. James, BSP professional books, 1987.
6. “Fundamentals of Pattern Recognition”, P. Monique and M. Dekker, 1989.

ICT 7066 Research Design and Techniques

Research Methodology: An Introduction - Meaning of Research, Objectives of Research, Motivation in Research, Types of Research, Research Approaches, Significance of Research, Research Methods versus Methodology, Research and Scientific Method, Importance of Knowing How Research is Done, Research Process, Criteria of Good Research

Defining the Research Problem: What is a Research Problem?, Selecting the Problem, Necessity of Defining the Problem, Technique Involved in Defining a Problem, An Illustration

Research Design: Meaning of Research Design, Need for Research Design, Features of a Good Design, Important Concepts Relating to Research Design, Different Research Designs, Basic Principles of Experimental Designs

Sampling Design: Census and Sample Survey, Implications of a Sample Design, Steps in Sampling Design, Criteria of Selecting a Sampling Procedure, Characteristics of a Good Sample Design, Different Types of Sample Designs, How to Select a Random Sample?, Random Sample from an Infinite Universe, Complex Random Sampling Designs

Measurement and Scaling Techniques: Measurement in Research, Measurement Scales, Sources of Error in Measurement, Tests of Sound Measurement, Technique of Developing Measurement Tools, Scaling, Meaning of Scaling, Scale Classification Bases, Important Scaling Techniques, Scale Construction Techniques

Methods of Data Collection: Collection of Primary Data, Observation Method, Interview Method, Collection of Data through Questionnaires, Collection of Data through Schedules, Difference between Questionnaires and Schedules, Some Other Methods of Data Collection, Collection of Secondary Data, Selection of Appropriate Method for Data Collection, Case Study Method

Processing and Analysis of Data: Processing Operations, Some Problems in Processing, Elements/Types of Analysis, Statistics in Research, Measures of Central Tendency, Measures of Dispersion, Measures of Asymmetry (Skewness), Measures of Relationship, Simple Regression Analysis, Multiple Correlation and Regression, Partial Correlation, Association in Case of Attributes, Other Measures

Sampling Fundamentals: Need for Sampling, Some Fundamental Definitions, Important Sampling Distributions, Central Limit Theorem, Sampling Theory, Sandler's A-test, Concept of Standard Error, Estimation, Estimating the Population Mean (μ), Estimating Population Proportion, Sample Size and its Determination, Determination of Sample Size through the Approach Based on Precision Rate and Confidence Level, Determination of Sample Size through the Approach, Based on Bayesian Statistics

Testing of Hypotheses-I (Parametric or Standard Tests of Hypotheses): What is a Hypothesis?, Basic Concepts Concerning Testing of Hypotheses, Procedure for Hypothesis Testing, Flow Diagram for Hypothesis Testing, Measuring the Power of a Hypothesis Test, Tests of Hypotheses, Important Parametric Tests, Hypothesis Testing of Means, Hypothesis Testing for Differences between Means, Hypothesis Testing for Comparing Two Related Samples, Hypothesis Testing of Proportions, Hypothesis Testing for Difference between Proportions, Hypothesis Testing for Comparing a Variance to Some Hypothesized Population Variance, Testing the Equality of Variances of Two Normal Populations, Hypothesis Testing of Correlation Coefficients, Limitations of the Tests of Hypotheses

Chi-square Test: Chi-square as a Test for Comparing Variance, Chi-square as a Non-parametric Test, Conditions for the Application of 2 Test, Steps Involved in Applying Chi-square Test, Alternative Formula, Yates' Correction, Conversion of 2 into Phi Coefficient, Conversion of 2 into Coefficient by Contingency, Important Characteristics of 2 Test, Caution in Using Test

Analysis of Variance and Covariance: Analysis of Variance (ANOVA), What is ANOVA?, The Basic Principle of ANOVA, ANOVA Technique, Setting up Analysis of Variance Table, Short-cut Method for One-way ANOVA, Coding Method 261 Two-way ANOVA, ANOVA in Latin-Square Design, Analysis of Co-variance (ANOCOVA), ANOCOVA Technique, Assumptions in ANOCOVA

Testing of Hypotheses-II(Nonparametric or Distribution-free Tests) : Important Nonparametric or Distribution-free Test, Relationship between Spearman's r's and Kendall's W, Characteristics of Distribution-free or Non-parametric Tests

Multivariate Analysis Techniques: Growth of Multivariate Techniques, Characteristics and Applications, Classification of Multivariate Techniques, Variables in Multivariate Analysis, Important Multivariate Techniques, Important Methods of Factor Analysis, Rotation in Factor Analysis, R-type and Q-type Factor Analyses, Path Analysis

Interpretation and Report Writing: Meaning of Interpretation, Why Interpretation?, Technique of Interpretation, Precaution in Interpretation, Significance of Report Writing, Different Steps in Writing Report, Layout of the Research Report, Types of Reports, Oral Presentation, Mechanics of Writing a Research Report, Precautions for Writing Research Reports

The Computer: Its Role in Research, Introduction, The Computer and Computer Technology, The Computer System, Important Characteristics, The Binary Number System, Computer Applications, Computers and Researcher

TEXT & REFERENCE BOOKS

1. Research Methodology: Methods and Techniques, C.R. Kothari, New Age International Publishers
2. Research Methodology: A Handbook for Beginners, Pagadala Suganda Devi, Notion Press
3. Research Methodology for Management and Social Sciences, Aditham Bhujanga Rao, Excel Books
4. Research Methodology: A Handbook for Beginners, Pagadala Suganda Devi, Notion Press

ICT 7067 Mathematical Models in Health Care

Overview of mathematical modeling, types of mathematical models and methods to solve the same; Discrete time linear models – Fibonacci rabbit model, cell-growth model, prey-predator model; Analytical solution methods and stability analysis of system of linear difference equations; Graphical solution – cobweb diagrams; Discrete time age structured model – Leslie Model; Jury's stability test; Numerical methods to find eigen values – power method and LR method.

Discrete time non-linear models- different cell division models, prey-predator model; Stability of non-linear discrete time models; Logistic difference equation; Bifurcation diagrams.

Introduction to continuous time models – limitations & advantage of discrete time model, need of continuous time models; Ordinary differential equation (ODE) – order, degree, solution and geometrical significance; Solution of first order first degree ODE – method of separation of variables, homogeneous equation, Bernoulli equation; Continuous time models – model for growth of micro-organisms, chemostat; Stability and linearization methods for system of ODE's.

Continuous time single species model – Allee effect; Qualitative solution of differential equations using phase diagrams; Continuous time models – Lotka Volterra competition model, prey-predator models.

TEXT & REFERENCE BOOKS

1. Mathematical Models in Biology and Medicine, J.N. Kapur, East-West Press Private limited.
2. Mathematical Models in Biology, Leah, Edelstein, Keshet, SIAM publications.
3. Mathematical Biology Vol. I, II, 3rd edition, 3.J.D. Murray, Springer publications.

ICT 7068 Health Informatics

Introduction to Health Informatics & Data, Information, and Knowledge: Introduction to health informatics and its significance, Definitions and key concepts in health informatics , Background disciplines, historical overview, and future challenges, Introduction to knowledge hierarchy- Data, information, and knowledge, The definitions of healthcare data and information, Types of healthcare information (internal versus external data and information), The major purposes of maintain patient records, The content and uses of patient records and claim content, The common issues related to healthcare data quality, The challenges associated with measuring and ensuring healthcare data quality, Quality assessment including total quality management and data quality, Introduction to biomedical research and publicly available resources.

The National Landscape of Healthcare IT & History of Healthcare Information System: The major influences shaping the health IT landscape in the US, The roles played by the major government initiatives and private sectors in advancing health IT in the US,The major events that have influences the adoption of health IT and systems, History and evolution of healthcare information systems (HCIS), The major advances in information technology and significant federal initiatives that influenced the adoption of healthcare information systems, The major types of administrative and clinical information systems used in healthcare, Current issues pertaining to the use HCIS.

Medical Algorithms & Medical Decision Making: Various ways to describe algorithms, such as flowchart, pseudocode, and conceptual graph, Introduction to medical algorithms, Algorithms in computer science, such as decision tree and regression, Calculation of measurements of classification performance—sensitivity and specificity, Decision-making process, Medical decision-making process (diagnosis, treatment, monitoring, prognosis), Informatics in clinical decision-making, Introduction to evidence-based medicine, Develop understanding of modeling and simulation, Become familiar with applications of modeling and simulation in biomedicine, Data and information needs of health systems in managing population health, Key health IT tools and strategies for population health management, Concepts of precision medicine

Standards in Health Informatics: Introduction to standards The Need for Health Informatics Standards, The role of federal initiative and legislation that that have significant impact on the adoption of healthcare information standards in the United States, Major types of healthcare information standards and the organization that develop or approve them, The importance of healthcare IT standards to the future of the US health care delivery system.

Knowledge management system & Organizing Health IT services: Introduction to knowledge management, Knowledge discovery, data mining and text mining, Knowledge management and decision making support in biomedicine, The roles, responsibilities, and major functions of the IT department in healthcare organizations, The roles, responsibilities, and major functions of the IT leaders, The various ways to organize IT services, The key attributes of highly effective IT departments The role and major function of the data analytics department.

TEXT & REFERENCE BOOKS

1. Health care information systems: A practical approach for health care management - 4th Edition, Wager, K. A., Lee, F. W., & Glaser, J. P. (2017). Jossey-Bass.
2. Contemporary Health Informatics, Mark L. Braunstein, AHIMA Press, 2014
3. Health Informatics - An Interprofessional Approach, Ramona Nelson, Nancy Staggers, Elsevier Mosby
4. Introduction to Computer Systems for Health Information Technology, Nanette B. Sayles, Kathy C. Trawick, AHiMA

ICT 7069 Advanced Satellite Communication

Recap of SATCOM Fundamentals: Characteristics of LEO, MEO, GEO, Satellites and their Pros and Cons, Satellite Frequency Bands and their Pros and Cons, Multiplex Schemes: FDMA, TDMA, CDMA, SCPC, MCPC, etc., Linear and Circular Polarization, Satellite Beams: Global, Regional, Spot Beams, Steerable Beams, EIRP and G/T, Link Planning: Transmit Power, Antenna Gains, Free Space Loss, Receive Power, etc. Transponder: Carriers, Channel Assignments, Bent Pipe, Regenerative Type

System Design and Engineering: Link Path Calculations, Link Budget Parameters, Isotropic vs Directional Antenna, Design Calculations for Antenna Gain and Beamwidth, Effective Isotropic Radiated Power (EIRP) and Power Flux Density (PFD), Solar Outrage Calculations, Atmospheric Attenuation.

Satellite Radio Link Planning Workshop: Software Tool, Design Parameters, Link Budget Design, Case Study: Detail Design via Software,Antenna Gain and Beamwidth, Factors Affecting Antenna Gain, Calculating Antenna Gain and Beamwidth via Software, Effective Isotropic Radiated Power (EIRP), Path Loss Calculations, Look Angles: Elevation and Azimuth Angle, Transponder: Antenna, LNA, BPF, Down-Converter, HPA, Adjacent Channel Interference, Input and Output Back Off, Uplink Power Control (UPC), LNB Noise Figure, Designing via Software: Uplink/Downlink, ASI, Rain Model, Satellite, and Carrier-related Parameters, Figure of Merit (G/T) and Energy per BIT (Eb/No), Transponder Types , ITU Rain Regions, FEC Code Rate, Carrier Spacing, Roll-off Factor, Implementation Loss, Generating Final Report/Design, More Design Exercises, Orbital Math: Gravitation vs Centripetal Force, Calculating Geosynchronous Radius, Calculating Geosynchronous Velocity, More Exercises

VSAT Applications – PDH, SDH, DVB and Ethernet: Evolution of DVB Standards, Interfaces on Satellite Modem, Legacy Interfaces: PDH and SDH, TDM vs Ethernet Interfaces, OAM, Mobile Backhaul, Satellite News Gathering

Additional Link Planning Exercises: More Case Studies, Computation of Look Angles, Bent Pipe vs Advanced Transponder, Analysis of Design Output Results, Optimization of Design, Examples and Exercises.

Security in Space: Increasingly Sophisticated Threats, Cybersecurity for tomorrow's Space Industry, Satellite Industry Leadership in Cybersecurity Collaboration, ITU's Global Cybersecurity Agenda, Core Principles for Cybersecurity, Major Security Issues, Classification of the Major Scientific Contributions dealing with Security in SATCOM, Integration of NTN with TN and New Security Environment, Security Challenges in Space and Ground Segments, IPSec Architecture, Potential Security Solutions, Security Key Management

VSAT Equipment and Bandwidth Procurement: SATCOM Market Structure and Ecosystem, Defining the Needs, Procuring End-to-end vs Component Services, Technical Considerations , Shared Vs Committed Bandwidth, Bursting Capacity, Selecting a Partner Provider, RFP, RFQ, RFI, Evaluating Proposals, Signing the SLA,
Carrier Ethernet Overview: Role of MEF, ITU and IEEE, Standardized Services, Services Operations, Administration and Management (SOAM), Reliability, Point to Point and Multipoint Services in SATCOM, Quality of Service and Class of Servicem, Performance Management.
Satellite Solutions for 4G/5G: Satellite Benefits for 5G, Bandwidth and Latency Requirements of 5G Use Cases. 5G Use Cases: eMBB, uRLLC, mMTC, Technical and Standardization Issues
VoIP and IPLC Over Satellite: Characteristics of VoIP, Challenges of VoIP over Satellite, QoS and Traffic Prioritization, Comparison Techniques, Bandwidth Requirement, Bit Rate Calculations, Transponder Management, VoIP Protocols , International Private Leased Circuit (IPLC), International Ethernet Private Line (IEPL), Features of IPLC and IEPL, VPN Via Satellite, Satellite E-Line and EVPL

Transponder Bandwidth Calculations:
Transponder Bandwidth Equilvalent, Bandwidth-Limited vs Power-Limited, Factors that affect Bandwidth and Power, Relationship of Modulation, FEC, and BER, Symbol Rate and Roll Off Factor.
Navigation Systems and Synchronization: GPS, GLONASS, Beidou, Galileo, etc., GNSS-1 vs GNSS-2, Global Satellite-Based Augmentation Systems, Comparison of Systems, GPS Frequencies and Orbits, Positioning, Navigation and Timing , Network Synchronization in Communication Networks, Clock Stratum, Translation of Time from GPS, GPS Signal Concerns and Security Issues, NTP vs PTP (IEEE 1588 v2)

TEXT & REFERENCE BOOKS

1. Satellite Communications Systems Systems, Techniques and Technology, Gerard Maral, Michel Bousque, Wiley .
2. Satellite Communication, P. Banerjee, PHI Learning
3. Satellite Communication, Virgil Labrador

ICT 7070 Information Systems and Securities

Overview of Information System: History of Information Systems and its Importance, Basic Concepts and Terminologies, Changing Nature of Information Systems.
Principles of Information Security: Security Goals of Information- Confidentiality, Integrity Availability, Information Security Threats and Attacks, Security Services and Mechanisms, Security in Mobile and Wireless Computing, Security Challenges in Mobile Devices, Authentication Service Security, Security Implication for Organizations, Laptops Security Basic, Security Technology- Firewalls and VPNs, Intrusion Detection and Prevention Systems.
Access Control: Types and Parts of Access Control, Threats to Access Controls, Effects of Access Control Violations. Malicious Attacks.
Threats and Vulnerabilities: Classification of Threats and Assessing Damages, Security Breach, Malicious Software, Countermeasures.
Intellectual Property Right (IPR): Concept of Virtual Property, Trademarks, Copyrights, Patents, Data Protection Laws, Plagiarism, Software Piracy, Issues in Data and Software Privacy, Requirements of a Website, E-Marketing, E-Advertising, Online Payment Collection System, Legal.
Ethnical and Professional Issues in Information Security: Legal Dimensions in Cyber World, IT Acts and Cyber Crime, IT Act, Information Assurance and E-Governance, ICT Act, ICT Policy, Trademark, Copyright and Patent Law of Bangladesh.
Cryptography and Steganography: Brief History, Basic Concepts and Terminologies, Business and Security Requirement, Applications and Uses in Information System Security, Cryptographic Hash Functions, Digital Signatures and Certificate Authorities, Integrity.
Authentication and Key Management: Message Integrity and Message Authentication; Passwords, Challenge-Response, Zero-Knowledge and Biometric Authentications; Symmetric and Public-key Distributions; Information Security Standards: NIST, ISO, IEC, W3C, IETF, ITU-T, ANSI.

TEXT & REFERENCE BOOKS

1. Fundamentals of Information Systems Security by David Kim, Michael G Solomon; 3rd Edition.

2. Principles of Information Security by Michael E Whitman, Herbert J Mattord; 4th Edition.
3. Cryptography and Network Security by Behrouz A Forouzan; 2nd Edition.
4. Cyber Law: The Law of the Internet by Jonathan Rosenoer.
5. Cyber Law in Bangladesh by Dr. Zulfiquar Ahmed.

ICT 7071 Advanced Wireless and Cellular Communications

Fundamentals: General Structure of 4G Signals; Next Generation Internet; Cloud Computing and Network Virtualization; Wireless Grids and Clouds.
Adaptive Coding: Adaptive and Reconfigureable Block Coding/Convolutional coding; Concatenated Codes with Interleavers; Distributed Source Coding. Adaptive and Reconfigureable Modulation; Space time coding.
Multiuser Communication: Pseudorandom Sequences; Multiuser CDMA Receivers; MMSE Linear Multiuser Detection; Single User LMMSE Receivers for Frequency Selective Fading Channels; Signal Subspace-Based Channel Estimation for CDMA Systems; Iterative Receivers for Layered Space Time Coding.
Channel Estimation and Equalization: LMS equalizer; Turbo Equalization; Kalman Filter Based Joint Channel Estimation and Data Detection Over Fading Channels.
Ultra Wide Band Radio; Linear Precoding for MIMO Channels: Space Time Precoders and Equalizers for MIMO Channels,
Advanced Wireless Networks: Cognitive Networks; Relay-Assisted Wireless Network. Biologically Inspired Paradigms in Wireless Networks: MANET; Wireless Sensor Network.
6G Future Vision: Requirements, Design Issues and Applications.
5G Innovation – Using New Technical Capabilities to Explore New Use-Cases.
Enhanced Massive Machine Type Communications for 6G Era

TEXT & REFERENCE BOOKS

1. Advanced Wireless Communication and Internet by Savo G. Glisi, Willy; 3rd Edition.
2. Channel Coding for Telecommunications by Martin Bossert; Willy.
3. Recent Advances in Wireless Communications and Networks by IntechOpenU, Madhow.
4. Fundamentals of Digital Communication by Cambridge University Press; 2008.
5. Digital Communications by J. G. Proakis, McGraw-Hill, 2001; 4th Edition.
6. Principles of Communication Engineering by J. M. Wozencraft and I. M. Jacobs; Wiley, 1965.
7. Digital Modulation and Coding by Stephen G. Wilson; Pearson Education (Asia) Pte. Ltd. 2003.
8. Wireless Digital Communications: Modulation and Spread Spectrum Applications by Kamilo Feher; Prentice-Hall of India, 2004.

ICT 7072 Big Data Analytics

Introduction: Information Technology Fundamentals, Enterprise Hardware & Software, Virtualization, Evolution of IT, Information Technology Leadership & Systems.
Cloud Computing: What does “X as a Service” mean (X=Platform, Infrastructure or Software), Service Models & Business Benefits, Scalability, Reliability & Security, Development frameworks (e.g. AWS, Azure, AppEngine).
Data Science & Analytics: Trends in data science for marketing, data analytics, evolution of marketing and data science, data visualization, data visualization in information design, the tools and software used in data visualization, importance of data visualization.
Artificial Intelligence: History of artificial intelligence, how expert systems and artificial intelligence are used to solve complex problems, Machine learning models, Deep neural nets.
Big Data & Cyber Security: Big Data technologies, Smart Healthcare systems, Big data analytics. Big data computing platforms, Big data insights and adoption, Large-scale data system, anomaly detection, Data streaming and big data.
Internet of Things: The “Post-PC” Era, IoT applications 5G Network, Blockchain Technology, different forms and types of digital and virtual currencies, the creation of cryptocurrency and the uses of blockchain technologies, Ethical, Economical & Social Impact of Current Technology Trends.

TEXT & REFERENCE BOOKS

1. Textbook of Emerging Trends in Information Technology Paperback – 1 January 2011 by Ravi P Patki, Publisher: Techtree Educations.
2. Introduction to Information Systems: People, Technology and Processes, 4th edition.
3. Published by Pearson (July 6th 2020) - Copyright © 2021, Patricia Wallace Johns Hopkins University.

ICT 7073 Internet of Things

IOT: What is the Internet of Things (IOT), Different parts or components of IOT Elements of an IOT Ecosphere, Technology. Trends of IOT and implications, Overview of Governance, Privacy and Security Issues. Architectural formation and communication models.
RFID Technology: Principle of RFID, Components of an RFID system, RFID Applications. Wireless Sensor Networks: The node, Connecting Nodes, Securing Communication. Power line Communication technologies: PLC technologies and standards, Architectures for home network applications, IOT using PLC technology.
Cloud Computing: Cloud Computing Services. Middleware and Big Data.
HTTP: basics of the HTTP protocol, use of HTTP in IoT applications, request/response, and event subscription communication patterns, UPnP: basics of the UPnP protocol, use of UPnP to discover devices in an ad hoc local area network, build devices that publish such discoverable services and events.
CoAP: Basic, Adding CoAP to sensor, actuator and using CoAP in controller. MQTT protocol: Basic, Adding MQTT support to sensor, actuator and controller.
Applications on Smart Cities, Industrial Internet of Things (IIoT), Smart Grids, Smart Homes, Smart Agriculture, Smart Health, Smart Mobility, Smart Environment.

TEXT & REFERENCE BOOKS

1. The Internet of things: connecting objects to the web / edited by Hakima Chaouchi. ISBN 978-1-84821-140-7
2. Learning Internet of Things, Peter Waher, PACKT Publishing, 2015
3. Distributed and Cloud Computing, Kai Hwang, Geoffrey C. Fox, Jack J. Dongarra, Elsevier, 2012.
4. Internet of Things and Data Analytics Handbook, Hwaiyu Geng, John Wiley & Sons, 2017.
5. Principles of Internet of Things (IoT) Ecosystem: Insight Paradigm, Sheng-Lung Peng, Souvik Pal, Lianfen Huang, Springer, Intelligent Systems Reference Library, Volume 174.

ICT 7074 Applied Cryptography

Introduction, Attacks on crypto, Crypto history, One time pad, Perfect secrecy, Stream ciphers, Semantic security.
Block ciphers, DES, Attacks on block ciphers, AES, Using block ciphers, EBC, CBC, CTR.
Message integrity, MAC, Collision resistance, Authenticated encryption.
Basic key exchange, Number theory review, Public key crypto intro, RSA, El Gamal.
Key management and distribution, Digital signatures, Digital certificates, PKI, Identity based encryption.
Identification and authentication, Zero knowledge protocols, Kerberos, Electronic mail security.
Web and transport level security, IP security, Wireless network security, Anonymous communication, TOR, Cryptocurrencies, Bitcoin.
Hardware–based security, Physically Unclonable Function, Trusted Platform Module, Quantum cryptography.

TEXT & REFERENCE BOOKS

1. Cryptography and Network Security: Principles and Practice (6th Edition) by William Stallings.
2. The Handbook of Applied Cryptography by Menezes, van Oorschot, and Vanstone.
3. Introduction to modern cryptography, Jonathan Katz, Yehuda Lindell, Chapman & Hall/CRC, 2008.
4. A Graduate Course in Applied Cryptography, Dan Boneh and Victor Shoup, 2020, http://toc.cryptobook.us/
5. Ren J and Wu J. Survey on Anonymous Communications in Computer Networks. Computer Communications. 2010, 33(4): 420–431.
6. R. Dingledine, N. Mathewson, and P. Syverson. Tor: The second-generation onion router. In Proceedings of the 13 USENIX Security Symposium, August 2004.

ICT 7076 High Speed Computer Networks

Introduction: A Brief Networking History, The Need for Speed and Quality of Service, Advanced TCP/IP and ATM Networks.
Protocols and Network Fundamentals: Protocols and TCP/IP Suite: The Need for a Protocol Architecture, The TCP/IP Protocol Architecture, The OSI Protocol Architecture, Internetworking.
Data Networks: Packet-Switching Networks, Frame Relay Networks, Congestion in Data Networks and Internets.
High Speed Networks: Asynchronous Transfer Mode, ATM Protocol Architecture, ATM Logical Connections, ATM Cells, ATM Service Categories, ATM Adaptation Layer.
High-Speed LANs: Fast Ethernet and Gigabit Ethernet, ATM LANs. Performance Modeling and Estimation: Overview of Probability and Stochastic Processes: Probability, Random Variables, Stochastic Processes, Queuing Analysis, Self-similar Traffic.
End-System Traffic Management: Link-level Flow and Error Control: The Need for Flow and Error Control, Link Control Mechanisms, ARQ Performance.
Transport-level Traffic Control: Transmission Control Protocol (TCP), TCP Congestion Control, Performance of TCP over ATM, Real-time Transport Protocol.
Network-Traffic Management: Internetwork traffic management: The Internet Protocol (IP), IPv6, Integrated Services Architecture (ISA), Queuing Discipline, Random Early Detection.
Internet Routing: Overview of graph theory and least-cost path: Elementary Concepts of Graph Theory, Shortest Path Length Determination, Routing Protocols: Internetwork Routing Principles.

TEXT & REFERENCE BOOKS

1. High-Speed Networks: TCP/IP and ATM Design Principles by William Stallings.
2. High-Speed Networks and Internet: performance and quality of service by William Stallings.
3. Architecture and Protocols for High Speed Networks by Otto Spaniol.
4. Traffic Management for High-Speed Networks by H. T. Kung.

ICT 7077 Applied Cyber Security and Cryptocurrency

Foundations of Cyber Security : Cyber Security principles, security lifecycle, threat models, cyber laws, data confidentiality, integrity, and availability, and dynamics of Cyber Security.
Foundations of Information Security: Risk Management, Cryptography , Network Security, Cloud Security.
Understanding Cyber Attacks: Types of Cyber Attacks, Threats and Threat Actors, Tactics, Techniques, and Procedures (TTP), Kill Chain Methodology, SolarWinds and Colonial Pipeline Attacks.
Designing Security Controls: Detecting Security Threats, SIEM Purpose, Interpreting Computer-Generated Logs, Cyber Threat Intelligence, Network and Web Application Firewalls , Antivirus Applications, Shell Scripting.
Introduction to Cryptocurrencies, Become a Cryptocurrency User – Wallet Protection, Exploring Bitcoin Transactions, Cryptocurrencies beyond Bitcoin, Introduction to Blockchains, Global Adoption and Regulatory Landscape, Smart Contract Fundamentals, Blockchain Applications beyond Banking and Finance I, Blockchain Applications beyond Banking and Finance II, Blockchain Applications for Banking and Finance, Traditional Crowdfunding vs ICOs vs STOs, The Future of Cryptocurrencies and Blockchain.

TEXT & REFERENCE BOOKS

1. Applied Cyber Security and the Smart Grid: Implementing Security Controls into the Modern Power Infrastructure, Eric D. Knapp and Raj Samani
2. Practical Cybersecurity Architecture: A guide to creating and implementing robust designs for cybersecurity architects" by Scott Spencer.
3. Mastering Bitcoin: Unlocking Digital Cryptocurrencies" by Andreas M. Antonopoulos
4. Cryptocurrency Security: Everything You Need to Know", Miles Price

ICT 7078 Digital Integrated Systems Design

MOS technology and device fabrication overview: Review of MOSFET transistor device, static and dynamic behavior via analysis and SPICE circuit models and simulations, Review of the CMOS inverter, Designing Combinational Logic Gates, with Layout Design Rules and CMOS Layout Techniques, Scaling and submicron technology issues.
Designing Sequential Logic Circuits: Timing Metrics for Sequential Circuits, Classification of Memory Elements, Static Latches and Registers, Dynamic Latches and Registers, Pulse Registers, Sense-Amplifier Based Registers, Pipelining: An Approach to Optimize Sequential Circuits, Non-Bistable Sequential Circuits, Implementation.
Strategies for Digital ICs: From Custom to Semicustom and Structured-Array Design Approaches, Custom Circuit Design, Cell-Based Design Methodology, Array-Based Implementation Approaches.
Coping with Interconnect: Capacitive Parasitic, Resistive Parasitic, Inductive Parasitic, Advanced Interconnect Techniques, Introduction to Networks-on-a-Chip (NoC).
Timing Issues in Digital Circuits: Timing Classification of Digital Systems, Synchronous Design-An In-Depth Perspective, Self-Timed Circuit Design, Synchronizers and Arbiters, Clock Synthesis and Synchronization Using a Phased-Locked Loop (PLL).
Designing Arithmetic Building Blocks: Datapaths in Digital Processor Architectures, The Adder, The Multiplier, The Shifter, Other Arithmetic Operators, Power and Speed Trade-Offs in Datapath Structures.
Designing Memory and Array Structures: The Memory Core, Memory Peripheral Circuitry, Memory Reliability and Yield, Power Dissipation in Memories, Case Studies in Memory Design.

TEXT & REFERENCE BOOKS

1. Digital Integrated Circuits: A Design Perspective*:* 2nd ed. Prentice Hall, 2002 by Jan M. Rabaey, Anantha Chandrakasan, Borivoje Nikolic.
2. Modern VLSI Design: Systems on Silicon by W. Wolf, Prentice; 2nd Edition, 1998.
3. Synthesis and Optimization of Digital Circuits by G.De Micheli, McGraw-Hill; 1994 Edition.
4. Logic Synthesis and Verification Algorithms by G. Hachtel and F. Somenzi, Kluwer; 1998 Edition.

ICT 7079 Project Management and Quality Assurance

Project Planning: Overview, Capital expenditure, Phases of capital budgeting, Project development cycle, 7-s of project management, Requirements of a project manager, Forms of project organization.
Project Analysis: Market Analysis, Technical Analysis, Financial Analysis, Risk Analysis, Social cost Benefit Analysis.
Project Control: Control Systems, Control of major constraints, Project management software

information systems, Performance of Evaluation, Abaudonment Analysis, Behavioral issues in Project Management.
Quality Management: Quality systems, ISO 9000 series, ISI, Benchmarking, Quality Function development (QFD), Total Productive Maintenance (TPM).
Concept Sampling: Sampling designs and schemes, Errors in sampling, Simple random sample, stratified random sample, Cluster sample, Sample size destination, Estimating population mean, Estimating population proportion.

TEXT & REFERENCE BOOKS

1. Projects preparation, Apprisal, Budgeting Implementation – Prasanna Chandra – Tata McGraw Hill
2. Projects – Planning, Analysis, Selection, Implementation Review – Prasanna Chandra – Tata McGraw Hill
3. Project Management – Harvey Maylor – Pearson Education
4. Total Quality Management – Dale H. Besterfield – Pearson Education
5. Quality control and Improvement – Amitava Mitra – Pearson Education
6. Quality assurance and TQM –

ICT 7080 Leadership and Human Resources Management

Introduction of Human Resource Management: Nature, Definition and Challenges, External and Organizational Environments, Job Analysis and Design, Human Resource Planning, Recruiting Employees, Selecting Employees Orientation and Employees Training.
Management and Organizational Development: The Organizational Reward System, Career Development, Employee Safety and Health, International Human Resource Management.
Leadership and Management Development: Human Resource Management Practice in Context, Coaching and Mentoring, Leading Organizational Design and Development, Research Methods and Research Based Output.
Global Business Strategy: Innovation Management in a Digital Age, Success Through Business Ethics, Leading, & Developing People, Strategic Human Resource Management, Coaching, Mentoring & Development, Relations, Organizational Development, Responsibility of Directors, Business Project, Professional Development.
Organization Development: Theoretical and Historical Base, The OD Process, Implications of OD in Globalized, Environment, OD in the Philippines, Future Challenges in OD, Global Expansion of Organizational, Infrastructure: Framework and Systems, OD and Organization Culture, Theoretical Bases of organization, Development, Managing the OD process, Organizational culture and change, Organization development and other Ethical Branding.
Partnering for and Embracing Change: Emotional Intelligence, The importance of EI for leaders, The impact of EQ versus IQ, Measuring EQ, The Model of EQ, The IQ Communication Style, The EQ Communication Style, Bridging the GAP between IQ and EQ, Hiring, Emotional Intelligence as HR Leverage.

TEXT & REFERENCE BOOKS

1. Fundamentals of Human Resource Management 8th Edition; by Raymond Noe and John Hollen Beck 2020
2. Human Resource Management 10th Edition; Raymond Noe; John Hollen Beck; Barry Gerhart and Patrick Wright 2017
3. Human Resource Selection; Robert Gatewood 2016

ICT 7081 Geographical Information Systems

Introduction to GIS: Spatial Thinking, Geographic Concepts, Geographic Information Systems for Today and Beyond, Map Anatomy, Maps and Map Types, Map Scale, Coordinate Systems, and Map Projection, Map Abstraction.
Data Models for GIS: Data and Information, Data about Data, Finding Data, Raster Data Models, Vector Data Models, Satellite Imagery and Aerial Photography.
Geospatial Data Management: Geographic Data Acquisition, Geospatial Database Management, File Formats, Data Quality, Data Characteristics and Visualization, Descriptions and Summaries, Searches and Queries, Data Classification.
Geospatial Analysis: Single Layer Vector Operations Analysis, Multiple Layer Vector Operations Analysis, Raster Data, Basic Geoprocessing with Raster, Scale of Analysis, Surface Analysis, Spatial Interpolation, Surface Analysis: Terrain Mapping.
Geographic Data Analysis: Watershed Analysis. Terrain Analysis, Network Analysis Spatial Interpolation, Geosocial Data Mining, Explore Patterns.

TEXT & REFERENCE BOOKS

1. Chang, Kang-tsung, 2019. Introduction to Geographic Information Systems, McGraw Hill Higher Education, 9th Edition, ISBN10: 1259929647, ISBN13: 9781259929649 or more recent edition.
2. Lo, C.P. and Yeung, Albert K.W., 2002. Concepts and Techniques of Geographic Information Systems, Prentice Hall, New Jersey, ISBN 0-13-080427-4; 2nd Edition, 2007
3. Tor Bernhardsen, 2002. Geographic Information Systems - an Introduction, 3rd Edition, John Wiley & Sons, Inc. ISBN 0-471-41968-0
4. Christopher Jones, 1997. Geographical Information Systems and Computer Cartography, Longman, ISBN 0 582

ICT 7082 Natural Language Processing

Introduction: What is natural language processing, regular expressions and automata CFGs for English, NLTK, Python 3 and the Jupyter Notebook, Introduction to HPC.
Morphology: APIs, Social Media, Web Scraping, Building your Corpus, FSTs, Phonetics, Phonology and text-to-speech, N-grams and machine learning.
Pre-processing: Word pronunciation and spelling, Automatic speech recognition, Word classes and POS tagging, Tokenization, N-grams and Scriptio continua, Stemming and Lemmatization, Synsets and Hypernyms, Tokenizing Corpus.
Parsing and Syntax: Basic parsing with CFGs, Parsing problems and some solutions, Probabilistic and lexicalized parsing.
Semantic Analysis: Meaning representations and semantic analysis, Lexical semantics, Word sense disambiguation OS Tagging and Stopwords, Text “Features” and TF-IDF Classification, The “Words” in a “Text”, Named Entity Recognition (NER).
Advanced Structure and Application: Document Clustering and Word Vectors, Advanced Vector Analysis, Robust semantics and information retrieval, Hidden Markov and maximum entropy models. Hidden Markov and maximum entropy models.

TEXT & REFERENCE BOOKS

1. Daniel Jurafsky, James H. Martin,"Speech and Language Processing: An Introduction to Natural Language Processing, Computational Linguistics and Speech Recognition", Prentice Hall, 1st edition, 2000.
2. Christopher D. Manning, Hinrich Schtze,"Foundations of Statistical Natural Language Processing", The MIT Press; 1st edition, 1999.
3. Natural Language Understanding James F. Allen

ICT 7083 Recent Trends in ICT

Introduction: Information Technology Fundamentals, Enterprise Hardware & Software, Virtualization, Evolution of IT, Information Technology Leadership & Systems.
Cloud Computing: What does “X as a Service” mean (X=Platform, Infrastructure or Software), Service Models & Business Benefits, Scalability, Reliability & Security, Development frameworks (e.g. AWS, Azure, AppEngine).
Data Science & Analytics: Trends in data science for marketing, data analytics, evolution of marketing and data science, data visualization, data visualization in information design, the tools and software used in data visualization, importance of data visualization.
Artificial Intelligence: History of artificial intelligence, how expert systems and artificial intelligence are used to solve complex problems, Machine learning models, Deep neural nets.
Big Data & Cyber Security: Big Data technologies, Smart Healthcare systems, Big data analytics. Big data computing platforms, Big data insights and adoption, Large-scale data system, anomaly detection, Data streaming and big data.
Internet of Things: The “Post-PC” Era, IoT applications 5G Network, Blockchain Technology, different forms and types of digital and virtual currencies, the creation of cryptocurrency and the uses of blockchain technologies, Ethical, Economical & Social Impact of Current Technology Trends.

TEXT & REFERENCE BOOKS

1. Textbook of Emerging Trends in Information Technology Paperback – 1 January 2011 by Ravi P Patki, Publisher: Techtree Educations.
2. Introduction to Information Systems: People, Technology and Processes, 4th edition
3. Published by Pearson (July 6th 2020) - Copyright © 2021, Patricia Wallace Johns Hopkins University