### B. Tech ( Computer and Communication Engineering) (applicable to students admitted from 2018 onwards)

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Year** | **Subject code** | **THIRD SEMSTER** | | | | | **Subject code** | **FOURTH SEMESTER** | | | | |
| **Subject Name** | **L** | **T** | **P** | **C** | **Subject Name** | **L** | **T** | **P** | **C** |
| 2 | MAT 2155 | Mathematics - III | 2 | 1 | 0 | 3 | MAT 2256 | Mathematics - IV | 2 | 1 | 0 | 3 |
| ICT 2153 | Data Structures | 3 | 1 | 0 | 4 | ICT 2251 | Computer Network Protocols | 4 | 0 | 0 | 4 |
| ICT 2171 | Digital Systems and Computer Organization | 3 | 1 | 0 | 4 | ICT 2255 | Database Systems | 3 | 0 | 0 | 3 |
| ICT 2155 | Object Oriented Programming | 3 | 1 | 0 | 4 | ICT 2253 | Design and Analysis of Algorithms | 3 | 0 | 0 | 3 |
| ICT 2156 | Principles of Data Communication | 3 | 1 | 0 | 4 | ICT 2254 | Operating Systems | 3 | 1 | 0 | 4 |
| ICT 2162 | Data Structures Lab | 0 | 1 | 3 | 2 | \*\*\*\* | Open Elective - I |  |  |  | 3 |
| ICT 2165 | Digital System Design Lab | 0 | 1 | 3 | 2 | ICT 2261 | Algorithms Lab | 0 | 0 | 3 | 1 |
| ICT 2164 | Object Oriented Programming Lab | 0 | 0 | 3 | 1 | ICT 2264 | Database Systems Lab | 0 | 1 | 3 | 2 |
|  |  |  |  |  |  | ICT 2263 | Operating Systems Lab | 0 | 0 | 3 | 1 |
|  | **TOTAL** | **14** | **7** | **9** | **24** |  | **TOTAL** | **15** | **3** | **9** | **24** |
|  | **Total Contact Hours (L + T + P)** | | **(14+7+9) = 30** | | | |  | **Total Contact Hours (L + T + P) + OE** | **(15+3+9)+3=30** | | | |
| **FIFTH SEMESTER** | | | | | | |  | **SIXTH SEMESTER** |  | | | |
| 3 | HUM 3052 | Essentials of Management | 2 | 1 | 0 | 3 | HUM 3051 | Engg. Economics and Financial Management | 2 | 1 | 0 | 3 |
| ICT 3155 | Data Mining and Predictive Analysis | 3 | 0 | 0 | 3 | ICT 3253 | Embedded Systems Design | 3 | 0 | 0 | 3 |
| ICT 3156 | Information Security | 3 | 0 | 0 | 3 | ICT 3254 | Wireless Communication and Computing | 3 | 1 | 0 | 4 |
| ICT 3157 | Network Programming and Advanced Communication Networks | 3 | 0 | 0 | 3 | ICT \*\*\*\* | Program Elective - I | 3 | 0 | 0 | 3 |
| ICT 3158 | Software Design Technology | 3 | 1 | 0 | 4 | ICT \*\*\*\* | Program Elective –II | 3 | 0 | 0 | 3 |
| \*\*\*\* | Open Elective - II |  |  |  | 3 | \*\*\*\* | Open Elective - III |  |  |  | 3 |
| ICT 3164 | Advanced Programming Lab | 0 | 1 | 3 | 2 | ICT 3264 | Embedded Systems and Iot Lab | 0 | 1 | 3 | 2 |
| ICT 3165 | Data Mining and Predictive Analysis Lab | 0 | 1 | 3 | 2 | ICT 3265 | Mobile Application Development Lab | 0 | 0 | 3 | 1 |
| ICT 3166 | Network Design and Programming Lab | 0 | 0 | 3 | 1 | ICT 3266 | Network Simulation Lab | 0 | 0 | 3 | 1 |
|  | **TOTAL** | **14** | **4** | **9** | **24** |  | **TOTAL** | **14** | **3** | **9** | **23** |
|  |  | **Total Contact Hours (L + T + P) + OE** | **(14+4+9)+3=30** | | | |  | **Total Contact Hours (L + T + P) + OE** | **(14+3+9)+3 =29** | | | |
| **SEVENTH SEMESTER** | | | | | | |  | **EIGHTH SEMESTER** |  |  |  |  |
| 4 | ICT \*\*\*\* | Program Elective - III | 3 | 0 | 0 | 3 | ICT 4298 | Industrial Training | 0 | 0 | 0 | 1 |
| ICT \*\*\*\* | Program Elective - IV | 3 | 0 | 0 | 3 | ICT 4299 | Project Work / Practice School | 0 | 0 | 0 | 12 |
| ICT \*\*\*\* | Program Elective- V | 3 | 0 | 0 | 3 |  |  |  |  |  |  |
| ICT \*\*\*\* | Program Elective- VI | 3 | 0 | 0 | 3 |  |  |  |  |  |  |
| ICT \*\*\*\* | Program Elective- VII | 3 | 0 | 0 | 3 |  |  |  |  |  |  |
| ICT \*\*\*\* | Open Elective - IV |  |  |  | 3 |  |  |  |  |  |  |
|  | **TOTAL** | **15** | **0** | **0** | **18** |  | **TOTAL** | **0** | **0** | **0** | **13** |
|  |  | **Total Contact Hours (L + T + P) + OE** | **(15+0) + 3 = 18** | | | |  |  |  |  |  |  |

|  |  |  |
| --- | --- | --- |
| **Minor Specializations**  **I. Advanced Network Systems**  ICT 4041: Mobile Computing  ICT 4042: Multimedia Communication  ICT 4043: Next Generation Telecom Networks  ICT 4044: Software Defined Networking  **II. Computational Intelligence**  CSE 4053: Artificial Intelligence  ICT 4031: Computer Vision  ICT 4032: Machine Learning  CSE 4054: Soft Computing Paradigms  **III. Computer Graphics & Visualization \*\***  CSE 4051: Augmented and Virtual Reality  ICT 4033: Computer Graphics  ICT 4031: Computer Vision  CSE 4052: Digital Image Processing  **IV. Data Analytics**  ICT 4034: Big Data Analytics  ICT 4035: Information Retrieval  ICT 4032: Machine Learning  ICT 4036: Semantic Web | **V. Material Science**  PHY \*\*\*\*:  PHY \*\*\*\*:  CHM \*\*\*\*:  CHM \*\*\*\*:  **VI. Business Management**  HUM 4051: Financial Management  HUM 4052: Human Resource Management  HUM 4053: Marketing Management  HUM 4054: Operation Management  **VII. Computational Mathematics**  MAT 4051: Applied Statistics and Time Series Analysis  MAT 4052: Computational Linear Algebra  MAT 4053: Computational Probability and Design of Experiments  MAT 4054: Graphs and Matrices | **Other Programme Electives**  ICT 4045: Cloud Computing  ICT 4046: Deep Learning  ICT 4047: Game Theory with Computer Applications  ICT 4048: High Performance Computing  ICT 4049: Human Computer Interaction  ICT 4050: Internet of Things  ICT 4051: Natural Computing  ICT 4052: Neural Networks and Fuzzy Logic  ICT 4053: Pattern Recognition  ICT 4054: Social Network Analysis  ICT 4055: Software Reliability  **Open Electives**  ICT 4301: Computer Graphics and Animation  ICT 4302: Design and Development of Web Applications  ICT 4303: Fundamentals of Data Structures and Algorithms  ICT 4304: Machine Learning Tools and Technologies  ICT 4305: Networking with TCP/IP  ICT 4306 : Cyber Security  ICT 4307: Game Theory & Applications |

**THIRD SEMESTER**

**MAT 2155: MATHEMATICS-III [2 1 0 3]**

Boolean Algebra: Partial ordering relations, Poset, Lattices, Basic Properties of Lattices. Distributive and complemented lattices, Boolean lattices and Boolean Algebra. Propositional and Predicate Calculus: Well-formed formula, connectives, quantifications, Inference theory of propositional and predicate calculus. Elementary configuration: Permutations and Combinations, Generating function, Principle of inclusion and exclusion Partitions, compositions. Ordering of permutations: Lexicographical and Fikes. Graph theory: Basic definitions, Degree, regular graphs, Eulerian and Hamiltonian graphs, Trees and Properties, Center, radius and diameter of a graph, Rooted and binary trees, Matrices associated with graphs, Algorithms for finding shortest path. Group theory: Semi groups, Monoids, Groups- subgroups, Normal Subgroups, Cosets, Lagrange’s Theorem, Cyclic groups.

**References:**

1. Liu C.L., *Elements of Discrete Mathematics (2e),* McGraw Hill, New Delhi, 2007.
2. Trembaly J.P. and Manohar R., *Discrete Mathematics Structures with application to computer Science*, Tata McGraw Hill, 2012.
3. Page E.S. and Wilson L.B., *An Introduction to Computational Combinatorics*, Cambridge Univ. Press, 1979.
4. Narasingh Deo, *Graph theory with Applications to computer science*, PHI, 2012.

**ICT 2153: DATA STRUCTURES [3 1 0 4]**

Introduction, Programming fundamentals, Stacks, Queues and their applications, Sparse Matrix, Pointers and dynamic memory allocation, Linked Lists: Singly linked lists, Dynamically Linked Stacks and Queues, Polynomial representation and polynomial operations using singly linked list, Singly Circular Linked List, Doubly Linked Lists, Trees: Binary trees, Heaps, Binary Search Trees, Threaded binary trees, Graphs: Depth First Search, Breadth First Search, Connected components, Spanning trees, Sorting and searching Techniques.

**References:**

1. Horowitz E., Sahni S., Mehta D., *Fundamentals of Data Structures in C++ (2e),* Golgotha Publications, 2008.
2. Weiss M. A., *Data Structures and Algorithm Analysis in C++ (3e),* Pearson Education, 2009.
3. Michael T. Goodrich, Tamassia R., Mount D., *Data Structures and Algorithms in C++ (2e),* John Wiley & Sons, 2011.
4. Horowitz E., Sahni S., Anderson-Freed S.*, Fundamentals of Data structures in C (2e),* Silicon Press, 2008.

**ICT 2171: DIGITAL SYSTEMS AND COMPUTER ORGANIZATION [3 1 0 4]**

Introduction, Simplification of Boolean functions – K-map method, NAND and NOR implementation, Combinational logic, Design of Adders/Subtractors, code converters, Application of typical TTL integrated circuit components like Binary Parallel adder[74283], multiplier using 74283, Magnitude Comparator [7485], Decoders [74138,7442], Encoders [74148], Multiplexers [74157], combinational shifter design, De Multiplexers, Sequential logic –counters and shift registers, Computer organization- Introduction, ALU unit, Control unit, Hardwired and Micro – programming approach, Memory unit, Input and Output unit.

**References:**

1. Mano M.R.,‎ Kime C.R.,‎ Martin T., *Logic & Computer Design Fundamentals (5e),* Prentice Hall India, 2015.
2. Tocci R.J., Widmer N.S., Greegory L.M., *Digital Systems: principles and Applications* *(12e),* Pearson Education India, 2017.
3. Rafiquzzaman M., Chandra R., Modern computer Architecture (3e), Galgotia publications Pvt Ltd, 2010.

**ICT 2155: OBJECT ORIENTED PROGRAMMING [3 1 0 4]**

Introduction to the java programming language, Importance of Java in the internet, Data types, Variable and arrays, Type conversion and casting, Operators and control statements, Classes and inheritance, Packages and interfaces, Collections Framework - array list, vector and dictionary, String handling, Exception handling, Thread concepts – synchronization, inter thread communication, Input/output – File:file input stream, File output stream, Random access files, Reader, Writer, Serialization, Serializable, Object input stream, Object output stream, Swings - swing fundamentals, Introduction to event handling.

**References:**

1. Schildt H., *Java-The Complete Reference (9e)*, Tata McGraw-Hill 2014.
2. [Horstmann](https://www.amazon.in/Cay-S.-Horstmann/e/B000AQ1QDY/ref=sr_ntt_srch_lnk_1?qid=1519985819&sr=1-1) C. S. & Cornell G., *Core Java Volume I – Fundamentals (9e), Prentice Hall 2013.*
3. [Horstmann](https://www.amazon.in/Cay-S.-Horstmann/e/B000AQ1QDY/ref=sr_ntt_srch_lnk_1?qid=1519985819&sr=1-1) C. S. & Cornell G., *Core Java Volume II* *– Advanced Features* *(9e)*, Prentice Hall 2013.

**ICT 2156 PRINCIPLES OF DATA COMMUNICATION [3 1 0 4]**

Introduction to Data Communication, Signals, Basic properties of data communication system, NY Quist rate, Shannon Capacity, Signal encoding and TX and Rx models, Modulation schemes. Properties of Media and digital transmission systems, wired and wireless medium, Error detection and correction, Block codes, CRC, Hamming code, Stop and wait flow control, Sliding window flow control, ARQs, HDLC, Multiplexing, Media Access Sub layer and LAN, Approaches to sharing transmission medium, Random access protocols, Token passing protocols, IEEE LAN standards, Bridges, MAN, FDDI.

**References:**

1. Stallings W., *Data & Computer Communications* *(9e),* Pearson Education Inc., Noida, 2017.
2. Frozen B., *Introduction to data communication & networking* *(4e),* Tata McGraw Hill, New Delhi-2014.
3. Garcia A. L., Widjaja I., *Communication Networks (2e),* Tata McGraw Hill, 2011.

**ICT 2162: DATA STRUCTURES LAB [0 1 3 2]**

Application using arrays, String operations, Class concepts: Creation, Initialization using constructors, Applications of stacks, Arithmetic expression conversion and evaluation using stack, queues, Sparse matrix representation, Transpose of a sparse matrix, Singly linked lists and applications, Circular linked lists, Doubly linked lists, polynomial addition and multiplications using circular linked lists, Binary Tree: creation, deletion and traversal techniques, Binary search tree operations, sorting and searching techniques.

**References:**

1. Horowitz E, Sahni S., Mehta D., *Fundamentals of Data Structures in C++ (2e),* Golgotha Publications, 2008.
2. Weiss M. A., *Data Structures and Algorithm Analysis in C++ (3e),* Pearson Education, 2009.
3. Horowitz E., Sahni S., Anderson-Freed S.*, Fundamentals of Data structures in C (2e),* Silicon Press, 2008.

## **ICT 2165: DIGITAL SYSTEM DESIGN LAB [0 1 3 2]**

Verification of Boolean algebra and De Morgan theorems, Simplification of Boolean expressions using K-maps, combinational logic circuit implementation like BCD adder, multiplier, code converter, comparator, comparator with cascading inputs using 4 bit binary adder [7483], 3 to 8 decoder [74138], magnitude comparator [7485], Multiplexers [74151, 74153, 74157] ICs, Sequential logic circuits that include conversion of flip-flops, analyzing timing diagram using output waveform, Asynchronous and Synchronous counters [7490, 9495, 74193 ICs], Shift registers, sequence generators, sequence detector.

**References:**

1. Mano M.R.,‎ Kime C.R.,‎ Martin T., *Logic & Computer Design Fundamentals (5e),* Prentice Hall India, 2015.
2. Tocci R.J., Widmer N.S., Greegory L.M., *Digital Systems: principles and Applications* *(12e),* Pearson Education India, 2017.
3. Wakerly J.F., *Digital Design Principles and Practices* *(4e),* Pearson Education, 2014.

**ICT 2164: OBJECT ORIENTED PROGRAMMING LAB [0 0 3 1]**

Programs based on the following concepts: Data types, Type conversions, Operators, Control statements, Classes, Inheritance, Polymorphism, Threads, Interfaces and abstract classes, Collections: array list and vector, String handling, file handling, Swings.

**References:**

1. Schildt H., *Java-The Complete Reference (9e)*, Tata McGraw-Hill 2014.
2. [Horstmann](https://www.amazon.in/Cay-S.-Horstmann/e/B000AQ1QDY/ref=sr_ntt_srch_lnk_1?qid=1519985819&sr=1-1) C. S. & Cornell G., *Core Java Volume I – Fundamentals (9e),* Prentice Hall 2013.
3. [Horstmann](https://www.amazon.in/Cay-S.-Horstmann/e/B000AQ1QDY/ref=sr_ntt_srch_lnk_1?qid=1519985819&sr=1-1) C. S. & Cornell G., *Core Java Volume II* *– Advanced Features* *(9e)*, Prentice Hall 2013.

**FOURTH SEMSTER**

**MAT 2256: MATHEMATICS-IV [2 1 0 3]**

Basic Set theory, Axioms of probability, Sample space, conditional probability, total probability theorem, Baye’s theorem. One dimensional and two dimensional random variables, mean and variance, properties, Chebyschev’s inequality, correlation coefficient, Distributions, Binomial,

Poisson, Normal and Chisquare. Functions of random variables: One dimensional and Two

Dimensional, F & T distributions, Moment generating functions, Sampling theory, Central limit

Theorem, Point estimation, MLE, Interval estimation, Test of Hypothesis: significance level, certain best tests; Chi square test.

**References:**

1. P.L.Meyer, *Introduction to probability and Statistical Applications (2e),* Oxford and IBH

Publishing, 1980.

1. Miller, Freund and Johnson, *Probability and Statistics for Engineers (8e),* PHI, 2011.
2. Hogg and Craig, *Introduction to mathematical statistics (6e),* Pearson education, 2012.
3. Ross Sheldon M, *Introduction to Probability and Statistics for Engineers and Scientists*, Elseveir, 2010.

**ICT 2251: COMPUTER NETWORK PROTOCOLS [4 0 0 4]**

Introduction to Computer Networks: Definition, Network Layer, Network Layer services, Interfacing - Bridges, IP addressing, Subnetting and Supernetting, IPv6 addressing, Delivery Forwarding, and Routing of IP Packets, Internet Protocol **-** Datagram, Fragmentation, Options, Checksum, Introduction to Routing Protocols, Interior and Exterior routing, Dynamic IP Routing Protocols - RIP, RIP Version 2, OSPF, Routing between peers – BGP, ARP and RARP, Internet Control Message Protocol, User Datagram Protocol, Transmission Control Protocol and Introduction to application layer, Domain Name System (DNS), DHCP, FTP, SNMP.

**References:**

1. Behrouz A. F., *TCP/IP Protocol Suite (4e),* Tata McGraw-Hill 2017.
2. Andrew S. T., *Computer Network (5e),* Prentice Hall of India Pvt Ltd 2013.
3. Behrouz A. F., *Data Communications and Networking (5e),* Tata McGraw Hill 2013.
4. Garcia L.,Widjala, *Communication Networks (2e),* Tata McGraw Hill 2004.

## **ICT 2255: DATABASE SYSTEMS [3 0 0 3]**

Introduction to database system, Database users, Database architecture, Relational database, Keys, Schema, Formal relational query language, SQL basics, Constraints, Intermediate SQL, Joins, Nested queries, Advanced SQL, Functions, Procedures, Triggers, High level data modelling using entity relationship model, Relational database design, Notion of functional dependencies, Normalization, Transaction management, ACID properties, Serializability, Concurrency control, Locking, Deadlock handling, Unstructured database, Introduction to NoSQL, Basics of document-oriented database, MongoDB.

**References:**

1. Silberschatz A., Korth H. F., Sudarshan S., *Database system concepts* *(6e)*, McGraw-Hill, 2013.
2. Elmasri, Ramez, Navathe S., *Fundamentals of database systems* *(7e)*, Pearson, 2016.
3. Molina, Hector, Ullman J. D., Widom J., *Database systems, The Complete Book* *(2e),* Pearson Prentice Hall, 2013.
4. Chodorow K., MongoDB: *The definitive guide* *(2e)*, O’Reilly, 2013.

**ICT 2253: DESIGN AND ANALYSIS OF ALGORITHMS [3 0 0 3]**

Introduction, Graphs: Representation of graphs & Digraphs, Graph Search Methods: Breadth First Search, Depth First Search, Shortest path algorithms, Algorithm Design Techniques: The Greedy Method, Divide and Conquer, Dynamic Programming, Tree-Binary search trees, Heap Trees, Height Balanced Tree, B Trees, B+ trees. Hashing: hash functions, collision resolution techniques. Heaps and priority Queues, P, NP, NP-Complete and NP hard problems, Approximation Algorithms.

**References:**

1. Cormen T H., Leiserson C. E., Rivest R. L., Stein C., *Introduction to Algorithms* *(3e),* Prentice-Hall India, 2009.
2. Sahni S., *Data Structures, Algorithms and Applications in C++* *(2e),* Silicon Press, 2005.
3. Weiss M., *Data Structures and Algorithm Analysis in C* *(3e),* Pearson Education, 2009.

## **ICT 2254: OPERATING SYSTEMS [3 1 0 4]**

Introduction to Operating systems - Operating System Services, Operating system Structure, System calls, Process management - Process concept, Threads, Inter-process communication, CPU Scheduling, Process synchronization, Handling deadlocks – Deadlock Characterization, Deadlock Detection, Prevention, Avoidance and Recovery, Memory management - Main memory, Swapping, Contiguous Memory Allocation, Paging, Segmentation, Virtual memory – Demand Paging, Page Replacement, Thrashing, Allocating Kernel Memory, Storage Management- File management, Disk scheduling, Case study on Unix based Operating system – Design Principles, Kernel Modules, Basic concepts of Real time operating systems – Classification of Real Time Systems, Microkernels, Scheduling.

**References:**

1. Silberschatz A., Galvin P.B. & Gagne G*., Operating System Concepts (9e),* Wiley, 2012*.*
2. Stallings W., *Operating Systems: Internals and Design Principles (9e),* Pearson, 2017*.*
3. Laplante P.A. & Ovaska S.J., *Real time systems design and analysis (4e),* Wiley, 2013*.*
4. Mall R., *Real time systems: Theory and Practice (2e),* Pearson, 2009.

**\*\*\* \*\*\*\*: OPEN ELECTIVE-I [3 0 0 3]**

**ICT 2261: ALGORITHM LAB [0 0 3 1]**

Graphs: Finding a Path, cycle. Greedy Method: 0/1 Knapsack Problem, Dijkstra’s Algorithm, Minimum spanning tree using Prim’s/Kruskal’s Algorithm. Divide and Conquer Method: Merge Sort, Quick Sort, Strassen’s Matrix multiplication method, Binary Search, Closest Pair of points. Dynamic Programming: Matrix Multiplication Chain Problem, 0/1 Knapsack problem, All pairs shortest path. Backtracking/Branch and Bound: Travelling sales person problem, 0/1 Knapsack Problem. Approximation Algorithm: Travelling sales person problem, Vertex cover problem.

**References:**

1. Cormen T. H., Leiserson C. E., Rivest R. L., Stein C, *Introduction to Algorithms* *(3e),* Prentice- Hall India, 2009.
2. Sahni S., *Data Structures, Algorithms and Applications in C++ (2e),* Silicon Press, 2005.

## **ICT 2264: DATABASE SYSTEMS LAB [0 1 3 2]**

Basics of Visual C# for GUI design and control, Data Definition Language, Basic database query operations, Nested sub queries, Join Operations ,Views, Stored procedures, Functions, Trigger, Cursors, Transaction control queries, Data Access from Visual C#, Introducing NoSQL-MongoDB ,Design and development of application based on database concepts.

**References:**

1. Ivan B., SQL, PL/SQL: *The Programming Language of Oracle* *(4*e), BPB Publications, 2010.
2. Ken C., Csharp, Available : <https://www.homeandlearn.co.uk/csharp/csharp.html> [Online]
3. JavaTPoint, Oracle-tutorial, Available : https://www.javatpoint.com/oracle-tutorial [Online]
4. W3Schools, SQL Tutorial ,Available : <https://www.w3schools.com/sql/> [Online]
5. MongoDB, MongoDB Tutorials, Available : <https://docs.mongodb.com/manual/tutorial/> [Online]

**ICT 2263: OPERATING SYSTEMS LAB [0 0 3 1]**

UNIX based operating system commands, executing shell scripts, inter process communication using system calls, implementing CPU scheduling algorithms, memory and deadlock management.

**References:**

1. Blurn R. & Bresnahan C., *Linux Command Line Shell Scripting Bible, Wiley* *(3e),* 2015.
2. Silberschatz A., Galvin P.B. & Gagne G*., Operating System Concepts (9e),* Wiley, 2012*.*

**FIFTH SEMSTER**

**HUM 3052: ESSENTIALS OF MANAGEMENT [2 1 0 3]**

Definition of management and systems approach, Nature & scope. The functions of managers. Corporate social responsibility. Planning: Types of plans, Steps in planning, Process of MBO, How to set objectives, Strategies, policies & planning premises. Strategic planning process and tools. Nature & purpose of organising, Span of management, Factors determining the span, Basic departmentation, Line & Staff concepts, Functional authority, Art of delegation, Decentralisation of authority. HR planning, Recruitment, Development and training. Theories of motivation, Special motivational techniques. Leadership- leadership behaviour & styles, Managerial grid. Basic control process, Critical control points & standards, Budgets, Non-budgetary control devices. Profit & loss control, Control through ROI, Direct, Preventive control. Managerial practices in Japan & USA, Application of Theory Z. The nature & purpose of international business & multinational corporations, Unified global theory of management. Entrepreneurial traits, Creativity, Innovation management, Market analysis, Business plan concepts, Development of financial projections.

**References:**

1. Harold Koontz & Heinz Weihrich, *Essentials of Management,* McGraw Hill, New Delhi, 2012.
2. Peter Drucker, *Management: Tasks, Responsibilities and Practices,* Harper and Row, New York, 1993.
3. Peter Drucker, *The Practice of Management,* Harper and Row, New York, 2004.

## **ICT 3155: DATA MINING AND PREDICTIVE ANALYSIS [3 0 0 3]**

Introduction to Data mining, Importance of data mining, Kinds of data to be mined, Major issues in Data Mining, Data objects and Attribute types, Data visualization, Data cleaning, Data integration, Data reduction, Data transformation strategies, Association rule mining: Apriori algorithm**,** Dynamic item set counting algorithm, Pincer – Search Algorithm, FP-tree growth algorithm, PC Tree, Cluster analysis, Partitioning methods: K-means, K-Medoid, Hierarchical methods, Density-Based methods: DBSCAN, Classification techniques: Decision tree induction, Bayes classification method, Model evaluation and selection, Regression techniques: Simple linear regression, Multivariable linear regression with gradient descent, support vector machine for regression**,** Introduction to web mining, temporal, spatial data mining

References:

1. Han J., Kamber M., Jian P., *Data Mining Concepts and Techniques (3e),* Morgan Kauffmann Publishers 2011.
2. Pujari A. K., *Data Mining Techniques (4e),* Orient BlackSwan/Universities Press 2016.
3. Pang-N. T., Steinbach M., Anuj K, Vipin K., *Introduction to Data Mining, Pearson Education* *(2e)*, Pearson 2016.
4. Kelleher J D., Brian M N, D’ Arcy A., *Fundamentals of Machine Learning for predictive Data Analytics: Algorithms, Worked Examples and Case Studies (1e),* MIT Press, 2015.

**ICT 3156: INFORMATION SECURITY [3 0 0 3]**

Introduction to Information and Network Security, Symmetric-Key Ciphers: Classical and Modern encryption techniques, Block ciphers, Advanced Encryption Standard, Uses block ciphers, Asymmetric-Key Cryptographic Ciphers, Principles of public key cryptosystems, Number theory concepts, Uses of primes, Message Integrity and Message Authentication, Cryptographic hash functions, Application of cryptographic hash functions, Digital Signature, Key Management, Entity Authentication, Transport Level Security, System Security concepts, Firewalls, Network Intrusion detection and prevention systems.

**References:**

1. Stallings W., *Cryptography and Network Security: Principles and Practice (7e),* Pearson Publications, 2016.
2. [Pfleeger](https://www.amazon.com/Charles-P.-Pfleeger/e/B001ILI9HQ/ref=dp_byline_cont_book_1) C. P., ‎  [Pfleeger](https://www.amazon.com/s/ref=dp_byline_sr_book_2?ie=UTF8&field-author=Shari+Lawrence+Pfleeger&search-alias=books&text=Shari+Lawrence+Pfleeger&sort=relevancerank) S.L., ‎ [Margulies](https://www.amazon.com/Jonathan-Margulies/e/B00Q74RUJC/ref=dp_byline_cont_book_3) J., *Security in Computing (5e),* Prentice Hall, 2015.
3. Michael E., Whitman and Mattord H.J., *Principles of Information Security (5e),* Cengage Learning, 2015.
4. Stamp M., *Information Security: Principles and Practice (2e),* John Wiley & Sons, 2011.
5. Forouzan B.A., Mukhopadhyay D., *Cryptography and Network Security (2e),* (Revised), Tata McGraw-Hill Education India, 2010.

**ICT 3157:** **NETWORK PROGRAMMING AND ADVANCED COMMUNICATION NETWORKS [3 0 0 3]**

High Speed Communication Networks: Queuing Models, Optical Networks, High Speed Network, Components, Integrated and Differentiated Services, Multiprotocol Label Switching, Virtual Private Networks, Signaling, Applications. UNIX Programming: Elementary Sockets, Elementary TCP, IPv4 and IPv6 Interoperability, Daemon Process, Multicasting, Multicast Routing, Multicast Socket Options, Advanced UDP Sockets, Datagram Truncation.

**References:**

1. Stevens R. W., Fenner B., Rudoff A. M., *UNIX Network Programming Volume 1* *(3e),* Addison Wesley 2011.
2. Stallings W., *High Speed Networks and Internet* (*2e),* Pearson Education New Delhi 2002.
3. James P.G. Sterbenz, Touch J. D.*, High Speed Networking: A systematic approach to High Bandwidth Low Latency Communication (1e),* John Wiley and Sons 2001.
4. Garcia L., IndraWidjaja, *Communication Networks* *(2e),* Tata Mc. Graw Hill publication 2002.
5. Yuan R. and Strayer T. W., *VPN technologies and solutions* (*1e),* Addison wesley publishing company incorporated 2001.

**ICT 3158: SOFTWARE DESIGN TECHNOLOGY [3 1 0 4]**

Introduction to Software Engineering, Process Models, Agile Process Model, Requirement Engineering**,** Analysis Modeling- Data Modeling, Scenario-based Modeling, Class based Modeling, Design Engineering- Design Models and Patterns, Architectural Design, Software Testing- Strategies and Techniques, Testing Object Oriented Applications, Software Project Management, Software Quality Assurance, Project Planning, Scheduling and Estimation Techniques.

**References:**

1. Pressman R.S., *Software engineering - A practitioner’s approach* *(8e)*, McGraw Hill, 2014.
2. Booch G., Rumbaugh J., Jacobson I., *The Unified Modelling Language User Guide* *(1e)*, Pearson, 2015.
3. Jalote P., *Software Project Management in Practice (1e)*, Addison Wesley Professional, 2009.
4. Hughes, *Software Project Management (5e)*, McGraw Hill, 2017.
5. Kelkar S. A., *Software Project Management: a concise study* *(3e)*, PHI learning-New Delhi, 2013.

**\*\*\* \*\*\*\*: OPEN ELECTIVE-II [3 0 0 3]**

**ICT 3164: ADVANCED PROGRAMMING LAB [0 1 3 2]**

List, Tuples, Sets, Strings , Dictionaries, Dictionary Operations, Boolean Expression, Control Flow, Functions, Parameter Options, Local, Nonlocal, Global Variables, Modules, Programs, Classes and Object Oriented Programming Static and Class Methods, Inheritance, Private Variables, Destructors and Memory Management, Exception Handling, File System, Regular Expressions, Packages, Graphical User Interface, Database Connectivity, Web Designing, Networking using Python Programming.

Students are expected to develop a mini project using the concepts practiced in the lab.

**References:**

1. Eric M., *Python Crash Course: A Hands-On, Project-Based Introduction to Programming (1e)*, William Pollock Publication, 2016.
2. Mark L., *Learning Python* *(5e),* O’REILLY publication, 2013.
3. Daryl H., Kenneth M. M. and Vernon C., *The Quick Python Book (2e),* Manning Publications, 2011.
4. Allen B. D., *Think Python: How to think like a Computer Scientist (2e)*, O’REILLY publication, 2015.

## **ICT 3165: DATA MINING AND PREDICTIVE ANALYSIS LAB [0 1 3 2]**

Pre-processing the raw-datasets using data mining software, Applying data mining techniques such as association rule mining, clustering, classification and Regression on the pre-processed data using software tools, Construction of physical data model, Populating data into tables using data flows, serial and parallel execution of data flows in control flow using data warehousing software, Implementation of Apriori algorithm, K-means, Decision tree, Simple linear regression, Design and development of Mini Project.

**References:**

1. Han J., Kamber M., Jian P., *Data Mining Concepts and Techniques (3e),* Morgan Kauffmann Publishers 2011.
2. Pujari A. K., *Data Mining Techniques (4e),* Orient BlackSwan/Universities Press 2016.
3. Kelleher J. D., Brian M. N., D’ Arcy A., *Fundamentals of Machine Learning for predictive Data Analytics: Algorithms, Worked Examples and Case Studies (1e),* MIT Press, 2015.
4. Silberschatz A., Sudarshan S., *Database System Concepts (6e),* McGraw Hill Education 2013.

**ICT 3166: NETWORK DESIGN AND PROGRAMMING LAB [0 0 3 1]**

Simulation of Ethernet LAN protocol, token bus and token ring protocols, implementation of distance vector algorithm, link state routing algorithm and finding shortest path using packet tracer; Socket programming; Python APIs for Socket programming.

**Reference:**

1. Stevens R., Stephen R. A.*, Advanced Programming in the UNIX Environment (2e),* Pearson Education 2013.
2. [Jesin A](https://www.flipkart.com/author/jesin-a)., *Packet Tracer Network Simulator (1e),* Packt Publishing 2014.
3. [Faruque S.](https://www.amazon.in/s/ref=dp_byline_sr_book_1?ie=UTF8&field-author=Dr.+M.+O.+Faruque+Sarker&search-alias=stripbooks) M. O., ‎ [Washington](https://www.amazon.in/s/ref=dp_byline_sr_book_2?ie=UTF8&field-author=Sam+Washington&search-alias=stripbooks) S., *Learning Python Network Programming (1e),* Packt Publishing 2015.

**SIXTH SEMESTER**

**HUM 3051: ENGG. ECONOMICS AND FINANCIAL MANAGEMENT [2 1 0 3]**

Nature and significance, Micro & macro differences, Law of demand and supply, Elasticity & equilibrium of demand & supply. Time value of money, Interest factors for discrete compounding, Nominal & effective interest rates, Present and future worth of single, Uniform gradient cash flow. Bases for comparison of alternatives, Present worth amount, Capitalized equivalent amount, Annual equivalent amount, Future worth amount, Capital recovery with return, Rate of return method, Incremental approach for economic analysis of alternatives, Replacement analysis. Break even analysis for single product and multi product firms, Break even analysis for evaluation of investment alternatives. Physical & functional depreciation, Straight line depreciation, Declining balance method of depreciation, Sum-of-the-years digits method of depreciation, Sinking fund and service output methods, Introduction to balance sheet and profit & loss statement. Ratio analysis - Financial ratios such as liquidity ratios, Leverage ratios, Turn over ratios, and profitability ratios.

**References:**

1. Prasanna Chandra, *Fundamentals of Financial Management,* Tata Mc-Graw Hill Companies, New Delhi, 2005.
2. James L Riggs, David D Bedworth and Sabah U Randhawa, *Engineering Economics,* Tata McGraw – Hill Publishing Company Ltd, New Delhi, 2004.
3. T. Ramachandran, *Accounting and Financial Management,* Scitech Publications Pvt. Ltd. India, 2001.
4. Eugene F. B. & Joel F. H, *Fundamentals of Financial Management (12e),* Cengage Learning Publisher, 2009.
5. M. Y. Khan & P. K. Jain, *Financial Management (5e),* Tata McGraw Hill Publication, New Delhi, 2008.
6. Thuesen G.J, *Engineering Economics,* Prentice Hall of India, New Delhi, 2005.
7. Blank Leland T. Tarquin Anthony J*, Engineering Economy,* McGraw Hill, Delhi, 2002.
8. Chan S. Park, *Fundamentals of Engineering Economics (3e),* Pearson Publication, 2013.

## **ICT 3253: EMBEDDED SYSTEMS DESIGN [3 0 0 3]**

An overview of ARM-Cortex- M Architecture, CISC versus RISC, The RISC and ARM design philosophy, ARM addressing modes, data transfer instructions, arithmetic and logical instructions, shift and rotate instructions, branch and conditional branch instructions, function call and return, stack, recursive functions, conditional execution, assembly language programming, Input/output (I/O) programming, timer/counter programming, I/O interfacing : LED, LCD, keyboard, stepper motor, ADC, and DAC, PWM, UART, Hardware and software synchronization, multithreading, Nested Vectored Interrupt Controller (NVIC), external hardware interrupts, IO interrupts, SysTick interrupts, implement architectural design for IoT.

**References:**

1. Jonathan W.V., *Embedded systems: real-time interfacing to ARM Cortex-M microcontrollers* *(4e),* Createspace Independent Publishing Platform, June 2014.
2. Wilmshurst T., *Fast and Effective Embedded System Design applying the ARM mbed*, Elsevier, 2017.
3. Jonathan W.V., *Embedded systems: Introduction to Arm(r) Cortex-M Microcontrollers, Createspace Independent publishing platform* *(5e),* June 2017.
4. UM10360, LPC 176x/5x *User Manual, NXP Semiconductors*, Rev. 3.1, 2014.
5. Joseph V., *A definitive Guide to ARM Cortex-M3 and Cortex-M4 processors (3e),* Elsevier, 2014.

**ICT 3254: WIRELESS COMMUNICATION AND COMPUTING [3 1 0 4]**

Introduction to Wireless Systems, Advanced Modulation / Acess Techniques (MFSK, Spread Spectrum, OFDM), Convolutional Coding, Antenna and Propagation: Line of Sight and Non Line of Sight, Fading, Link Budget Analysis, Wireless networks Cellular Concepts, channel assignments, Handoff strategies, GoS, Improving Coverage & Capacity. Physical modelling for wireless channels, Statistical channel models. Point to point communication: diversity, Cellular Systems: multiple access and interference management, GSM systems, GPRS, CDMA, WCDMA, OFDM, Multiuser capacity and opportunistic communication. Modeling of MIMO fading channels, cooperative wireless communication.

**References:**

1. Dalal U., *Wireless communication* *(1e),* Oxford 2014.
2. Molisch A., *Wireless Communications* *(2e),* John Wiley & Sons Ltd. 2011.
3. Pahlavan K., Krishnamurthy P., *Principles of Wireless Networks* *(1e),* Prentice Hall 2009.
4. Goldsmith A., *Wireless Communications* *(2e),* John Wiley & Sons Ltd. 2011.

**ICT \*\*\*\*: PROGRAM ELECTIVE-I [3 0 0 3]**

**ICT \*\*\*\*: PROGRAM ELECTIVE-II [3 0 0 3]**

**\*\*\* \*\*\*\*: OPEN ELECTIVE-III [3 0 0 3]**

## **ICT 3264: EMBEDDED SYSTEMS AND IOT LAB [0 1 3 2]**

Familiarization of data transfer from code segment to data segment and from data segment to data segment, arithmetic operations, logical instructions, branch instructions, code conversion from hexadecimal to decimal and decimal to hexadecimal, packing and unpacking of ASCII digits, sorting using selection sort and bubble sort techniques, searching using linear and binary search techniques, recursion, I/O interfacing of LEDs, LCD, keyboard, 7 segment display, stepper motor, DAC and ADC, PWM, implement architectural design for IoT.

In addition to the above list of experiments, students are required to develop a mini project.

**References:**

1. Jonathan W.V., *Embedded systems: real-time interfacing to ARM Cortex-M microcontrollers* *(4e),* Createspace Independent Publishing Platform, June 2014.
2. Wilmshurst T., *Fast and Effective Embedded System Design applying the ARM mbed*, Elsevier, 2017.
3. Jonathan W.V., *Embedded systems: Introduction to Arm(r) Cortex-M Microcontrollers, Createspace Independent publishing platform* *(5e),* June 2017.
4. UM10360, LPC 176x/5x *User Manual, NXP Semiconductors*, Rev. 3.1, 2014.
5. Joseph V., *A definitive Guide to ARM Cortex-M3 and Cortex-M4 processors (3e),* Elsevier, 2014.

**ICT 3265: MOBILE APPLICATION DEVELOPMENT LAB [0 0 3 1**]

Introduction to Android Basics of Android Mobile Application Development Tool, Introduction to Activity and Layouts in Android and Event Handler, Input Controls in Android, Input Controls-Spinners, Pickers ,Menu, Creating Contextual and Pop-up Menus, Android Sqlite and Shared Preferences ,Security and Permissions, Services, Broadcast Receiver and Intent Filters, Camera, Bluetooth and Wi-Fi.

Mini Project based on above concepts.

**References:**

1. Zheng P. and Ni L.M., *Smart Phone and Next Generation Mobile Computing (1e)*, Morgan Kaufmann, 2006.
2. Horton J., *Android Programming For Beginners,* Packt Publishing Ltd, 2015.
3. Griffiths D., *Head First Android Development* *(2e),* O’Reilly Media, Inc., 2015.

**ICT 3266: NETWORK SIMULATION LAB [0 0 3 1]**

Building wired topologies, wireless network topologies, tracing using NS3, NetAnim and supporting tools like SUMO/MOVE, Trace Route, 5G Network simulation using NS3-mmwave.

**Reference:**

1. Forouzan B. A., *TCP/IP Protocol Suite (4e),* Tata McGraw – Hill 2017.

**SEVENTH SEMESTER**

There are five program electives and one open elective with total of 18 credits to be taught in this semester.

**EIGHTH SEMESTER**

**ICT 4298: INDUSTRIAL TRAINING**

Each student has to undergo industrial training for a minimum period of 4 weeks. This may be taken in a phased manner during the vacation starting from the end of third semester. Student has to submit to the department a training report in the prescribed format and also make a presentation of the same. The report should include the certificates issued by the industry.

**ICT 4299: PROJECT WORK/PRACTICE SCHOOL**

The project work may be carried out in the institution/industry/ research laboratory or any other competent institutions. The duration of the project work shall be a minimum of 16 weeks which may be extended up to 24 weeks. A mid-semester evaluation of the project work shall be done after about 8 weeks. An interim project report on the progress of the work shall be submitted to the department during the mid-semester evaluation. The final evaluation and viva-voice will be conducted after submission of the final project report in the prescribed form. Student has to make a presentation on the work carried out, before the department committee as part of project evaluation.

**MINOR SPECIALIZATIONS**

**I. ADVANCED NETWORK SYSTEMS**

**ICT 4041: MOBILE COMPUTING [3 0 0 3]**

Introduction to Mobile Wireless Communication, Mobile IP and WAP, Internet mobility, Agent discovery and registration, Tunneling, mobile computing models, Client-Server models, location management for mobile networks, VANET: IEEE802.11p, Vehicular Mobility Modeling for VANET, Introduction to GPS, GPRS, Wireless LAN – IEEE802.15: Bluetooth, Zigbee, performance evaluation of technologies involved in mobile environment.

**References:**

1. Rappaport T.S., *Wireless Communications: Principles and Practices (2e),* McGraw Hill Education Private Ltd. 2017.

1. Stallings W., *Wireless Communications and Networks* (*2e),* Pearson Education 2012.
2. Schiller J., *Mobile Communication* *(2e),* Pearson Education Pvt ltd. 2011.
3. Adelstein F., Gupta S. K. S., Richard G., Schwiebert L., *Fundamental of Mobile and Pervasive Computing (1e),* TMH 2008.
4. Hartenstein H., *VANET: Vehicular Applications and Inter-Networking Technologies* *(1e),* John Wiley and Sons 2010.

**ICT 4042: MULTIMEDIA COMMUNICATION [3 0 0 3]**

Introduction to Media and Data Streams, Overview of Multimedia processes and Coding, Multimedia Coding/ Compression Standards, Huffman Coding, Runlength Coding, JPEG, GIF, TIFF, MPEG, DVI, H.261, Text compression, Compression principles, Audio Video compression, Media Coding, Media processing, Synchronization issues, synchronization specification, Multimedia Operating system and database management, MDBMS, Multimedia Communications, Delay compensation, Prototype Multimedia systems, Video-on-Demand, Video conferencing, Media Data Modeling.

**References:**

1. Li N., Drew M. S., *Fundamentals of Mutlimedia* *(2e),* Pearson Education, 2014.
2. Steinmetz R., Nahrstedt K., *Multimedia Computing, Communications and Applications* *(1e),* Pearson Education, 2012.
3. Woods J. W., *Multi-Dimensional Signal, Image and Video Processing and Coding (2e),* Academic Press, 2011.
4. Rao K.R., Bojkovic Z., Milovanovic D. A., *Multimedia Communication Systems (2e),* Prentice Hall, 2012.

**ICT 4043: NEXT GENERATION TELECOM NETWORKS [3 0 0 3]**

Introduction to Next Generation Technologies, Next Generation Services, Telecommunication Optical Networks, Active and Passive Optical Network, HSPA Technology, HSDPA Channels, Resource management in HSDPA, 3GPP LTE, LTE System Architecture, WiMax overview, Design Principles of the WiMax Network Architecture, Application, Unlicensed Mobile Access (UMA), Convergence and IP Multimedia Sub Systems, Cognitive Radio, Principles of Interweaving, Spectrum sensing, Spectrum management, Spectrum sharing, Overview of New Technologies for 5G system.

**References:**

1. Cox C., *An Introduction to LTE: LTE, LTE Advanced, SAE and 4G Mobile Communication* *(1e),* John Wiley & Sons 2012.
2. Mishra A.R.., *Cellular Technologies for Emerging Markets: 2G, 3G and Beyond* *(1e),* John Wiley & Sons 2010.
3. Plevyak T., Sahin V., *Next Generation Telecommunication Networks, Services and Management (1e),* John Wiley & Sons 2010.
4. Molisch A.F., *Wireless Communications (2e),* Wiley 2013.
5. Saunders S., Carlaw S., Giustina A., Bhat R. R., Rao S. V., Siegberg R., *Femtocells Opportunities and Challenges for Business and Technology (1e),* John Wiley & Sons 2009.

**ICT 4044: SOFTWARE DEFINED NETWORKING [3 0 0 3]**

History and Evolution of SDN, Control and Data Plane Separation, Moving information between planes, Distributed control planes,OpenFlow Architecture, Configuration and extension ability, Virtual Networking, SDN Controllers, Mininet, Network Programmability, Network Function Virtualization, OpenStack, CloudStack, Traffic Engineering, Use Cases of SDNs, Use Cases for Data Center Overlays.

**References:**

1. Hu F., *Network Innovation through OpenFlow and SDN: Principles and Design (1e),* CRC Press 2014.
2. Nadeau T. D., Gray K., *SDN: Software Defined Networks (3e),* O'Reilly Media 2016.
3. Azodolmolky S., Software *Defined Networking with OpenFlow (1e),* Packt Publishing 2013.

**II. COMPUTATIONAL INTELLIGENCE**

**CSE 4053: ARTIFICIAL INTELLIGENCE [3 0 0 3]**

Foundations of Artificial Intelligence, History of Artificial Intelligence, The state of the Art. Agents and Environments, The concept of Rationality, The Nature of Environments, The structure of Agents. Problem Solving agents, Example Problems, Searching for Solutions, Uninformed search strategies, informed (Heuristic) search strategies, Heuristic functions. Games, Optimal decision in games, Alpha Beta Pruning Knowledge based agents, The Wumpus World, Logic, Propositional logic, Propositional Theorem Proving. Representation revisited, Syntax and semantics of First order logic, Using First order logic, Knowledge engineering in First order. Ontological Engineering, Categories and objects, Reasoning systems for categories, The internet shopping world. Acting under uncertainty, Basic probability notation, Baye’s rule, representing knowledge in uncertainties, semantics of Bayesian networks.

**References:**

1. Russell S., and Norvig P., *Artificial Intelligence A Modern Approach* (3e), Pearson 2010.
2. Rich E., Knight K., Nair S.B., *Artificial Intelligence* (3e), Tata McGraw Hill, 2008.

**ICT 4031:** **COMPUTER VISION [3 0 0 3]**

Introduction to computer vision and its applications, Image formation, Liner Filtering, Image transformations and Colour models, Edge Detection methods (Laplacian detectors and canny edge

detector), Points and patches, Harris corner detector, Histogram of Gradients, Difference of Gaussian detector, SIFT, Colour and Texture, Feature based alignment, least squares and RANSAC, Camera models, Camera calibration, Stereo vision, Stereo correspondence, Epipolar geometry, Optical flow, Lucas Kanade method, KLT tracking method, Mean shift method, Dense

Motion estimation, Support Vector Machines, Face detection and recognition, Bag of words, deep

Learning.

**References:**

1. Szeliski R., *Computer Vision: Algorithms and Applications*, Springer 2011.
2. David A. F. and Ponce J., *Computer Vision: A Modern Approach, PHI learning* 2009.
3. Solem J. E., *Programming Computer Vision with Python*, O’Reilly, 2012.

**ICT 4032: MACHINE LEARNING [3 0 0 3]**

Introduction to Machine Learning, Mathematical Preliminaries, Supervised Learning-LMS, logistic regression, GDA, Naive Bayes, SVM, model selection, Learning theory-bias/variance tradeoff, union and Chernoff bounds, VC dimensions, Unsupervised learning-clustering, k-means, Gaussian mixture, factor analysis, PCA, ICA, Reinforcement learning-MDPs, Bellman equations, value and policy iteration, LQR, LQG, Q-learning, policy search, POMDPs.

**References:**

1. Murphy K.P., *Machine Learning: A Probabilistic Perspective*, MIT Press, 2012.
2. Mohri M., Rostamizadeh A., and Talwalkar A., *Foundations of Machine Learning*, MIT Press, 2012.
3. Koller D., and Friedman N, *Probabilistic Graphical Models: Principles and Techniques*, MIT Press, 2009.
4. Bishop C.M., *Pattern Recognition and Machine Learning* (2e), Springer, 2013.

**CSE 4054: SOFT COMPUTING PARADIGMS [3 0 0 3]**

Soft Computing, Artificial Intelligence, Soft-Computing Techniques, Expert Systems Types of Problems, Modeling the Problem, Machine Learning, Handling Impreciseness, Clustering , Hazards of Soft Computing, Road Map for the Future . Artificial Neural Networks, The Biological Neuron, The Artificial Neuron, Multilayer Perceptron, Modeling the Problem, Types of Data Involved, Training, Issues in ANN, Example of Time Series Forecasting. Types of Artificial Neural Networks, Radial Basis Function Network, Learning Vector Quantization, Self-Organizing Maps, Recurrent Neural Network, Hopfield Neural Network, Adaptive Resonance Theory, Character Recognition by Commonly Used ANNs. Fuzzy Systems, Fuzzy Logic, Membership Functions, Fuzzy Logical Operators, More Operations, Fuzzy Inference Systems, Type-2 Fuzzy systems, Other Sets, Sugeno Fuzzy Systems, Example: Fuzzy Controller Evolutionary Algorithms: Evolutionary Algorithms, Biological Inspiration. Evolutionary Algorithms Genetic Algorithms, Fitness Scaling, Selection, Mutation, Crossover, Other Genetic Operators, Algorithm Working, Diversity, Grammatical Evolution, Other Optimization Techniques, Metaheuristic Search, Traveling Salesman Problem. Introduction, Key Takeaways from Individual Systems, Adaptive Neuro-Fuzzy Inference Systems, Evolutionary Neural Networks, Evolving Fuzzy Logic, Fuzzy Artificial Neural Networks with Fuzzy Inputs, Rule Extraction from ANN, Modular Neural Network.

**References:**

1. Shukla A., Tiwari R., Kala R., *Real Life Applications of Soft Computing*, CRC Press, Taylor and Francis Group, London 2010.
2. Ross T.J., *Fuzzy Logic with Engineering Applications*, Wiley publication, 2010.
3. Sivanandam S.N., Deepa S.N., *Principles of Soft Computing*, (2e), Wiley Publication, 2010.
4. Rajasekaran S., and Pai G. A. V., *Neural Networks, Fuzzy Logic and Genetic Algorithms*, PHI Learning, 2010.
5. Jang J. S .R., *Neuro-Fuzzy and Soft Computing*, PHI 2003.

**III. COMPUTER GRAPHICS AND VISUALIZATION**

**CSE 4051: AUGMENTED AND VIRTUAL REALITY [3 0 0 3]**

Introduction of Virtual and Augmented reality, Definition and scope, A Brief History 3 I’s of Virtual Reality A Short History of Early Virtual Reality, Early Commercial VR Technology, VR Becomes an Industry, Components of a VR System, Displays In augmented reality Multimodal Displays, Audio Displays Haptic, Tactile, and Tangible Displays, Displays, Visual Perception, Requirements and Characteristics, Multiple Models of I/O Gesture Interfaces Three-Dimensional

Position Trackers, Navigation and Manipulation Interfaces, Gesture Interfaces. Output Devices, Haptic Display, Graphics Displays, Sound Displays. Computer Vision for Augmented Reality, Natural Feature Tracking by Detection, Incremental Tracking, Simultaneous Localization and Mapping, Outdoor Tracking, Computing Architectures for VR, The Rendering Pipeline, Workstation-Based Architectures, Distributed VR Architectures, Geometric Modeling, Kinematics Modeling, Physical Modeling, Behavior Modeling.

**References:**

1. Burdea, G. C. and P. Coffet. *Virtual Reality Technology (2e),* Wiley-IEEE Press, 2006.
2. Dieter Schmalstieg, Tobias Hollerer, *Augmented Reality: Principles & Practice (1e),* Addison-Wesley, 2016.
3. Tony parisi, *Learning Virtual Reality: Developing Immersive Experiences and Applications for Desktop, Web, and Mobile (1e),* O’Reilly Media, 2015.
4. Steve Aukstakalnis, *Practical Augmented Reality: A Guide to the Technologies, Applications, and Human Factors for AR and VR (Usability) (1e),* Addison-Wesley Professional, 2016.
5. Jonathan Linowes, *Unity Virtual Reality Projects* *Paperback*, Packt Publishing eBooks Account, September 2015.

**ICT 4033: COMPUTER GRAPHICS [3 0 0 3]**

Introduction: History of computer graphics and applications, Introduction to OpenGL, Geometric

Transformations: Homogeneous coordinates, affine transformations (translation, rotation, scaling,

Shear, reflection), concatenation, matrix stacks and use of model view matrix in OpenGL for these

operations Examples, Viewing (3D), Visibility- z-Buffer, BSP trees, Open-GL culling, hiddensurface algorithms, Shading, Rasterization- Line segment and polygon clipping, 3D clipping, scan conversion, polygonal fill, Bresenham's algorithm, Discrete Techniques: Texture mapping, compositing, textures in OpenGL; Ray Tracing, Representation and Visualization: Bezier curves and surfaces, B-splines, visualization, interpolation, marching squares algorithm.

**References:**

1. Hearn D and Baker P., *Computer Graphics with OpenGL (4e),* Pearson, 2014.
2. Edward Angel, *Interactive Computer Graphics A Top-Down Approach Using OpenGL* (*6e),* Pearson Education, 2011.
3. F. S. Hill Jr. and S. M. Kelley, *Computer Graphics using OpenGL (3e),* Prentice Hall, 2006.
4. Peter Shirley and Steve Marschner, *Computer Graphics (1e),* A. K. Peters, 2010.

**ICT 4031: COMPUTER VISION [3 0 0 3]**

Introduction to computer vision and its applications, Image formation, Liner Filtering, Image transformations and Colour models, Edge Detection methods (Laplacian detectors and canny edge

detector), Points and patches, Harris corner detector, Histogram of Gradients, Difference of Gaussian detector, SIFT, Colour and Texture, Feature based alignment, least squares and RANSAC, Camera models, Camera calibration, Stereo vision, Stereo correspondence, Epipolar geometry, Optical flow, Lucas Kanade method, KLT tracking method, Mean shift method, Dense

Motion estimation, Support Vector Machines, Face detection and recognition, Bag of words, deep

Learning.

**References:**

1. Szeliski R., *Computer Vision: Algorithms and Applications*, Springer 2011.
2. David A. F. and Ponce J., *Computer Vision: A Modern Approach, PHI learning* 2009.
3. Solem J. E., *Programming Computer Vision with Python*, O’Reilly, 2012.

**CSE 4052: DIGITAL IMAGE PROCESSING [3 0 0 3]**

Introduction, components of image processing system, Spatial domain transformations, histogram

processing, smoothing, sharpening spatial filters, Filtering in the frequency domain- Introduction to Fourier transform, image smoothing, image sharpening using frequency domain filters. Image restoration- Noise models, restoration using spatial filtering, periodic noise reduction by frequency

domain filtering, Morphological image processing- Preliminaries, dilation and erosion, opening and closing, hit-or-miss transformation, basic algorithms, extension to gray-scale images, Image segmentation- Point, line, and edge detection, Thresholding, Region Segmentation Using Clustering and Superpixels, Graph Cuts, morphological watersheds, motion in segmentation.

**References:**

1. Rafael C. Gonzalez, Richard E. Woods, *Digital Image Processing* *(4e),* Pearson, 2017.
2. Milan Sonka, Vaclav Hlavac, Roger Boyle, *Image Processing, Analysis and Machine Vision (4e*), CENGAGE Learning, 2014.
3. Rafael C. Gonzalez, Richard E. Woods, Steven L. Eddins, *Digital Image Processing Using MATLAB (2e),* Mc Graw Hill India, 2010.
4. Gloria Bueno García, Oscar Deniz Suarez, José Luis Espinosa Aranda, Jesus Salido Tercero, Ismael Serrano Gracia, Noelia Vállez Enano, Learning Image Processing with *OpenCV (1e),* Packt Publishing, 2015.

**IV. DATA ANALYTICS**

## **ICT 4034: BIG DATA ANALYTICS [3 0 0 3]**

Understanding Big Data: Concepts and Terminology, Big Data Characteristics, Different Types of Data, Case Study Background. Big data and Hadoop: Understanding Hadoop features, Learning the HDFS and MapReduce architecture, Understanding Hadoop subprojects, Understanding the basics of MapReduce, Introducing Hadoop MapReduce, Understanding the Hadoop MapReduce fundamentals, writing a Hadoop MapReduce example. Spark and Big Data: Theoretical concepts in Spark, Core components of Spark, The Spark architecture, Spark SQL, Spark Streaming. NoSQL databases: Need for NoSQL, NoSQL databases, In-memory databases, columnar databases, Document-oriented databases, Key-value databases, Graph databases, Other NoSQL types and summary, working on NoSQL systems using MongoDB. Applications: Implementation of machine learning algorithms using MapReduce and Spark.

**References:**

1. Erl T., Khattak W., and Buhler P., *Big Data Fundamentals, Concepts, Drivers & Techniques* *(1e)*, The Prentice Hall Service Technology Series, 2016.
2. Prajapati V., *Big Data Analytics with R and Hadoop*, Packt Publishing Ltd., 2013.
3. Dasgupta N., *Practical Big Data Analytics*, Packt Publishing Ltd, 2018.
4. Rajaraman A., and Ullman J. D., *Mining of Massive Datasets*, Cambridge University Press, 2011.
5. Zaharia [M.](https://www.safaribooksonline.com/search/?query=author%3A%22Matei%20Zaharia%22&sort=relevance&highlight=true), Wendell [P](https://www.safaribooksonline.com/search/?query=author%3A%22Patrick%20Wendell%22&sort=relevance&highlight=true)., Konwinski [A](https://www.safaribooksonline.com/search/?query=author%3A%22Andy%20Konwinski%22&sort=relevance&highlight=true)., Karau [H.](https://www.safaribooksonline.com/search/?query=author%3A%22Holden%20Karau%22&sort=relevance&highlight=true), *Learning Spark,,* [O'Reilly Media, Inc.](https://www.safaribooksonline.com/library/publisher/oreilly-media-inc/), 2015.

**ICT 4035: INFORMATION RETRIEVAL [3 0 0 3]**

Boolean Retrieval Model, Index Construction, Index Compression, Vector Space Model, Evaluation in IR, Relevance Feedback and Query Expansion, Latent Semantic Indexing, Web Search Basics, Web Crawling and Indexes, Link Analysis

**References:**

1. Manning C. D., Raghavan P., and Schütze H., *Introduction to Information Retrieval*, Cambridge University Press, 2008.
2. Buettcher S., Charles L. A., Clarke, and Cormack G. V., *Information Retrieval: Implementing and Evaluating Search Engines*, MIT Press, 2010.
3. Grossman D. A. and Frieder O., *Information Retrieval: Algorithms and Heuristics,* Springer*,* 2004.

**ICT 4032: MACHINE LEARNING [3 0 0 3]**

Introduction to Machine Learning, Mathematical Preliminaries, Supervised Learning-LMS, logistic regression, GDA, Naive Bayes, SVM, model selection, Learning theory-bias/variance tradeoff, union and Chernoff bounds, VC dimensions, Unsupervised learning-clustering, k-means, Gaussian mixture, factor analysis, PCA, ICA, Reinforcement learning-MDPs, Bellman equations, value and policy iteration, LQR, LQG, Q-learning, policy search, POMDPs.

**References:**

1. Murphy K.P., *Machine Learning: A Probabilistic Perspective*, MIT Press, 2012.
2. Mohri M., Rostamizadeh A., and Talwalkar A., *Foundations of Machine Learning*, MIT Press, 2012.
3. Koller D., and Friedman N, *Probabilistic Graphical Models: Principles and Techniques*, MIT Press, 2009.
4. Bishop C.M., *Pattern Recognition and Machine Learning (2e),* Springer, 2013.

**ICT 4036: SEMANTIC WEB [3 0 0 3]**

Semantic Web Vision, Layered approach, Describing Web Resource : RDF data models, syntax, semantics, schema, RDFS, Direct inference system, RDF Data structures, Containers and colletcions, Querying Semantic Web: SPARQL matching patterns, filters, querying schemas Ontology and Information Systems L use of ontologies, types, design principles, methodologies, Ontology Languanges : OWL2, OWL2 profiles, Ontology Reasoning: Monotonic rules, Rule interchange format, Semantic web rules languages, RuleML, Ontology Design and Management: Types, purposes, creating ontology manually, reusing existing, mapping, Ontology Programming : Programming in Go

**References:**

1. Grigoris Antoniou, Paul Groth, Frank van vanHarmelen and Rinke Hoekstra, *A Semantic Web Primer*, MIT Press, 2012.
2. Bob DuCharme, *Learning SPARQL (2e),* O’REILLY, 2013.
3. Brain McBride, Dan Brickley, R.V. Guha, *‘RDF Schema 1.1*’, 2014, [Online], Available: <https://www.w3.org/TR/rdf-schema>, [Accessed: 29-Jan-2018]
4. Lex Sheehan*, Learning Functional Programming in Go*, Packt Publishing, 2017, ISBN : 978-1-78728-139-4
5. Frank Manola, Eric Miller, David Veckett, Ivan Herman, *'RDF Primer Turtle Version'*, 2007. [Online]. Available: <https://www.w3.org/2007/02/turtle/primer/> . [Accessed: 29- Jan- 2018]
6. Vandana Kabilan, Ontology for Information Systems (O4IS) Design Methodology (Doctoral dissertation, 2007.

**V. MATERIAL SCIENCE**

PHY \*\*\*\*:

PHY \*\*\*\*:

CHM \*\*\*\*:

CHM \*\*\*\*:

**VI. BUSINESS MANAGEMENT**

**HUM 4051: FINANCIAL MANAGEMENT [3 0 0 3]**

Introduction and objectives of financial management, Evolution of corporate finance and its responsibilities. Types of accounts, Golden rules of accounting, Preparation of journal, Ledger, Trial balance and final accounts. Sources of long term finance, Characteristics of equity capital, Preference capital, Debenture capital & Term loans. Valuation of securities, Concepts, Bond valuation and related models, Bond value theorems, Yield to maturity. Equity valuation; Dividend capitalization approach, Leverage, Operating leverage, Financial leverage, Total leverage, Indifference point analysis. Working capital management, Capital budgeting: appraisal criteria, pay-back period, Average rate of return, Net present value, Benefit cost ratio and internal rate of return. Risk analysis in capital budgeting, Cost of capital: introduction, cost of debt capital, Preference capital and Equity capital, Weighted average cost of capital, Determination of proportions, Cash management, and Dividend decisions.

**References:**

1. Prasanna Chandra, *Fundamentals of Financial Management*, Tata McGraw Hill, Delhi, 2006.
2. I M Pandey, *“Financial Management”,* Vikas Publishing house, Delhi, 2007.
3. Subir Kumar Banerjee *“Financial Management”,* Sultan Chand & Co., Delhi*,* 1999.
4. ICFAI, “*Corporate Financial Management”,* ICFAI, Hyderabad, 2003.
5. Maheshwari S.N., *“Financial Management”,* Sultan Chand & Co., Delhi, 2002.

**HUM 4052: HUMAN RESOURCE MANAGEMENT [3 0 0 3]**

Evolution and development: Introduction, Scope of HRM, Objectives of HRM, Functions of HRM, Activities of HRM, Managerial skills and roles, HRD organization and responsibilities; Evolution of HRM, Influence of various factors on HRM, Theories of HRM; Human resource planning- Introduction, Strategic considerations, Nature and scope, Human resources inventory, Forecast, Job analysis, Job description, Job specification, Job evaluation, Employment stability; Recruitment, Selection, Placement and induction, Scientific selection, Policy, Process, Tests, Interview, Work history, References, Provisional selection, Medical/Physical examinations, Final selection, Employment; Induction, & socialization - Placement policy, Induction programs, socialization programmes; Training and development - Basic concepts, Employees training, Training process, Planning, Preparation of trainees, Implementation, Performance evaluation, Follow-up training; Management executive development and Career development - Basic concepts, Stages of career development, Career development programmes; Promotion transfers and separations; Wages and salaries administration; Discipline and grievances, Industrial and labour relations and Trade unionism, Collective bargaining, Industrial health, Performance appraisal and Merit rating.

**References:**

1. T.V. Rao and Pereira D, *Recent experiences in Human Resources Development,* Oxford and IBH Publishing*,* 1986.
2. Subbrao A., *Essentials of Human Resource Management and industrial Relations,* Himalaya Publishing House, 1999*.*
3. N G Nair and Latha Nair, *Personnel Management and Industrial Relations,* S. Chand Company, 1995.
4. Virmani B R; Rao Kala, *Economic restructuring technology transfer and human resource development,* Response books, 1997.
5. Pareek Udai et al., *Human Resource Development in Asia: Trends and Challenges,* Oxford and IBH Publishing, 2002.
6. Michael Armstrong., *A handbook of Human Resource Management Practice, (10e),* Kogan Page limited.
7. Gary Dessler & Biju Varkkey, *Human Resource Management,* Pearson education, 2011.

**HUM 4053: MARKETING MANAGEMENT [3 0 0 3]**

Defining marketing for the Twenty-first Century, Scope of marketing, Marketing concepts; Adapting marketing to the New Economy: Major drivers of the new economy, how business practices are changing. Building Customer Satisfaction, Value, and Retention: Defining customer value and satisfaction, Corporate and division strategic planning, Business unit strategic planning. Market Demand: Components of a modern marketing information system. Scanning the Marketing Environment: Analysing needs and trends in the microenvironment. Consumer Markets: Factors influencing buying behaviours. Business Markets: The business market versus the consumer market, major influences on buying decisions, institutional and government markets. Dealing with the Competition: Identifying competitors, analysing competitors. Market Segments: Patterns of market segmentation, Segmenting consumer and business markets. Product Life Cycle: Product life-cycle marketing strategies. New Market Offerings: Challenges in new-product development, organizing new-product development, New-product development process, Consumer-adoption process. Designing and Managing Services: Characteristics of services, managing product support services. Price Strategies: Setting the price, Adapting the price, Initiating and responding to price changes. Retailing, Wholesaling: Trends in retailing, Wholesaling, Wholesaler marketing decisions. Integrated Marketing Communications: The major modes of communication, and Marketing communications mix.

**References:**

1. Philip Kotler, *Marketing Management – Analysis, Planning, Implementation and Control*, Prentice Hall of India Private Limited, New Delhi, 2000.
2. ICFAI, *Marketing Management*, ICFAI, Hyderabad, 2003.
3. Varshney R L and Gupta S L, *Marketing Management*, Sultan Chand & Sons, New Delhi, 2004.
4. Adrian Palmer, *Principles of Marketing*, Oxford University Press, New York, 2000.

**HUM 4054: OPERATION MANAGEMENT [3 0 0 3]**

Introductions to operations management – process view and supply chain view, Types of production activities, Competitive priorities and capabilities. Break-even analysis, Evaluating services or products, Evaluating processes - make or buy decision, Decision making under risk, and decision trees. Introduction to forecasting, Importance and uses of forecasting, Demand patterns, Demand management options, Judgment methods, Causal methods - linear regression, time series method – Naïve method, Moving average, Weightage moving average, and Exponential smoothing curve. Planning long-term capacity, Measures of capacity and utilization, Economies of scale, Diseconomies of scale, Capacity timing and Sizing strategies, Sizing capacity cushions, Timing and sizing expansion – Expansionist strategy, Wait and see strategy, and a Systematic approach to long term capacity decision. Levels in operations planning and scheduling across the organization, Sales and operation planning strategies- Chase strategy, Level strategy, Operations planning using linear programming technique, scheduling job and facility scheduling, and work for scheduling. Theory of constraints, Managing bottle necks in manufacturing and service processes, Identifying bottle necks, Relieving bottle necks, Drum buffer rope system, and Managing constraints in a line system. Supply chain design across the organization, Supply chains for services and manufacturing, Measures of supply chain performance - Inventory measures, financial measures, Inventory and supply chains - pressures for small inventories, Pressures for large inventories, Types of inventory, Inventory reduction tactics, and Inventory placement. Costs of quality, Total quality management, Acceptance sampling, Statistical process control - Control charts, and Process capability. Continuous improvement using lean systems, Different types of wastes, Strategic characteristics of a lean system, Designing lean system layout, and Kanban system.

**References:**

1. Krajewski L. J., Ritzman L. P., Malhotra M., and Srivastava S. K., *Operations Management (11e),* Pearson Education (Singapore) Pvt. Ltd., Delhi, 2016.
2. Heizer J. and Render B., *Operations Management (11e),* Pearson Education India, 2016.
3. Khanna R. B., *Production and Operations Management (2e),* PHI Learning Private Limited, 2015.

**VII. COMPUTATIONAL MATHEMATICS**

## **MAT 4051: APPLIED STATISTICS AND TIME SERIES ANALYSIS**

## **MAT 4052: COMPUTATIONAL LINEAR ALGEBRA**

## **MAT 4053: COMPUTATIONAL PROBABILITY AND DESIGN OF EXPERIMENTS**

## **MAT 4054: GRAPHS AND MATRICES**

**OTHER ELECTIVES**

## **ICT 4045: CLOUD COMPUTING [3 0 0 3]**

Introduction, Cloud infrastructure, Cloud computing delivery models and services, Cloud computing at Amazon, The Google perspective, Microsoft Windows Azure, Application paradigms, Architectural styles of cloud computing, Cloud resource management and scheduling, Cloud resource virtualization, Types of virtualization, Understanding hypervisors, Virtual machine and its components, Resource management, Memory ballooning, Thin virtual provisioning, Storage tiering, Virtual LAN, VLAN trunking, VLAN tagging, Business continuity and cloud management, Virtual machine fault tolerance, Virtual machine replication methods, Cloud security, Virtual machine security, Access control and identity management, Cloud tools: Eucalyptus, OpenNebula/OpenStack, CloudSim.

**References:**

1. Dan Marinescu C., *Cloud Computing Theory and Practice*, Elsevier, 2013.
2. Rajkumar Buyya, Christian Vecchiola, Thamarai Selvi S., *Mastering Cloud Computing*, McGraw Hill, 2017.
3. Anthony Velte T., Toby Velte J., Robert Elsenpeter, *Cloud Computing: A Practical Approach*, McGraw Hill, 2017.

**ICT 4046: DEEP LEARNING [3 0 0 3]**

Introduction, Mathematical Preliminaries, Machine Learning Basics, Deep Feedforward Networks, Regularization for Deep Learning, Optimization for Training Deep Models, Convolutional Networks, Recurrent and Recursive Networks, Practical Methodology

**References:**

1. Goodfellow I., Bengio Y., and Courville A., *Deep Learning*, MIT Press 2017.
2. Haykin S., *Neural Networks and Learning Machines*, PHI, 2016.
3. Patterson J., and Gibson A., *Deep Learning: A Practitioner's Approach, O'Reilly*, 2017.

**ICT 4047: GAME THEORY WITH COMPUTER APPLICATIONS [3 0 0 3]**

Introduction to Game Theory and Mechanism Design, Mathematical Preliminaries, Non-Cooperative Game Theory, Cooperative Game Theory, Mechanism Design

**References:**

1. Narahari Y., *Game Theory and Mechanism Design*, World Scientific, Chennai, 2015.
2. Fudenberg D, and Tirole J., *Game Theory*, ANE Books, New Delhi, 2015.
3. Bauso D.*, Game Theoy with Engineering Applications*, SIAM, Philadelphia, 2016.
4. Roughgarden T., *Twenty Lectures on Algorithmic Game Theory*, Cambridge University Press, 2016.

**ICT 4048: HIGH PERFORMANCE COMPUTING [3 0 0 3]**

Introduction to CPU & GPU micro-architecture, Flynn’s taxonomy, Amdahl’s law, Challenges in parallel programming, Parallel programming languages, Introduction to CUDA C programming, Data parallelism, Mapping threads to multidimensional data, Synchronization, Querying device properties, Data Parallel Algorithm Primitives, Reduction, Parallel histogram computation, Convolution, Parallel prefix sum, Introduction to CUDA Library, Basic thrust features, Interoperability, Thrust algorithm, Optimization Techniques, Memory optimizations, Common compiler optimizations, Profiling, Application Case Study.

**References:**

1. Kirk D. B. and Hwu W., *Programming Massively Parallel Processors: A Hands-on Approach (3e),*Morgan Kaufmann Publishers Inc., 2016.
2. Barlas G., *Multicore and GPU Programming: An Integrated Approach*. Morgan Kaufmann Publishers Inc., 2015.
3. Gaster B., Howes L., Kaeli D. R., Mistry P., and Schaa D., *Heterogeneous Computing with OpenCL (2e)*, Morgan Kaufmann Publishers Inc., 2012.

**ICT 4049: HUMAN COMPUTER INTERACTION [3 0 0 3]**

Contexts for HCI, Processes for user-centered development, Different measures for evaluation, Usability heuristics and the principles of usability testing, Physical capabilities that inform interaction design, Cognitive models that inform interaction design, Social models that inform interaction design, Principles of good design and good designers, Accessibility, Interfaces for differently-aged population groups.

**References:**

1. Dix A., Finlay J.E., Abowd G.D. and Beale R., *Human-Computer Interaction (3e),* Prentice Hall, 2003.
2. Shneiderman B., Plaisant C., Cohen M. and Jacobs S., *Designing the User Interface: Strategies for Effective Human-Computer Interaction (5e),* Addison-Wesely, 2009.
3. Rubin J. and Chisnell D., *Handbook of Usability Testing: How to Plan, Design, and Conduct Effective Tests (2e),* New York: Wiley, 2008.
4. Rogers Y., Sharp H. and Preece J., *Interaction Design: Beyond Human - Computer Interaction (3e),* Wiley, 2011.

## **ICT 4050: INTERNET OF THINGS [3 0 0 3]**

Introduction to M2M communication and IoT, An emerging industrial structure for IoT, IoT system architecture, IoT reference model, IoT deployment and operational view, IoT physical devices and endpoints, Communication and networking protocols-MQTT and AMQP protocols, IoT enabling technologies-RFID, WSN,SCADA etc., Analytics for the IoT, Applying the geospatial analytics to IoT data, Real world design constraint, Technical design constraint, Future internet design for various IoT use cases such as smart cities, smart environments, smart homes, smart health etc.

**References:**

1. Holler J., Tsiatsis V., Mulligan C., Karnouskos S., Boyle D., *From Machine-to-Machine to the Internet of Things: Introduction to a New Age of Intelligence* *(1e),* Elsevier 2014.
2. Bahga A., Madisetti V., *Internet of Things-A Hands on Approach (1e),* Orient Blackswan Private Limited, 2015.
3. Roderick O., Marko N., Sanchez D. and Aryasomajula A., *Internet of Things and Data Analytics Handbook (1e),* Wiley-Blackwell, 2017.
4. Patil Y., *Azure IoT Development Cookbook (1e),* Packt publishing Ltd, 2017.
5. Minteer A., *Analytics for the Internet of Things (1e),* Packt publishing Ltd, 2017.

**ICT 4051: NATURAL COMPUTING [3 0 0 3]**

Basic Notations of Biochemistry and Molecular Biology, DNA Computing, Basic Computing Models: Finite Automata (FA), Push Down Automata (PDA), Linear Bounded Automata (LBA) and Turing Machine (TM), Quantum Turing Machine (QTM) and Quantum Languages, Computation by circuits, Thermodynamics of Computation, Algorithmic Botany, Cellular Automata, DNA Computation Models:Lipton Model, Sticker model, DNA Splicing model, DNA Self Assembly, Hairpin Model, Algorithms for Natural Security and Cryptography, Experiments in Self-Assembly, DNA Origami (2D and 3D), Error-Correction in Self- Assembly, Bacterial Computers and Data Storage, Peptide Computing, Membrane Computing, Chemical Computing.

**References:**

1. Leandro Nunes de Castro, *Fundamentals of Natural Computing: Basic Concepts, Algorithms and Applications*, CRC Press, USA, 2006.
2. Ignatova Z., Martnez-Prez I., and Karl-Heinz Zimmermann, *DNA Computing Models*, Springer, 2008.
3. Amos M., *Theoretical and Experimental DNA Computation*, Springer, 2005.
4. Hopcroft J.E., Motwani R., and Ullman J.D., *Introduction to Automata Theory, Languages and Computation*, Pearson Asia, 2001.

**ICT 4052: NEURAL NETWORKS AND FUZZY LOGIC [3 0 0 3]**

Introduction to Neural Networks and Fuzzy Logic, Learning Processes, Single-Layer Perceptron, Multi-Layer Perceptron, Radial Basis Function Networks, Support Vector Machine, Fuzzy Sets and Crisp Sets, Fuzzy Relations, Membership Functions, Fuzzy Logic and Inference, Membership Development.

**References:**

1. Haykin S.*, Neural Networks and Learning Machine* *(3e),* Pearson Education, New Delhi, 2016.
2. Hagan M.T., Demuth H B., and Beale M.H., *Neural Network Design* *(2e),* Pearson Education, New Delhi, 2014.
3. Ross T.J., Fuzzy Logic with Engineering Applications *(3e),* Wiley, USA, 2011.

**ICT 4053: PATTERN RECOGNITION [3 0 0 3]**

Machine perceptron, Pattern recognition, design cycle, Minimum error rate classification, Discriminant features, Normal desnsity, Bayesian belief network, Missing and noisy features, Maximum-likelihood estimation, Gaussian case, Computational complexity, Fisher linear discriminant, Nearest neighbor, Fuzzy classification, Linear discriminant function, Minimizing Perceptron criterion function, Relaxation MSE, Ho-Kashyap procedures, Hidden Markov models, Evaluation, Decoding, Learning, Unsupervised bayesian learning, Criterion functions for clustering, Iterative optimization, Hierarchical clustering.

**References:**

1. Duda R. O., Peter E.H. and David G. S., *Pattern Classification* *(2e)*, Wiley-Interscience, 2000.
2. Fukunaga K., *Introduction to Statistical Pattern Recognition* *(2e),* Academic ress, 2013.
3. Bishop C. M., *Pattern Recognition and Machine Learning* *(1e),* Springer, 2011.
4. Hastie T., Tibshirani R.and Friedman J., *The Elements of Statistical Learning: Data Mining, Inference, and Prediction* *(2e*), Springer, 2017.

## **ICT 4054: SOCIAL NETWORK ANALYSIS [3 0 0 3]**

Introduction to social networks: matrices used to analyze the network, types of network mode, Graph Concepts: connectivity, DFS and BFS in network, Datasets, Strong and Weak Ties: Strength of weak ties, Network structure in Large scale data, Graph Partitioning, Networks in their surrounding contexts: Homophily, Spatial model of Segregation, Positive and negative relations: Structural balance, characteristics, applications Information cascades: Baye’s rule, Simple cascade model, Network effects: Economy with and without network effects, Power laws and Rich Get Richer Phenomena: Effect of search tools and recommendation system, analysis of Rich-Get-Richer Processes, Cascading behavior in the network: Diffusion, cascades and clusters, Small world phenomena: Six Degrees of Separation, Decentralized Search, Visualization using Gephi: Graph layout algorithm

**References:**

1. Easley D. and Kleinberg J., *Networks, Crowds, and Markets: Reasoning About a Highly Connected World*, Cambridge University Press, 2010.
2. Prell C., *Social Network Analysis*, SAGE Publications, 2012.
3. Yang S., Keller F. B., Lu Zheng, *Social Network Analysis*, SAGE Publications, 2017.
4. Khokhar D., *Gephi Cookbook*, Packt Publishing, 2015.

**ICT 4055: SOFTWARE RELIABILITY [3 0 0 3]**

Need and concepts of software reliability; Software reliability models-classification, limitations and issues; model disagreement and inaccuracy, predictive accuracy, recalibration; The operational profile –concepts and development procedures, test selection; Testing for reliability measurement; Software testing; operational profiles – difficulties, estimating reliability, time/structure based software reliability; Fundamentals of measurement product metrics **–**measurement of internet product attributes, size and structure , measurement of quality; Reliability growth model.

**References:**

1. Lyu M., *Handbook of Software Reliability Engineering*, IEEE Computer Society Press, ISBN: 0-07-039400-8, 1996.
2. Connor P. D., *Practical Reliability Engineering* *(5e)*, John Wesley & sons, 2012.
3. Fenton N. E., Beiman J., *Software metrics-A rigorous and practical approach* *(3e)*, Chapman & Hall/CRC Innovations in Software Engineering and Software Development Series, 2014.
4. Musa J. D., *Software Reliability Engineering* *(2e)*, Tata McGraw Hill, 2005.
5. Yamada S., *Software Reliability Modeling: Fundamentals and Applications (Springer Briefs in Statistics)*, 2014 Edition, Springer, 2014.

**OPEN ELECTIVES**

**ICT 4301: COMPUTER GRAPHICS AND ANIMATION [3 0 0 3]**

Introduction to Computer Graphics, Video Display Devices, Raster Scan Systems, Graphics Output Primitives, Line Drawing Algorithms, Circles and Ellipses Generating Algorithms, Geometrical Transformation, Two Dimensional and Three Dimensional Transformations, Inverse Transformations, Three Dimensional Translation, Rotation and Scaling, , Transformation, Two Dimensional and Three Dimensional Viewing , Animation, Raster Methods for Computer Animation, Design of Animation sequences, Articulated Figure Animation, Periodic Motion, Graphics Programming using OpenGL,

**References:**

1. Donald D. H., Warren C., M. Pauline B., *Computer Graphics with OpenGL* (*4e),* Pearson, Education, 2014.
2. Zhigang X., *Computer Graphics: Theory and Practice with OpenGL (3e),* Pearson Education, 2016.
3. Edward A., *Interactive Computer Graphics- A top down approach using OpenGL (5e),* Pearson Education, 2012.
4. Foley J. D., VanDam A., Feiner S. K., Hughes J. F., *Computer Graphics, Principles and Practice (3e)*, Addision-Wesley, 2014.

**ICT 4302: DESIGN AND DEVELOPMENT OF WEB APPLICATIONS [3 0 0 3]**

Introduction to Internet and Web. Basic components of web page and fundamental concepts of languages required for Client side scripting and Server side scripting: HTML markup for structure of the simple page, text, creating links, adding images, table markup and forms. CSS for presentation: Orientation, formatting text, different selectors, colors background plus even more selectors, box model, padding, border, positioning, layouts, transitions, transformation and animation. Java script data types, control structure, DOM, arrays, objects, event handling. PHP introduction, control statements, arrays, objects, functions, connecting to mysql data base.

**References:**

1. Robbins J.N., *Learning Web Design (4e)*, O’reilly Media, reprint 2017.
2. Harris A., *HTML 5 and CSS 3: All in One for Dummies (3e),* Wiley Brand, reprint 2017.
3. Nixon R., *Learning PHP, MySQL, JavaScript with Jquery CSS and HTML5 (4e*), O’reilly Media, reprint 2017.

**ICT 4303: FUNDAMENTALS OF DATA STRUCTURES AND ALGORITHMS [3 0 0 3]**

Introduction to algorithms, Arrays: Elementary operations, Applications, Performance Analysis, Sparse matrix representation, Transpose of sparse matrix, Stacks operations, Arithmetic expression conversion and evaluation using stack, Queue Operations, Singly linked Lists, Circular lists, Doubly linked lists, Trees, Binary Tree traversals and different operations, Binary search Tree, Heaps, Graph Abstract type: Representations and elementary operations, Sorting and searching techniques, Analysis of algorithm.

**References:**

1. Horowitz E., Sani S., Dinesh Mehta, *Fundamentals of Data Structures in C*++ *(2e),* Golgotha Publications, 2008.
2. Weiss M. A., *Data Structures and Algorithm Analysis in C++ (3e),* Pearson Education, 2009.
3. Horowitz E., Sahni S., Anderson-Freed S.*, Fundamentals of Data structures in C (2e),* Silicon Press, 2008.

**ICT 4304: MACHINE LEARNING TOOLS AND TECHNOLOGIES [3 0 0 3]**

Introduction to Machine Learning, Mathematical Preliminaries, Supervised Learning-LMS, logistic regression, GDA, Naive Bayes, SVM, model selection, Learning theory-bias/variance tradeoff, union and Chernoff bounds, VC dimensions, Unsupervised learning-clustering, k-means, Gaussian mixture, factor analysis, PCA, ICA, Machine Learning with Python.

**References:**

1. Murphy K.P., *Machine Learning: A Probabilistic Perspective*, MIT Press, 2012.
2. Mohri M., Rostamizadeh A., and Talwalkar A., *Foundations of Machine Learning*, MIT Press, 2012.
3. Koller D., and Friedman N, *Probabilistic Graphical Models: Principles and Techniques*, MIT Press, 2009.
4. Bishop C.M., *Pattern Recognition and Machine Learning (2e),* Springer, 2013.

**ICT 4305: NETWORKING WITH TCP/IP [3 0 0 3]**

Introduction to Networking and brief History of Internet, OSI and TCP/IP Reference Models, Network Layer, IP Addresses, Internet Protocol (IP) Datagram, Fragmentation, Options, Address Translation, ICMP and IGMP, Intra and Inter domain Routing, Distance Vector Routing, RIP, Link State Routing, OSPF, Path Vector Routing, BGP, User Datagram and Transmission Control Protocol, SCTP, Application Layer Protocols, The Web and HTTP, DNS: Services Provided by the DNS.

**References:**

1. Beerhouse A. F., *TCP/IP Protocol Suite (4e),* Tata McGraw Hill 2017.
2. Andrew S. T., *Computer Network (5e),* Prentice Hall of India Pvt Ltd 2013.
3. James F. K., *Computer Networking A top-Down Approach Featuring the Internet (6e),* Pearson Education Inc 2013.
4. Beerhouse A. F., *Data Communications and Networking (5e),* Tata McGraw Hill 2013.

**ICT 4306 : CYBER SECURITY [3 0 0 3]**

Introduction to Information, Network and System Security, Encryption techniques, Message Integrity and Message Authentication, Digital Signature, Key Management, User Authentication. Web security model: Browser security model including same-origin policy, Client-server trust boundaries, Session management, authentication: Single sign-on, HTTPS and certificates. Application vulnerabilities and defenses: SQL injection, XSS, CSRF. Client-side security: Cookies security policy, HTTP security extensions, Plugins, extensions, and web apps, Web user tracking, Server-side security tools, e.g. Web Application Firewalls (WAFs) and fuzzers. Cybercrime, Cybercrime investigation, Laws and ethics

**References:**

1. Mayank Bhushan, Fundamentals of cybersecurity, BPB publications, 2017

2.Raef Meeuwisse, Cyber Security for Beginners, 2015

3.Rolf Oppliger, Security Technologies for the World Wide Web, 2nd edition,Artech House, 2002.

4.Seth Fogie, Jeremiah Grossman, Robert Hansen and Anton Rager, XSS Attacks: Cross Site Scripting Exploits and Defense, Syngress, 2007.

5.Justin Clarke et.al.,SQL Injection Attacks and Defense, 2nd edition, Syngress, 2012.

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| **ICT 4307** | **GAME THEORY AND APPLICATIONS** | **[3 0 0 3]** |

Introduction, Mathematical Preliminaries, Non-Cooperative Game Theory: Extensive Form Games, Strategies Form Games, Dominant Strategy Equilibria, Nash Equilibria, Matrix Games, Bayesian Games, Cooperative Game Theory: Two Person Bargaining Problem, Coalition Games, Shapely Values, Mechanism Design: Social Choice Functions, Incentive Compatibility and Revelation Theorem, Auctions

**References:**

1.Y Narahari, Game Theory and Mechanism Design, World Scientific, Chennai, 2015

2.Drew Fudenberg and Jean Tirole, Game Theory, ANE Books, New Delhi, 2015

3.Dario Bauso, Game Theoy with Engineering Applications, SIAM, Philadelphia, 2016