M.TECH- IT

Applicable with effect from 2023 admitted batch and onwards

Mathematics for IT (IT 4001)

Objective: This course covers linear algebra, Matrix theory and probability (discrete & continuous) for information technology. The objective is to give fundamental knowledge to students and application on IT with more emphasis on problem solving

Course outcome

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

- learn fundamentals of Mathematics for IT and
- apply these knowledge in practical problems

Linear Equations

Systems of linear equations; Row reduction and echelon forms; Matrix operations, including inverses; Linear dependence and independence; Subspaces and bases and dimensions; Orthogonal bases and orthogonal projections; Gram-Schmidt process; Projections; Linear models and least-squares problems; Determinants and their properties.

Eigenvalues and eigenvectors

Eigenvalues and eigenvectors; Diagonalization of a matrix; Symmetric matrices; Positive definite matrices; Similar matrices; Linear transformations; Singular Value Decomposition.

Events and Probability Spaces

Events and Probability Spaces; Conditional Probability; Independence; Random Variables and Distributions; Expectation, Limit Theorems, Deviations; Markov Chains; Random Walks.

Text Books

- Gilbert Strang. Introduction to Linear Algebra.
- Bertsekas, Dimitri, and John Tsitsiklis. Introduction to Probability.

Advanced Programming Practices (IT 4002)

Objective: To revise basic programming skills and coding data structures for PG (IT) students

Course outcome

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

- revise their skills in basic programming and data structures.
- They shall have the ability to solve problems using basic data structures in C and will be poised to implement more complicated algorithms that they shall encounter in later semesters

Quick overview on C language

Pointers and arrays, Linked lists, Dynamic tables

Disjoint sets using trees

Hashing by chaining, Perfect hashing, Heaps using trees Search algorithms for graphs (DFS & BFS) Balanced trees, B-tree, Kruskal's algorithm, Eulerian path, Hamiltonian cycle

Shell scripts in Linux environment

Programming in bash and whiptail, Automatic testing using shell scripts.

Text Books

Reference

- Pro Bash Programming by Chris F.A. Johnson, Apress.
- C Programming Language (Ed 2) by Brian W. Kernighan and Dennis M. Ritchie, Prentice Hall
- Data Structures Using C and C++ by Yedidyah Langsam, Moshe J. Augenstein and Aaron M. Tenenbaum, Pearson
- Introduction to Algorithms (Ed 3) by TH Cormen, CE Leiserson, RL Rivest and C Stein, MIT Press.

Introduction to Machine Learning (IT 4003)

Objective: This course gives an introduction to machine learning. It is about unified understanding of the models and algorithms used in machine learning

Course outcome

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

- to understand basic concepts and they will be able to successfully apply it on real datasets.

Introduction to Machine Learning

Course Logistics, Supervised learning (Distance based methods - kNN), Decision Trees for Classification and Regression, Random Forest, Bagging, Boosting, Linear Regression

Learning via Probabilistic Modeling

(Naïve Bayes, MLE, MAP), Probabilistic Models for Supervised Learning: Discriminative and Generative Approaches, Basics of Convexity, Gradient Descent, Stochastic GD, Hyperplane based Classifiers (Perceptron and SVM), SVM Multiclass and One-Class SVM, Making Linear Models Nonlinear via Kernel Methods

Unsupervised Learning

K-means Clustering and Extensions Parameter Estimation in Latent Variable Models, Expectation Maximization, Model Selection, Evaluation Metrics, Learning from Imbalanced Data, Linear and Non-Linear Dimensionality Reduction (PCA, LLE, Isomap etc), Bias/Variance Trade-off, Some Practical Issues, Semi-supervised and Active Learning.

Introduction to Artificial Neural Networks

Introduction to Deep Neural Networks, Learning to Recommend via Matrix Factorization/Completion, Reinforcement Learning

Text Books

Reference

- Christopher Bishop, “Pattern recognition and machine learning”, Springer, 2007.
- Duda, Peter Hart, David Stork, “Pattern Classification”, Wiley; Second edition
- Tom Mitchell, “Machine Learning”.
- Hal Daumé III, A Course in Machine Learning (http://ciml.info), 2015
- Kevin Murphy, “Machine learning: a probabilistic perspective”, MIT Press, 2012.
- Etham Alpaydin, “Machine Learning”, (https://www.cmpe.boun.edu.tr/~ethem/i2ml3e/)
- Hal Daumé III, “A Course in Machine Learning (CIML)”, 2017 (freely available online)
- Kevin Murphy, “Machine Learning: A Probabilistic Perspective (MLAPP)”, MIT Press, 2012

Image and Video Processing (IT 4004)

Objective: To provide the basic understanding of digital image formation and visualization, relationships between spatial and frequency, the understanding of mapping the signal processing techniques to the digital image and to provide an idea of multimedia data (image, video) and exposure to various image and video compression standards

Course outcome

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

- apply the knowledge gained during the course to solve various real time problems.
- shall be able to develop new state of the art image and video processing methods.

Digital Image Fundamentals

Simple image model, digital image formation, sampling, quantization, resolutions and representation, relationship among pixels, types of digital images. Color Image Processing: Color Representation, Chromaticity Diagram and Color Spaces, types of digital imaging and application areas. Enhancement- Point Processing: Contrast Stretching, Power-law and Gamma Transformation. Histogram Processing: Histogram Equalization and Matching.

Filtering and Restoration

Degradation function and Noise Models, Spatial Domain Filtering: Correlation and Convolution, Smoothing Linear and Nonlinear Filters: Mean and Median Filters, Adaptive Filtering, Sharpening Linear and Nonlinear Filters: Derivative, Laplacian, Unsharp Masking, High-boost Filtering. Frequency Domain Filtering: Filtering: Low-pass (Smoothing) & High-Pass (Sharpening), Ideal, Butterworth and Gaussian Filtering, Unsharp Masking and High-Boost Filtering, Homomorphic Filtering, Periodic Noise Reduction and Inverse Filtering & Wiener Filtering.

Edges, Lines and Boundary Detection

First and Second Order Edge Operators, Multi-scale Edge Detection, Canny Edge Detection Algorithm, Hough Transform: Line and Edge Detection, Morphological Operations and Application: Boundary, Skelton, Convex-Hull, Thinning, Pruning etc. Segmentation & Feature Extraction: Model-based and probabilistic methods and Image Classification Optimal and Multilevel Thresholding, Gray Image Segmentation, Watershed Algorithm.

Compression

Lossy and Lossless compression techniques, JPEG, JPEG2000 and Variants, Introduction to video processing, Compression standards and formats (MPEG & H.XXX), Video Streaming.

Text Books

- Digital Image Processing (3rd Edition) by Willam K. Pratt, John Willey & Sons

Reference

Research Methodology & IPR (AS 4100)

Objective: To provide students with basic of research Methodology and IPR

Course outcome
At the end of this course, Students will be able to

- understand the basis basic of research Methodology
- have basic knowledge of IPR, patent filing and other related aspect.

Introduction
Research attitude & Choosing Research Problem.

Scientific Writing
Different types of scientific writing (thesis, paper, review, proposal, CV, Cover letter, popular article)

Communication
Communicating Science (research journalism, lecture, poster)

IPR
IPR, Plagiarism, use of computers, search engines, language and grammar, answering in interviews, Basic Statistical Concepts

Text Books

- Alley, M., 2003, The craft of Scientific presentations:Critical steps to succeed and critical errors to avoid, Springer, New York. Gustavii, B, 2003, How to write and illustrate a scientific paper, Cambridge University press, Cambridge
- Matthews J.R., Bowen J.M. and Matthews R.W. 2000, Successful scientific writing, a step-by-step Guide for the Biological and Medical Sciences, Cambridge University press, Cambridge
- Swales.M. & Feak C.B. 2000, English in today's Research world, A writing guide, University of Michigan Press, Ann Arbour
- Introducing Research Methodology: A Beginner's Guide to Doing a Research Project Second Edition by Uwe Flick (Author) ISBN-10: 1446294242
- The Research Methods Knowledge Base, 3rd Edition, by William M. K. Trochim and James P. Donnelly; ISBN-13: 978-1592602919; ISBN-10: 1592602916
- Research Design: Qualitative, Quantitative, and Mixed Methods Approaches, 4th Edition, by John W. Creswell; ISBN-13: 978-1452226101; ISBN-10: 1452226105
- Qualitative Research: A Guide to Design and Implementation 4th Edition, by Sharan B. Merriam and Elizabeth J. Tisdell; ISBN-13: 978-1119003618; ISBN-10: 111900361X
- Doing Your Research Project (Open Up Study Skills) 5th Edition, by Judith Bell; Paperback (2010)

Reference

Research Methodology-2 (AS 4200)

Objective: To provide students with basic statistical analysis mechanism and to provide statistical hands-on for beginning research

Course outcome

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

- understand the basis statistical analysis needed for research
- have basic knowledge of the software tools needed for statistical analysis and will have hands-on experience

Describing Data

Overview, Observations and Variables, Types of Variables, Central Tendency, Distribution of the Data, Confidence Intervals, Hypothesis Tests

Preparing Data Tables

Overview, Cleaning the Data, Removing Observations and Variables, Generating Consistent Scales Across Variables, New Frequency Distribution, Converting Text to Numbers, Converting Continuous Data to Categories, Combining Variables, Generating Groups, Preparing Unstructured Data, Visualizing Relationships Between Variables, Calculating Metrics About Relationships

Data Visualization

Visualization Design Principles, Tables, Univariate Data Visualization, Bivariate Data Visualization, Multivariate Data Visualization, Visualizing Groups, Dynamic Techniques

Hands-On Tutorials

Reading in Data, Preparation Tools, Tables and Graph Tools, Statistics Tools

Text Books

- A Practical Guide to Exploratory Data Analysis and Data Mining - I and II 2nd Ed. by GLENN J. MYATT WAYNE P. JOHNSON Wiley Publication 111900361X
- How to Keep Your Research Project on Track Edited by Keith Townsend, Mark N.K. Saunders

Reference

- Head First Statistics by Dawn Griffiths, O'Reilly, 2009

Deep Learning (IT 4005)

Objective: To get the students and researchers exposed to the state of the art deep learning techniques, approaches and how to optimize their results to increase its efficiency and get some hands-on experience on the same to digest the important concepts

Course outcome

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

- exposed to the background mathematics involved in deep learning solutions.
- deal with real time problems and problems being worked upon in industries.
- Accept the machine learning community – both as an intelligent software developer as well as a matured researcher.

Basic concepts of perceptron, learning and recognition

supervise and unsupervised learning. Fundamentals of delta learning rules and back propagation algorithm, SVM, KNN. Machine Learning, machine learning techniques, challenges motivating deep learning. over fitting and under fitting, bias and variance, Gradient based optimization, Maximum LikelihoodEstimation. Deep Feed-forward network, backpropagation. SomeRegularization and Optimization Techniques, Convolutional Neural Network, RNN, methodology and Applications of deep learning Linear Factor Models and Autoencoders, Monte Carlo Methods, Stochastic Maximum, Likelihood and Contrastive Divergence

Deep Generative Models

Boltzmann Machine, RBM, Deep Belief Nets, Deep Boltzmann Machine, Convolutional Boltzmann Machine

Text Books

- Deep Learning by- Ian Goodfellow, Yoshua Bengio and Aaron Courville

Reference

Probabilistic Machine Learning and Graphical Models (IT 4006)

Objective: Introduce probabilistic view on machine learning and discuss graphical models with Mathematical rigor and application in real problems. This course will make extensive use of probability, statistics, and optimization

Course outcome

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

- understand about probabilistic machine learning and get exposure to current cutting edge research.
- develop an in-depth understanding of probabilistic graphical models.
- describe and analyze properties of graphical models, and formulate suitable models for concrete estimation and learning tasks.

Probabilistic supervised learning and Probabilistic Unsupervised learning

Graphical Model representation

Bayesian and Markov networks, and dynamic Bayesian networks. Probabilistic inference algorithms, both exact and approximate; Sampling; and learning methods for both the parameters and the structure of graphical models.

Generative Adversarial Network (GAN)

Encoder-Decoder, Variational Autoencoder, GAN

Text Books

Reference

- Kevin Murphy, “Machine learning: a probabilistic perspective”, MIT Press, 2012.
- Daphne Koller and Nir Friedman, Probabilistic Graphical Models: Principles and Techniques
- Michael I. Jordan, An Introduction to Probabilistic Graphical Models, in preparation. Course2

HSMC

List of courses are:

- Constitution of India
- Professional Ethics
- Universal Human Values
- Environmental Studies
- Physical Education

Constitution of India (MS1102)

Objective: Students will be able to understand the Fundamental features of the Indian Constitution, Union Government, Rights and Duties, Statutory Institutions.

Course Outcome
Students will be able to:

- Understand Indian Constitution, its composition and functions, Union and state Government
- Understand Rights and Duties, Statutory Institutions etc

Introduction
Evolution of the Indian Constitution, Acts, Fundamental features of the Indian Constitution, Union, State and Local Government.

Rights and Duties
Fundamental Rights and Duties, Directive Principles, Relation between Federal and Provincial units: Union-State relations, Administrative, legislative& Financial, Inter-State Council, NITI Ayog, Finance Commission of India, Union List, State List, Concurrent List, Statutory Institutions: Elections-Election Commission of India, National Human Rights Commission, National Commission for Women

Reference

- D.D. Basu, Introduction to the Constitution of India, Lexis Nexis, New Delhi
- Subhash Kashyap, Our Parliament, National Book Trust, New Delhi
- Peu Ghosh, Indian Government &Politics, Prentice Hall of India, New Delhi

Universal Human Values (MS1103)

Objective: Students will be able to understand the human values.

Course Outcome
Students will be able to:

- Understand the importance of human values, family, society, nature etc.
- Develop commitment and courage to act.

Introduction
Development of a holistic perspective based on self-exploration about themselves (human being), family, society and nature/existence, Understanding (or developing clarity) of the harmony in the human being, family, society and nature/existence

Self Reflection
Right understanding Strengthening of self-reflection, Development of commitment and courage to act, Method to fulfill the human aspirations: understanding and living in harmony at various levels.

Reference

Professional Ethics (MS1104)

Objective: Students will be able to understand the awareness on Engineering Ethics and Human Values.

Course Outcome
Students will be able to:

- Understand social responsibility of an engineer etc.
- To appreciate ethical dilemma while discharging duties in professional life.

Values
Human Values Morals, Integrity, Work Ethics, Honesty, Courage, Empathy etc. Kohlberg's theory, Gilligan's theory, Models of Professional Roles.

Ethics
Codes of ethics, Challenger case study, Safety and Risk, The Three Mile Island And Chernobyl Case Studies, global issues, moral leadership

Reference

- Mike Martin and Roland Schinzinger, “Ethics in Engineering”, McGraw-Hill, New York 1996.
- Govindarajan M, Natarajan S, Senthil Kumar V. S, “Engineering Ethics”, Prentice Hall of India, New Delhi, 2004.
- Charles D. Fleddermann, “Engineering Ethics”, Pearson Education / Prentice Hall, New Jersey, 2004 (Indian Reprint now available).
- Charles E Harris, Michael S. Protchard and Michael J Rabins, “Engineering Ethics – Concepts and Cases”, Wadsworth Thompson Leatning, United States, 2000 (Indian Reprint now available)
- John R Boatright, “Ethics and the Conduct of Business”, Pearson Education, New Delhi, 2003.

Environmental Studies (MS1107)

Objective: To make student learn the importance of environmental studies, different resources, ecosystem etc.

Course Outcome

Students will be able to

- Understand the Multidisciplinary nature of environmental studies.
- Structure and function of an ecosystem
- Environmental Pollution etc.

Nature of Environmental studies, Ecosystems

Definition, Scope and importance, Need for public awareness. Different resources, Concept of an ecosystem, Structure and its function, Food chains, Different eco systems, Biodiversity, Threats, In-situ and Ex-situ conservation of biodiversity.

Environmental Pollution & Field Work

Causes, effects and control measures of different pollution, Nuclear hazards, Pollution case studies, Disaster management, Water conservation, rain water harvesting, watershed management, Case studies on Environmental ethics, Climate change, global warming, Case studies. - Wasteland reclamation, Environment Protection Act, Water Act, Wildlife Protection Act, Visit to a local polluted site and Study of ecosystems.

References:

- Agarwal, K.C.2001 Environmental Biology, Nidi Publ. Ltd. Bikaner.
- BharuchaErach, The Biodiversity of India, Mapin Publishing Pvt.Ltd. , Ahmedabad
- Brunner R.C., 1989, Hazardous Waste Incineration, McGraw Hill Inc.
- Clark R.S., Marine Pollution, Clanderson Press Oxford (TB)
- Cunningham, W.P.Cooper, T.H.Gorhani, E &Hepworth, M.T.2001. Environmental Encyclopedia, Jaico Publ. House. Mumbai, 1196p
- Dc A.K., Environmental Chemistry, Wiley Eastern Ltd.
- Down to Earth, Centre for Science and Environment(R)
- Gleick, 11.P. 1993. Water in crisis, Pacific Institute for Studies in Dev., Environment & Security. Stockholm Env. Institute. Oxford Univ. Press. 473

Physical Education (Sports) (MS1108)

Objective: To aware the students on the importance of physical education for a healthy life and train them on various sports, games, yoga, etc. for physical fitness.

Course Outcome

Students will be able to

- Understand the knowledge of various ways for maintaining both physical and mental wellness

Know your body

First Aid for basic medical conditions, CPR for emergency, Diabetic and Obesity condition of Indian and world, Importance of physical education.

Yoga and Meditation

Yoga for wellness and concentration, Meditation for wellness

Athletics and Aquatics

Rules, benefits and mastering of various track and field events such as Sprint, Marathon, Hurdles, Long Jump, High Jump, Javelin throw, Shot Put, Discus throw, etc.

Rules, benefits and mastering of various styles of swimming, butterfly, freestyle, backstroke, and breaststroke, Sports for physical fitness like Cricket, basketball, football, volleyball, etc.

References:

- Dr. V K Sharma, “Health and Physical Education”. New Sarasvati House Publishers.
- “Yoga: A Healthy Way of Living”. By National Council of Educational Research and Training.
- Mark Young. “The Complete Beginners Guide to Swimming”.
- Dr. Ashwini Bhardwaj. “A Complete Guide to Family Safety and First Aid”. GoodWill’s Publishers.

Optimization (IT 4007)

Objective: The course aims to introduce students to modern convex optimization and its applications in fields such as machine learning

Course outcome

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

- recognize and formulate convex optimization problems as they arise in practice.

Convex Analysis

Convex Sets, Convex Functions, Calculus of convex functions
Optimality of Convex Programs: 1st order nec. and suff. conditions, KKT conditions
Duality: Lagrange and Conic duality

Standard Convex Programs and Applications

Gradient descent, Stochastic gradient descent, Newton's methods, Interior Point method.Nonsmooth Problems: Subgradient descent..

Online convex optimizationNon-convex optimization

Adom and other variants.

Text Books

- S.Boyd and L.Vandenberghe. Convex Optimization. Cambridge University Press, 2004.

Reference

- R.T.Rockafellar. Convex Analysis. Princeton University Press, 1996.
- A.Nemirovski. Lectures On Modern Convex Optimization (2005). Available at
- www2.isye.gatech.edu/~nemirovs/Lect_ModConvOpt.pdf
- Y.Nesterov. Introductory Lectures on Convex Optimization: A Basic Course. Kluwer Academic Publishers, 2004

Robot Motion Control (IT 4020)

Objective: To be able to obtain a working mathematical model of a system and be able to do a time-domain and frequency-domain analyses of the model to predict the system's behavior.

Course outcome

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

- To design control systems that meet design specifications.
- To perform various analysis to predict the behavior of the system.

Introduction & Mathematical modeling

Motivation, examples of control systems, feed-back control systems, Mathematical modeling of: electrical systems, mechanical systems, electro-mechanical systems. Laplace transforms, transfer functions, electrical analogues of other dynamical systems. State-space modeling of dynamical systems. Block diagrams, block diagram reductions. Signal flow graph, Mason's gain formula. Linearity, time-invariance versus nonlinearity and time-variance. Linearization. Distributed parameter systems

Time response of dynamical systems, Stability & Feedback

Obtaining solutions from mathematical models. Poles and zeros and their effects on solutions. Step response of standard second order systems, time-domain specifications and their formulae, Definition of stability. Routh-Hurwitz test. Lyapunov theory, Basic idea of feedback control systems. Error analysis. P, PI, PD, PID controllers.

Design of controllers & Frequency domain analysis

The root-locus technique, steps in obtaining a root-locus. Design of controllers using root-locus Pole placement with state feedback, controllability. Pole placement with output feedback, observability, Luenberger observer. LQR control, Bode plot, Nyquist plot, Nyquist stability criterion, gain and phase margins, robustness.

Compensators

Design of Lead compensator, lag compensator, lead-lag / lag-lead compensators.

Text Books

- Franklin G. F., Powell J. D., Emami- Naeini A., Feedback Control of Dynamic Systems, Pearson, Upper Saddle River, New Jersey, 5th edition,2006.
- Ogata K., Modern Control Engineering, Prentice-Hall of India Pvt Ltd., New Delhi, 3rd edition,2000.
- Kuo B. C., Automatic Control Systems, Prentice-Hall of India Pvt Ltd., New Delhi, 6th edition,1991

Reference

Foundation of Robotics (IT 4030)

Objective: To build a strong mathematical foundation for modeling, analyzing, and designing robotic systems and to introduce advanced concepts in robot kinematics, dynamics, and control methodologies.

Course outcome

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

- Familiarize with sensory systems, information fusion techniques, and programming for robotic applications.
- Demonstrate proficiency in robotic kinematics, dynamics, and control for analyzing and designing robotic systems.
- Apply sensory information fusion and programming techniques for robotic perception and real-time applications.
- Engage in human-robot interaction and intelligent object manipulation tasks to address real-world challenges.

Fundamentals of Robotics

Introduction to the Profession, Mathematical Foundation for Spatial Rigid Body Representation, Spatial Orientation Transformation, Homogeneous Coordinate Transformation Matrix, Forward and Inverse Kinematics Problems, D-H Principle

Modeling and Analysis

Modeling Principle of a Cyber-Physical System , Manipulator Jacobian and Singularity, Robot Modeling Using Dynamics, Trajectory Planning

Control Systems for Robotics

Robot Control Principles, Master-Slave Control Architecture, PD-PID Control, Computed Torque/Model-Based Methodology, Nonlinear Control, Sensory Devices for Robots

Programming and Advanced Topics

Robot Programming, Basics of Human-Robot Interactions

Text Books

- Introduction to Robotics: Mechanics and Control- by John J. Craig
- Robotics: Modelling, Planning and Control by Bruno Siciliano, Lorenzo Sciavicco, Luigi Villani, and Giuseppe Oriolo
- Modern Robotics: Mechanics, Planning, and Control by Kevin M. Lynch and Frank C. Park

Reference

- A Mathematical Introduction to Robotic Manipulation by Richard M. Murray, Zexiang Li, and S. Shankar Sastry.
- Robotics, Vision and Control: Fundamental Algorithms in MATLAB®" by Peter Corke.

Advanced Graphics & Animation (IT 4040)

Objective: The course introduces techniques, algorithms and principles of interactive 3D computer graphics and animation

Course outcome

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

- identify and describe the fundamentals of 2D and 3D computer graphics,
- apply mathematics and physics in the design and development of graphics applications

Overview

2D and 3D transformations, Matrix representation of transformations, 2D viewing pipeline, 3D viewing pipeline, Introduction to OpenGL graphic programming

Object representation methods

Illumination and color models, Shading, Texture mapping, Graphics Acceleration algorithms such as Level-of-detail rendering, Image-based effects

Different generations of GPUs

Fixed & Programmable-function graphics pipeline, Graphics programming using CUDA, Principles of Animation, Traditional animation method, Key-frame animation, Morphing

Advanced topics in Animation

Facial Animation, Modeling & Animating Human Figure, Physically-based Animation; Group assignments on implementation of a Graphics & Animation Application using open-source toolkits/ libraries such as OpenGL, WebGL, CUDA or packages such as Maya etc.

Text Books

- Rick Parent, “Computer Animation: Algorithms & Techniques”, Morgan Kaufmann Pub.
- Tomas Akenine-Möller and Eric Haines Naty Hoffman, “Real-Time Rendering, 2nd Ed.”, A.K. Peters.
- D. Hearn & M.P. Baker, “Computer Graphics with OpenGL”, 4th Ed., Pearson Education.
- Francis S Hill Jr., Stephen M Kelley, “Computer Graphics Using OpenGL”, Prentice Hall of India.
- NVidia CUDA Repository, URL: http://developer.nvidia.com/category/zone/cuda-zone

Reference

Virtual Reality (IT 4041)

Objective: To promote the understanding of this technology, underlying principles, its potential and limits and to learn about the criteria for defining useful applications

Course outcome

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

- learn a ton about Virtual and Augmented Reality,
- get familiar with the latest technology, techniques and software, and build an application during the course

Introduction

Components of a VR system, 3D User Interface Input and Output devices, 3D viewing, Designing & Building VR Systems, Introduction to Augmented Reality (AR)

VR Modeling

Geometric modeling, Kinematic, Physical and Behavior modeling; Selection and Manipulation during 3D Interaction

Travel and Wayfinding in Virtual Environments

Strategies for Designing and Developing 3D UIs, Evaluation of 3D User Interfaces, Traditional and Emerging VR/AR applications

Human Factors in Virtual Reality

Case study on Construction of Geographic Virtual World. Group assignments on implementation of a Virtual/ Augmented Reality Application using open-source toolkits/ libraries such as OpenSceneGraph, Vega, VRML etc

Text Books

- G.C. Burdea & P. Coiffet, “Virtual reality Technology, Second Ed.”, Wiley-India.
- GJ Kim, “Designing VR Systems: The Structured Approach”, Springer.
- D.A. Bowman et al., “3D User Interfaces: Theory and Practice”, Addison Wesley.
- John Vince, “Virtual Reality Systems”, Pearson Ed.
- Rick Parent, “Computer Animation: Algorithms & Techniques”, Morgan Kaufmann.

Reference

Data Analytics (IT 4008)

Objective: The course discusses the methods & algorithms of data analysis and its related issues

Course outcome

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

- get exposure of various algorithms to be used in different application domain for data analysis and its practical implementations

Introduction

Fundamentals of data mining, Data Mining Functionalities, Classification of Data Mining systems, Major issues in Data Mining, Preprocessing the Data (Data Cleaning, Integration, Transformation & Reduction)Mining Association Rules: Association Rule Mining, Mining Single-Dimensional Boolean Association Rules from Transactional Databases, APRIORI, Variations of APRIORI (Sampling, Hash Based, Partitioning, Transaction Reduction), Frequent Pattern Growth, Mining Multilevel Association Rules from Transaction Databases, Mining Multidimensional Association Rules, Concept of LIFT, Clustering of Association rules

Classification and Prediction

Classification by Decision Tree Induction, Bayesian Classification, Classification by Back propagation, Classification Based on concepts from association Rule Mining, SVM, Prediction, and Classifier Accuracy

Clustering

Data types in cluster analysis, Categories of clustering methods, partitioning methods- K-Means, PAM, CLARA, CLARANS, KNN. Hierarchical Clustering- Agglomerative and Divisive Clustering, BIRCH and Chameleon, Density Based methods-DBSCAN, CURE, OPTICS, Grid Based Methods- STING, Wave Cluster, COBWEB, Outlier Analysis.

Text Books

Reference

- Jiawei Han MichelineKamberJian Pei “Data Mining: Concepts and Techniques” 3rd Edition, 2011
- Hadzic F., Tan H. & Dillon T. S. “Mining data with Complex Structures” Springer, 2011
- Yates R. B. and Neto B. R. “Modern Information Retrieval ” Pearson Education, 2005

Software Design and Architecture (IT 4400)

Objective: To provide students with the background to design, implement, and use mid size and large software systems

Course outcome

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

- understand the objectives of Software Architectural design and
- learn various Software Architecture prevalent wrt MVC , SOA etc

Introduction

Design objectives, purpose and approaches, Functional Independence with Coupling and Cohesion. Overview of OO Design: Class Diagrams Object Diagrams. Sequence and Collaboration Diagrams, Static and dynamic modeling approaches

Software Design Principles

Role of Modeling and Design, Design Metrics, OO Software Design. Design Principles with applications. . Iterative Refinement Behavior, Iterative Refinement Minimalism. Mobile Software and Design: Characteristics and Requirements, Mobile Interaction designs, UX design

Design Patterns and Architectural consideration

Recent Trends in Software Design, GoF and evolution of Design Patterns

Pattern based Design

Creational Design, Structural Design, Behavioral Design Patterns. Example, Architecture Types and Representation : Role of Software Architecture, Business Architecture, Solutions Architecture & Enterprise Architecture. Architecture for Web enabled applications. Separation of Concerns, Developing Application Architecture with GUI and Database connectivity. Database Design and Data Centric Architectures Architectural Implementations : MVC Architecture and Separation of Concerns, SOA and Web Services, RESTFul services and API. Advances in Software Architecture.Recent Trends in Software Architecture: Cloud Based Architecture, Service Oriented Architecture etc..

Text Books

- G. Booch, Object-Oriented Analysis and Design with Applications 2nd Ed.PHI, New Delhi, 1993.
- Design Patterns by R Johnson, John Vlissides, Richard Helm, and Erich Gamma.
- Software Architecture: Foundations, Theory, and Practice by Richard N. Taylor et al.(John Wiley and Sons).

Reference

- F Buschmann, Kelvin Henney& Douglas Schimdt, “Pattern-Oriented Software Architecture - A System of Patterns”, Volume 1, Wiley,2007.
- F Buschmann, K Henney & D Schimdt, “Pattern-Oriented Software Architecture – Pattern for Concurrent and Networked Objects”, Volume 2 ,Wiley, 2000

Software Requirements and Estimation (IT 4401)

Objective: Execute a complete requirements negotiation process, Perform a comprehensive feasibility analysis, Lead a software project planning process, Apply the principles and processes of software engineering project enactment

Course outcome

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

- Gain Knowledge about software requirements and will
- Analyze requirement elicitation techniques and prototyping

Software Requirements

Essential Software Requirement Good practices for requirement engineering Improving requirements processes Software Requirements and Risk Management

Software Requirements Engineering

Requirements elicitation Requirement analysis documentation, review, elicitation techniques, analysis models, software quality ttributes Risk reduction through prototyping, setting requirements priorities, verifying requirements quality, software requirements modeling Use case modelling, Analysis model, dataflow diagrams, state transition diagram, class diagram, object analysis, problem frames,

Design Patterns and Architectural consideration

Requirements management principles and practices Requirement attributes, change management process Requirement traceability matrix Links in requirements chain Requirement management tool,benefits of requirement management tools, commercial requirement management tools Rational Requisite pro Caliber-RM, Implementing requirement management automation

Software Estimation

Components of software estimation, software estimation models, Problems associated with estimation, Key project factors that influence estimation Size estimation- two views of sizing, Function point analysis, Mark II FPA, full function point, LOC estimation, conversions between size measures. What is productivity, estimation factors, approaches to effort and schedule estimation COCOMO II, Putnam estimation model Algorithmic models, cost estimation, software estimation tools, desirable features of software estimation tools IFPUG, USC's COCOMO II, SLIM tools.

Text Books

- Swapna Kishore, Rajesh Naik, Software Requirements and Estimation,1stEdition, Tata McGraw Hill, 2001.

Reference

- Karl E. Weigers, Software Requirements, 2ndEdition, Microsoft Press, 2003.
- Ian K. Bray, An Introduction to Requirements Engineering, Addison Wesley, 2002
- Ian F. Alexander, Richard Stevens, Writing better requirements, Addison-Wesley, 2002

Software Testing and Quality Management (IT 4500)

Objective: Develop methods and procedures for software development that can scale up for large systems and that can be used to consistently produce high-quality software.

Course outcome

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

- Software "V" model of testing Static and dynamic testing techniques
- Software testing metrics Process management etc

Software Testing

Bug, Reasons of Bugs, Cost of Bugs, Software Tester Task. Introduction to Software Development Models Software Testing: Testing axioms, Terms & Definitions Testing Fundamentals: Types, Black Box, White Box, Static & Dynamic Testing. Static Black Box Testing. Dynamic Black Box Testing: Test to Pass & Test to Fail, Equivalence Partitioning, Data Testing, State Testing, , Other Black Box Testing Techniques

Static White Box Testing

Formal & Peer Reviews, Coding Standards and Guidelines. Review Check List Dynamic White Box Testing: Comparison with Debugging, Testing Pieces: Unit & Integration Testing Configuration Testing: Deciding Hardware Configurations. Compatibility Testing: Overview, Backward and Forward Compatibility. Testing Multiple versions. Data Sharing Compatibility Effective UI, Testing for Disabled. Data Coverage & Code Coverage

Documentation Testing

Documentation Testing. Security Testing: Threat Modelling, Buffer Overrun, Safe String Functions, Computer Forensics Web Site Testing, Black Box Testing: Text, Hyperlinks, graphics, Forms. Gray Box Testing & White Box Testing, Configuration and Compatibility Testing System Testing Recovery Testing Security Testing Stress Testing Performance

Planning Testing

Goals, Test phases, Strategy, Resource Requirements, Schedule, Test Cases, Bug Reporting, Metrics. Test Cases: Test Case Planning, Design, Cases, Procedures, Organization and Tracking. Bug Life Cycle and Tracking System. Testing, QA and QC Quality Management Quality Planning Process Quality Assurance Process Quality Control process Organisational Structures: CMM Capability Maturity Model, ISO 9000

Text Books

- KshirasagarNaik and PriyadarshiTripathy, Software Testing and Quality Assurance: Theory and Practice, John Wiley & Sons, Inc.

Reference

- William Perry, "Effective Methods for Software Testing", John Wiley & Sons, New York, 1995. Louise Tamres, "Software Testing", Pearson Education Asia, 2002
- Robert V. Binder, "Testing Object-Oriented Systems-Models, Patterns and Tools", Addison Wesley, 1999. CemKaner, Jack Falk, Nguyen Quoc, "Testing Computer Software", Second Edition, Van Nostrand Reinhold, New York, 1993.

Data Visualization (IT 4601)

Objective: This course covers graphical representation of information and data for information technology.

Course Outcomes

Students will be able to:

- fundamentals and be able to apply these knowledge in practical problems..

Information Visualization

Visual Display of Quantitative Information, Power of Representation, Data-Ink and Graphical Redesign, Data Density, Interactive Data Visualization for the Web. Scalable, Versatile and Simple Constrained Graph Layout, Visualization of Adjacency Relations in Hierarchical Data

Graphical Models Theory, Experimentation and the Application to the Development of, Layering Interactive Dynamics for Visual Analysis, Animated Transitions in Statistical Data Graphics Effectiveness of Animation in Trend Visualization

Cartogram

Value-by-Area Mapping. Cartography Thematic Map Design and Adaptive Composite Map Projections. Information Visualization for Search Interfaces, Information Visualization for Text Analysis, Supporting Asynchronous Collaborative Information Visualization, Designing for Social Data Analysis

Tool based Visualization of different data

Visual analytics, Dashboard development, Exploratory visualization

Text Book

- The Visual Display of Quantitative Information (2nd Edition). E. Tufte. Graphics Press, 2001.
- Envisioning Information, E. Tufte. Graphics Press, 1990

References

Big Data Analytics (IT 4250)

Objective: This course covers the concept of big data analytics, algorithms, applications and frameworks

Course Outcomes

Students will be able to:

- study of big data analytics and
- be able to apply in practical problems.

Introduction to Big Data and its importance

3 Vs and more, Big data analytics, Big data applications. Hadoop & Hadoop EcoSystem, Moving Data in and out of Hadoop, Inputs and outputs of MapReduce, Hadoop Architecture, HDFS, Common Hadoop Shell commands, NameNode, Secondary NameNode, and DataNode

Maps

Hadoop Map Reduce paradigm, Map and Reduce tasks, Job, Task trackers , Algorithms using MapReduce, Examples of Map Reduce (Word count problem, Matrix-Vector vector multiplication), YARN & Zookeeper, Hadoop Cluster Setup & Hadoop Configuration, and HDFS Administration: Monitoring & Maintenance

Hive Architecture, Comparison with Traditional Database, HiveQL - Querying Data - Sorting And Aggregating, Map Reduce Scripts, Joins & Subqueries, HBase Concepts; Advanced Usage, Schema Design & Indexing - PIG, Zookeeper

Spark

RDD in Spark, Data Frames & Spark SQL, Spark Streaming, MongoDB, NoSQL

Text Book

- Chris Eaton, Dirk Deroos et al. , “Understanding Big data ”, McGraw Hill, 2012
- Boris Lublinsky, Kevin t. Smith, Alexey Yakubovich, “Professional Hadoop Solutions," Wiley, ISBN: 9788126551071, 2015

References

- Tom White, “HADOOP: The Definitive Guide”, O'Reilly 2012
- Aven Jeffrey, Data Analytics with Spark Using Python | Big Data | First Edition | Pearson Paperback, November 2018

Parallel and Distributed Computing (IT 4522)

Objective: To introduce various Parallel and Distributed hardware architectures and programming models

Course Outcome

Students will be able to:

- Understand the basics of various parallel and distributed computing platforms
- Identify the models and frameworks best suited to various workloads.
- Provide solutions to parallel and distributed computing problems.

Introduction to PDC

Latency vs Bandwidth, Applications and Challenges, Types of architecture, Flynn's taxonomy, Basic concepts: cores, nodes, threads, processes, speedup, efficiency, overhead, strong and weak scaling (Amdahl's law, Gustafson's law), Cache, Principle of Locality, Programming Models

Distributed Computing

Distributed Memory, Message Passing Interface, Asynchronous/Synchronous computation/communication, concurrency control, fault tolerance, Distributed Programming with Open MPI

Parallel Computing

Shared memory, data & task parallelism, Synchronization, Concurrent Data Structures, Shared Memory Programming with available APIs: PThreads, OpenMP, TBB

GPU Programming

GPU Architecture, Programming Models: CUDA/OpenCL, Basic Concepts: Threads, Blocks, Grids, GPU memory hierarchy, Thread Scheduling, Warps and Control divergence, Memory Coalescing, Programming with CUDA, Using: CuBLAS, CuFFT.

Textbooks:

- "Introduction to Parallel Computing", Ananth Grama, Anshul Gupta, George Karypis, Vipin Kumar, Addison-Wesley, Second Edition.
- "Programming Massively Parallel Processors: A Hands-on Approach", Wen-Mei W Hwu, David B Kirk, Morgann Kaufmann, Third edition.

References:

- "The Art of Multiprocessor Programming", Maurice Herlihy and Nir Shavit, Morgan Kaufmann Publishers.
- "Principles of Parallel Programming", Calvin Lin and Larry Snyder, Addison-Wesley.
- "Introduction to Parallel Programming", Peter S. Pacheo, Morgan Kaufmann Publishers.

Introduction to Cryptography (IT 4009)

Objective: : The objective of this course is to impart knowledge of the basic principles and concepts of modern cryptography

Course Outcome

Students will be able to:

- Understand modern cryptography which shall be self- sufficient for any second course in the area of security

Introduction

Modern cryptography, Historical ciphers and their cryptanalysis, heuristic principles of defining security, Perfectly-Secret Encryption: Definitions, the one-time pad; proven limitations, Private-Key (Symmetric) Encryption: Computational security, Defining secure, encryption, Constructing secure encryption; pseudo randomness, Stronger security notions, Constructing CPA-secure encryption, Modes of operation; Security of CTR with n − k bit counter for messages to size 2k blocks with proof to the LR definition, CCA.

Message Authentication Codes

Message integrity, Definition of security, Constructions from pseudorandom functions, CBC-MAC, Authenticated encryption. Collision-Resistant Hash Functions: Definitions, The Merkle-Damgard transform, HMAC, Birthday attacks, The Random oracle model, Password hashing, Constructions of Pseudorandom Permutations (Block Ciphers) in Practice, Substitution-permutation and Feistel networks, DES and attacks on reduced-round versions, double-DES and triple-DES, AES, Hash functions from block ciphers.

Parallel Computing

Number Theory: Preliminaries and basic group theory, Primes, factoring and RSA, Cryptographic assumptions in cyclic groups, Collision resistant hash functions from discrete log, Public-Key (Asymmetric) Cryptography: Introduction and motivation, Diffie-Hellman key exchange

Public-Key (Asymmetric) Encryption

Model and definitions, Hybrid encryption and KEM/DEM, El Gamal, RSA: textbook encryption, attacks on textbook RSA, padded RSA; CCA-secure RSA KEM.
Digital Signatures: Definition and applications, Hash and sign, RSA signatures: textbook RSA, hashed RSA, security with ROM, Certificates and public-key infrastructures.

Textbooks

References:

- Jonathan Katz and Yehuda Lindell, Introduction to Modern Cryptography, second edition 2014, CRC Press.
- Cryptography: Theory and Practice by Douglas Stinson, Third edition, CRC Press.
- Handbook of Applied Cryptography by Alfred Menezes, Paul Oorschot and Scott Vanstone. Available Online.
- Foundations of Cryptography by Oded Goldreich. Available Online.

Networking Concepts (IT 4010)

Objective: This course introduces the fundamental concepts of computer networks and different protocols used to connect and transfer data

Course Outcome

Students will be able to:

- realize the network communication, practical experience of networking and
- usage of specific protocols in various requirements.

Introduction

Network vs. distributed system, Point to point Network vs. Multipoint Network, Classify networks, Network performance measures, OSI Reference Model, TCP/IP Reference Model, Multiplexing, circuit switching, message switching, packet switching. Physical Layer: baud {modulation rate}, data rate {capacity}, bandwidth, Nyquist Theorem, Shannon's Result, Data Encoding Techniques, digital data, analog signals, digital data, digital signals, Transmission Media

Data Link Layer

Transmission Errors, error detection and error correction, Hamming Codes, Parity Checks, Checksum, CRC, Framing, bit stuffing, byte stuffing, Data Link protocols such as PPP, BYSYNC, DDCMP, HDLC, Stop-and-Wait, sliding window protocols, MAC Layer Protocols such as Aloha (Pure Aloha & Slotted Aloha), Persistent and Non persistent CSMA, CSMA/CD, LAN Standards, 802.1 to 802.5 and 802.11.

Network Layer

IPv4 details, Routing Protocols, Distance Vector Routing (RIP), Link State Routing (OSPF), Border Gateway Protocols (BGPv4), Network Layer Utility Protocols like ICMP, Ping, ARP, RARP, DHCP, Traceroute, IPv6 details Transport Layer: Simple Demultiplexer (UDP), Reliable Byte Stream(TCP), End to End Issues, Connection Establishment and Termination of TCP, TCP Sliding Windows

Congestion Control

TCP Congestion Control, AIMD, Slow Start, Fast Transmit and fast recovery, Congestion Avoidance Mechanism DECbit and Random Early Detection (RED). Application Protocols: HTTP, DNS, DHCP, SMTP, IMAP, RTP

Textbooks

- Computer networks – Larry L. Peterson and Bruce S. Davie.
- Computer Networks – Andrew S. Tenenbaum

References:

- Data and Computer Communications – William Stallings
- Internetworking with TCP/IP – Douglas E. Comer Vol. II and I.
- Computer Networks and Internet – Douglus E. Coumer
- Unix Network Programming – Richards Steavens
- Cryptography and Network security – William Stallings

Principles of Wireless Communication (IT 4700)

Objective: To enable the student to synthesis and analyze wireless and mobile cellular communication systems over a stochastic fading channel.

Course Outcome

Students will be able to:

- able to analyze wireless and mobile cellular systems and
- design wireless and mobile cellular systems..

Digital communication systems

Baseband and Bandpass

Information theory and error control codes

Information theory and error control codes.

Physical modeling for wireless channels

Free space fixed transmitting and receive antennas, free space moving antenna, reflecting wall fixed antenna, reflecting wall moving antenna, power decay with distance and shadowing, two-ray model, etc., Link budget design using path-loss model, Outdoor and indoor propagation models, Small scale multipath propagation, Delay spread, Coherence bandwidth, Doppler spread & Coherence time, Flat fading, Frequency selective fading, Fast fading, Slow fading

Diversity concept, Non-coherent and coherent reception

Time diversity, Repetition coding, Frequency diversity, Receiver diversity (SC, EGC and MRC), Multiple receive antenna system model and its error performance analysis, Transmit diversity, Channel estimation for multi-antenna system, Diversity order analysis

Textbooks

- T. S. Rappaport, Wireless Communications, 2nd ed. Principles and Practice, Pearson Education India, 2009.
- D. Tse and P. Viswanath, Fundamentals of Wireless Communications, Cambridge University Press, 2005

References

- B. Carlson, P. B. Crilly, and J. C. Rutledge, Communication Systems: An Introduction to Signals and Noise in Electrical Communication, 4th ed. McGraw Hill, 2002.
- L. Song and J. Shen, Evolved Cellular Networks planning and optimization for UMTS and LTE,
- Y.-W. P. Hong, W.-J. Huang, C.-C. Jay Kuo, Cooperative Communications and Networking:Technologies and System Design, 1st ed. Springer, 2010.

Cloud and Edge Computing (IT 4701)

Objective: To introduce concepts of Cloud and Edge Computing.

Course Outcome

Students will be able to:

- approach designing of parallel computation based better
- not only know the theoretical concepts but also practical skills to implement the solutions

Introduction to Cloud Computing

Introduction to Cloud Computing, Recent Trends in Computing Cloud Computing, Evolution of cloud computing.

Cloud Computing Architecture

Service Management in Cloud Computing Infrastructure as a Service (IaaS), Platform as a Service (PaaS), Software as a Service(SaaS), Data Management in Cloud Computing, Resource Management in Cloud Computing, Cloud Implementation

Open Source and Commercial Clouds

Cloud Simulator, Research trend in Cloud Computing, Fog Computing, VM Resource Allocation, Management and Monitoring, Introduction to Edge Computing, the Cloud Computing analytics pipeline, Coordination of Cloud Services.

Serverless Computing and FaaS Model

Cloud-Fog-Edge enabled Analytics, Cloud Security, Case Studies and Recent Advancements

Textbooks

References

- Cloud Computing: Principles and Paradigms, Editors: RajkumarBuyya, James Broberg, Andrzej M. Goscinski, Wiley,2011.
- Enterprise Cloud Computing - Technology, Architecture, Applications, GautamShroff, Cambridge University Press, 2010.
- Cloud Computing Bible, Barrie Sosinsky, Wiley-India, 2010.
- Cloud Security: A Comprehensive Guide to Secure Cloud Computing, Ronald L. Krutz, Russell Dean Vines, Wiley- India, 2010.
- Cloud Computing: Principles, Systems and Applications, Editors: Nikos Antonopoulos, Lee Gillam, Springer, 2012

Embedded System and IoT (IT 4800)

Objective: To introduce concepts of Cloud and Edge Computing.

Course Outcome

Students will be able to:

- approach designing of parallel computation based better
- not only know the theoretical concepts but also practical skills to implement the solutions

Embedded, Cyber-Physical Systems and IoT

Introduction, application areas, examples, Common characteristics, Challenges and design flows, Modeling of Embedded and Cyber Physical Systems - Requirements, models of computation, Finite State Machines, Timed Automata, State Charts, Modeling of Hierarchy; Data flow modeling , Discrete Event Modeling , Continuous and Discrete time system concepts.

Design

Choosing the components HW platforms Processors, Sensors, Actuators; SW stack – RTOS, Scheduling Real Time control tasks, IoT Fundamentals - Devices, Gateway; Elements of IoT - IoT Functional blocks, IoT Communication Modules and API

Basics of Networking

Machine-to-Machine interaction, IoT Communication Protocols MQTT, ZigBee, Bluetooth, CoAP, UDP, TCP

Concept of Cloud Computing

Everything as a Service (XaaS), Role of Cloud; Software Components - Programming API's; IoT Application Development - Solution Framework for IoT. Advanced topics - Data Analytics for IoT, Fault Tolerance in IoT based Systems; IoT Security.

Textbooks

References

- Peter Mardwel, Embedded System Foundations of Cyber Physical Systems Springer 2nd Edition.
- E. A. Lee, Sanjit Seshia Introduction to Embedded Systems – A Cyber–Physical Systems Approach.
- Rajeev Alur, Principles of Cyber-Physical Systems.
- Pethuru Raj and Anupama C. Raman (CRC Press) , The Internet of Things : Enabling Technologies, Platforms and Use Cases.
- Arshdeep Bagha and Vijay Madisetti Internet of Things: A Hands-on Approach

Information Security laws and Regulation (IT 4900)

Objective: The purpose of this course is to develop the foundation of Information security governance, implementation of cyber security practices in the organization.

Course Outcome

Students will be able to:

- Create information security policies;
- systematically decode the element of cyber crime in order to understand the cyber attack execution strategies.
- learn the component of information security programmes and how to ensure compliance of international frameworks

Information security laws, regulation and standards

Information Security programmes and practices, Analysis of cyber crime based on parameter to develop attack vector pathways. Information security strategies for effective information security implementation. Information security requirements and classification. Overview of information security metrics used in organizational need for information security. Use of CVE database, Overview of IS027001. IT Act,2000.

Information security Regulation

Components of CII, Threat Landscape, Critical Digital Assets, Regulation NERC 5.71, Framework implementation guidance. Information Security Regulation for Payment Card Industry, Design consideration based on Network flow and Data flow requirements. The regulatory need for operators, merchants and its implementation,Best practices implementation, Compliance requirements.

Data protection laws and regulations

GDPR, Privacy impact analysis, Implement, Investigation life cycle

Textbook

- P.W. Singer and Allan Friedman, Cybersecurity and Cyberwar: What Everyone Needs to Know (2014, Oxford University Press) , Nina Godbole, Cyber Security(Wiley India

References

- Guide to cyber laws : information technology act-2000, e-commerce, data protection & the internet by Ryder Rodney D.
- A Guide to Information Technology : Cyber Laws & E-commerce By: Ahmed Syed, Shakil ; Raheja, Rajiv.
- Legal dimensions of cyberspace By: edited by S. K. Verma ; Raman Mittal.

Network Security (IT 4901)

Objective: This course provides an essential study of network security issues and methods in networking systems.

Course Outcome

Students will be able to:

- get knowledge about the network security
- implementation and requirements of network security

Introduction to Network security

Model for Network security, Model for Network access security, Real-time Communication Security: Introduction to TCP/IP protocol stack, Implementation layers for security protocols and implications, IPsec: AH and ESP, IPsec: IKE. Media- Based-Vulnerabilities, Network Device Vulnerabilities, Back Doors, Denial of Service (DoS), Spoofing, Man-in-the-Middle, and replay, Protocol -Based Attacks, DNS Attack, DNS Spoofing, DNS Poisoning, ARP Poisoning, TCP/IP Hijacking, Virtual LAN (VLAN), Demilitarization Zone (DMZ) , Network Access Control (NAC), Proxy Server , Honey Pot , Network Intrusion Detection Systems (NIDS) and Host Network Intrusion Prevention Systems Protocol Analyzers, Internet Content Filters, Integrated Network Security Hardware

Authentication

Kerberos, X.509 Authentication Service, Scanning: Port Scanning, Port Knocking- Advantages, Disadvantages. Peer to Peer security. Electronic Mail Security: Distribution lists, Establishing keys, Privacy, source authentication, message integrity, non-repudiation, proof of submission, proof of delivery, message flow confidentiality, anonymity, Pretty Good Privacy (PGP).

Firewalls and Web Security

Packet filters, Application level gateways, Encrypted tunnels, Cookies. Assignments on latest network security techniques, Security applications in wireless sensor network and wireless Communication networks

Textbook

- William Stallings, “Cryptography and Network Security – Principles and Practices”, Prentice Hall of India, Third Edition, 2003.

References

- Cisco: Fundamentals of Network Security Companion Guide (Cisco Networking Academy Program).
- Saadat Malik, Saadat Malik. “Network Security Principles and Practices (CCIE Professional Development)”. Pearson E ducation. 2002. (ISBN: 1587050250) .
- Mark Ciampa “Security + Guide to Network Security Fundamentals/Edition 3” Cengage Learning publisher, ISBN-10: 1428340661, ISBN-13: 978-1428340664

Cyber Physical System Security (IT 4950)

Objective: This course will cover the CPS basics, Vulnerabilities, Risk and security along with legal perspective.

Course Outcome

Students will be able to:

- understand the CPS basics, implementation, possible vulnerabilities, impacts and solutions.
- understand the various legal and privacy aspects and Risk Management in CPS.

Introduction to Industrial Control Systems and Operations

Industrial Network Protocols, Cyber Physical System Modeling, Plant Models, Feed Back Control Model, and Anomaly Detection Models

CPSS

Concepts and Principles, Securing Industrial Control Systems, Advanced Cyber-Physical Systems Security Concepts, Cyber threat model - Types of Cyber Threats to Industrial Critical System Modeled in a 3 dimensional Attack Space.

Critical Infrastructures

Power Grid, Railways Systems, Transportation Systems, Water/Sewage Systems and their automation architecture, Vulnerabilities, and Past Cases of Cyber Security Compromises and Trends.Stuxnet Case Study, SCADA Based Control, Sensors (IEDs, PLCs), field network and its protocols (profibus, DNP3 etc), ICS/SCADA Security, IoT Security, Legal and Privacy Aspects, CPSS: Risk Management

Textbook

References

- Handbook on Securing Cyber-Physical Critical Infrastructure, Sajal K. Das, Krishna Kant, Nan Zhang, Morgan Kaufmann (Elsevier), ISBN 978-0-12-415815-3, Publication: 2012.

==========

M.TECH- AS

Applicable with effect from 2023 admitted batch and onwards

OMICS (AS 4001)

Objective: The aim is to provide the fundamental knowledge of Molecular biology, Biochemistry, Genomics and Proteomics.

Course Outcome

Students will be able to:

- understand a basic understanding of Advanced Biology.
- Endow with knowledge about the different biological processes and the biomolecules involved.
- Will learn the principles of different laboratory techniques from Proteomics and Genomics which will be implemented in the practical classes.

Genomics

Central dogma of molecular biology, Gene structure and its expression, Concepts of gene regulation, Genetic codon, Restriction enzymes and mapping, Site directed Mutagenesis, Major DNA sequencing techniques

Transcriptomics

Transcription and post-transcriptional modifications of RNA, Tools for read mapping, identification of splicing variants and differential expression analysis, characteristics and analysis of small and long non-coding RNA, Gene Ontology.

Proteomics

Translation and post-translational modifications of proteins, Basic tools and techniques for protein expression, separation and analysis, Cloning and expression plasmid, Recombinant DNA technology, Software packages and available tools for proteomics.

Analytical techniques used in Genomics, Transcriptomics and Proteomics

Agarose Gel electrophoresis, SDS-PAGE, 2D-PAGE, Blotting Techniques, EMSA, PCR, RT-PCR, Immunoprecipitation, Chip-seq, RNA-seq, DNA Microarray, ELISA, Mass spectrometry, Protein microarray.

Textbook

- Bioinformatics for omics data: methods and protocols (2011), Mayer, B., New York: Humana Press. ISBN 978-1617790270
- OMICS: Applications in Biomedical, Agricultural, and Environmental Sciences (2013), Barh D., Zambare V., Azevedo V. CRC Press. Taylor and Francis Group. ISBN 9781138074750

References

- Applications of Advances Omics Technologies: from Genes to Metabolites (2014), Wilson and Wilsons. Elsevier. ISBN: 9780444626509
- Genomics, Proteomics and Metabolomics in Nutraceuticals and Functional Foods (2015), Bagchi D., Swaroop A., Bagchi M. Wiley Blackwell. ISBN:9781118930427
- Principles of Proteomics (2013), Twyman, R., Garland Science,

Data Analytics Fundamental for Biology (AS 4002)

Objective: To expose the students with the advanced techniques of Probability and statistics applied to biological data.

Course Outcome

Students will be able to:

- learn modern statistical techniques (sampling, hypothesis tests, correlation, regression analysis, etc.) to analyze different kinds of data associated with Health Sciences
- to build their skill to become practicing health professionals

Basic Concepts of Probability

Review of the basic concepts of Probability (upto Bayes Theorem) and Statistics (Central tendencies and standard deviations)

Probability Distribution functions

Binomial, Poissonand Normal distributions, Central Limit The oremandit's applications.

Sampling

Sampling distribution, Estimation, Interval estimation, Confidence interval, Test of hypotheses, Z-test, t-test, the chi-square test, F-test and ANOVA test.

Correlation and Regression analyses

Correlation Coefficients, Least square method and curve fittings, Single and multi-variable regression.

Text Book

- Biostatistics-A Foundation for Analysis in the Health Sciences'by Wayne E. Daniel and Chad L.Gross.

References

- Fundamental of Biostatistics by Bernard Rosner.

Scripting and Computer Environments (AS 4003)

Objective: To expose the students to scripting languages of relevance to Bioinformatics.

Course Outcome
Students will be able to:

- Learn scripting languages Perl, Python and R to accomplish tasks required for general purposes in Bioinformatics.

Basics
Function, Modules, Collections, Control Statements, File Handling, Pattern Matching

Sequence
Sequence Objects, Sequence Handling, Search Tools, Online Databases, Numpy, Pandas and Matplotlib

Handling PDBs
Local and Global Alignments, Dynamic Programming: Smith & Waterman, Needleman & Wunsch Algorithm

Multiple Sequence Alignment
Concepts & Implementations, Amino Acid Substitution Matrices PAM & BLOSUM Derivation of Dayhoff Matrices, Profiles & Motifs General Tools, Techniques & Resources Clustal W, BLAST and FASTA

Text Book:

- Learning Perl Randal Schwartz, Tom Phoenix, driandfoy (O'Reilly)

References:

- Molecular Modeling: Principles and Applications (2ndEdition) Andrew R.Leach (PrenticeHall)
- Proteins:Structures and Molecular Properties Thomas E.Creighton(Freeman)
- Fast Lane to Python http://heather.cs.ucdavis.edu/~matloff//Python/PLN/FastLanePython.pdf

Data Structure and Algorithms (AS 4004)

Objective: To impart the knowledge of basic programming and elementary data structure.

Course Outcome
Students will be able to:

- Understand data structures and algorithms
- create logical solutions to solve them.

Basics
Flowcharts, Algorithms, Data Structures – Definition, Linear Data Structures, Non-Linear Data Structures Python Specific Data Structures: List, Tuples, Set, Dictionaries, Comprehensions and its Types, Strings, slicing.

Arrays
Types of Arrays, Operations on Arrays, Arrays vs List. Searching -Linear Search and Binary Search. Sorting - Bubble Sort, Selection Sort, Insertion Sort, Merge Sort, Quick Sort, Implementation of Singly Linked Lists, Doubly Linked Lists, Circular Linked Lists.

Stacks
Overview of Stack, Implementation of Stack (List & Linked list), Applications of Stack Queues: Overview of Queue, Implementation of Queue (List & Linked list), Applications of Queues, Priority Queues.

Graphs -Introduction, Directed vs Undirected Graphs, Weighted vs Unweighted Graphs, Representations, Breadth First Search, Depth First Search. Trees - Overview of Trees, Tree Terminology, Binary Trees: Introduction, Implementation, Applications. Tree Traversals, Binary Search Trees: Introduction, Implementation.

References:

- Think Python(2e), Allen Downey, O'Reilly
- Introduction to Algorithms, Thomas H. Cormen, Charles E. Leiserson, Ronald. L. Rivest, Clifford Stein.
- Data Structures Using C and C++, Yedidyah Langsam, Moshe J. Augenstein, and Aaron M. Tenenbaum.

Data Engineering for Molecular Structure Prediction (AS4101)

Objective: To provide knowledge and exposure on Molecular Structure Prediction for use in control of disease (pathophysiological condition of health) through application.

Course Outcome
Students will be able to:

- Learn tools and techniques for biomolecular structure predictions.
- Get well versed with the principle of predicting authentic structures of biomolecules
- Gain fundamental knowledge of applications of systems engineering principles

Basic structural principles
Building blocks of life, Chemical properties of polypeptides, Intermolecular forces and Types, Entropy and temperature, Protein folding, Levinthal Paradox, Levels, Quaternary structure, Motifs, folds and domains of Protein structure: Hydrophobic and hydrophilic regions, Ramachandran Plot, Alpha-helix, Beta-sheets, Loops.

Structure determination & prediction primer
X-Ray crystallography & NMR; Other Structure determination methods, Fundamental of Protein structure prediction, Impediments, Secondary structure prediction, Comparative models, Homology, Threading/Fold recognition model, Energy landscape; Validation.

Structure prediction of small proteins using ab-initio stochastic simulation models:
Lattice simulation, Random walk model, Self-avoiding model, HP- models, Structure prediction of small proteins using ab initio Deterministic simulation models, Molecular Dynamics principle, Ergodic hypothesis, Use of Newtonian equations of motion, Structure optimization/refinement techniques, Steepest descent, GA simulated Annealing.

RNA structure prediction & Tools
Secondary Structure prediction, validation techniques for proteins: Calculations of Potential energy, Ramachandran Score & Ramachandran Z-score, Visualization, validation, Simulation, Gromacs, prediction using Modeller, Rose TTA Google AlphaFold.

Text Book:

- Introduction to Protein Structure: Carl Branden, John Tooze (Garland)
- Proteins: Structures and Molecular Properties: Thomas E. Creighton (Freeman)

Reference Books

- Guidelines for practical's: A two credit lab is to be conducted by covering them relevant and useful topics from aforementioned syllabus.
- Molecular Modelling: Principles and Applications (2ndEdition): Andrew R. Leach (Prentice Hall)

Next Generation Sequencing Tools and Algorithms (AS4103)

Objective: To get acquainted with the high throughput sequencing data and its processing and to enable the students to ponder more about the string processing

Course Outcome

Students will be able to:

- Work with real-world genomic and transcriptomic data
- Gain proficiency in sequence matching and assembly techniques and tools
- Gain competence in applying data science tools to biological data and skills

DNA sequencing, strings, and matching

DNA sequencers and working principle, DNA as a string. Parsing and manipulating real genome sequences and real DNA sequencing data. Naïve exact matching, homology detection; optimal pair-wises sequence alignment, alignment score statistics, efficient database searches (BLAST), Data science of metabolomics, pathway models.

Preprocessing, indexing, and approximate matching

Improving on naïve exact matching with Boyer-Moore. Preprocessing and indexing. grouping and ordering, Approximate matching and the pigeonhole principle. Edit distance, assembly, overlaps, Algorithms for computing edit distance. Dynamic programming. Global and local alignment. De novo assembly. Overlaps and overlap graphs.

Algorithms for assembly

Shortest common superstring and the greedy version. De Bruijn graphs and Eulerian walks. How real assemblers work. The future of assembly.

Data variability and replication

Data transforms, Clustering, Dimension reduction, Pre-processing and normalization, Linear models with categorical covariates, Logistic regression, Null and alternative hypotheses analysis, false discovery rate, permutation and boot strapping, GEO.

Text Book

- Bioinformatics Algorithms: An Active Learning Approach, by Phillip Compeau & Pavel Pevzner, Active Learning Publishers.
- Bioinformatics with Python Cookbook: Use modern Python libraries and applications to solve real-world computational biology problems, by Tiago Antao, Packet Publishing.

Reference Books

- DNA Sequencing From Experimental Methods To Bioinformatics by Alphey, Luke
- Next-Generation Sequencing Data Analysis by Xinkun Wang. Biological Information System and Management

Circuits and Instrumentation for Biomedical Engineering (AS4500)

Objective: To instruct about medical instruments currently in use in the medical domain with a special focus on the building blocks of such instruments.

Course Outcome
Students will be able to:

- Become familiar with key Medical Devices such as ECG, EMG, EEG, Cardiac Output Computer, Blood Pressure Measurement, ultrasound Machine, etc.,
- Know their operation principle, static and dynamic characteristics.

Transducers for Biomedical Application
Resistive transducers – Muscle force and Stress (Strain gauge), Spirometers (Potentiometric), humidity, Respiration (Thermistor); Inductive Transducers – Flow measurements, muscle movement (LVDT).

Capacitive Transducers
Heart sound measurement, Pulse pick up; Photoelectric Transducers - Pulse transducers, Blood pressure, oxygen Analyses; Piezoelectric Transducers – Pulse pickup, ultrasonic blood flowmeter; Chemical Transducer.

Operation principle, static and dynamic characteristics
ECG (Amplifiers and Circuits), EEG, Plethysmography, Cardiac Output Measurement. Ultrasonic, Transducers, and Ultrasonic Imaging, Beam Steering, Flow meters, Full Body Plethysmograph, EMG, LabVIEW

Text Book

- D. Patranabis, Sensors and Transducers, Prentice Hall of India, 2nd Edition,1984
- H. S. Kalsi , Electronics instrumentation, Tata Mc Grow Hill education Pvt. Ltd., 3rdedition 2010.

Reference

- Jon. B. Olansen and Eric Rosow, Virtual Bio-Instrumentation Biomedical, Clinical and Healthcare Applications using LabVIEW, Prentice Hall, first edition, 2002.

Biomechanics (AS4501)

Objective: To teach the concepts of mechanics concerning human movement, particularly those about exercise, sport, and physical activity.

Course Outcome
Students will be able to:

- Understand mechanical and anatomical principles from a mechanical perspective.
- Understand the domain of Biofluid mechanics and Cardiovascular mechanics
- Gain an understanding of disease of cardiovascular system & Artificial heart valve.
- Learn the concepts of Mechanical properties of biological materials.

Introduction to biomechanics
Joint mechanics, Human joint forces, Mechanics of elbow joints, Mechanics of shoulder joints, Mechanics of hip joints, Mechanics of knee joints, Mechanics of ankle joints

Tissue mechanics
Mechanical properties, Biological materials, Bone as composite material, Adaptation of bone stress and strain, Properties of cortical bone, cancellous bone, Teeth and its properties, Viscoelasicity, Dynamic behavior, Viscoelastic model, Soft tissue mechanics & properties: collagen, Elastin and mucopolysaccarides, Mechanical testing of soft tissue

Human locomotion, Gait analysis
Events of gait, Variable measured during gait, Motion analysis, Energy considerations, Muscles function, Force data, Prediction of segment moment of inertia, Measurement devices, Kinematics, Foot pressure pedobarograph.

Biofluid mechanics
Viscosity and viscometry, Capillary viscometer, Coaxial cylindrical viscometer, Cone and plate viscometer, Blood, Model of peripheral circulation, Coagulation, Blood rheology and its clinical application, Red cell size and shape, Cell membrane, Osmotic swelling, Area dilation, Shear of membrane, Synovial fluid, Cardiovascular mechanics.

Text Book:

- Fung, Y. C.: Biomechanics: Mech. Properties of Living Tissues. 2nd Ed., Springer
- C. Ross Ethier and Craig A. Simmons: Introductory Biomechanics: From Cells to Organisms. Cambridge University Press.
- J.D. Humphrey and S.L. Delange. An Introduction to Biomechanics: Solids and Fluids, Analysis and Design. Springer.

Reference Books

- B. Alberts, D. Bray, J. Levis, M. Raff, K. Roberts & J. D. Watson: Molecular Biology of the Cell; 5th Ed, Garland Science.

Bio-signal Processing (AS 4530)

Objective: To comprehend biological signal acquisition, sampling rate, and analysis.

Course Outcome
Students will be able to:

- Get familiar with discrete domain analysis and application of signal processing tools to extract information relevant to the medical domain.
- Become conversant with implementations of various signal processing functions in MATLAB environment.

Continuous-time signals and systems
Essentials of continuous-time signals and systems: convolution; Discrete-time signals and systems.

Sampling and quantization
Sampling and quantization, the sampling theorem and signal reconstruction; Z-transform, Filters

Fourier transforms
System transfer functions, Frequency analysis of discrete signals and systems: the discrete Fourier transform,

Power spectrum estimation
Power spectrum estimation and system identification; Systems with Feedback Control: stability analysis.

Text Books

- A.V. Oppenheim, A.S. Willsky & H.S. Nawab: Signals & Systems, Prentice Hall, India, 1997

Reference Books

- Discrete Time Signal Processing, Oppenheim, Schaefer, Pearson

Mathematics and Statistics for Biology (AS4531)

Objective: To make understand basic concepts of Matrix Theory, ODE, key probability distribution, and statistical tools.

Course Outcome
Students will be able to:

- Solve systems of linear equations and ordinary differential equations and apply key probability distributions to biological data.
- Analyze biological data using statistical tests.
- Model biological data using ODE and infer the data using statistical tools.

Matrices
Addition, multiplication, transpose, inverse and determinant of a square matrix, Gauss Elimination Method to solve the system of linear equations, Cramer's Rule, Rank of a matrix, Eigen Value and Eigen Vectors, Algebraic multiplicity and geometric multiplicity of an eigenvalue, Diagonalizability.

Ordinary Differential Equations (ODE)
Separable first-order ODE, Exact first-order ODE, Homogeneous first-order ODE,

Basic concepts of Probability
Review of the basic concepts of Probability (up to Bayes Theorem) and Statistics (Central tendencies and standard deviations) Probability Distribution functions: Binomial, Poisson and Normal distributions, Central Limit Theorem and its applications.

Sampling distribution
Estimation, Interval estimation, Confidence interval, Test of hypotheses, Z-test, t-test, the chi-square test. Correlation and Regression analyses, Correlation Coefficients, linear regression (one variable).

Text Book

- Advanced Engineering Mathematics by Erwin Kreyszig.
- Biostatistics-A Foundation for Analysis in the Health Sciences' by Wayne E. Daniel and Chad L. Gross.

Reference Book

- Fundamental of Biostatistics' by Bernard Rosner

Molecular Biology (AS4550)

Objective: To make understand basic biomolecules involved in cell structure and functions in prokaryotes and eukaryotic cells and basic structure of DNA, RNA, & protein.

Course Outcome
Students will be able to:

- Learn the basic structure of DNA, RNA, and protein.
- Understand molecular pathways control cellular functions
- Develop critical thinking and laboratory skills like plasmid and genomic DNA purification, Agarose gel electrophoresis, isolations of proteins, and PAGE analysis.

Biomolecules
Biomolecules involved in cell structure and functions in prokaryotes and eukaryotic cells. Structure of nucleotides, the chemical structure of DNA and RNA, Watson-Crick model, Supercoiled DNA. Genome organization in prokaryotes and eukaryotes and epigenetics.

Central dogma
DNA replication, repair and recombination, PCR, Gel Electrophoresis, Transcription. Structure and function of RNA polymerases. Transcription factors and machinery in Prokaryotes, formation of initiation complex, transcription activators and repressors.

Protein synthesis
Protein synthesis and processing Ribosome, formation of initiation complex, initiation factors, and their regulation, elongation and elongation factors, termination, genetic code, SDS PAGE

Cell cycle
Study of cell cycle and apoptosis, ROS, techniques for detection of Apoptosis and ROS, FACS

Text Books

- Freifelder D (2012). Molecular Biology, 5th edition. Narosa Publishing House, India
- Berg JM, Tymoczko JL, Gatto GJ and Stryer L (2015) Biochemistry, 8th Edition, WH Freeman & Co., New York. iii. Allison A. Lizabeth (2012) Fundamental Molecular Biology, 2nd Edition. J Willey and Sons, Hoboken,New Jersey.

Reference Books

- Freifelder D and Malacinski GM (2005) Essentials of Molecular Biology, 4th Edition, John and Bartlett Publishing, UK
- Watson JD, Baker TA, Bell SP, Gann A, Levine M and Losick R (2008) Molecular Biology of the Gene, 6th edition, Cold Spring Harbour Laboratory Press, Pearson Publication.

Anatomy & Physiology (AS4551)

Objective: To make learn the concepts of the different levels of structural organization that make up the human body and explain their relationships.

Course Outcome
Students will be able to:

- Get an overview of how the body is organized, and how the body's organ systems work together.
- Understand the different organ systems of the human body and explain the major functions of each.

Bones
Bones of an appendicular skeleton – Scapula, humerus, radius, ulna, Joint - Hip, Femur, ankle, and foot

Muscles
Principal Muscles – Deltoid, Biceps, triceps, respiratory, abdominal and gluteal

Systemic physiology
Nervous System, Neuromuscular system; Blood and lymph; Circulatory system; Respiratory and Cardiovascular system.

Gastro-intestinal system
Kidney and excretory system, Sensory systems- visual, auditory, vestibular

Text Books

- Arthur C. Guyton: Textbook of Medical Physiology, 8th ed, Prism Books (Pvt) Ltd & W.B. Saunders Company, 1991.
- W. F. Ganong, Review of Medical Physiology, 13th ed., Prentice-Hall, 17th edition, 1995.

Reference Books

Advanced Medical Instrumentation (AS4200)

Objective: To impart working knowledge of real-time and embedded systems in the healthcare domain

Course Outcome
Students will be able to:

- Gain familiarity with device safety-associated regulations.
- Became aware of micro and nano-scale sensors and devices for healthcare.

Microcontroller and microprocessors
Concept of microcontrollers, microprocessors, device safety, ethics, and regulatory standards in medical instruments, EMI testing.

Sensors and Micro/Nanodevices
Molecular/ MEMS Sensors and Micro/Nanodevices for Biomedical Engineering Applications,

Embedded Systems & Real- Time Systems
Biomedical Instrument Design, Introduction to Embedded Systems & Real- Time Systems for Bio-signals & DSP.

Text Books

- R. S. Khandpur “Handbook of Biomedical Instrumentation”, Tata McGraw Hill.
- Carr& Brown, “Introduction to Biomedical Equipment Technology” Pearson Education, Asia.
- J.Webster, “Bioinstrumentation”, Wiley & Sons.
- R S Khandpur, Handbook of Analytical Instruments, Second Edition

Reference Books

- Joseph Bronzing, “Biomedical Engineering and Instrumentation”, PWS Engg. , Boston.
- Geddes & Baker, “Principles of Applied Biomedical Instrumentation” Wiley.
- Leslie Cromwell, “Biomedical Instrumentation and Measurements”

Biomedical Imaging (AS4201)

Objective: To develop background on the building blocks of medical imaging instruments

Course Outcome
Students will be able to:

- Gain knowledge of the physics of medical imaging.
- Learn the sources of signals and correlation with tissue features.

US imaging
Ultrasound wave propagation in homogenous medium, scattering, absorption and attenuation of ultrasound waves in tissue, pulse-echo imaging, pulse parameters, ultrasound transducers, field calculation for a single element transducer, delay-sum beam forming for array transducers, Doppler ultrasound.

Optical coherence
Tomography-Michelson Morley experiment, X-ray imaging- Instrumentation, mechanism of attenuation of X-ray in tissue, scintillation detection, digital radiography, X-ray CT, back projection algorithm

MRI imaging-angular momentum
Nuclear magnetic moment, Zeeman effect, Larmour precision, T 1, T 2, T 2 * relaxations, chemical shift, free induction decay, 900, 1800 pulse sequence, magnetic coils, localization of MRI signals.

Nuclear imaging
introduction to SPECT, and PET, pair production, coincidence detection

Text Books

- The Essential Physics of Medical Imaging, Bushberg, Lippincott, Williams and Wilkins, Third Edition.
- The Physics of Medical Imaging, Webb, CRC Press, 1988.

==========

M.TECH- EC

Applicable with effect from 2023 admitted batch and onwards

Digital System Design (EC 4001)

Objectives: To make students familiar with the fundamentals of Digital circuit and system Design.

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

- design the digital integrated circuits and systems and
- estimate the performance.

Introduction
MOSFETs, CMOS process design kit, Static Characteristics: Introduction, Resistive-Load Inverters, Inverters with n-Type MOSFET Load, CMOS Inverter. Dynamic characteristics and interconnect effect: Introduction, Delay-Time Definitions, Calculation of Delay-Times, Inverter Design with Delay Constraints, Estimation of Interconnect Parasitic, Calculation of Interconnect Delay, Switching Power Dissipation of CMOS Inverters..

Combinational and Sequential Circuits

MOS Logic Circuits with Depletion nMOS Loads, CMOS Logic Circuits, Complex Logic Circuits, CMOS Transmission Gates (Pass Gates), Behavior of Bistable Elements, SR Latch Circuits, Clocked Latch and Flip-Flop Circuits, CMOS D-Latch and Edge-Triggered FlipFlop..

Dynamic Logic Circuits
Introduction, Basic Principles of Pass Transistor Circuits, Dynamic CMOS Circuit Techniques like Precharge-Evaluation logic, NORA, ZIPPER, Stick Diagrams, Physical Design Rules; Layout Designing; Euler's Rule for VLSI Physical Design

Clock Generation, Distribution, and Timing Analysis
Simple clock generation circuits, Clock Distribution schemes, Input and Output Interface circuits: Set up time, hold time, clock skew, slack, calculation of set up time and hold time violation, clock frequency, propagation delay, metastability, Standard designs of Dynamic Random Access Memory (DRAM), Static Random Access Memory (SRAM) and Non-volatile Memory, Flash Memory.

Text Books

- Kang, Sung-Mo, and Yusuf Leblebici. CMOS digital integrated circuits. Tata McGraw-Hill Education, 2003

Reference Books

- Uyemura, John P. "Introduction to VLSI circuits and systems." (2002).
- Rabaey, Jan M., Anantha P. Chandrakasan, and BorivojeNikolic. Digital integrated circuits. Vol. 2. Englewood Cliffs: Prentice hall, 2002.

VLSI Technology (EC 4002)

Objectives: : The subject provides an in-depth knowledge of how a semiconductor device is prepared right from the substrate preparation to device fabrication

Course Outcomes:

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

- to understand the technology and basic principles underlying the fabrication process of semiconductor devices.

Introduction
Crystal growth, and wafer preparation: crystal structures, wafer fabrication, crystal defects, gettering.

Thermal Oxidation
Oxidation kinetics, impurity redistribution during oxidation, oxide charges, nitridation of Silicon.

Lithography
Photolithography steps, photoresists, wet and dry etching, introduction to E-beam, X-ray and ion-Beam lithography

Basic diffusion process, equations, and profiles
Ion Implantation and implant range, Ion stopping and ion channeling interconnects, modern CVD and PVD techniques and systems, refractory metals, Modern CMOS processes.

Text Book

- J. D. Plummer, M. D. and P. D. Griffin, Silicon VLSI Technology: Fundamentals, Practice, and Modeling, Pearson Education.

Reference Books

- S. M. Sze, VLSI Technology, McGraw Hill Education, Second Edition.
- G. S. May and S M Sze, Fundamentals of Semiconductor Fabrication, John Wiley & Sons,
- S. K. Gandhi, VLSI Fabrication Principles: Silicon and Gallium Arsenide, John Wiley & Sons, Second Edition.

Solid State Devices (EC 4003)

Objectives: The objective of this course is to provide a comprehensive understanding of semiconductor physics, including quantum mechanical principles, semiconductor junctions, and the operation of key devices like Bipolar Junction Transistors and Field Effect Transistors

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

- Understand Quantum Mechanical Concepts and Charge Carrier Behavior
- Explore Semiconductor Junctions and Their Applications
- Analyze BJTs, FETs and their models

Basic Semiconductor Physics
Quantum mechanical concepts and atomic states, band structure, charge carriers, diffusion of carriers, BTE, etc.

Junctions
p-n junctions, Schottky barrier junctions, heterojunctions, ohmic contacts, introduction to photonic devices.

Bipolar Junction Transistors
principle of operation,I-V characteristics, Ebers-Moll Model, Gummel-Poon model, small signal amplifier

Field Effect Transistors
MOS Capacitor, MOSFET, principle of operation,I-V characteristics, short channel and non-ideal effects in MOSFETs

Text Books

- Michael Shur, Physics of Semiconductor Devices, PHI, 1995.
- Ben G. Streetman, Solid State Electronic Devices, PHI, 4th Edition.

Reference Books

- S. Sedra and K. C. Smith, Microelectronic Circuits, Oxford Univ. Press, 5th Edition..

Embedded System Design (EC 4004)

Objectives: To make students familiar with the fundamentals of embedded system Design and techniques

Course Outcomes:

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

- to model and design the processor, memory, and controllers for the system applications

Evolution of processors for embedded application
High performance computing and low power computing; Moore's law and Amdahl's law; Brief overview of performance estimation; Performance gap in microprocessor and memory; Introduction of Cache hierarchy in processors; Memory elements and hierarchy (SRAM, DRAM, Flash, Hard Disk).Techniques for hardware Performance improvement; Design Process of embedded system; Hardware/Software Interface

ARM
Performance and efficiency of ARM architecture (ARM 7, ARM 9, ARM 11). Thumb and ARM Instruction set and Programming; Data processing, Data transfer, and Control flow instructions. Data Level Parallelism and Thread level parallelism, Memory Interfacing,, I/O interfacing, Interface IP: AMBA, DDR, Ethernet, USB, Analog IP: Data Converter and PLL, Embedded Memory IP; Serial Communication and Parallel Communication

Sensors and actuators
Interfacing to sensors and actuators, Constraints in design, Reaction constraints and execution constraints, Heterogeneity, Constructivity; Execution and Interaction Semantics, Composition of state machines, Hierarchical state machines.

Real Time Operating systems
Scheduling, Memory and I/O management, Bus I/O and networking considerations, System verification, Testing of embedded systems.

Text Books

Reference Books

- Heath, Steve. Embedded systems design. Newnes, 2002.
- Hennessy, John L., and David A. Patterson. Computer architecture: a quantitative approach. Elsevier, 2012.
- Wolf, Wayne. FPGA-based system design. Pearson Education, 2004.

Testing and Verification (EC 4005)

Objectives: To let the students exposed to Testing and to demonstrate their application on real time system.

Course Outcomes:

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

- handle Verification Students will be exposed to Testing and explore many areas of Testing & Verification

Introduction
Basics of testing and fault modelling: Introduction- Principle of testing - types of testing - DC and AC parametric tests - fault modelling

Testing and testability
Testing and testability of combinational & sequential circuits, algorithms, Boundary scan, Memory, IDDQ.

Testing
Testable memory design - test algorithms for RAMs, IDDQ testing - testing methods - limitations

Built-in self-test
Test pattern generation (BIST) - Output response analysis – BIST architectures..

Text Books

- M.L. Bushnell and V.D. Agrawal, "Essentials of Electronic Testing for Digital, Memory and Mixed-Signal VLSI Circuits", Kluwar Academic Publishers.

Reference Books

- P. K. Lala, "Digital Circuit Testing and Testability", Academic Press.
- N.K. Jha and S.G. Gupta, "Testing of Digital Systems", Cambridge University Press.
- N. Zainalabedin, "Digital System Test and Testable Design: Using HDL Models and Architectures", Springer.

Analog Integrated Circuit Design (EC 4006)

Objectives: Students will be able to learn about the process flow of IC designing, importance and design of analog sub circuits, various amplifiers and will eventually learn the art of designing analog VLSI circuits.

Course Outcomes:

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

- Explain process flow of IC designing
- Develop analog sub circuits, Current mirrors etc
- Design various amplifiers like Differential amplifier, Cascode, Telescopic Amplifier etc
- Design analog and understanding of mixed signal circuits

Introduction to Analog IC Design
IC design flow, Device characteristics, Operation of Transistors, Equation and Models.

Analog Sub-Circuits and Single Stage Amplifiers
MOS Diode, Current Mirrors and their types, Single Stage Amplifiers CS, CG and CD and their frequency response, Design of Cascode Amplifier.

Multi Stage Amplifiers
Differential amplifier, op-amps, Compensations, Design of 2 stage op-amp and application

Others Amplifiers and Feedback
Design of Telescopic Amplifiers, Folded Cascode Amplifers, Feedback Techniques and Filters.

Text Books

- Gray, Paul R., and Robert G. Meyer. Analysis and Design of Analog Integrated Circuits. John Wiley & Sons, Inc., 1990
- Allen Holberg, CMOS Analog Circuit Design, 3rd Edition, OUP USA, 2012.

Reference Books

- Razavi, Behzad. Design of Analog CMOS Integrated circuits, McGraw Hill, 2nd Edition, 2017.

Advanced Digital Communication (EC 4075)

Objectives: To make students familiar with the Digital communication concepts and technologies.

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

- Apply mathematical modelling to problems in wireless digital communications.
- Identify modulation and demodulation techniques, coding and decoding scheme for the design of a transmitter and receiver.
- Evaluate the impact of noise on communication performance and design optimum receiver to mitigate these effects.
- Explore emerging technologies and standards in digital communication, such as 5G and beyond, and assess their applications in real-world scenarios.

Introduction
Review of digital communication, Passband pulse and quadrature-amplitude modulation, Pulse code modulation (PCM), Delta modulation, Inter-symbol interference and pulse shaping, Optimum detection, Probability of error analysis.

Introduction to Digital Modulation Techniques
Line Coding, Review of Digital modulation techniques, Multiplexing and multiple access techniques, Adaptive Modulation and Coding, Spread spectrum modulation, Probability of error analysis of digital modulation techniques

Source Coding
Mathematical models for information sources, Entropy and mutual information, Lossless data compression, Coding for discrete sources, Huffman coding, Run-length coding, Lempel-Ziv algorithm, Lossy data compression, Rate distortion functions

Advanced Channel Coding
Review of Linear Block codes and convolutional codes, LDPC codes, Turbo codes, serially concatenated codes, bit- interleaved coded modulation, Polar codes.

Text Books

- J. G. Proakis, Digital Communications, fourth edition, McGraw–Hill, 2001.
- B. Carlson et.al., Communication Systems: An Introduction to Signals and Noise in Electrical Communication, 4th Edition, McGraw Hill International, 2002.

Reference Books

- R. G. Gallager, Principles of Digital Communication, Cambridge University Press, 2008.
- S. Haykin, Communication Systems, John Wiley & Sons, 2001.

Statistical Signal Analysis (EC 4076)

Objectives: The subject provides an in-depth knowledge of Statistical Signal Analysis

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

- Exploit the knowledge of various mathematical models in wide range of engineering applications.
- Understand fundamental concepts of probability theory, including random variables, probability distributions, and expected values.
- Familiarize with the detection and estimation of random signals.
- Implement estimation and detection techniques, including parameter estimation and hypothesis testing, for real-world signal processing applications

Introduction
Review of random signals, Transformation (function) of random variables, Moment generating function, characteristic function, Conditional expectation, Sequences of random variables, Law of large numbers, Central limit theorem, Jointly Gaussian random vectors, Covariance matrices, Principal component analysis.

Introduction to Random Processes and Random Vectors
Wide-sense stationary processes, Ergodicity, Moments, Autocorrelation and autocovariance functions, Spectral representation of random signals, Poisson process, Gaussian processes, Wiener process, White noise, MA, AR, ARMA models, Overview of Markov Chains

Hypothesis Testing and Detection
Bayes Rule, Likelihood ratios, Sufficient statistics, Minimax Rule, Composite Hypothesis Testing, Neyman-Pearson test, Receiver operating characteristics

Parameter Estimation
Maximum likelihood estimation, Maximum a posteriori probability estimation, Minimum mean-square estimation, Linear least square estimation, Cramer Rao lower bound, Kalman filtering.

Text Book

- Papoulis, Probability, Random Variables and Stochastic Processes, 2nd Ed., McGraw Hill, 1983.
- H. L. Van Trees, Detection, Estimation and Modulation Theory (Part I), John Wiley & Sons, 2001.

Reference Books

- Larson and B.O. Schubert, Stochastic Processes, Vol. I and II, Holden-Day, 1979.
- S. M. Kay, Fundamentals of Statistical Signal Processing - Estimation Theory (Vol. 1), Prentice- Hall, Inc., 1993, ISBN: 978-0133457117.

Radiating System (EC 4077)

Objectives: The objective is to provide a comprehensive understanding of electromagnetic theory, focusing on wave propagation, radiation, antenna, and the working principles of different antenna types, with an emphasis on design and analysis.

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

- Learn the basics of radiation principle and foundational concepts through mathematical analysis and will gain insight about fundamental parameters and terminology used in Antenna Engineering.
- Analyze and design various types of antennas to achieve a specified performance.
- understand various modes of EM wave propagation.
- acquire hands-on experience with antenna measurements and testing

Introduction to Electromagnetic Theory
Review of Maxwell's Equation and boundary conditions, Wave propagation, Normal and Oblique incidence of plane wave at conducting and dielectric media

Radiation Integrals and Auxiliary Potential Functions
Vector Potential, Electric and Magnetic Fields for Electric and Magnetic Current Sources, Solution of the Inhomogeneous Vector Potential Wave Equation, Far-Field Radiation, Duality Theorem, Reciprocity and Reaction Theorems

Antenna Fundamentals & Radiation from Wires and Loops
Principle of Radiation, Radiation Pattern, Field Regions, Radiation Power Density, Beamwidth, Directivity, Antenna Efficiency, Gain, Bandwidth, Polarization, Input Impedance, Maximum Directivity and Maximum Effective Area, Friis Transmission Equation and Radar Range Equation. Infinitesimal dipole, finite-length dipole, linear elements near conductors, dipoles for mobile communication, small circular loop.

Working Principle of Antenns, Antenna Arrays & Microstrip Antennas
Two-Element Array, N-Element Linear Array, Design Procedure, Synthesis of antenna arrays, Analysis of uniformly spaced arrays with uniform and non-uniform excitation amplitudes, extension, folded dipole, Yagi-Uda, Log-periodic, Parabolic reflector, Horn, V-antenna, Rhombic antenna, Resonant and non-resonant antenna. Microstrip antennas, feeding methods, methods of analysis, design of rectangular and circular patch antennas.

Text Books

- C A Balanis, Antenna Theory and Design.3rd Ed., John Wiley & Sons. 2005.
- R. Harish, and M. Sachidananda. Antennas and wave propagation. Oxford University Press, USA, 2007.

Reference Books

- R. S. Elliot, Antenna Theory and Design. Revised edition, Wiley-IEEE Press. 2003.
- R. E. Collin, Antennas and Radio Wave Propagation. McGraw-Hill. 1985.
- R. K. Shevgaonkar, Electromagnetic waves. Tata McGraw-Hill Education, 2005.

Introduction to Machine learning (EC 4078)

Objectives: To make students familiar with techniques for analysis and modelling of speech both from signal processing and machine learning aspects coving number of applications

Course Outcomes:

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

- principles and algorithms for machine learning

Introduction to Machine Learning
Basic ML concepts and examples, Basic Probability Notations, Bayesian Inference, Basic concepts of statistics, probability and calculus.

Supervised Machine Learning
Regression (Linear Regression, Ridge regression, Regression Trees, Non-linear regression, Bayesian Linear regression, polynomial regression, Lasso regression, Gradient decent) Classification (Random forest, Decision Trees etc Maximum Likelihood estimation, Regularization/MAP, Soft/Hard Margin SVM, SVM Duality

Unsupervised Machine Learning
(K-means clustering (Soft/Hard), KNN (k-nearest neighbors), Hierarchical clustering, Anomaly detection, Neural networks, Principal Component Analysis, Independent Component Analysis, A-priori algorithm, Posteriori Algorithm, Singular value decomposition) Association

Reinforcement Machine Learning
Reinforcement Learning overview, The learning Task, Q-Learning, Nondeterministic Q-Learning, Temporal Difference-Learning, RL-General formulation, Multi-armed Bandits, Markov Decision Process and Deep Reinforcement Learning

Text Books

Reference Books

- Pattern Recognition and Machine Learning by Bishop, Springer, 2006.
- Machine Learning: A Probabilistic Perspective by Kevin P. Murphy, MIT Press, 2012
- The Elements of Statistical Learning, 2nd edition by Hastie, Tibshirani and Friedman, Springer-Verlag, 2008.
- Bayesian Reasoning and Machine Learning by David Barber, Cambridge University Press, 2012.
- Information Theory, Inference, and Learning Algorithms by David Mackay, Cambridge University Press, 2003.

Principles of Wireless Communications (EC 4035)

Objectives: To enable the student to synthesis and analyse wireless and mobile cellular communication systems over stochastic fading channels.

Course Outcomes:

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

- analyse and design wireless and mobile cellular systems, and 2) the students will have the ability to work in advance areas of wireless and mobile cellular environments

Introduction
Evolution of mobile radio communication, Cellular communication, Cellular system design fundamentals: frequency reuse concept, channel assignment, co-channel interference, adjacent channel interference, system capacity, cell splitting, sectoring, etc., Cellular System Architectures: GSM system, Multiple access techniques of cellular networks, Orthogonal frequency division multiplexing LTE architecture, 5G architecture

Physical modelling for wireless channels
Link budget design using path-loss model, Outdoor and indoor propagation models, small scale multipath propagation, Delay spread, Coherence bandwidth, Doppler spread & Coherence time, Flat fading, Frequency selective fading, Fast fading, Slow fading

Diversity in Wireless Communication
Diversity concept, Non-coherent and coherent reception, Time diversity, Repetition coding, Receiver diversity (SC, EGC and MRC), Multiple receive antenna system model and its error performance analysis, Transmit diversity, Channel estimation for multi-antenna system, Diversity order analysis

5G and Beyond Wireless Technologies
Cooperative relaying communications, Cognitive radio networks, Device-to-Device (D2D) Communications, Ambient backscatter communications (AmBC), Reconfigurable intelligent surface (RIS), Non-orthogonal multiple access (NOMA)

Text Books

- J. Goldsmith, Wireless Communications, Cambridge University Press, 2005.
- T. S. Rappaport, Wireless Communications, Prentice Hall, 1996.

Reference Books

- D. Tse and P. Viswanath, Fundamentals of Wireless Communications, Cambridge University Press, 2005.
- M. K. Simon and M. S. Alouini, Digital Communications over Fading Channels, John Wiley & Sons, 2000.

Recent Advances in Machine Learning (EC 4036)

Objectives: To provide basics of recent techniques of machine learning and to introduce students with deep reinforcement learning methods

Course Outcome

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

- acquire the advanced methods of machine learning
- understand the Deep Learning algorithms and its properties
- examine the applications of Deep ML and Deep RL in the communication.
- develop student's modeling and analytical skill for solving complex sequential decision problems

Introduction

Artificial Neural Networks, Deep Neural Networks

Generative adversarial networks (GAN)

Q learning, Deep Reinforcement Learning, Deep Q Network, Policy network

Monte Carlo Tree Search, Applications to communication systems, IoT, and cyber physical systems

Text Book

- Vivek S. Borkar, Stochastic Approximation: A Dynamical Systems Viewpoint, Springer, 2nd Edition, 2022.
- 2. Harold Kushner and G. George Yin, Stochastic Approximation and Recursive Algorithms and Applications, Springer, 2nd Edition, 2003.
- 3. Richard S. Sutton and Andrew G. Barto, Reinforcement Learning: An Introduction, Bradford Books, 2nd Edition, 2018.
- 4. David Silver et. al., Mastering the game of Go with Deep neural networks and tree search, Nature, Volume 529, Feb., 2016.
- 5. Ian Goodfellow, Yoshua Bengio and Aaron Courville, Deep Learning, An MIT Press Book, 2016.