CENTRE FOR ADVANCED STUDIES

Dr. APJ Abdul Kalam Technical University, Lucknow

Syllabus for

M.Tech - Computer Science and Engineering (CSE)

With Specialization in - Cyber Security (CyS)
&
Information and Communication Technologies (ICT)
&
Machine Learning (ML)

INDEX

MARKS DISTRIBUTION

Following is Marks Distribution for courses depending upon the credit of the courses:

(1 credit = 50 marks)

Credit	Type of Course	Max. Marks	Major (End Semester examination)	Performance Evaluation		Lab Evaluation
				Minor I & II	Internal Assessments (Attendance, Quiz, Seminar & Assignments)	
3	Theory course	150	75	40 (20 each)	35	-
4	Theory course (with lab)	200	75	40 (20 each)	35	50
4	Thesis / dissertation -I	200	100	100		-
14	Thesis / dissertation -I	700	300	400		-

Note: Maximum Marks is fixed for all the courses. Only internal assessments and lab evaluation marks distribution may vary as per the instructions communicated by the assigned Faculty. Refer to M.Tech Ordinance & Regulation for Assessment Procedures and Performance Evaluation.

SEMESTER-I

CORE COURSES - COMPULSARY (Common for All Branches)

1. **Course Code: MCSC-105 Course Name: Discrete Mathematics and Graph Theory Credit: 4**

Basic counting principle: Pigeonhole principle, inclusion - exclusion principle, recurrence relations, generating functions. Fundamentals of logic, set theory, language, and finite state machines.

Undirected and direct graphs, modelling with graphs, trial and cycle- Eulerian trial and Hamilton cycle, connectivity and trees. Graph algorithms: BFS, DFS, shortest path, optimal spanning trees, matching, job assignment problem, optimal transportation through flows in networks.

2. **Course Code: MCSC-103, Course Name : ADVANCED COMPUTER NETWORKS AND COMMUNICATION, Credit: 4**

1) telecommunications history; 2) telecommunications media (conducted and radiated); 3) transmission characteristics (including an introduction to coding and modulation techniques); 4) error characteristics, detection, and correction; 5) local and wide area networking applications, hardware, and software; 6) the OSI model; 7) industry standards; 8) topologies; 9) protocols; 10) internetworking devices; 11) communications management; 12) security and recovery; 13) information system applications; and 14) the selection of telecommunications and networking systems communication security, Digital signatures, authentication protocols. WLAN, Mobile IP. SNMP (V1 and V2)-Organizational model-System Overview, The information model,communication model-Functional model, SNMP proxy server. Broadband networks and services, ATM Technology, Configuration management, Fault management, performance management. Network Management Tools, Network Statistics Measurement Systems Web Based Management, XML Based Network Management

Lab: Programming protocol USING C/C++ and MATLAB and practicing theory.

3. **Course Code: MCSC-202, Course Name : PROBABILITY AND STATISTICS , Credit: 3**

Syllabus : Introduction. Events and outcomes. Probability rules. Conditional probability. Independence. Bayes' Rule. Combinatorics. Random variables and their distributions. Discrete random variables. Discrete distributions: Bernoulli, Binomial, Geometric, Negative Binomial, Poisson. Continuous distributions and probability densities. Continuous distributions: Exponential, Gamma, Weibull, Hyperexponential, Normal Expectation and moments. Central Limit Theorem. Simulation of discrete and continuous random variables. Monte Carlo methods.

Stochastic processes. Main concepts and classification. Bernoulli process. Poisson process. Markov chains and simple queuing systems. Simulation, performance evaluation, bootstrapping. Statistics and sampling distribution of the sample mean; Statistics and sampling distribution of the sample proportion .Statistical inference; Parameter Estimation (Method of Moments, Maximum Likelihood Method); Confidence Intervals (Pivotal Quantity Method). Hypothesis Testing; type I and type II errors; anomalous events and how to identify them. Parameters and statistics. Parameter estimation and hypothesis testing. Graphics and exploratory data analysis, Simple/multiple regression and least squares, Logistic regression, Analysis of variance, Robust and nonparametric statistics.

4. Course Code: MCSC-106, Course Name : Pattern Recognition Credit: 3

Introduction, Algorithmic models of learning, Learning classifiers, functions, relations, grammars, probabilistic models, value functions, behaviors and programs from experience. Bayesian, maximum posteriori, and minimum description length frameworks. Parameter estimation, sufficient statistics, decision trees, neural networks, support vector machines, Bayesian networks, bag of words classifiers, N-gram models; Markov and Hidden Markov models, probabilistic relational models, association rules, nearest neighbour classifiers, locally weighted regression, ensemble classifiers. Computational learning theory, mistake bound analysis, sample complexity analysis, VC dimension, Occam learning, accuracy and confidence boosting. Dimensionality reduction, feature selection and visualization. Clustering, mixture models, k-means clustering, hierarchical clustering, distributional clustering, Applications Document Recognition.

5. Course Code: MCSC-201, Course Name : RESEARCH METHODOLOGY , Credit: 3

1. Foundations of Research: Meaning, Objectives, Motivation, Utility. Concept of theory, empiricism, deductive and inductive theory. Characteristics of scientific method Understanding the language of research Concept, Construct, Definition, Variable. Research Process. 2. Problem Identification & Formulation Research Question Investigation Question Measurement Issues Hypothesis Qualities of a good Hypothesis Null Hypothesis & Alternative Hypothesis. Hypothesis Testing Logic & Importance 3. Research Design: Concept and Importance in Research Features of a good research design Exploratory Research Design concept, types and uses, Descriptive Research Designs concept, types and uses. Experimental Design: Concept of Independent & Dependent variables. 4. Qualitative and Quantitative Research: Qualitative research Quantitative research Concept of measurement, causality, generalization, replication. Merging the two approaches. 5. Measurement: Concept of measurement what is measured? Problems in measurement in research Validity and Reliability. Levels of measurement Nominal, Ordinal, Interval, Ratio. 6. Sampling: Concepts of Statistical Population, Sample, Sampling Frame, Sampling Error, Sample Size, Non-Response. Characteristics of a good sample. Probability Sample Simple Random Sample, Systematic Sample, Stratified Random Sample & Multi-stage sampling. Determining size of the sample Practical considerations in sampling and

sample size. 7. Data Analysis: Data Preparation Univariate analysis (frequency tables, bar charts, pie charts, percentages), Bivariate analysis Cross tabulations and Chi-square test including testing hypothesis of association. 8. Interpretation of Data and Paper Writing Layout of a Research Paper, Journals in Computer Science, Impact factor of Journals, When and where to publish? Ethical issues related to publishing, Plagiarism and Self-Plagiarism. 9. Use of Encyclopedias, Research Guides, Handbook etc., Academic Databases for Computer Science Discipline. 10. Use of tools / techniques for Research: methods to search required information effectively, Reference Management Software like Zotero/Mendeley, Software for paper formatting like LaTeX/MS Office, Software for detection of Plagiarism.

SEMESTER-II

CORE COURSES - COMPULSARY (Common for All Branches)

1. Course Code: MCSC-101, Course Name : ADVANCE DESGIN AND ANALYSIS OF ALGORITHMS , Credit: 4

Network flows (max flow and min-cost flow/circulation) , Data structures (Fibonacci heaps, splay trees, dynamic trees) , Linear programming (structural results, algorithms) and SDP based , Dealing with intractability: approximation algorithms (techniques for design and analysis), Dealing with large data sets (compression, streaming algorithms, compressed sensing), Computational geometry, Hardness of approximation - Approximation Algorithms based on Algorithmic Game Theory, Randomized Algorithms, complexity theory, Parallel Algorithms.

Lab : Programming on searching , sorting and linked list , Binary Tree, Binary Search Tree, Traversal: BFS, DFS; Minimum Spanning Tree, Implementing String Matching Algo's, Greedy & Dynamic Approach, Backtrack/ Branch & Bound, Approximation Algorithms.

CYBER SECURITY CORE COURSES – COMPULSARY

2. Course Code: MCySC-101, Course Name : FUNDAMENTAL OF INFORMATION SECURITY & PRACTICES, Credit: 3

Introduction to information security, need, scope, basic principles- CIAA , policies, procedures, Guidelines, Standards Administrative Measures and Technical Measures info sec culture, interpretation of info sec culture, dynamic organizational model, modeling the information sharing of organization. Standards available for infosec: Cobit, ISO 27001 Overview, Vulnerability, Threat and Risk, Risk Assessment and Mitigation + Quick fixes,

Introduction to HIPPA/PCI DSS/ BCP / DRP / ITIL. Segregation and Separation of Duties & Roles and responsibilities. Introduction to IT ACT 2000. Current trends in security, OWASP, OSSTMM SANS 2014 Trends That Will Reshape Organizational Security , issues of info security

in Choose your own IT (CYOIT) , Increased virtualization and use of cloud and software-as a-service (SaaS) , Supply chain integrity worries ,The Internet of Things/Everything , Bitcoin currencies, Security Services, Security Mechanism , Security Attacks and explanation. Use of different information security models in emerging IT Technologies. Types of assessments for Information Security - VAPT of Networks; Assessment of Security Devices (Web Filtering, Firewalls, IDS / IPS, Routers; Data Center Assessment; Security of Application Software; SAP Security; Desktop Security; RDBMS Security. Use of information security for Nations defence. Computer Software and Intellectual Property-Objective, Copyright Protection, Reproducing, Defences, Patent Protection, Database and Data Protection-Objective, domain name and Intellectual Property, disputes under Intellectual Property Rights, Jurisdictional Issues, International Perspective.

3. Course Code: MCySC- 201, Course Name : CRYPTOGRAPHY , Credit: 4

History and overview of cryptography, identification protocols. Password protocols, salts, PBKDF2; one time passwords (S/Key and SecurID); challenge response authentication, One time pad and stream ciphersperfect secrecy and the one time pad, semantic security and stream ciphers, Block ciphers. Case studies: Feistel networks, DES, 3DES, and DES basic modes of operation: CBC and counter mode. Block cipher abstractions: PRPs and PRFs . Pseudo Random Permutations (PRP); Pseudo Random Functions (PRF);security against chosen plaintext attacks (CPA); nonce-based CBC encryption and nonce-based counter mode. Attacks on block ciphers exhaustive search, time-space tradeoffs, differential & linear cryptanalysis, meet in the middle, side channels. Message integrity: definition and applications CBC-MAC and PMAC. Collision resistant hashing ,Merkle-Damgard and Davies-Meyer. MACs from collision resistance. Elliptic key cryptography. Case studies: SHA and HMAC. Authenticated encryption: security against active attacks , intro to session setup using a key distribution center (KDC). Cryptography using arithmetic modulo primes, vanilla key exchange (DiffieHellman); the CDH and discrete-log assumptions . Public key encryption semantically secure El Gamal encryption; CCA security. Arithmetic modulo composites. RSA and Rabin functions ,how to encrypt with trapdoor permutations. Digital signatures: definitions and applications. How to sign using RSA. More signature schemes Lamport and Merkle schemes. Overview of signatures based on discrete-logcertificates and trust management. Identification protocols :Password protocols, salts; one time passwords (S/Key and SecurID); challenge response authentication. Authenticated key exchange and SSL/TLS session setup, Zero knowledge protocols

Lab : Programming and implementation of cipher , cryptographic algo and digital signatures in C/java and practicing theory.

CYBER SECURITY ELECTIVE COURSES - ANY TWO

4. Course Code: MCSC- 203, Course Name: INTRODUCTION TO FORMAL METHODS AND VERIFICATION OF LARGE SYSTEMS, Credit: 3

Process algebras and concurrent systems: Reactive systems, Formal methods for reactive systems, Labelled transition systems, Operational semantics for concurrent processes, Operators for process modelling, Pi-calculus. Behavioural equivalences and proof techniques: Bisimulation, Induction and co-induction proofs, Induction as a fixed point technique, Weak bisimulation, Weak bisimulations upto , Bisimulation in concurrency, Other equivalences such as failure equivalence, testing, testing equivalence. Type systems: Revisit to Pi-calculus, Simply typed Pi-calculus, Input output types, Linear types, Session types. Model checking: Finite state model checking, Symbolic model checking, Probabilistic model checking, Real time model checking, Optimal scheduling using model checking. Stochastic modelling: Foundation, Quantitative modelling, Markovian methods, PEPA as case study. Tools:
Experimental practice on mobility workbench (MBW), concurrency workbench (CWB- NC), CTMC.

5. Course Code: MCySE-204, Course Name: Ethical Hacking, Credit: 3

Computer network and defense fundamentals, Network security threats, vulnerabilities, and attacks. Overview of the Top 20 OWASP Security vulnerabilities. CVSS Scoring system including VAPT techniques, Network security controls, protocols, and devices, Network security policy design and implementation, Physical security, Host security, Secure firewall configuration and management, Secure IDS configuration and management, Secure VPN configuration and management, Wireless network defense, Network traffic monitoring and analysis, Network risk and vulnerability management, Data backup and recovery, Network incident response and management , ethical hacking, Foot printing and reconnaissance, Scanning networks, Enumeration, Sniffing, System hacking, Malware threats, Social engineering, Denial of service, Session hijacking, Hacking web applications, SQL injection, Hacking wireless networks, Hacking web servers, Hacking mobile platforms, Evading IDS, Firewalls, and Honeypot.

6. Course Code: MCySE-201, Course Name: SECURITY STANDARDS & PROJECT MANAGEMENT, Credit: 3

Introduction, design goals, role and security architecture relationship to information security, incident management and IT auditing processes; security risk management; legal and ethical issues of security and privacy .Trusted computing base, protection measures of trusted computing base, system security assurance concepts, confidentiality and integrity models, security risk management process, data classification, regulatory requirements, web services. What is

information security management (ISM) , Why ISM is important to an organization , What are the benefits of ISM, What is the background of ISM ,What are the key concepts and principles in ISO/IEC 27001:2013 , The terms and definitions used, The main requirements of ISO/IEC 27001:2013, COBIT , ITIL, PCI DSS, HIPPA.

7. Course Code: MCySE-202, Course Name: SYSTEM SECURITY, Credit: 3

Introduction to Database Security Issues, Types of Security, Database Security and DBA, Access Protection, User Accounts, and Database Audits. Introduction to Access Control, Purpose and fundamentals of access control, brief history, Policies of Access Control, Models of Access Control, and Mechanisms, Discretionary Access Control(DAC), NonDiscretionary Access Control , Mandatory Access Control (MAC). Capabilities and Limitations of Access Control Mechanisms: Access Control List (ACL) and Limitations, Capability List and Limitations, Role-Based Access Control (RBAC) and Limitations, Core RBAC, Hierarchical RBAC, Statically Constrained RBAC, Dynamically Constrained RBAC, Limitations of RBAC. Comparing Discretionary Access Control and Mandatory Access Control, Role-Based Access Control , Access Control Policies for E-Commerce and the Web, Introduction to Statistical Database Security, Introduction to Flow Control, Covert Channels. Concept of Trusted system and multilevel security model as : Bell lapadula model ,Biba‟s intrigity model, Clark-Wilson model, Domain type enforcement model, , mapping the enterprise view to the system view, RBAC for UNIX and JAVA environments Case study: Multiline Insurance Company. Database vulnerability and attack: SQL Injection, and security mechanisms : Advanced Encryption Standards, Public Key Encryption , Digital Signatures , Dabase auditing : Data Control Language (DCL) activities, Data Definition Language (DDL) activities, and Data Manipulation Language (DML). Smart card operating system-fundamentals, design and implantation principles, memory organization, smart card files, file management, atomic operation, smart card data transmission ATR,PPS Security techniques- user identification , smart card security, quality assurance and testing, smart card life cycle-5 phases, smart card terminals.

8. Course Code: MCySE- 203, Course Name: IDENTITY AND ACCESS MANAGEMENT & TRUSTED COMPUTING, Credit: 3

Identity and access management (IAM) overview , Attributes of information security, Symmetric and asymmetric cryptography ,Hashing and digital signature,Key management, Public Key Infrastructure (PKI) Architecture: certification and registration authority, Life cycle management, Types of certificates and usage patterns Encryption, Digital signature, Client certificate,SSL server certificate, Attribute based certificate, Case studies (e.g. email protection, mobile banking, and document signing), Identification verification and authentication overview, Mechanisms of identification and authentication -One time password,Biometric,Digital signature,Smartcard,Soft/hard tokens, Mobile device, Risk based authentication, Step-up authentication, Single-sign on and federated single-sign-on,OATH, OpenID, BorwserID, and SAML, Architecture framework and industrial tools,Trusted computing role in identity assurance,

Security risks associated with the discussed mechanisms Access control , Principles of authorization , Access control schemes , OAuth protocol, Enterprise rights management and digital rights management, Privileged account management , Governance and compliance . IAM framework and use cases, IAM architecture framework, IAM echo system, IAM and cloud computing, Illustrative use cases - Border control, E-passport, National ID, E-banking, E-health system and EMV scheme

ICT CORE COURSES –COMPULSARY

2. **Course Code: MICTC-101, Course Name : MATHEMATICAL FOUNDATIOS FOR COMPUTING IN ICT, Credit: 3**

Fundamental Concepts of Mathematics: Statements Connectives Truth Tables Normal forms Predicate calculus Inference Theory for Statement Calculus and Predicate Calculus automata theorem proving. Review of Permutation and Combination Proofs - Mathematical Induction - Pigeon hole principle - Principle of Inclusion and Exclusion - generating function - Recurrence relations. Semi goup - Monoid Groups- Cyclic group - Permutation group - Substructures - Homomorphism of semi group, monoid and groups - Cosets and Lagrange Theorem Normal Subgroups - Rings and Fields. Recursive functions - Primitive recursive functions - computable and non - computable functions. Partial order relation, poset Lattices. Discrete Structures: Modular Arithmetic, Graphs, Trees, State machines, Counting Analysis techniques based on counting methods and recurrence equations; Discrete Probability Theory; Application of these in Computer Science and algorithms.

3. **Course Code: MICTC-203, Course Name: Computer Vision, Credit: 3**

Digital Image Formation and low-level processing: Overview and State-of-the-art, Fundamentals of Image Formation, Transformation: Orthogonal, Euclidean, Affine, Projective; Fourier Transform, Convolution and Filtering, Image Enhancement, Restoration, Histogram Processing.Feature Extraction: Edges -Canny, LOG, DOG; Line detectors (Hough Transform), Corners-Harris and Hessian Affine, Orientation Histogram, SIFT, SURF, HOG, GLOH, Scale-Space. Analysis-Image Pyramids and Gaussian derivative filters, Gabor Filters and DWT. Image Segmentation: Region Growing, Edge Based approaches to segmentation, Mean- Shift, Texture Segmentation; Object detection. Pattern Analysis: Clustering: K-Means, K-Medoids, Classification: Discriminant Function, Supervised, Un-supervised, Semi-supervised; Classifiers: Bayes, KNN, ANN models; Dimensionality Reduction: PCA, LDA. Motion Analysis: Background Subtraction and Modeling, Optical Flow, KLT, Spatio-Temporal Analysis, Dynamic Stereo; Motion parameter estimation. Laboratory Work: To implement various techniques and algorithms studied during the course.

ICT ELECTIVE COURSES - ANY TWO

4. **Course Code: MCSC- 203, Course Name: INTRODUCTION TO FORMAL METHODS AND VERIFICATION OF LARGE SYSTEMS, Credit: 3**

   Process algebras and concurrent systems: Reactive systems, Formal methods for reactive systems, Labelled transition systems, Operational semantics for concurrent processes, Operators for process modelling, Pi-calculus. Behavioural equivalences and proof techniques: Bisimulation, Induction and co-induction proofs, Induction as a fixed point technique, Weak bisimulation, Weak bisimulations upto , Bisimulation in concurrency, Other equivalences such as failure equivalence, testing, testing equivalence. Type systems: Revisit to Pi-calculus, Simply typed Pi-calculus, Input output types, Linear types, Session types. Model checking: Finite state model checking, Symbolic model checking, Probabilistic model checking, Real time model checking, Optimal scheduling using model checking. Stochastic modelling: Foundation, Quantitative modelling, Markovian methods, PEPA as case study. Tools: Experimental practice on mobility workbench (MBW), concurrency workbench (CWB- NC), CTMC.

5. **Course Code: MICTC- 301, Course Name: EMBEDDED SYSTEMS, Credit: 3**

   Overview of Embedded System- Categories, Requirements , Challenges and Issues in Embedded Software Development, Applications. Hardware Architecture, Micro- Controller Architecture, Communication Interface Standards, Embedded System Development Process, Embedded Operating systems, Types of Embedded Operating systems. 8Bit microcontrollers Architecture on chip peripherals instruction set/ programming of Intel M CS51 family (8 bit) microcontroller, Inter facing of 8051 with LCD, ADC, sensors, stepper motor, key board, DAC, memory. Real Time & Database Applications: Real-Time Embedded Software Development, Sending a Message over a Serial Link, Simulation of a Process Control System, Controlling an Appliance from the RT Linux System, Embedded Database Applications using examples like Salary Survey, Energy Meter Readings. Microchip PIC16 family PIC16F873 processor features architecture memory organization register file map I/ O ports. Implementing Embedded Systems. Impact of VLSI technology on digital systems and architectures. A variety of applications of these architectures explored with emphasis on digital signal processing and other arithmetic intensive computations. Introduction to hierarchical structural design: IC design for parallel architecture: Use of pipelining and parallelism, self-synchronized designs, VLSI computing structures. Introduction to systolic arrays, mapping algorithms on systolic arrays, design of systolic arrays, system examples and design exercises. Circuits and DSP. architecture design: Fast filtering algorithms, retiming and pipelining, block processing, folding, distributed arithmetic architectures, VLSI performance measures (area, power, and speed), structural modelling in VHDL. DSP module synthesis: Arithmetic unit architectures (adders, multipliers, dividers), bit-parallel, bit-serial, digit-serial, carry-save architectures,

redundant number system, modelling for synthesis in VHDL, synthesis via SYNOPSYS, place-androute via CADENCE

6. **Course Code: MCSC- 301, Course Name: Data Science, Credit: 3**

Data Science : Statistical Thinking ,Examples ,Numerical Data, Summary Statistics ,From Population to Sampled Data, Different Types of Biases , Probability, Statistical Inference . Association and Dependence , Association and Causation ,Conditional Probability and Bayes Rule, Simpsons Paradox, Confounding ,Introduction to Linear Regression, Special Regression Models ,Exploratory Data Analysis and Visualization-Goals ,Graphs of Data, Graphs of Fitted Models, Graphs to Check Fitted Models, Principles of graphics. Apply basic machine learning algorithms (Linear Regression, k-Nearest Neighbors (k-NN), k-means, Naive Bayes) for predictive modeling. Bayesian Modeling-Bayesian inference: combining models and data in a forecasting problem, Bayesian hierarchical modeling for studying public opinion, Bayesian modeling for Big Data

7. **Course Code: MICTE- 202, Course Name: INFORMATION THEORY AND CODING , Credit: 3**

Entropy, mutual information, channel capacity, information rate, Shannon's noiseless coding theorem and Shannon's fundamental coding theorem; modelling of information sources zero memory and Markov models; modelling of information channels--BSC and BEC channels, additivity of information and cascaded channels; construction of compact source codes--Kraft inequality, compact codes, Huffman and Shannon Fano compression codes; and analysis and design of error-control channel codes--Hamming distance, binary linear codes and the parity-check matrix, Hamming codes, checksum codes, cyclic codes and the generator polynomial and CRC codes, convolutional codes, Viterbi and other decoding algorithms.

8. **Course Code: MICTC- 202, Course Name: SPEECH COMMUNICATION AND BIOMEDICAL SIGNAL PROCESSING, Credit: 4**

The Speech Production mechanism. Physiological and Mathematical Model. Relating the physiological and mathematical model. Categorization of Speech Sounds based on the source-system and the articulatory model. Basic Speech Signal Processing Concepts. Discrete time speech signals, relevant properties of the fast Fourier transform and Z-transform for speech recognition, convolution, linear and non linear filter banks. Spectral estimation of speech using the Discrete Fourier transform. Pole-zero modelling of speech and linear prediction (LP) analysis of speech. Homomorphic speech signal de convolution, real and complex cepstrum. The Speech Recognition Front End. Feature extraction for speech recognition, Static and dynamic features for speech recognition, robustness issues, discrimination in the feature space, feature selection. Mel frequency cepstral co-efficients (MFCC), Linear prediction cepstral coefficients (LPCC), Perceptual LPCC. Distance measures for comparing speech patterns. Log spectral distance, cepstral distances, weighted cepstral distances, distances for linear and warped scales Vector quantization

models and applications in speaker recognition. Gaussian mixture modelling for speaker and speech recognition. Discrete and Continuous Hidden Markov modelling for isolated word and continuous speech recognition. Using the HTK toolkit for building a simple speech recognition system.

Biomedical Signals and Images ECG: Cardiac electrophysiology, relation of electrocardiogram (ECG) components to cardiac events, clinical applications. Guest lecture. Speech Signals: The source-filter model of speech production, spectrographic analysis of speech. Speech Coding: Analysis-synthesis systems, channel vocoders, linear prediction of speech, linear prediction vocoders. Imaging Modalities: Survey of major modalities for medical imaging: ultrasound, X-ray, CT, MRI, PET, and SPECT.MRI: Physics and signal processing for magnetic resonance imaging. Fundamentals of Deterministic Signal and Image Processing. Data Acquisition: Sampling in time, aliasing, interpolation, and quantization. Digital Filtering: Difference equations, FIR and IIR filters, basic properties of discrete-time systems, convolution. DTFT: The discrete-time Fourier transform and its properties. FIR filter design using windows. DFT: The discrete Fourier transform and its properties, the fast Fourier transform (FFT), the overlap-save algorithm, digital filtering of continuous-time signals. Sampling Revisited: Sampling and aliasing in time and frequency, spectral analysis. Image processing, I: Extension of filtering and Fourier methods to 2-D signals and systems. Image processing II: Interpolation, noise reduction methods, edge detection, homomorphic filtering. Probability and Random Signals PDFs: Introduction to random variables and probability density functions (PDFs). Classification: Bayes' rule, detection, statistical classification. Random signals I: Time averages, ensemble averages, autocorrelation functions, cross correlation functions. Random signals II: Random signals and linear systems, power spectra, cross spectra, Wiener filters. Blind source separation: Use of principal component analysis (PCA) and independent component analysis (ICA) for filtering

ML CORE COURSES – COMPULSARY

2. Course Code: MMLC- 201, Course Name: Probabilistic Graphical Model, Credit: 3

Fundamentals: Fundamentals of Probability Theory - Views of Probability, Random Variables and Joint Distributions, Conditional Probability, Conditional Independence, Expectation and Variance, Probability Distributions - Conjugate Priors, Introduction to Exponential Family; Fundamentals of Graph Theory - Paths, Cliques, Subgraphs, Cycles and Loops. Graphical Models: Introduction - Directed Models (Bayesian Network), Undirected Models (Markov Random Fields), Dynamic Models (Hidden Markov Model & Kalman Filters) and Factor Graph; Conditional Independence (Bayes Ball Theorem and D-separation), Markov Blanket, Factorization (Hammersley-Clifford Theorem), Equivalence (I-Maps & Perfect Maps); Factor Graphs - Representation, Relation to Bayesian Network and Markov Random Field. Inference in graphical models: Exact Inference - Variable Elimination, Elimination Orderings, Relation to Dynamic Programming, Dealing with Evidence, Forward-Backward Algorithm, Viterbi Algorithm; Junction Tree Algorithm; Belief Propagation (Sum Product); Approximate Inference - Variational Methods (Mean Field, Kikuchi &

Bethe Approximation), Expectation Propagation, Gaussian Belief Propagation; MAP Inference - Max-Product, Graph Cuts, Linear Programming Relaxations to MAP (Tree-Reweighted Belief Propagation, MPLP); Sampling - Markov Chain Monte Carlo, Metropolis Hastings, Gibbs (Collapsing & Blocking), Particle filtering. Learning in Graphical Models: Parameter Estimation - Expectation Maximization, Maximum Likelihood Estimation, Maximum Entropy, Pseudolikelihood, Bayesian Estimation, Conditional Likelihood, Structured Prediction; Learning with Approximate Inference; Learning with Latent Variables; Structure Learning, Structure Search, L1 priors.

3. **Course Code: MMLC- 202, Course Name: Foundation of Machine Learning, Credit: 3**

Foundations for ML: ML Techniques overview, Validation Techniques (Cross-Validations), Feature Reduction/Dimensionality reduction, Principal components analysis (Eigen values, Eigen vectors, Orthogonality). Regression: Regression basics: Relationship between attributes using Covariance and Correlation, Relationship between multiple variables: Regression (Linear, Multivariate) in prediction. Multiple Linear Regression. Clustering: Distance measures, Different clustering methods (Distance, Density, Hierarchical), Iterative distance-based clustering; Classification: Naïve Bayes Classifier, Feature selection, K-Nearest Neighbours classifier, Support Vector Machines, Decision Trees, Ensembles methods : boosting and its impact on bias and variance

ML ELECTIVE COURSES - ANY TWO

4. **Course Code: MMLE- 201, Course Name: Big Data Analytics, Credit: 3**

Big Data introduction - Big data: definition and taxonomy - Big data value for the enterprise - Setting up the demo environment - First steps with the Hadoop "ecosystem" The Hadoop ecosystem - Introduction to Hadoop - Hadoop components: MapReduce/Pig/Hive/HBase - Loading data into Hadoop - Handling files in Hadoop - Getting data from Hadoop Querying big data with Hive - Introduction to the SQL Language - From SQL to HiveQL, Querying big data with Hive - Introduction to HIVE e HIVEQL - Using Hive to query Hadoop files Big data & Machine learning - Quick into to Machine learning - Big Data & Machine Learning - Machine learning tools - Spark & SparkML , H2O , Azure ML

5. **Course Code: MMLE- 202, Course Name: Optimization Techniques, Credit: 3**

Mathematical preliminaries, Linear algebra and matrices, Vector space, eigen analysis, Elements of probability theory, Elementary multivariable calculus, Linear Programming, Introduction to linear programming model, Simplex method, Duality, Karmarkar's method, Unconstrained optimization, One-dimensional search methods, Gradient-based methods, Conjugate direction and quasi-Newton methods, Constrained Optimization, Lagrange theorem, FONC, SONC, and SOSC

conditions, Non-linear problems, Non-linear constrained optimization models, KKT conditions, Projection methods

6. Course Code: MCSC- 301, Course Name: Data Science, Credit: 3

Data Science : Statistical Thinking ,Examples ,Numerical Data, Summary Statistics ,From Population to Sampled Data, Different Types of Biases , Probability, Statistical Inference . Association and Dependence , Association and Causation ,Conditional Probability and Bayes Rule, Simpsons Paradox, Confounding ,Introduction to Linear Regression, Special Regression Models ,Exploratory Data Analysis and Visualization-Goals ,Graphs of Data, Graphs of Fitted Models, Graphs to Check Fitted Models, Principles of graphics. Apply basic machine learning algorithms (Linear Regression, k-Nearest Neighbors (k-NN), k-means, Naive Bayes) for predictive modeling. Bayesian Modeling-Bayesian inference: combining models and data in a forecasting problem, Bayesian hierarchical modeling for studying public opinion, Bayesian modeling for Big Data

7. Course Code: MMLE- 203, Course Name: Neural Networks and Evolutionary Algorithms, Credit: 3

Artificial Neural Networks: Biological neurons and its working. Simulation of biological neurons to problem solving. Different ANNs architectures. Training techniques for ANNs. Applications of ANNs to solve some real life problems. Fuzzy logic: Introduction to Fuzzy logic. Fuzzy sets and membership functions. Operations on Fuzzy sets. Fuzzy relations, rules, propositions, implications and inferences. Defuzzification techniques. Fuzzy logic controller design. Some applications of Fuzzy logic. Genetic Algorithms: Concept of Genetics and Evolution; and its application to probabilistic search techniques, Basic GA framework and different GA architectures. GA operators: Encoding, Crossover, Selection, Mutation. Solving single-objective optimization problems using GAs. Deep Learning: Deep Feed Forward network, Regularizations, Training deep models, dropouts, Convolutional Neural Network, Recurrent Neural Network, Deep Belief Network.

8. Course Code: MICTC-203, Course Name: Computer Vision, Credit: 3

Digital Image Formation and low-level processing: Overview and State-of-the-art, Fundamentals of Image Formation, Transformation: Orthogonal, Euclidean, Affine, Projective; Fourier Transform, Convolution and Filtering, Image Enhancement, Restoration, Histogram Processing.Feature Extraction: Edges -Canny, LOG, DOG; Line detectors (Hough Transform), Corners-Harris and Hessian Affine, Orientation Histogram, SIFT, SURF, HOG, GLOH, Scale-Space. Analysis-Image Pyramids and Gaussian derivative filters, Gabor Filters and DWT. Image Segmentation: Region Growing, Edge Based approaches to segmentation, Mean- Shift, Texture Segmentation; Object detection. Pattern Analysis: Clustering: K-Means, K-Medoids, Classification: Discriminant Function, Supervised, Un-supervised, Semi-supervised; Classifiers: Bayes, KNN, ANN models; Dimensionality Reduction: PCA, LDA. Motion Analysis: Background Subtraction and Modeling, Optical Flow, KLT, Spatio-Temporal Analysis, Dynamic Stereo;

Motion parameter estimation. Laboratory Work: To implement various techniques and algorithms studied during the course.

SEMESTER-III

CORE COURSES - COMPULSARY (Common for All Branches)

1. Course Code: MCSC-303, Course Name: The Internet of things, Credit: 4

The IoT Networking: Technologies involved in IoT Development: Internet/Web and Networking, Sub-netting, Communication protocol, Network Topologies referred with Web, Introduction to Web Servers, Introduction to Cloud Computing IoT Platform overview of IoT supported Hardware platforms such as: Raspberry pi, ARM Cortex Processors, Arduino and Intel Galileo boards. Network Fundamentals: Overview and working principle of Wired Networking equipment's – Router, Switches, Overview and working principle of Wireless Networking equipment's – Access Points, Hubs etc. Linux Network configuration Concepts: Networking configurations in Linux Accessing Hardware & Device Files interactions. IoT Architecture: History of IoT, M2M – Machine to Machine, Web of Things, IoT protocols

Applications: Remote Monitoring & Sensing, Remote Controlling, Performance Analysis, the Architecture, The Layering concepts, IoT Communication Pattern, IoT protocol Architecture, The 6LoWPAN Security aspects in IoT, IoT Application Development: Application Protocols MQTT, REST/HTTP, CoAP, MySQL Back-end Application Designing Apache for handling HTTP Requests, PHP & MySQL for data processing, MongoDB Object type Database, HTML, CSS & jQuery for UI Designing, JSON lib for data processing, Security & Privacy during development, Application Development for mobile Platforms: Overview of Android / IOS App Development tools, Case Study & advanced IoT Applications: IoT applications in home, infrastructures, buildings, security, Industries, Home appliances, other IoT electronic equipment's. Use of Big Data and Visualization in IoT, Industry 4.0 concepts. Agriculture, Healthcare, Activity Monitoring.

2. Course Code: MCSC-302, Course Name: THESIS /DISSERTATION - I, Credit: 4

The students will identify a research area of interest and a relevant research problem to work on. A list of objectives and deliverables along with the timeline are also identified. Research Progress Seminar will be held twice a month for continuous evaluation. The students will continue to work on the problem identified in Major Project (in Semester IV) also.

CYBER SECURITY CORE COURSES – COMPULSARY

3. MCSC-104, Course Name : CLOUD COMPUTING, Credit: 3

Introduction , Cloud Computing Architecture - Cloud Reference Model, Types of Clouds, Cloud Interoperability & Standards, Scalability and Fault Tolerance, **Cloud Solutions:** Cloud Ecosystem, Cloud Business Process Management, Cloud Service Management. **Cloud Offerings**: Cloud Analytics, Testing Under Control, Virtual Desktop Infrastructure. Cloud Management & Virtualization Technology: Resiliency, Provisioning, Asset management, Concepts of Map reduce, Cloud Governance, High Availability and Disaster Recovery. Virtualization: Fundamental concepts of compute ,storage, networking, desktop and application virtualization .Virtualization benefits, server virtualization, Block and file level. storage virtualization Hypervisor management software, Infrastructure Requirements , Virtual LAN(VLAN) and Virtual SAN(VSAN) and their benefits. Cloud Security: Cloud Information security fundamentals, Cloud security services, Design principles, Secure Cloud Software Requirements, Policy Implementation, Cloud Computing Security Challenges, Virtualization security Management, Cloud Computing Security Architecture. Market Based Management of Clouds , Federated Clouds/Inter Cloud: Characterization & Definition , Cloud Federation Stack , Third Party Cloud Services . Case study : Google App Engine, Microsoft Azure , Hadoop , Amazon , Aneka. Performance, scalability and consistency on Clouds.

CYBER SECURITY ELECTIVE COURSES - ANY ONE

4. MCySC-301, Course Name : Digital and Cyber Forensics, Credit: 3

Computer forensics in today's world • Computer forensics investigation process , Data Acquisition and Duplication • Understanding hard disks and file systems • Defeating antiforensics techniques • Operating system forensics • Network forensics • Investigating web attacks • Database forensics • Cloud forensics • Malware forensics • Investigating email crimes • Mobile forensics process , Mobile OS architecture, boot process, and file systems , Mobile threats and security • Forensics report writing and presentation , encryption and stenography analysis. Investigation process : legal process of investigation, jurisdiction and agencies, internet investigation, ip address and domain names, investigation method , evidence collection . Legal Issues: Constitutional law, search and seizure guidelines, ECPA , challenges in process, international computer crime law.

5. MCySE-301, Course Name : Network Protocol Security, Credit: 3

Understand Security Issues Related to Networks- OSI and TCP/IP Models, Internet Protocol (IP) Networking, Network Topographies and Relationship, Commonly Used Ports and Protocols, and HTTP Proxying, Network Access Control: Network Access Control, Extensible Authentication Protocol, IEEE 802.1X Port-Based Network Access Control, IP Security: IP Security Overview, IP Security Policy, Encapsulating Security Payload, Combining Security Associations, Internet Key Exchange (IKE). IPv6 Security, Transport-Level Security: Web Security Considerations, Secure Sockets Layer, Transport Layer Security, HTTPS standard, Secure Shell (SSH) application., Simple Network Management Protocol (SNMP), Electronic Mail Security: Pretty Good Privacy, S/MIME,

Domain Keys Identified Mail, Wireless Network Security: Mobile Device Security, IEEE 802.11i, Wireless LAN Security.

6. **Course Code: MCSC-102, Course Name: WIRELESS SENSOR NETWORKS, Credit: 3**

Syllabus: Introduction to Wireless Sensor Networks and applications Tracking chemical plumes- Smart transportation, Network Architecture - Energy Consumption of Sensor Nodes , Operating Systems and Execution Environments, Network Architecture -Sensor Network Scenarios, Hardware Platforms, ns-3 core , Medium Access Control Protocol design, Introduction to Markov Chain, MAC Protocol Analysis, Routing protocols-Resource-aware routing, Data-centric, Geographic Routing, Broadcast, Multicast, MANETS, Routing protocols for WSN, Opportunistic Routing Analysis, Clustering, QoS management ,Sensor mode selection, Localization, Time Synchronization, Security-SPINS, Static and dynamic key distribution, Energy Harvesting WSNs, Programming in WSNs, Sensor Node Hardware Berkeley Motes, Programming Challenges, Node-level software platforms, Node-level Simulators, State-centric programming, Open Research Issues.

7. **Course Code: MCySE-302, Course Name: Media Security, Credit: 3**

Mathematical Preliminaries: Discrete Fourier Transform (DFT), Discrete Cosine Transform, Random Sequence Generation, The Chaotic Map, Error Correction Code, Set Partitioning in Hierarchical Tree. Introduction to Multimedia Security, Brief history and applications of Information Security, Fundamentals of Information Security, Basics of Digital Imaging and Digital Audio, Introduction to Cryptography, Introduction to Digital Watermarking; Multimedia Security, Introduction to Digital Rights Management (DRM)Multimedia Encryption, Classical Cryptography, Symmetric Encryption, Hash Functions, Message Authentication Codes, Asymmetric Encryption, Digital Signatures, Overview of Advanced Encryption Standard (AES); Block and stream ciphers; Information theoretic secrecy. Principles for selective encryption; Image and Video encryption schemes: Chaotic maps, Transform domain encryption, Huffman tree mutation, Steganography; Steganalysis, Introduction to Steganography, Steganalysis Schemes, JPEG Steganography: LSB Embedding in DCT Coefficients (JSteg), Detecting JSteg with Histograms, patching up the histograms with Outguess, Hamming Codes and Syndrome Coding, Matrix Embedding and Wet Paper Codes, chi square test, Steganalysis: Sample Pair Analysis, Digital Watermarking, Introduction to digital watermarking, Models of Watermarking, Basic Message Coding, Error Correction, Coding, Mutual Information and Channel Capacity, How to Design a Good Digital Watermark, Digital, Watermarking Schemes, Digital Watermarking: Protocol, Video Watermarking, Audio Watermarking, Binary Image Watermarking, Introduction to Digital Right Management Product & Laws, Introduction to DRM Products, Introduction to DRM Laws, Fingerprinting; Digital Forensics, Data Sanitization; Privacy Preserving Surveillance.

8. **Course Code: MICTC-301, Course Name: INTELLIGENT SYSTEM & GREEN ICT, Credit: 3**

Artificial Intelligence and expert systems. Advanced Intelligent Systems- Neural Computing and Machine Learning , Neural Network Fundamentals, Neural Network Application Development , Data Collection and Preparation, Neural Network Architecture Neural Network Preparation, Learning Algorithms, Back propagation, Testing, Implementation. Application of Advanced Intelligent Systems: Credit Approval with Neural Networks , Stock Market Prediction System with Modular Neural Networks , Integrated ANNs and Expert Systems , Optimization Algorithms. Intelligent Agents: An Overview , Characteristics of Agents, Single Task , Why Intelligent Agents? , Classification and Types of Agents ,Internet-Based Software Agents , Electronic Commerce Agents. Understand the overall need for an organisation to adopt a Green IT strategy, Provide an understanding of the historic development and context of the Kyoto Protocol. The key elements of Green IT , Commonly accepted definitions , IT as an energy consumer , IT as a green 'enabler', The concept and dangers of 'Green Wash', Identify and understand an organisation's external drivers and opportunities for greening its IT, identify and understand the internal drivers, opportunities and benefits of adopting a Green IT strategy for both an organisation and its IT service provider(s) -Cost , Operations , Marketing/PR ,Culture. The role of a Green IT policy , The importance of a Green IT policy, Definition of carbon footprints: direct and indirect emissions - Examples of an organisation's footprints: direct and indirect emissions , An understanding of carbon emissions across a product/service lifecycle including: 1. Concept & design 2. Material extraction 3. Transport 4. Manufacture 5. Usage 6. Disposal , Carbon Footprint Calculators , Carbon Offsetting and Carbon Neutrality , Carbon trading. Establishing a continuous improvement framework for Green ICT including use of the ITIL Continual Service Improvement Model. Understand the importance and risks, issues and opportunities around improving efficiency. Understand how best to re-use, recycle and dispose of IT assets.

ICT CORE COURSES – COMPULSARY

3. **Course Code: MICTC-201, Course Name: Multimedia Signal Processing, Credit: 3**

Discrete-time signals and systems, Constant coefficient difference equation. Review of Z Transform: properties, R.O.C, stability and Causality criterion. Structures for digital filters. DTFT and DFT: properties, linear and circular convolution.FFT: Decimation in time & Decimation in frequency. Design of IIR Filters: Bilinear transformation, Impulse invariant transformation. Butterworth, Chebychev, Inverse Chebychev and Elliptical filters etc. Design of F.I.R filters by windowing: rectangular, Bartlett, Hann, Hamming, Kaiser window filters, Design method, Relationship of Kaiser to other windows. Application of MATLAB for design of digital filters. Advanced signal processing techniques: Multirate Signal processing Down sampling/up sampling.

Representation of deterministic signals: Orthogonal representation of signals. Dimensionality of signal spaces. Construction of orthogonal basis functions. Time-bandwidth relationship: RMS duration and bandwidth, uncertainty relations. Random variables: Distribution and density functions, Some special random variables, Conditional distributions and total probability. Functions of one random variable: Mean, variance, Moments, Characteristic functions. Functions of two random variables: Moments and joint distributions, Conditional distributions, Conditional expected values, Mean square estimation. Random Processes: Definition and classification, stochastic integrals, Fourier transforms of random processes, stationary and non-stationary processes, correlation functions. Ergodicity, power spectral density, transformations of random processes by linear systems. Representation of random processes (via sampling, K-L expansion and narrow band representations).

ICT ELECTIVE COURSES - ANY ONE

4. Course Code: MCSC-102, Course Name: WIRELESS SENSOR NETWORKS, Credit: 3

Introduction to Wireless Sensor Networks and applications Tracking chemical plumes- Smart transportation, Network Architecture - Energy Consumption of Sensor Nodes , Operating Systems and Execution Environments, Network Architecture -Sensor Network Scenarios, Hardware Platforms, ns-3 core , Medium Access Control Protocol design, Introduction to Markov Chain, MAC Protocol Analysis, Routing protocols-Resource-aware routing, Data-centric, Geographic Routing, Broadcast, Multicast, MANETS, Routing protocols for WSN, Opportunistic Routing Analysis, Clustering, QoS management ,Sensor mode selection, Localization, Time Synchronization, Security-SPINS, Static and dynamic key distribution, Energy Harvesting WSNs, Programming in WSNs, Sensor Node Hardware Berkeley Motes, Programming Challenges, Node-level software platforms, Node-level Simulators, State-centric programming, Open Research Issues.

5. Course Code: MICTE-301, Course Name: Secure Coding, Credit: 3

Introduction: Security, CIA Triad, Viruses, Trojans, and Worms In a Nutshell, Security Concepts-exploit, threat, vulnerability, risk, attack. Malware Terminology: Rootkits, Trapdoors, Botnets, Key loggers, Honeypots. Active and Passive Security Attacks. IP Spoofing, Tear drop,DoS, DDoS,XSS, SQL injection, Smurf, Man in middle, Format String attack. Types of Security Vulnerabilities- buffer overflows, Invalidated input, race conditions, access-control problems, weaknesses in authentication, authorization, or cryptographic practices. Access Control Problems. Need for secure systems: Proactive Security development process, Secure Software Development Cycle (S-SDLC) , Security issues while writing SRS, Design phase security, Development Phase, Test Phase, Maintenance Phase, Writing Secure Code – Best Practices SD3 (Secure by design, default and deployment), Security principles and Secure Product Development Timeline. Threat modelling process and its benefits: Identifying the Threats by Using Attack Trees and rating threats using DREAD, Risk Mitigation Techniques and Security Best Practices. Security techniques, authentication, authorization. Defence in Depth and

Principle of Least Privilege. Secure Coding Techniques: Protection against DoS attacks, Application Failure Attacks, CPU Starvation Attacks, Insecure Coding Practices In Java Technology. ARP Spoofing and its countermeasures. Buffer Overrun- Stack overrun, Heap Overrun, Array Indexing Errors,FormatString Bugs. Security Issues in C Language: String Handling, Avoiding Integer Overflows and Underflows and Type Conversion Issues- Memory Management Issues, Code Injection Attacks,Canary based countermeasures using StackGuard and Propolice. Socket Security, Avoiding Server Hijacking, Securing RPC, ActiveX and DCOM Database and Web-specific issues: SQL Injection Techniques and Remedies,Race conditions, Time of Check Versus Time of Use and its protection mechanisms. Validating Input and Interprocess Communication, Securing Signal Handlers and File Operations. XSS scripting attack and its types – Persistent and Non persistent attack XSS Countermeasures and Bypassing the XSS Filters. Testing Secure Applications: Security code overview, secure software installation. The Role of the Security Tester, Building the Security Test Plan. Testing HTTP-Based Applications, Testing File-Based Applications, Testing Clients with Rogue Servers

6. MCSC-104, Course Name : CLOUD COMPUTING, Credit: 3

Introduction, Cloud Computing Architecture - Cloud Reference Model, Types of Clouds, Cloud Interoperability & Standards, Scalability and Fault Tolerance, Cloud Solutions: Cloud Ecosystem, Cloud Business Process Management, Cloud Service Management. Cloud Offerings: Cloud Analytics, Testing Under Control, Virtual Desktop Infrastructure. Cloud Management & Virtualization Technology: Resiliency, Provisioning, Asset management, Concepts of Map reduce, Cloud Governance, High Availability and Disaster Recovery. Virtualization: Fundamental concepts of compute ,storage, networking, desktop and application virtualization .Virtualization benefits, server virtualization, Block and file level storage virtualization Hypervisor management software, Infrastructure Requirements , Virtual LAN(VLAN) and Virtual SAN(VSAN) and their benefits. Cloud Security: Cloud Information security fundamentals, Cloud security services, Design principles, Secure Cloud Software Requirements, Policy Implementation, Cloud Computing Security Challenges, Virtualization security Management, Cloud Computing Security Architecture. Market Based Management of Clouds , Federated Clouds/Inter Cloud: Characterization & Definition , Cloud Federation Stack , Third Party Cloud Services . Case study : Google App Engine, Microsoft Azure , Hadoop , Amazon , Aneka. Performance, scalability and consistency on Clouds.

7. **Course Code: MCySE-302, Course Name: Media Security, Credit: 3**

Mathematical Preliminaries: Discrete Fourier Transform (DFT), Discrete Cosine Transform, Random Sequence Generation, The Chaotic Map, Error Correction Code, Set Partitioning in Hierarchical Tree. Introduction to Multimedia Security, Brief history and applications of Information Security, Fundamentals of Information Security, Basics of Digital Imaging and Digital Audio, Introduction to Cryptography, Introduction to Digital Watermarking; Multimedia Security, Introduction to Digital Rights Management (DRM)Multimedia Encryption, Classical Cryptography, Symmetric Encryption, Hash Functions, Message Authentication Codes, Asymmetric Encryption, Digital Signatures, Overview of Advanced Encryption Standard (AES); Block and stream ciphers; Information theoretic secrecy. Principles for selective encryption; Image and Video encryption schemes: Chaotic maps, Transform domain encryption, Huffman tree mutation, Steganography; Steganalysis, Introduction to Steganography, Steganalysis Schemes, JPEG Steganography: LSB Embedding in DCT Coefficients (JSteg), Detecting JSteg with Histograms, patching up the histograms with Outguess, Hamming Codes and Syndrome Coding, Matrix Embedding and Wet Paper Codes, chi square test, Steganalysis: Sample Pair Analysis, Digital Watermarking, Introduction to digital watermarking, Models of Watermarking, Basic Message Coding, Error Correction, Coding, Mutual Information and Channel Capacity, How to Design a Good Digital Watermark, Digital, Watermarking Schemes, Digital Watermarking: Protocol, Video Watermarking, Audio Watermarking, Binary Image Watermarking, Introduction to Digital Right Management Product & Laws, Introduction to DRM Products, Introduction to DRM Laws, Fingerprinting; Digital Forensics, Data Sanitization; Privacy Preserving Surveillance.

8. **Course Code: MICTC-301, Course Name: INTELLIGENT SYSTEM & GREEN ICT, Credit: 3**

Artificial Intelligence and expert systems. Advanced Intelligent Systems- Neural Computing and Machine Learning , Neural Network Fundamentals, Neural Network Application Development , Data Collection and Preparation, Neural Network Architecture Neural Network Preparation, Learning Algorithms, Back propagation, Testing, Implementation. Application of Advanced Intelligent Systems: Credit Approval with Neural Networks , Stock Market Prediction System with Modular Neural Networks , Integrated ANNs and Expert Systems , Optimization Algorithms. Intelligent Agents: An Overview , Characteristics of Agents, Single Task , Why Intelligent Agents? , Classification and Types of Agents ,Internet-Based Software Agents , Electronic Commerce Agents. Understand the overall need for an organisation to adopt a Green IT strategy, Provide an understanding of the historic development and context of the Kyoto Protocol. The key elements of Green IT , Commonly accepted definitions , IT as an energy consumer , IT as a green 'enabler', The concept and dangers of 'Green Wash', Identify and understand an organisation's external drivers and opportunities for greening its IT, identify and understand the internal drivers, opportunities and benefits of adopting a Green IT strategy for both an organisation and its IT service provider(s) -Cost , Operations , Marketing/PR ,Culture.

The role of a Green IT policy , The importance of a Green IT policy, Definition of carbon footprints: direct and indirect emissions - Examples of an organisation's footprints: direct and indirect emissions , An understanding of carbon emissions across a product/service lifecycle including: 1. Concept & design 2. Material extraction 3. Transport 4. Manufacture 5. Usage 6. Disposal , Carbon Footprint Calculators , Carbon Offsetting and Carbon Neutrality , Carbon trading. Establishing a continuous improvement framework for Green ICT including use of the ITIL Continual Service Improvement Model. Understand the importance and risks, issues and opportunities around improving efficiency. Understand how best to re-use, recycle and dispose of IT assets.

ML CORE COURSES – COMPULSARY

3. Course Code: MMLC-301, Course Name: Reinforcement Learning, Credit: 3

Introduction to Reinforcement Learning, How to act given know how the world works: Tabular setting, Markov processes, Policy search, Policy iteration, Value iteration, Learning to evaluate a policy when don't know how the world works, Model-free learning to make good decisions: Q-learning, SARSA, Scaling up: RL with function approximation, RL with function approximation, Imitation learning in large spaces, Policy search, Exploration/Exploitation, Meta-Learning, Batch Reinforcement Learning, Monte Carlo Tree Search

ML ELECTIVE COURSES - ANY ONE

4. Course Code: MMLE-301, Course Name: Advanced Kernel Methods, Credit: 3

Kernel Vector Spaces: Fundamentals of kernel-based machine learning- The learning subspace property (LSP) and "kernelization" of learning models, Unsupervised learning for cluster discovery, Supervised learning for linear classifiers, Generalized inner products and kernel functions, Kernel-induced vector spaces- Mercer kernels and kernel-induced similarity metrics, Training-data-independent and dependent intrinsic feature vectors, The kernel-trick for nonvectorial data analysis. Feature selection, PCA/KPCA and Cluster Discovery PCA and kernel PCA- Subspace projection and PCA, Kernel principal component analysis (KPCA), Unsupervised learning for cluster discovery, Kernel methods for cluster analysis-Kernel-based K-means learning models, Kernel K-means for nonvectorial data analysis, K-means learning models in kernel-induced spectral space, Kernelized K-means learning models. Kernel ridge regressors, Support Vector Machines and variants, Kernel-based regression and regularization analysis-Linear least-squares-error analysis, Kernel-based regression analysis, Multi-kernel regression analysis, Linear regression and discriminant analysis for supervised classification-Kernelized learning models in empirical space: linear kernels Linear support vector machines, SVM with fuzzy separation: roles of slack variables, Kernel-based support vector machines, Kernel methods for green Machine learning technologies Efficient kernel methods for learning and classification-System design consideration, Selection of cost-effective kernel functions, Classification of complexities: empirical and intrinsic degrees, Learning complexities: empirical and intrinsic degrees. Kernel methods and Statistical estimation theory- Kernel methods for estimation, prediction, and system identification

5. Course Code: MMLE-302, Course Name: Deep Learning, Credit: 3

Course overview: What is deep learning? DL successes; Gradient descent, logistic regression, Probability, continuous and discrete distributions; maximum-likelihood; Intro to neural networks: cost functions, hypotheses and tasks; training data; maximum-likelihood based cost, cross entropy, MSE cost; feed-forward networks; MLP, sigmoid units; neuroscience inspiration; Learning in neural networks: output vs hidden layers; linear vs nonlinear networks;Back propagation: learning via gradient descent; recursive chain rule (back propagation), bias-variance trade-off, regularization; output units: linear, Softmax; hidden units: tanh, RELU; Deep learning strategies (GPU training, regularization, RLUs, dropout, etc.); Transfer Learning; Deep Learning Models: Convolutional neural networks, Deep Belief Nets and its variants, Recurrent neural networks, Unsupervised deep learning: autoencoders, deep generative models.

6. MCSC-104, Course Name : CLOUD COMPUTING, Credit: 3

Introduction , Cloud Computing Architecture - Cloud Reference Model, Types of Clouds, Cloud Interoperability & Standards, Scalability and Fault Tolerance, Cloud Solutions: Cloud Ecosystem, Cloud Business Process Management, Cloud Service Management. Cloud Offerings: Cloud Analytics, Testing Under Control, Virtual Desktop Infrastructure. Cloud Management & Virtualization Technology: Resiliency, Provisioning, Asset management, Concepts of Map reduce, Cloud Governance, High Availability and Disaster Recovery. Virtualization: Fundamental concepts of compute ,storage, networking, desktop and application virtualization .Virtualization benefits, server virtualization, Block and file level storage virtualization Hypervisor management software, Infrastructure Requirements , Virtual LAN(VLAN) and Virtual SAN(VSAN) and their benefits. Cloud Security: Cloud Information security fundamentals, Cloud security services, Design principles, Secure Cloud Software Requirements, Policy Implementation, Cloud Computing Security Challenges, Virtualization security Management, Cloud Computing Security Architecture. Market Based Management of Clouds , Federated Clouds/Inter Cloud: Characterization & Definition , Cloud Federation Stack , Third Party Cloud Services . Case study : Google App Engine, Microsoft Azure , Hadoop , Amazon , Aneka. Performance, scalability and consistency on Clouds.

7. Course Code: MMLE-303, Course Name: Machine Learning Applications, Credit: 3

Image pre-processing: Read image, resize image, Remove noise (Denoise), Segmentation, Morphology (smoothing edges). Feature extraction Techniques: Gray Level Co-occurrence Matric (GLCM), Local Binary Pattern (LBP), Canny Edge Operator and Bag of Words (BoW). Dimensionality Reduction Techniques: Principal Component Analysis (PCA), Independent Component Analysis (ICA), Linear Discriminant Analysis (LDA) and Autoencoders (AE). Classification methods: Logistic Regression, Naive Bayes Classifier, Nearest Neighbor, Support Vector Machines, Decision Trees, Random Forest, Neural Networks.Applications of Machine learning in Medicine and biology: Machine Learning to Detect and Diagnose Breast Cancer: Dividing the Data Set, Defining the Metrics, Evaluating the Models, creating a machine learning/deep learning Model, Evaluating Output Quality Through

Receiver Operating Curves, Segmentation of Nuclei in microscopic Images using U-Net and similar problems, Machine learning applications in One dimensional signals like biomedical signals, speech signals.

8. **Course Code: MMLE-304, Course Name: Topological Data Analysis, Credit: 3**

Basic concepts (graphs, connected components, topological space, manifold, point clouds) Combinatorial structures on point cloud data (simplicial complexes) New techniques in dimension reduction (circular coordinates, etc.) Clustering (topology-based data partition, classification) Homology and persistent homology Topological signatures for classification Structural inference and reconstruction from data Topological algorithms for massive data Multivariate and high-dimensional data analysis Topological data analysis for visualization (vector fields, topological structures) Practical applications of TDA

SEMESTER-IV

1. **Course Code: MCSC-401, Course Name: THESIS /DISSERTATION - II, Credit: 14**

The students will continue to work on the problem identified in Minor Project (in Semester III) as per the work plan. The work is continued until all stated objectives and deliverables are met. Student will prepare a comprehensive report containing introduction to the problem, literature review, methodology, results and discussion and conclusion. Research Progress Seminar will be held twice a month for continuous evaluation. The thesis grading shall be done on the basis of research outcomes in the form of a working prototype or a patent or a publication in peer reviewed Journal, International Conference or National Conference