UNIVERSITY OF CALCUTTA
Faculty of Engineering & Technology
Curriculum for M.Tech. in Computer Science and Engineering
(Effective from 2024-2025)
CSR NO:

FIRST SEMESTER							
SL. NO.	PAPER CODE	PAPER NAME	L	T	P	CONTACT HRS./WEEK	CREDIT
01	Program Core I: CSC901	Mathematical Foundations of Computer Science	3	0	0	3	3
02	Program Core II CSC902	Advanced Algorithms	3	0	0	3	3
03	Program Elective I: CSE9xx	01. Machine Learning 02. Soft Computing	3	0	0	3	3
04	Program Elective II: CSE9xx	03: Wireless & Mobile Computing 04: Advanced Networking	3	1	0	4	4
05	CSA901	Research Methodology and IPR	3	0	0	3	3
06	CSA9xx	02. English for Research Paper Writing 03. Pedagogy Studies	2	0	0	2	0
07	Laboratory I: (from Core) CSPC901	Advanced Algorithm Laboratory	0	0	3	3	1.5
08	Laboratory II: (From Elective) CSPE9XX	01. Machine Learning Laboratory 02. Soft Computing Laboratory	0	0	3	3	1.5
		Total	17	1	6	24	19

SECOND SEMESTER							
SL. NO.	PAPER CODE	PAPER NAME	L	T	P	CONTACT HRS./WEEK	CREDIT
01	Program Core III: CSC1001	Advanced Database Systems	3	1	0	4	4
02	Program Core IV:CSC1002	Advanced Software Engineering	3	0	0	3	3
03	Program Elective III: CSE10XX	01. Cloud Computing 02: Internet of Things	3	1	0	4	4
04	Program Elective IV: CSE10xx	03. Computer Vision 04. Image Processing	3	1	0	4	4
05	Laboratory III: (from Core) CSPC1001	Advanced DBMS & Software Engineering Laboratory	0	0	3	3	1.5
06	Laboratory IV: (from Elective) CSPE10XX	03. Computer Vision 04. Image Processing	0	0	3	3	1.5
07	CSP1001	Mini Project with Seminar	0	0	6	6	3
		Total	15	0	10	27	21

THIRD SEMESTER							
SL. NO.	PAPER CODE	PAPER NAME	L	T	P	CONTACT HRS./WEEK	CREDIT
01	Program Elective V: CSE11XX	01. Information Security 02. Introduction to Data Science 03.VLSI Design 04. Deep Learning 05. Natural Language Processing 06. Quantum Computing	3	1	0	4	4
02	Open Elective: CSOE11XX	01. Bio-Informatics 02. Operation Research	3	1	0	4	4
03	CSP1101	Dissertation -I	0	0	24	24	12
		Total	6	2	24	32	20

FOURTH SEMESTER							
SL. NO.	PAPER CODE	PAPER NAME	L	T	P	CONTACT HRS./WEEK	CREDIT
01	CSP1201	Dissertation-II	0	0	36	36	18
02	CSP1202	General Viva-Voce	0	0	0	0	2
		Total	0	0	36	36	20

CSC901: Mathematical Foundations of Computer Science

Linear Algebra: Vector space: Definitions and examples, Subspace, Linear span, Generators of vector space, Finite dimensional vector space, Dimension of a vector space, Extraction of basis, Eigen value and eigenvectors of matrices, Caley Hamilton Theorem, Diagonalisation.

Probability and Random variables: Probability, Conditional probability and independence, Discrete and continuous random variables and their distributions, Computer simulation and Monte Carlo methods.

Stochastic Processes and Queuing Systems.

Statistics: Introduction, Bivariate and multivariate distributions, Laws of large numbers, Central limit theorem, Basic statistical inference, Parameter estimation, Confidence intervals, Hypothesis testing, Chi-square test, Non-parametric statistics, Bootstrap, Bayesian inference. Regression: Least square estimation, analysis of variance, prediction (ANOVA, R-square), Multivariate regression, Model building.

Computer Science & Engineering Applications: Applications (Use cases) from domains like Data mining, Network protocols, Analysis of Web traffic, Computer security etc .

Reference Books:

1. Michael Baron, Probability and Statistics for Computer Scientists, 2nd Ed., CRC Press.
2. Sheldon M. Ross, Introduction to Probability and Statistics, 4th Ed., Elsevier Academic Press, USA.
3. James L. Johnson, Probability and Statistics for Computer Science, Wiley, 2003.
4. William W. Hines, Douglas C. Montgomery, David M. Goldsman, and Connie M. Borror, Probability and Statistics in Engineering, 4th Ed., John Wiley and Sons, 2003.
5. K. S. Trivedi, Probability and Statistics with Reliability, Queuing and Computer Science Application, 18th Ed, Prentice Hall, Englewood Cliffs, 1982.

CSC902: Advanced Algorithms

Preliminaries: Asymptotic Notation, Algorithm Paradigm: Greedy, Divide and Conquer, Master Theorem Dynamic Programming. (Chained Matrix Multiplication). Review of Mathematical Background: Recurrence Relation, Generating Function.

Algorithmic Computation: Family of Algorithms, Number-theoretic Functions, Primitive recursion.

Advanced data structure: Skip list, Union find, 2-3-4 trees, red-black tree, splay tree, Tries and suffix trees, Universal Hashing. Word-level Parallelism. Transdichotomous Model.

Graph Algorithms: All pair shortest Path, Network flow, Ford Fulkerson method, Matching.

String matching algorithms: KMP and Rabin-Karp.

Number theoretic algorithms – Modular Arithmetic, Primality Testing, Chinese Remainder theorem.

Polynomial representation, DFT and FFT.

Geometric algorithms: convex hulls, line segment intersection, closest pair.

Randomized Algorithms: concept, problems.

Non-determinism, NP-completeness, Co-NP, P Space.

Fixed parameter algorithms- Parameterized Complexity, Kernelization for vertex cover.

Approximation Algorithm- Performance bounds, vertex cover problem, Travelling salesman problem Greedy Set Cover problem, Linear Programming Relaxations, Randomized Rounding.

On-line algorithms: competitive ratio, list accessing, paging, self-organizing data structures, k-server, networks, auction, load-balancing, lower-bounds, Ski Rental, River Search Problem, List Ordering and Move-to-Front.

Streaming algorithms: Streaming Data models: Distinct items, frequent items, frequency moments, estimating norms, clustering.

Parallel Algorithms: PRAM, Selection, Search, Merge, Sort algorithms. Pointer Jumping and Parallel Prefix, Tree Contraction, Divide and Conquer, Randomized Symmetry Breaking, Maximal Independent Set.

Reference Books:

1. Jon Kleinberg and Éva Tardos, Algorithm Design, Addison-Wesley, 2005.
2. Thomas Cormen, Charles Leiserson, Ronald Rivest, and Clifford Stein, Introduction to Algorithms, Third Edition, MIT Press, 2009.
3. Sanjoy Dasgupta, Christos Papadimitriou, and Umesh Vazirani, Algorithms, McGraw Hill, 2006.
4. Introduction to Computability, F C Hennie, Addison Wesley.
5. Discrete Mathematics, Johnsonbaugh Maxwell Macmillan.

CSE901: Machine Learning

Supervised Learning: Basic methods: Distance-based methods, Nearest-Neighbours, Decision Trees, Naive Bayes; Linear models: Linear Regression, Logistic Regression, Generalized Linear Models, Support Vector Machines, Nonlinearity and Kernel Methods, Beyond Binary Classification: Multi-class/Structured Outputs, Ranking

Unsupervised Learning: Clustering: K-means/Kernel K-means, Dimensionality Reduction: PCA and kernel PCA, Matrix Factorization and Matrix Completion, Generative Models (mixture models and latent factor models)

Evaluating Machine Learning algorithms and Model Selection, Introduction to Statistical Learning Theory, Ensemble Methods (Boosting, Bagging, Random Forests)

Sparse Modeling and Estimation, Modeling Sequence/Time-Series Data, Deep Learning and Feature Representation Learning

Scalable Machine Learning (Online and Distributed Learning): A selection from some other advanced topics, e.g., Semi-supervised Learning, Active Learning, Reinforcement Learning, Inference in Graphical Models,

Introduction to Bayesian Learning and Inference

Recent trends in various learning techniques of machine learning and classification methods for IOT applications. Various models for IOT applications.

CSE902: Soft-Computing

Introduction to Soft-computing and Neural Networks: Evolution of Computing: Soft Computing Constituents, From Conventional AI to Computational Intelligence: Machine Learning Basics

Fuzzy logic: Fuzzy Sets, Operations on Fuzzy Sets, Fuzzy Relations, Membership Functions: Fuzzy Rules and Fuzzy Reasoning, Fuzzy Inference Systems, Fuzzy Expert Systems, Fuzzy Decision Making.

Neural Networks: Machine Learning Using Neural Network, Adaptive Networks, Feed forward Networks, Supervised Learning Neural Networks, Radial Basis Function Networks : Reinforcement Learning, Unsupervised Learning Neural Networks, Adaptive Resonance architectures, Advances in Neural networks

Genetic Algorithms: Introduction to Genetic Algorithms (GA), Applications of GA in Machine Learning : Machine Learning Approach to Knowledge Acquisition.

Matlab/Python Lib: Introduction to Matlab/Python, Arrays and array operations, Functions and Files, Study of neural network toolbox and fuzzy logic toolbox, Simple implementation of Artificial Neural Network and Fuzzy Logic

Recent Trands in deep learning, various classifiers, neural networks and genetic algorithm.

CSE903: Wireless & Mobile Computing

Introduction- Historical Evolution, Physical and Technological Constraints, Impacts on Computing Science

Wireless communication - Radio Propagation & Media Access, Wireless Communication Systems, Cellular Radio and Personal Communications

Wireless Networking -Packet Radio Network, Wireless LAN/WAN, Personal Communication Services

Cellular Wireless (Single-hop) Networks- Network Architecture, Mobility and Traffic Models, Radio Resource Management, Location Management, GSM, GPRS, 3G/4G systems

Mobile Ad-hoc (Multi-hop) Networks- Architectural Overview, Medium Access Protocols, Routing: Unicast & Multicast, Bluetooth, IEEE 801.11x systems

Mobile Wireless Protocols- Mobile IP , Wireless TCP, Session Mobility

Mobile Computing- Data Dissemination and Broadcast Models, Mobile Database and Mobile Transaction, Naming, Locating, and Routing, Location Awareness and Environmental Discovery

Mobile Applications and Services- Mobile Agents, Transcoding and Proxy Architecture, WAP and mobile web services,

Wireless Mobile Security- Authentication Privacy, Protocols such as WTLS, IEEE 802.11g

Pervasive/Ubiquitous Computing- Sensor Networks & Smart Environments, Power Management and Energy-Awareness Computing, Human-Computer Interactions, Wearable Computing

CSE904: Advanced Networking

High Performance Switching and Routing, Bridging/Switching and VLAN Concepts Switching Services, Configuration of Switches, Store and Forward Techniques, VLAN Basic, VLAN Membership, Routing between VLAN, Configuration of VLAN. Static Routing, Dynamic Routing - RIP, EIGRP, IGRP, OSPF. TCP Congestion Control -Additive Increase / Multiplicative Decrease -Slow Start -Fast Retransmit and Fast Recovery - Congestion avoidance Mechanisms - DECbit-Random Early Detection - Source-based Congestion Avoidance –Tahoe-Reno-and Vegas.

Algorithms for IP address lookup and optimization, Hardware implementation of address lookup.

Software Defined Network: Comparison between SDN and traditional networks -SDN controller, Switch design, SDN Controller-Switch Protocols, Open Flow Protocol, Control Overhead & Handoff algorithms. Network Function Virtualization -NFV Architecture, Use cases, NFV Orchestration and NFV for 5G.
Data Center Networking (DCN) – Introduction, DCN topologies, Container Network Interfaces, Content Distribution on the Internet, Architectures for Information Centric Networking, Content Naming, Routing and Caching, Security in Named Data Networking.

Books:
1. High Performance Switches and Routers, H. Jonathan Chao, Bin Liu, 2007, John Wiley& Sons, Inc. ISBN-10: 0-470-05367-4
2. Information-Centric Networks: A New Paradigm for the Internet (Focus Series in Networks and Telecommunications), Gabriel M. de Brito, Pedro B. Velloso, Igor M. Moraes, Wiley-ISTE; 1st edition, 2013, ISBN: 9781848214491
3. Information-Centric Networking (ICN): Content Centric Networking (CCNx) and Named Data Networking (NDN) Terminology, B. Wissingh, C. Wood, A. Afanasyev, L. Zhang, D. Oran and C. Tschudin, RFC 8793, June 2020
4. Software-Defined Networks: A Systems Approach, Peterson, Cascone, O'Connor, Vachuska, and Davie, Online Free Reference Book available at https://sdn.systemsapproach.org/index.html

CSA901: Research Methodology & IPR

Unit 1: Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem.
Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations Unit 2: Effective literature studies approaches, analysis Plagiarism, Research ethics,
Unit 3: Effective technical writing, how to write report, Paper. Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee
Unit 4: Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.
Unit 5: Patent Rights: Scope of Patent Rights. Licensing and transfer of technology, Patent information and databases. Geographical Indications.
Unit 6: New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

References:

Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science & engineering students'"
Wayne Goddard and Stuart Melville, "Research Methodology: An Introduction"
Ranjit Kumar, 2 ndEdition, "Research Methodology: A Step by Step Guide for beginners"
Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd,2007.
Mayall, "Industrial Design", McGraw Hill, 1992.
Niebel, "Product Design", McGraw Hill, 1974.
Asimov, "Introduction to Design", Prentice Hall, 1962.

CSA903: Pedagogy Studies

Introduction and Methodology: Aims and rationale, Policy background, Conceptual framework and terminology, Theories of learning, Curriculum, Teacher education. Conceptual framework, Research questions. Overview of methodology and Searching.
Thematic overview: Pedagogical practices are being used by teachers in formal and informal classrooms in developing countries. Curriculum, Teacher education.
Evidence on the effectiveness of pedagogical practices, Methodology for the in depth stage: quality assessment of included studies. How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy?, Theory of change, Strength and nature of the body of evidence for effective pedagogical practices, Pedagogic theory and pedagogical approaches, Teachers' attitudes and beliefs and Pedagogic strategies.
Professional development: alignment with classroom practices and follow-up support, Peer support, Support from the head teacher and the community, Curriculum and assessment, Barriers to learning: limited resources and large class sizes
Research gaps and future directions: Research design, Contexts, Pedagogy, Teacher education, Curriculum and assessment, Dissemination and research impact.

Suggested reading
1. Ackers J, Hardman F (2001) Classroom interaction in Kenyan primary schools, Compare, 31 (2): 245-261.
2. Agrawal M (2004) Curricular reform in schools: The importance of evaluation, Journal of Curriculum Studies, 36 (3): 361-379.

3. Akyeampong K (2003) Teacher training in Ghana - does it count? Multi-site teacher education research project (MUSTER) country report 1. London: DFID.
4. Akyeampong K, Lussier K, Pryor J, Westbrook J (2013) Improving teaching and learning of basic maths and reading in Africa: Does teacher preparation count? International Journal Educational Development, 33 (3): 272–282.
5. Alexander RJ (2001) Culture and pedagogy: International comparisons in primary education. Oxford and Boston: Blackwell.
6. Chavan M (2003) Read India: A mass scale, rapid, 'learning to read' campaign.
7. www.pratham.org/images/resource%20working%20paper%202.pdf.

CSC1001: Advanced Database Systems

Distributed Database Concepts: Definition of Distributed Database Management System (DDBMS), Distributed transparent system. DDBMS Architecture: DBMS standardization, Global, Local, External, and Internal Schemas, Architectural models for DDBMS. Distributed database design: Design problem of distributed systems, Design & strategies, Fragmentation, Allocation and replication of fragments. Query Processing Overview, Query Optimization. Transaction Processing in Distributed databases: ACID properties, Concurrency Control protocols, Deadlock management. Distributed Reliability Protocols.

Big Data handling: unstructured data, Examples of big data in various application domains, Introduction to NoSQL, aggregate data models, aggregates, key-value and document data models, relationships, graph databases, schemaless databases, materialized views, distribution models, sharding, master-slave replication, peerpeer replication, sharding and replication, consistency, relaxing consistency, version stamps, map-reduce, partitioning and combining, composing map-reduce calculations. Case studies on the above said data models.

Data Warehousing: Components, Building a data warehouse, Data extraction, cleanup and transformation, OLAP.

Text book: Distributed Database; Principles• & Systems By Publications, Stefano Ceri and Giuseppo Pelagatti,, McGraw-Hill International Editions (1984) Database Management Systems, 3rd edition, Raghu Ramakrishnan and• Spatial Databases: A Tour by Shashi Shekhar and Sanjay Chawla, Prentice Hall, 2003 (ISBN 013-017480-7) Principles of Multimedia Database Systems, Subramanian V. S.• Elsevier Publishers, 2013. References: Principles of Distributed Database Systems; 2nd Editied By M. Tamer• Ozsu and Patrick Valduriez, Person Education Asia. Database System Concepts, 5th edition, Avi Silberschatz , Henry F.•Korth , S. Sudarshan: McGraw-Hill (2010) Database Systems: Concepts, Design and Applications, 2nd edition,• Shio Kumar Singh, Pearson Publishing, (2011). Multi-dimensional aggregation for temporal data. M. Böhlen, J.• Gamper, and C.S. Jensen. In Proc. of EDBT-2006, pp. 257-275, (2006). Moving objects databases (chapter 1 and 2), R.H. Güti•

CSC1002: Advanced Software Engineering

Framework for Requirements Engineering, Requirements Engineering activities – Elicitation, Analysis, Validation, Documentation, Management, Rationale for Requirements Engineering and the problems with requirements, The importance of requirements planning and estimating. Requirements Documentation- Documentation styles and levels of definition Requirements Catalogue, Identifier, Name Description, Acceptance criteria, Requirements Analysis- Prioritizing and packaging requirements for delivery organizing requirements, Ensuring well-formed requirements, Prototyping requirements, and verifying requirements.

Fundamental issues in software design: Goodness of design, cohesions, coupling. Function oriented design: structured analysis and design. Overview of object oriented concepts. Unified Modeling Language (UML). Unified design process. User interface design. Coding standards and guidelines.

Agile development – Classification of methods – The agile manifesto and principles – Agile project management –The facts of change on software projects – Key motivations for iterative development – Meeting the requirements challenge iteratively – Evolutionary and adaptive planning – Incremental delivery – Evolutionary delivery –Problems with the waterfall. A Business case for iterative development.

Unit testing. Black box and white box testing. Integration and system testing. Software quality and reliability, Quality framework characteristics – verification- Measuring test adequacy overview of black box testing techniques-decision tables-combinatorial testing classification tree method- white box testing- Random and exploratory.

PSP and Six Sigma. Clean room technique. Software maintenance issues and techniques. Software reuse.

Books: Ian Sommeriele, "Software Engineering", Addison Wesley. 2. C.Easteal and G.Davis, Software Engineering Analysis and Design, Tata McGraw Hill. 3. Pressman, Software Engineering –A Practitioner's Approach. 4. Craig Larman "Agile and Iterative Development – A Manager's Guide" Pearson Education – 2004. 5. Requirements Engineering: Fundamentals, Principles, and Techniques by Klaus Pohl 6. Requirements Engineering: A Good Practice Guide by Ian Sommerville, Pete Sawyer

CSE1001: Cloud Computing

Introduction to Distributed Computing: Properties of Distributed Algorithms, Inter Process Communication, Remote Procedure Calls, Web Services, Service Oriented Architecture, client-server architecture and p2p computing architecture

Introduction to Cloud Computing: Cloud computing at a glance – The vision of cloud computing, Definition of cloud computing, The cloud computing reference model, Characteristics and benefits of cloud computing. Evolution of cloud computing – parallel computing, distributed computing, cluster computing, grid computing. Business driver for adopting cloud computing. Cloud Service Models – IaaS, PaaS, SaaS, XaaS. Cloud Deployment Models – Private, Public, Hybrid, Community, Cloud Federation.
Virtualization Technologies: Introduction to virtualization. Characteristics of virtualized environment – Security, Managed execution, Portability. Types of Virtualization – Bare Metal and Hosted. Hardware level virtualization – Machine(x86) reference model, Hypervisor, Hardware assisted virtualization, Full virtualization, Paravirtualization. Operating system level virtualization. Other types of virtualization – storage virtualization, Network virtualization, Desktop virtualization. VM Migration techniques. Pros and cons of virtualization. Case studies – Xen, VMware and Microsoft Hyper-V.
Cloud Services and Platforms: AWS Services, Google Cloud Services, Windows Azure Services
Security Issues in Cloud Computing: Infrastructure Security: The Network Level, The Host Level, The application Level, Data Security and Storage, Aspects of Data Security, Data Security Mitigation Provider Data and Its Security Identity and Access Management - Trust Boundaries and IAM, IAM Challenges, Relevant IAM Standards and Protocols for Cloud Services, IAM Practices in the Cloud, Cloud Authorization Management
Management of Cloud Resources : Lifecycle management of cloud applications. Monitoring cloud resources – Zabix, Amazon CloudWatch. Feedback control based on dynamic thresholds, Bag-of-Task (BoT) scheduling problems, VM Placement problems, Resource bundling, combinatorial auctions, fair queuing, borrowed virtual time, Cloud scheduling subject to deadlines, Cost and Energy efficient Scheduling algorithms, Scheduling in Federated environment. Identity and Access management for Cloud Resources – Amazon Identity and Access Management Services, Windows Azure Active Directory.

Text Books:

1. Mastering Cloud Computing - Foundations and Applications Programming by Christian Vecchiola, RajkumarBuyya, and S. ThamaraiSelvi, Elsevier, 2013
2. Cloud Computing – A Hands-on Approach by ArshdeepBahga and Vijay Madasetti, Universities Press, 2014

Reference Books:

1. Cloud Computing Bible by Barrie Sosinsky, Wiley-India, 2010
2. Cloud Computing: Principles and Paradigms by Rajkumar Buyya, James Broberg, Andrzej M. Goscinski, Wile, 2014
3. Cloud Computing: Principles, Systems and Applications, Editors: Nikos Antonopoulos, Lee Gillam, Springer, 2012
4. Cloud Security: A Comprehensive Guide to Secure Cloud Computing by Ronald L. Krutz, Russell Dean Vines, Wiley-India, 2010

CSE 1002: Internet of Things

Unit 1: Environmental Parameters Measurement and Monitoring: Why measurement and monitoring are important, effects of adverse parameters for the living being for IOT
Unit 2: Sensors: Working Principles: Different types; Selection of Sensors for Practical Applications, Introduction of Different Types of Sensors such as Capacitive, Resistive, Surface Acoustic Wave for Temperature, Pressure, Humidity, Toxic Gas etc
Unit 3: Important Characteristics of Sensors: Determination of the Characteristics Fractional order element: Constant Phase Impedance for sensing applications such as humidity, water quality, milk quality Impedance Spectroscopy: Equivalent circuit of Sensors and Modelling of Sensors Importance and Adoption of Smart Sensors
Unit 4: Architecture of Smart Sensors: Important components, their features Fabrication of Sensor and Smart Sensor: Electrode fabrication: Screen printing, Photolithography, Electroplating Sensing film deposition: Physical and chemical Vapor, Anodization, Sol-gel
Unit 5: Interface Electronic Circuit for Smart Sensors and Challenges for Interfacing the Smart Sensor, Usefulness of Silicon Technology in Smart Sensor And Future scope of research in smart sensor
Unit 6: Recent trends in smart sensor for day to day life, evolving sensors and their architecture.
References:

1. Yasuura, H., Kyung, C.-M., Liu, Y., Lin, Y.-L., Smart Sensors at the IoT Frontier, Springer International Publishing
2. Kyung, C.-M., Yasuura, H., Liu, Y., Lin, Y.-L., Smart Sensors and Systems, Springer International Publishing

CSE 1003: Computer Vision

Unit 1: Overview, computer imaging systems, lenses, Image formation and sensing, Image analysis, pre-processing and Binary image analysis
Unit 2: Edge detection, Edge detection performance, Hough transform, corner detection
Unit 3: Segmentation, Morphological filtering, Fourier transform
Unit 4: Feature extraction, shape, histogram, color, spectral, texture, using CVIPtools, Feature analysis, feature vectors, distance /similarity measures, data preprocessing

Unit 5: Pattern Analysis: Clustering: K-Means, K-Medoids, Mixture of Gaussians Classification: Discriminant Function, Supervised, Un-supervised, Semi-supervised Classifiers: Bayes, KNN, ANN models; Dimensionality Reduction: PCA, LDA, ICA, and Non-parametric methods.
Unit 6: Recent trends in activity recognition, computational photography, Biometrics.
References:
1. Computer Vision: Algorithms and Applications by Richard Szeliski.
2. Deep Learning, by Goodfellow, Bengio, and Courville.
3. Dictionary of Computer Vision and Image Processing, by Fisher et al.

CSE 1004: Image Processing

Introduction to Image Processing Systems- Elements of Visual Perception - Connectivity and Relations between Pixels. Simple Operations - Arithmetic, Logical, Geometric Operations.
Mathematical Preliminaries - 2D Linear Space Invariant Systems - 2D Convolution - Correlation 2D Random Sequence - 2D Spectrum.
Image Transforms and Enhancement- 2D Orthogonal and Unitary Transforms-Properties and Examples. 2D DFT - FFT - DCT - PCA, Hadamard Transform - Haar Transform - Slant Transform - KL Transform - Properties Histogram Equalization Technique - Point Processing-Spatial Filtering - In Space and Frequency - Nonlinear Filtering - Use of Different Masks.
Image Restoration and Construction - Image Observation and Degradation Model, Circulant and Block Circulant Matrices and Its Application in Degradation Model - Algebraic Approach to Restoration - Inverse by Wiener Filtering - Generalized Inverse - SVD and Interactive Methods - Blind Deconvolution-Image Reconstruction from Projections.
Image Compression and Segmentation - Redundancy and Compression Models - Loss Less and Lossy.
Loss Less - Variable-Length, Huffman, Arithmetic Coding - Bit-Plane Coding, Loss Less Predictive Coding, Lossy Transform (DCT) Based Coding, JPEG Standard - Sub Band Coding.
Image Segmentation- Edge Detection - Line Detection - Curve Detection - Edge Linking and Boundary Extraction, Boundary Representation, Region Representation and Segmentation, Morphology - Dilation, Erosion, Opening and Closing. Hit and Miss Algorithms Feature Analysis.
Colour and Multispectral Image Processing - Processing Fundamentals, RGB Models, HSI Models, Relationship between Different Models. Colour Image Processing Three Dimensional Image Processing-Computerized Axial Tomography – Stereometry - Stereoscopic Image Display - Shaded Surface Display.
References Books:
1. R. C. Gonzalez and R. E. Woods, Digital Image Processing (3rd Edition): Pearson Education, 2008.
2. Digital Image Processing, Kenneth R. Castleman, Pearson Education, 1995.
3. Digital Image Processing, S. Jayaraman, S. Esakkirajan, T. Veerakumar, McGraw Hill Education, Pvt Ltd, New Delhi. 2009
4. Fundamentals of Digital Image Processing, A K. Jain, Prentice Hall of India, 1989.
5. Image Processing, Sid Ahmed, McGraw Hill, New York, 1995.

CSE1101: Information Security

Module 1: Introduction to Information Security (4 Hours): Overview of Information Security, Historical Perspective and Evolution, Threats and Vulnerabilities, Security Models and Frameworks
Module 2: Cryptography (12 Hours): Introduction to Cryptography, Symmetric Key Cryptography, Asymmetric Key Cryptography, Hash Functions and Digital Signatures, Cryptographic Protocols, Key Management and Distribution, Cryptanalysis
Module 3: Network Security (10 Hours): Introduction to Network Security, Firewalls and Intrusion Detection Systems (IDS), Secure Network Protocols, Wireless Network Security, Network Monitoring and Analysis
Module 4: System and Application Security (6 Hours): Operating System Security, Secure Software Development, Web Application Security, Database Security, Cloud Security
Module 5: Risk Management and Incident Response (6 Hours): Introduction to Risk Management, Security Policies and Standards, Incident Response and Handling, Business Continuity and Disaster Recovery, Security Auditing and Penetration Testing
Module 6: Legal, Ethical, and Social Issues in Information Security (2 Hours)
References:
□ Whitman, M. E., & Mattord, H. J. (2011). Principles of Information Security. Cengage Learning.
□ Stallings, W. (2016). Cryptography and Network Security: Principles and Practice. Pearson.
□ Schneier, B. (1996). Applied Cryptography: Protocols, Algorithms, and Source Code in C. Wiley.
□ Stallings, W. (2013). Network Security Essentials: Applications and Standards. Pearson.
□ Nichols, R. K., & Lekkas, P. C. (2002). Wireless Security: Models, Threats, and Solutions. McGraw-Hill.
□ Jaeger, T. (2008). Operating System Security. Morgan & Claypool Publishers.
□ Dowd, M., McDonald, J., & Schuh, J. (2006). The Art of Software Security Assessment: Identifying and

Preventing Software Vulnerabilities. Addison-Wesley Professional.
□ Basta, A., & Zgola, M. (2011). Database Security. Cengage Learning.
□ NIST. (2002). Risk Management Guide for Information Technology Systems. NIST Special Publication 800-30.

CSE1102: Introduction to Data Science

Data and its use: A case-study.

Elementary statistics: Representing data by histograms, mean, variance and its computation. The variance as a measure of randomness and its implication, 2-D scatter plots.

Population and sampling: Example of sub-sampling and the question of (i) parameter testing and (ii) hypothesis testing problem, need for random variables, basics of a discrete RV: Set and probabilities, axioms of probability, coin toss and the binomial distribution, the Poisson RV.

Continuous RV and the density function: uniform and normal random variable, Checking the density function of an unknown source through repeated trials, ubiquitousness of the normal RV through examples, Law of large numbers, Problem of estimation of mean and variance.

Two random variables and joint probability density, Independent RV, Testing for independence, Sum of two RVs, Functions of RV and expectation, variance and various identities, Examples of binomial.

Repeated trial and its mean, mean and variance, coin-toss parameter estimation problem and use of normal distribution, parameter estimation, estimation of mean with known variance. Type I and Type II error.

Clustering: K-Means algorithm and its variants, Agglomerative Clustering.

K-NN classification, Naïve Bayes classification, Data visualization.

The estimation of the variance, estimator and its distribution, The chi-square density function. Confidence intervals and hypothesis testing.

The t-distribution and its use to estimate mean, Interval and hypothesis versions.

Linear regression, Statement of the problem as a minimization problem and its solution, Error and its measurement, Some conundrums, Dimensionality reduction through PCA. Higher dimensional regression-only examples.

CSE1103: VLSI Design

Introduction: CMOS and FinFET Technology, process scaling, fabrication, VLSI Design style, Design Flow.

Introduction to VHDL/Verilog: Logic Simulation, Gate level Simulation for FPGAs.

High level synthesis: Scheduling, Allocation and Binding.

Logic Synthesis: Two level Boolean Logic Synthesis, Heuristic Minimization of Two-Level Circuits, Finite State Machine Synthesis, Multilevel Implementation, Role of BDD, Logic synthesis tools ESPRESSO, SIS etc.

Layout synthesis/physical design: Partitioning, Floor planning, Placement, Global and Detailed Routing for different design styles.

Specialized routing: clock, power and ground routing, Post layout optimization

Signal / power integrity, interconnect modeling, performance driven design flow, timing closure, compaction, design rule checks.

Design for manufacturability and reliability: process variation, redundant via, OPC, CMP, Multiple Patterning, EUV, E-beam, Nanowires.

SOC Design: ASIC and SOC, IP-Reuse and Integration, Design Factors, Design Flow

Low Power Design: Algorithm, Architecture, Optimization.

Reference Books:

1. R. K. Brayton, G. D. Hachtel, C. McMullen, and A. Sangiovanni-Vincentelli: Logic Minimization Algorithms for VLSI Synthesis, Kluwer Academic Publishers, Boston, 1984. 12

2. D. D. Gajski, N. D. Dutt, A. C.-H. We, and S. Y.-L. Lin: High Level Synthesis: Introduction to Chip and System Design, Kluwer Academic, Boston, 1992.

3. M. Sarrafzadeh and C. K. Wong: AN Introduction to VLSI Physical Design, McGraw Hill, New York, 1996.

4. N. A. Sherwani: Algorithms for VLSI Physical Design Automation, Kluwer Academic, Boston, 1999.

5. V. Metz and J. Rose: FPGA Architecture and CAD tools, Addison Wesley.

6. Reuse Methodology Manual for System on Chip Designs – Kluwer Academic Publishers.

7. Chang, Chen, and Chen, 'Physical design for Modern VLSI design' in Essential Issues in SOC Design (Lin, Editor), Springer, 2006.

8. Y.-W. Chang, K.-T. Cheng, and L.-T. Wang (Editors). Electronic Design Automation Synthesis, Verification, and Test, Elsevier, 2009.

9. S. M. Sait and H. Youssef, VLSI Physical Design Automation: Theory and Practice, World Scientific Publishing Co., 1999.

10. R. K. Pal, Multi-Layer Channel Routing: Complexity and Algorithms. NAROSA Publishing House, New Delhi, CRC Press, Boca Raton, USA, and Alpha Sc. Intl. Ltd., UK, 2000.

CSE 1104: Deep Learning

Artificial Neural Networks (ANNs), Perceptron, Multi-Layer Perceptron (MLP), Back propagation, Hyper-parameter selection, Activation functions (10 Hrs.)

Training Deep Neural Networks, Vanishing Gradients Problems, Batch Normalization, Optimizers: Ada Grad, RMS Prop, Adam Optimization, Regularization. (8 Hrs.)

Convolutional Neural Networks (CNNs), Convolutional Layers, Filters, Pooling strategies, CNN Architectures, Reutilizing Pretrained Layers (8 Hrs.)

Recurrent Neural Networks (RNNs), Recurrent Neurons, Training RNNs, LSTM, GRU. (5 Hrs.)

Auto encoders and Generative Adversarial Networks (GAN) (4 Hrs.)

Reinforcement Learning, Introduction to Open AI Gym, Markov Decision Processes, Q-Learning. (5 Hrs.)

CSE1105: Natural Language Processing

Overview of Natural Language Processing: Text Analytics and NLP; Different NLP Steps; Tokenization; PoS Tagging; Stop Word Removal; Text Normalization; Spelling Correction; Lemmatization; Stemming; Named Entity Recognition (NER); Word Sense Disambiguation; Sentence Boundary Detection.

Approaches for Feature Extraction: Data Categorization, Text Cleaning and Tokenization, extracting n-grams, Tokenizing Text, Regexp Stemmer, The Porter Stemmer, and Other Tokenizers Lemmatization, Singularization and Pluralization of Words, Language Translation, Removal of Stop Words from Text, Bag of Words (BoW), Creating a Bag of Words, Zipf's Law, Feature Extraction from Texts. Other Visualizations: Term Frequency-Inverse Document Frequency (TF-IDF), Feature Engineering, Word Clouds Dependency Parse Trees and Named Entities.

Creating a Classifier for Text: Building a Text Classifier, Extracting Features, Engineering Features, Eliminating Correlated .Features, Eliminating Highly Correlated Features (Tokens), Finding the RMSE and MAPE of a Dataset, assessing a Model's Performance, and Carrying Out Dimensionality Reduction Using Principal Component Analysis.

Topic Modelling: Topic exploration, converting unstructured to organized data, Algorithms for Topic-Modelling, The Operation of Latent Semantic Analysis (LSA) Using Latent Semantic Analysis to Examine Wikipedia World Cup Articles Latent Dirichlet Allocation (LDA): An Overview of Its Operation, Dirichlet Process and Distribution Using the LDA Model to Find Topics.

Creation of Text, Summarization, and Vector representation: Vector, Document Vectors, Uses of Document Vectors, Converting News Headlines to Document Vectors, Finding Similar News Articles Using Document Vectors, Generating Text using Markov Chains, Text Summarization.

Large Language Models (LLM), Concepts behind LLMs, Transformers: Transformer architecture, the encoder and the decoder, Computing the output of the self-attention layer, Embedding layers in the Transformer, Residuals and normalization. ChatGPT and Google BARD, GPT Models

Books 1. Natural Language Processing and Information Retrieval, TanveerSiddiqui, U.S. Tiwary, Oxford University Press, 2008. 2. Natural LanguageProcessing andText Mining Anne Kao and Stephen R. Potee Springer-Verlag London Limited 2007 3. Speech and Language Processing: An introduction to Natural Language Processing, Computational Linguistics and SpeechRecognition, Daniel Jurafsky and James H Martin, Prentice Hall 2008, 2nd Edition 4. Natural Language Understanding, James Allen Benjamin/Cummings, publishing company 2nd Edition, 1995.

CSE1106: Quantum Computing

Review of linear algebra: Basics of vectors and matrices; Eigenvalue & eigenvectors; Pauli matrices; Spectral Decomposition; Tensor Product.

Introduction: Postulates of quantum mechanics; Concept of qubits and superposition; Multipartite system; Mixed State and Density Matrix; Bloch sphere representation; POVM measurement; No Cloning Theorem.

Quantum Circuit: Church-Turing thesis; Circuit model of computation; Idea of Reversible computing; Reversible circuit to quantum circuit; Quantum gates – Walsh-Hadamard transform, SWAP, CNOT, FREDKIN gates; Universal quantum gates; Basicquantum circuits.

Entanglement: EPR Paradox and Bell Inequality; Quantum Entanglement; Dense Coding; Quantum Teleportation.

Quantum Algorithm: Deutsch Algorithm, Deutsch-Jozsa Algorithm, Simon Algorithm, Quantum Fourier Transform; Order finding problem; Shor's Factorisation algorithm; Hidden subgroup and discrete logarithm problems; Quantum Search Algorithm (Grovers); Quantum Walk.

Reference Books:

1. Quantum Computation and Quantum Information, Michael A. Nielsen and Isaac L. Chuang, Cambridge University Press, 2002.
2. From Classical to Quantum Shannon Theory, Mark M. Wilde, arXiv: 1106.1445
3. An Introduction to Quantum Computing, Phillip Kaye, Raymond Laflamme, and Michele Mosca. Oxford U. Press, New York, 2007.

CSEOE1101: Bioinformatics

Unit I: Introduction to bioinformatics and data generation What is bioinformatics and its relation with molecular biology. Examples of related tools(FASTA, BLAST, BLAT, RASMOL), databases(GENBANK, Pubmed, PDB) and software(RASMOL,Ligand Explorer). Data generation; Generation of large scale molecular biology data. (Through Genome sequencing, Protein sequencing, Gel electrophoresis, NMR Spectroscopy, X-Ray Diffraction, and microarray). Applications of Bioinformatics.

Unit II: Biological Database and its Types Introduction to data types and Source. Population and sample, Classification and Presentation of Data. Quality of data, private and public data sources. General Introduction of Biological Databases; Nucleic acid databases (NCBI, DDBJ, and EMBL). Protein databases (Primary, Composite, and Secondary). Specialized Genome databases: (SGD, TIGR, and ACeDB). Structure databases (CATH, SCOP, and PDBsum)

Unit III: Data storage and retrieval and Interoperability Flat files, relational, object oriented databases and controlled vocabularies. File Format (Genbank, DDBJ, FASTA, PDB, SwissProt). Introduction to Metadata and search; Indices, Boolean, Fuzzy, Neighboring search. The challenges of data exchange and integration. Ontologies, interchange languages and standardization efforts. General Introduction to XML, UMLS, CORBA, PYTHON and OMG/LIFESCIENCE.

Unit IV: Sequence Alignments and Visualization Introduction to Sequences, alignments and Dynamic Programming; Local alignment and Global alignment (algorithm and example), Pairwise alignment (BLAST and FASTA Algorithm) and multiple sequence alignment (Clustal W algorithm). Methods for presenting large quantities of biological data: sequence viewers (Artemis, SeqVISTA), 3D structure viewers (Rasmol, SPDBv, Chime, Cn3D, PyMol), Anatomical visualization.

Unit V: Gene Expression and and Representation of patterns and relationship General introduction to Gene expression in prokaryotes and eukaryotes, transcription factors binding sites. SNP, EST, STS. Introduction to Regular Expression, Hierarchies, and Graphical models (including Marcov chain and Bayes notes). Genetic variability and connections to clinical data.

CSEOE1102: Operation Research

Operations Research: Origin of Operation Research, Historical Standpoint, Methodology, Different Phases, Characteristics, Scope and Application of Operations Research.

Linear Programming Problem: Introduction, Requirement of LP, Basic Assumptions, Formulation of LP, General Statement of LP, Solution techniques of LP: Graphical Methods, Analytical Methods: Simplex, Big M and Two Phase, Special Case of LP Problem, Graphical Sensitivity Analysis. Primal and Dual Problems, Economic Interpretation. Introduction of Goal and Integer Programing.

Dynamic Programming: Steps involved in dynamic programming, characteristics and explanation of dynamic programming, formulation of Deterministic and probabilistic dynamic programming.

Transportation and Assignment: Transportation Problems definition, Linear form, Solution methods, Degeneracy in transportation, Modified Distribution method, Unbalanced problems and profit maximization problems. Transhipment Problems. Assignment Problems and Travelling sales man Problem.

Queuing Theory: Basis of Queuing theory, elements of queuing theory, Kendall's Notation, Operating characteristics of a queuing system, Classification of Queuing models, Preliminary examples of M/M/1:∞/∞/FCFS.

Game Theory: Introduction, Characteristics of Game Theory, Two Person, Zero sum games, Pure strategy. Dominance theory, Mixed strategies (2x2, M x2), Algebraic and graphical methods.

Decision Theory: Introduction, Decision under certainty, Decision under risk, Decision under uncertainty: Laplace criterion, MaxiMin criterion, MiniMax criterion, savage MiniMax regret criterion, Hurwicz criterion, Decision tree.

Project Management: Introduction to PERT and CPM, Critical Path calculation, float calculation and its importance. Cost reduction by Crashing of activity

Books: Operations Research: An Introduction by HamdyTaha, Pearson Education Inc 2. Operations Research: Principles and Practice by Pradeep PrabhakarPai, Oxford Higher Education, Oxford University press 3. Operations Research: Principles and Practice by Ravindran Phillips and Solberg by Wiley India Edition, 4. Operations Research by P Mariappan, Pearson 5. Operations Research by A M Natarajan, P Balasubramani, A Tamilarasi, Pearson Education Inc 6. Operations Research by H N Wagner, Prentice hall. 7. Optimization in Operations Research by Ronald Rardin, Pearson Education Inc.