Curriculum for Undergraduate Degree (B.Tech.) in Computer Science and Engineering (AI and ML) (w.e.f. AY: 2022-23)

Part III: Detailed Curriculum

Seventh Semester

Course Name:	**Quantum Computing**		
Course Code:	PE-CS701A	**Category:**	Professional Elective Courses
Semester:	7th	**Credit:**	3.0
L-T-P:	3-0-0	**Pre-Requisites:**	Basic understanding of Quantum Theory, Linear Algebra, Theory of Computation
Full Marks:	100		
Examination Scheme:	Semester Examination:70	Continuous Assessment:25	Attendance:05

Course Objectives:	
1	Inculcate the idea of Quantum Computing and its inevitability in the near future.
2.	Develop a basic idea on Qubit, Quantum gates, Quantum Cryptography and appreciate the power of parallel computing with few quantum algorithms.
3.	Get hands-on experience in building quantum circuits using IBM's Qiskit.

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1.	**Vector and Operators:** ✓ The Motivation: Shannon's Information theory & its connection to Entropy ✓ Concept of Vector Spaces. ✓ Basis & dimensions ✓ Linear Combination of Vectors: Representing a quantum state by a vector ✓ Uniqueness of a spanning set, Inner Product (its relation to the vector dot product), Orthonormality, Gram-Schmidt orthogonalization, Bra-ket formalism and its usefulness, the Cauchy schwarz Inequality. ✓ Outer Products, The Closure Relation ✓ Concept of Operators in Quantum Mechanics and their representation using matrices, Hermitian & Unitary operators ✓ Concept of Eigen values & Eigen Vectors and the span of vector space, Spectral Decomposition, Trace of an operator, important properties of Trace, Expectation Value of Operator, Projection Operator, Positive Operators	10

2.	**Tensor Products:** ✓ Representing Composite States in Quantum Mechanics, Tensor products of column vectors, operators and tensor products of matrices ✓ Concept of Pure and Mixed State ✓ Density Operator: Its usefulness ✓ Density Operator of Pure & Mixed state, Key Properties, Characterizing Mixed State	7
3.	**The Building Block:** ✓ Concept of Qubit: its difference with a conventional Bit. Bloch vector & Qubit. ✓ Pauli spin matrices, Quantum Gates: Pauli matrices as Phase & NOT gates. ✓ Irreversibility of classical gates, Introduction to Hadamard, CNOT and Toffoli gates with their truth tables. ✓ Entangled states: Its concept and mechanism of creation using quantum gates. Quantum teleportation using entanglement.	8
4.	**Parallel computing:** ✓ Deutsch Jozsa algorithm ✓ Unstructured search using Grover's algorithm. ✓ Quantum key distribution: The future of Cryptography	6
5.	**Hands-on:** ✓ Recent trends in Quantum Computing ✓ Learning to use IBM's Qiskit to build quantum circuits	5
Total		**36L**

Course Outcomes:	
After completion of the course, students will be able to:	
1.	Relate vectors to physical states of system and matrices to operators.
2.	Examine the application of various quantum gates on qubit.
3.	Discover the power of parallel computing using quantum algorithms.
4.	Construct simple quantum circuits by IBM's Qiskit.

Learning Resources:	
1.	'Quantum Computing without Magic' by Zdzislaw Meglicki
2.	'Quantum Computing Explained' by David Mc Mahon
3.	'Quantum Computer Science' by Marco Lanzagorta and Jeffrey Uhlmann
4.	'An Introduction to Quantum Computing' by Phillip Kaye, Raymond Laflamme and Michele Mosca.
5.	https://qiskit.org/textbook/preface.html

Course Name:	**Data Security and Authentication**		
Course Code:	PE-CS(D)701A	**Category:**	Professional Elective-IV
Semester:	Seventh	**Credit:**	3
L-T-P:	3-0-0	**Pre-Requisites:**	Computer Networks
Full Marks:	100		
Examination Scheme:	Semester Examination:70	Continuous Assessment:25	Attendance:05

Course Objectives:	
1	To explain the key security requirements aligning with type of threats and vulnerabilities that attack the security of information.
2	To present symmetric and asymmetric cryptographic systems covering most important parts of cryptology through introducing many cryptography techniques and algorithms.
3	To explain the hash function as an application of cryptography aligning with the concept of message integrity and digital signature authentication.

Course Contents:

Module No.	**Description of Topic**	**Contact Hrs.**
1	Attacks on Computers & Computer Security - An Overview on Security and Data Security, Need for Security, Security approaches, Principles of Security, Types of attacks	5
2	Cryptography: Concepts & Techniques-Introduction, Plaintext & Cipher text, Substitution, Transposition, Classical Cryptography, Symmetric Cryptosystems, Block Ciphers, Stream Ciphers, Encryption & Decryption, Symmetric & Asymmetric key Cryptography, Key Range & Key Size	7
3	Symmetric Key Algorithm - Introduction, Algorithm types & Modes, Overview of Symmetric Key Cryptography, DES (Data Encryption Standard) algorithm, IDEA (International Data Encryption Algorithm), RC5 (Rivest Cipher 5) algorithm. Analysis of Symmetric Ciphers	8
4	Asymmetric Key Algorithm, Digital Signature and RSA - Introduction, Overview of Asymmetric key Cryptography, RSA algorithm, Symmetric & Asymmetric key Cryptography together, Digital Signature, Basic concepts of Message Digest and Hash Function	5
5	Internet Security Protocols, User Authentication - Basic Concepts, SSL protocol, Authentication Basics, Password, Authentication Token, Certificate based Authentication, Digital Signature, Biometric Authentication. Basics of steganography and secret sharing.	11

	Electronic Mail Security - Basics of mail security, Pretty Good Privacy, S/MIME. Firewall - Introduction, Types of firewalls, Firewall Configurations, DMZ Network	
Total		**36L**

Course Outcomes:	
After completion of the course, students will be able to:	
1	Explain the basic principles of security, block, stream cipher and the importance of keys in the principle of encryption and decryption.
2	Identify the difference between symmetric and asymmetric key and the importance of hash function and message digest in cryptography.
3	Identify the Internet Security Protocols, Digital Signature, Biometric Authentication, steganography as well as secret sharing mechanism.
4	Explain the basics of e-mail security and Firewall including DMZ network's role in Defense organizations.

Learning Resources:	
1	Cryptography and Network Security: Principles and Practice, Global Edition, 7/E, William Stallings, Pearson, ISBN-10: 1292158581 • ISBN-13: 9781292158587 (Chapter 1 to 14)
2	Introduction to Cryptography: Principles and Applications. Hans Delfs & Helmut Knebl, Second Edition.
3	Cryptography & Network Security: Atul Kahate, TMH

Course Name:	**Computer Graphics**		
Course Code:	PE-CS(AM)701A	**Category:**	Professional Elective
Semester:	7th	**Credit:**	3
L-T-P:	3-0-0	**Pre-Requisites:**	
Full Marks:	100		
Examination Scheme:	Semester Examination: 70	Continuous Assessment: 25	Attendance: 05

Course Objectives:	
1	To familiarize the students with the basic concepts of computer graphics and scan conversion algorithms.
2	To acquaint the students with transformation, clipping algorithms and their application areas.
3	To develop the ability to compare shading models and hidden surface removal algorithms.

Course Contents:		
Module No.	**Description of Topic**	**Contact Hrs.**
1	**Introduction to computer graphics & graphics systems:** Overview of computer graphics, Visualization & image processing; RGB color model, direct coding, lookup table; display devices, Plotters, printers, digitizers, light pens etc.; Computer graphics software. Scan conversion algorithms: Points & lines; DDA & Bresenham's line algorithm, Circle generation algorithm; Ellipse generating algorithm; scan line polygon, boundary fill & flood fill algorithm.	9
2	**2D & 3D Transformation**: Basic transformations: Translation, Rotation, Scaling; Matrix representations & homogeneous coordinates, transformations between coordinate systems, Composite Matrix Transform; Reflection, Shear; Transformation of points, lines and related problems, 3D transformations: Translation, Rotation, Scaling.	8
3	**2D & 3D Clipping**: Viewing pipeline, Window to view port co-ordinate transformation, clipping operations, point clipping, line clipping algorithms:. Cohen and Sutherland, Liang Bersky, Cyrus-Beck line clipping algorithms; Polygon Clipping: Sutherland-Hodgeman Polygon clipping algorithm, 3D viewing & Projection: Parallel & Perspective projection, vanishing point	9
4	**Curves, Hidden surface removal algorithm & Shading models** Curves: Curve representation, surfaces, Bezier curves, B-spline curves, conditions for joining two Bezier Curve segments and related problems. Hidden surface removal algorithms: Depth comparison, Z-buffer algorithm, Back face detection, BSP tree method, the Painter's algorithm, scan-line algorithm; Hidden line elimination, wire frame methods , Fractal - geometry. Color & shading models: Lighting conditions: Ambient, diffuse etc.; Shading models: Flat, Gouraud & Phong shading models, comparison.	10
Total		**36L**

Course Outcomes:	
After completion of the course, students will be able to:	
1	Identify contemporary graphics hardware components
2	Solve problems on basic graphics algorithms for straight line, circle and ellipse.
3	Demonstrate working of clipping algorithms and distinguish between different clipping methods.
4	Use methods of transformations and solve problems on them.
5	Use spline properties, shading models and hidden surface removal algorithms for creating real world object.

Learning Resources:	
1	Hearn, Baker – "Computer Graphics (C version 2nd Ed.)" – Pearson education
2	Z. Xiang, R. Plastock – " Schaum's outlines Computer Graphics (2nd Ed.)" – TMH
3	D. F. Rogers, J. A. Adams – "Mathematical Elements for Computer Graphics (2nd Ed.)" – TMH
4	Anirban Mukhopadhyay, Arup Chattopadhyay, "Introduction to Computer Graphics & Multimedia"

Course Name:	**Fundamentals of Natural Language Processing**		
Course Code:	PE- CS(AM)702A	**Category:**	Professional Elective Courses
Semester:	7th	**Credit:**	3
L-T-P:	3-0-0	**Pre-Requisites:**	Formal Language and Automata Theory
Full Marks:	100		
Examination Scheme:	Semester Examination: 70	Continuous Assessment: 25	Attendance: 05

Course Objectives:	
1	To familiarize the concepts and techniques of Natural language Processing
2	To introduce basic mathematical models and methods used in NLP applications to formulate computational solutions
3	To provide students with the knowledge on designing procedures for natural language resource annotation and the use of related tools for text analysis using such tools
4	To introduce students to research and development work in information retrieval, information extraction, and knowledge discovery using different natural language resources

Course Contents:

Module No.	**Description of Topic**	**Contact Hrs.**
1	**Introduction:** Human Languages, Phases in natural language processing, Review of Regular Expressions, Finite State Automata, CFG and Different Parsing techniques.	2
2	**Tokenization:** Word tokenization, Normalization, Sentence segmentation	2
3	**Morphology:** Inflectional and Derivational Morphology, Finite State Morphological Parsing, The Lexicon and Morphotactic, Morphological Parsing with Finite State Transducers, Orthographic Rules and Finite State Transducers, Porter Stemmer	4
4	**Language Models:** Introduction to N-grams, Chain Rule, smoothing– Add-One Smoothing, Witten-Bell Discounting; Back off, Deleted Interpolation, N-grams for Spelling and Word Prediction, Evaluation of language models.	5
5	**Vector Models-Word Embedding:** Word Embeddings, Word2Vec, GloVe Word Embeddings, Applications of Word Embeddings	2
6	**Transformer and Pre-trained Models:** Attention Mechanism in Neural Language Models, transformers, large language Models, Generative Pre-trained Transformer (GPT), Bidirectional Encoder Representation from Transformers(BERT)	5
7	**Text Classification**: Text Classification, Naïve Bayes' Text Classification, Evaluation, Sentiment Analysis – Opinion Mining and Emotion Analysis, Resources and Techniques.	4

8	**POS Tagging:** Tagsets, HMM Part-of-Speech Tagging, Markov Chain, Hidden Markov Models, Viterbi Algorithm, Rule based and Machine Learning based approaches, Evaluation	5
9	**Computational Lexical Semantics:** Introduction to Lexical Semantics – Homonymy, Polysemy, Synonymy, Thesaurus – WordNet, Computational Lexical Semantics – Thesaurus-based and Distributional Word Similarity	3
10	**Information Retrieval:** Boolean Retrieval, Term document incidence, The Inverted Index, Query Optimization, Phrase Queries, Ranked Retrieval – Term Frequency – Inverse Document Frequency based ranking, Zone Indexing, Query term proximity, Cosine ranking, Combining different features for ranking, Search Engine Evaluation, Relevance Feedback	4
Total		**36L**

Course Outcomes:	
After completion of the course, students will be able to:	
1	**Describe** the fundamental concepts of natural language processing, including language structure, finite state automata, and parsing techniques.
2	**Apply** text preprocessing techniques such as tokenization, normalization, stemming, and morphological analysis in NLP tasks.
3	**Implement** statistical and machine learning models like N-grams, Naïve Bayes, HMMs, and POS tagging for language modeling and classification.
4	**Analyze** neural NLP methods using word embeddings (Word2Vec, GloVe), attention mechanisms, and transformer-based models like BERT and GPT.
5	**Evaluate** information retrieval models and ranking mechanisms such as TF-IDF, cosine similarity, and relevance feedback used in search engines.

Learning Resources:	
1	Speech and Language Processing, Jurafsky and Martin, Pearson Education
2	Foundation of Statistical Natural Language Processing, Manning and Schutze, MIT Press
3	Multilingual Natural Language Processing Applications from Theory to Practice: Bikel, Pearson.
4.	Understanding natural Language Processing: T V GEETHA, Pearson

Course Name:	**Block Chain Technology**		
Course Code:	PE-CS 702B	**Category:**	Professional Elective Course
Semester:	7th	**Credit:**	3
L-T-P:	3-0-0	**Pre-Requisites:**	Basic concepts of Computer Networks and Operating Systems
Full Marks:	100		
Examination Scheme:	Semester Examination: 70	Continuous Assessment: 25	Attendance: 05

Course Objectives:	
1	To understand the distributed decentralized database
2	To familiarize with fundamentals of Blockchain and its various applications
3	To identify distributed ledger technologies and their architecture.
4	To describe the Hashing in Blockchain mining
5	To get acquaintance with the Ethereum Virtual Machine (EVM), clients of EVM, and Ethereum Key pairs
6	To know about the cryptography and Bitcoin

Course Contents:		
Module No.	**Description of Topic**	**Contact Hrs.**
1	**Basics of Blockchain:** Introduction, Concept of Blockchain, History, Definition, Fundamentals & Characteristics of Blockchain, Public, Private and Hybrid Blockchains, Distributed Ledger Technologies, Architecture of Blockchain, Transactions, Chaining Blocks. Introduction of Decentralized System, Distributed Decentralized Databases, Decentralization.	6L
2	**Hash Functions:** Introduction, Hashing, Message Authentication Code, Secure Hash algorithm, Distributed Hash Tables, Hashing and Data Structures, Hashing in Blockchain Mining. **Consensus:** Introduction, Consensus Approach, Consensus Algorithms, Byzentine Agreement Methods.	6L
3	**Blockchain Components:** Introduction, Ethereum, History, Ethereum Virtual Machine, Working of Ethereum, Ethereum Clients, Ethereum Key Pairs, Ethereum Addresses, Ethereum Wallets, Ethereum Transactions, Ethereum Languages, Ethereum Development Tools.	6L
4	**Cryptography:** Introduction, Cryptography primitives, Symmetric Cryptography, Asymmetric Cryptography. **Smart Contacts:** Introduction, Absolute and Immutable, Contractual Confidentiality, Characteristics, Use cases.	6L
5	**Bitcoins:** Introduction, Working of Bitcoin, Creation of Bitcoins, Markle Trees, Bitcoin Block Structure, Bitcoin Address, Bitcoin Transactions, Bitcoin Network, Bitcoin Wallets, Bitcoin Payments, Bitcoin Clients, Bitcoin Supply.	6L

6	**Decentralized Applications:** Introduction, Today's Web applications Requirement, Mining in Blockchain, Blockchain in healthcare, safety and security, Validation and Identification of Bitcoin based task, Mining Hardware and Software, Bitcoins Management.	6L
Total		**36L**

Course Outcomes:	
After completion of the course, students will be able to:	
1	Describe the basic concepts and working of Blockchain Technology including Hash function and Consensus algorithms
2	Explain the design principles of Bitcoin, Ethereum, Smart Contracts and role of cryptography in these architectures.
3	Explain the working of smart contracts in developing different Decentralized applications with knowledge of Bitcoin concept.

Learning Resources:	
1	Mastering Blockchain: A deep dive into distributed ledgers, consensus protocols, smart contracts, DApps, cryptocurrencies, Ethereum, and more, 3rd Edition, Imran Bashir, Packt Publishing, 2020, ISBN: 9781839213199, book website: https://www.packtpub.com/product/mastering-blockchain-third-edition/9781839213199
2	Blockchain Technology-Concepts and Applications by Kumar Saurabh and Ashutosh Saxsena, Wiley Publishers.
3	Josh Thompson, 'Blockchain: The Blockchain for Beginnings, Guild to Blockchain Technology and Blockchain Programming', Create Space Independent Publishing Platform, 2017.
4	Hyperledger Tutorials - https://www.hyperledger.org/use/tutorials
5	Ethereum Development Resources - https://ethereum.org/en/developers

Course Name:	**Uncertainty Modelling and Multi-value Logic**		
Course Code:	PE CS(D)702C	**Category:**	Professional Elective Courses
Semester:	Seventh	**Credit:**	3
L-T-P:	3-0-0	**Pre-Requisites:**	Soft Computing
Full Marks:	100		
Examination Scheme:	Semester Examination: 70	Continuous Assessment: 25	Attendance: 05

Course Objectives:	
1	To introduce Uncertainty associated with Engineering Design
2	To familiarize computational methods of various types of uncertainty
3	Familiarization of Soft Computing and corresponding applications

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1	Fundamentals of uncertainty, Types of uncertainty: Aleatory uncertainty, Epistemic uncertainty, Concept of measurement uncertainty, Type-I and Type-II uncertainty, Uncertainty of data	5
2	Sampling methodology: Random sampling, stratified random sampling, Generate random numbers from a specific probability distribution, Inverse sampling technique, Latin hypercube sampling, Monte Carlo Simulation – Analog and digital Monte Carlo, Bootstrap, Confidence Interval estimation, percentiles of any probability distribution, Computation of Aleatory Uncertainty using Monte Carlo simulation, Applications of uncertainty modeling, Polynomial Chaos Theory, Uncertainty quantification of an engineering system using polynomial chaos theory, Kramer-Rao inequality, Propagation of aleatory uncertainty, Wilks' Theorem, Nonparametric technique for uncertainty propagation,	10
3	Concept of soft computing, Concept of Fuzzy set, Alpha cut of a fuzzy set, Zadeh's extension principle, Fuzzy vertex theory, Computation of epistemic uncertainty, Co-Norm and t-Co-Norm, Fuzzy relations, Fuzzy optimization, Numerical problems	6
4	Multicriteria Decision making method (MCDM) using crisp and fuzzy data, TOPSIS and Fuzzy TOPSIS	8
5	Bayesian statistics and its application to estimate joint density distribution, covariance and correlation, ANOVA, Autocorrelation, ARMA and ARIMA model, Uncertainty analysis of time series	7
Total		**36L**

Course Outcomes:	
After completion of the course, students will be able to:	
1	Identify the aleatory uncertainty, epistemic uncertainty.
2	Explain different type of sampling methodologies like random sampling, inverse sampling technique, Latin hypercube sampling and different simulation techniques like Monte Carlo Simulation Bootstrap Confidence Interval Estimation.
3	Explain the concept of fuzzy set, fuzzy vertex theory, fuzzy relations and optimizations.
4	Explain the multicriteria decision making using TOPSIS and Fuzzy TOPSIS.
5	Explain the Bayesian statistics, ANOVA, ARMA and ARIMA.

Learning Resources:	
1	C. Y. Lin and P. Hajela, Genetic algorithms in optimization problems with dis- crete and integer design variables, Engineering Optimization, Vol. 19, pp. 309–327, 1992.
2	P. van Laarhoven and E. Aarts, Simulated Annealing: Theory and Applications, D. Reidel, Boston, 1987.
3	A. K. Dhingra and S. S. Rao, A neural network based approach to mechanical design optimization, Engineering Optimization, Vol. 20, pp. 187–203, 1992.
4	J. Kennedy and R. C. Eberhart, Swarm Intelligence, Morgan Kaufmann, San Francisco, 2001.
5	John R. Taylor, An introduction to error analysis, The study of uncertainty analysis in physical measurements, Second Edition, University Science Books, California,1997
6	P. R. Bevington and K.D. Robinson, Data Reduction and Error Analysis for the Physical Sciences, McGraw-Hill, 1992
7	George J. Klir, Fuzzy Sets, Uncertainty and Information, First Edition,
8	Janusz T., Starczewski, Uncertainty in Fuzzy Sets, Studies in fuzzyness and soft computing, vol. 284,
9	George J. Klir, Mark J. Wierman, Uncertainty-Based Information, Springer Link,
10	George J. Klir, Mark J. Wierman, Principles of Uncertainty, Springer Link

Open Elective -I

Subject Code	Subject Name	Offered by
OE-EC701A	Adhoc and Sensor Network	ECE Department
OE-EC701B	Microprocessor and Microcontroller	ECE Department
OE-IT701D	Multimedia Systems	IT Department
OE-M701A	Operations Research and Optimizing Technique	BS Department

Course Name:	**Adhoc and Sensor Network**		
Course Code:	OE-EC701A	**Category:**	Open Elective Course
Semester:	Seventh	**Credit:**	3
L-T-P:	3-0-0	**Pre-Requisites:**	Computer Networks
Full Marks:	100		
Examination Scheme:	Semester Examination: 70	Continuous Assessment: 25	Attendance: 05

Course Objectives:	
1	Learn Ad hoc network and Sensor Network fundamentals
2	Explain the different routing protocols
3	Have an in-depth knowledge on sensor network architecture and design issues
4	Explain the transport layer and security issues possible in Ad hoc and Sensor networks
5	Have an exposure to mote programming platforms and tools

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1	**Adhoc Networks – Introduction & Routing Protocols :** Elements of Ad hoc Wireless Networks, Issues in Ad hoc wireless networks, Example commercial applications of Ad hoc networking, Ad hoc wireless Internet, Issues in Designing a Routing Protocol for Ad Hoc Wireless Networks, Classifications of Routing Protocols, Table Driven Routing Protocols – Destination Sequenced Distance Vector (DSDV), On–Demand Routing protocols –Ad hoc On–Demand Distance Vector Routing (AODV).	8
2	**Sensor Networks – Introduction & Architecture** : Challenges for Wireless Sensor Networks, Enabling Technologies for Wireless Sensor Networks, WSN application examples, Single-Node Architecture – Hardware Components, Energy Consumption of Sensor Nodes, Network Architecture – Sensor Network Scenarios, Transceiver Design Considerations, Optimization Goals and Figures of Merit.	8

3	**WSN Networking Concepts & Protocols :** MAC Protocols for Wireless Sensor Networks, Low Duty Cycle Protocols And Wakeup Concepts – S-MAC, The Mediation Device Protocol, Contention based protocols – PAMAS, Schedule based protocols – LEACH, IEEE 802.15.4 MAC protocol, Routing Protocols- Energy Efficient Routing, Challenges and Issues in Transport layer protocol.	8
4	**Sensor Network Security** : Security Requirements, Issues and Challenges in Security Provisioning, Network Security Attacks, Layer wise attacks in wireless sensor networks, possible solutions for jamming, tampering, black hole attack, flooding attack. Key Distribution and Management, Secure Routing – SPINS, reliability requirements in sensor networks.	6
5	**Sensor Network Platforms and Tools :** Sensor Node Hardware – Berkeley Motes, Programming Challenges, Node-level software platforms – TinyOS, nesC, CONTIKIOS, Node-level Simulators – NS2 and its extension to sensor networks, COOJA, TOSSIM, Programming beyond individual nodes – State centric programming	6
Total		**36**

Course Outcomes:	
After completion of the course, students will be able to:	
1	Know the basics of Ad hoc networks and Wireless Sensor Networks
2	Apply this knowledge to identify the suitable routing algorithm based on the network and user requirement
3	Apply the knowledge to identify appropriate physical and MAC layer protocols.
4	Explain the transport layer and security issues possible in Ad hoc and sensor networks.
5	Familiar with the OS used in Wireless Sensor Networks and build basic modules.

Learning Resources:	
1	C. Siva Ram Murthy and B. S. Manoj, "Ad Hoc Wireless Networks Architectures and Protocols", Prentice Hall, PTR, 2004.
2	Kazem Sohraby, Daniel Minoli, & Taieb Znati, "Wireless Sensor Networks-Technology, Protocols, and Applications", John Wiley, 2007.
3	Carlos De Morais Cordeiro, Dharma Prakash Agrawal "Ad Hoc & Sensor Networks: Theory andApplications", World Scientific Publishing Company, 2006.
4	Holger Karl, Andreas Willig "Protocols and Architecture for Wireless Sensor Networks" John Wiley andSons, Ltd.

Course Name:	**Microprocessor and Microcontroller**		
Course Code:	OE-EC701B	**Category:**	Open Elective Course
Semester:	Seventh	**Credit:**	3
L-T-P:	3-0-0	**Pre-Requisites:**	Basic Electrical & Electronics Engineering ES-EE101
Full Marks:	100		
Examination Scheme:	Semester Examination: 70	Continuous Assessment: 25	Attendance: 05

Course Objectives:	
1	To introduce architecture and operation of microprocessor and microcontroller
2	To learn assembly language programming for microprocessor and microcontroller
3	To understand and design microprocessor and microcontroller based real world applications.

Course Contents:		
Module No.	**Description of Topic**	**Contact Hrs.**
1	Intel 8085: pin description, architecture, addressing modes, interrupts, timing diagrams. Intel 8086: Pin description, architecture, memory segmentation, pipelining, min/max mode, addressing modes, data structure / access, interrupts.	8
2	Instruction Set and Assembly Language Programming of 8085 and 8086 microprocessors. Instruction formats, addressing modes, instruction set, simple programs involving logical, branch and call instructions, sorting, evaluating arithmetic expressions, string manipulations.	8
3	8255 PPI various modes of operation and interfacing to 8085. Intel 8279: Keyboard & display controller, D/A and A/D converter and other applications.	6
4	Overview of Intel 8051 microcontroller. Architecture. I/O Ports. Memory organization, addressing modes and instruction set of 8051, simple program.	8
5	Serial communication standards, Serial data transfer schemes. 8251 USART architecture and interfacing. Introduction to Advanced Processors (Intel 80286, Intel 80486) and PIC Microcontroller	6
Total		**36**

Course Outcomes:	
After completion of the course, students will be able to:	
1	Apply a basic concept of digital fundamentals to Microprocessor based personal computer system
2	Identify the detailed software & hardware structure of the Microprocessor.
3	Illustrate the operation, interface and instructions of microprocessor and microcontroller

Learning Resources:	
1	Microprocessor Architecture, Programming and Applications with the 8085, Ramesh Gaonkar, 2013, Penram International Publishing.
2	Fundamentals of Microprocessor and Microcomputer, B Ram, 2017, Dhanpat Rai Publications.
3	Advanced Microprocessor and Peripherals, K M Bhurchandi, A K Ray, 2017, McGraw Hill Education.
4	The 8051 Microcontroller, Kenneth J. Ayala, 1996, Penram International Publishing
5	The 8051 Microcontroller and Embedded Systems: Using Assembly and C, M. A. Mazidi, J. G. Mazidi and R D McKinlay, 2007, Pearson.
6	Microprocessors & Interfacing, Douglas V. Hall and SSSP Rao, 2017, McGraw Hill Education.
7	Computer Organization and Design: The Hardware/Software Interface, David A. Patterson, John L. Hennessy, 2016, Morgan Kaufmann Publishing

Course Name:	**Multimedia Systems**			
Course Code:	OE-IT701D	**Category:**	Open Elective Courses	
Semester:	7th	**Credit:**	3	
L-T-P:	3-0-0	**Pre-Requisites:**	Fundamental knowledge of Computation, Networking and DBMS	
Full Marks:	100			
Examination Scheme:	Semester Examination: 70	Continuous Assessment: 25	Attendance: 05	

Course Objectives:	
1	To give each student a firm grounding in the fundamentals of the underpinning technologies in graphics and multimedia.
2	To teach students the principled design of effective media for entertainment, communication, training and education.
3	To provide each student with experience in the generation of animations, virtual environments and multimedia applications, allowing the expression of creativity.

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1	**Introduction:** Multimedia today, Impact of Multimedia, Multimedia Systems, Components and Its Applications	2L
2	**Text and, Image:** Text: Types of Text, Ways to Present Text, Aspects of Text Design, Character, Character Set, Codes, Unicode, Encryption. Image: Formats, Image Color Scheme, Image Enhancement.	5L
3	**Audio and Video:** **Audio:** Basic Sound Concepts, Types of Sound, Digitizing Sound, Computer Representation of Sound (Sampling Rate, Sampling Size, And Quantization), Audio Formats, Audio tools, MIDI. **Video:** Analogue and Digital Video, Recording Formats and Standards (JPEG, MPEG, H.261) Transmission of Video Signals, Video Capture, and Computer based Animation.	6L
4	**Synchronization, Storage models and Access Techniques:** Temporal relationships, synchronization accuracy specification factors, quality of service, Magnetic media, optical media, file systems (traditional, multimedia) Multimedia devices – Output devices, CD-ROM, DVD, Scanner, CCD.	7L

5	**Image and Video Database, Document Architecture and Content Management:** Image representation, segmentation, similarity based retrieval, image retrieval by color, shape and texture; indexing- kd trees, R-trees, quad trees; Case studies- QBIC, Virage. Video Content, querying, video segmentation, indexing, Content Design and Development, General Design Principles Hypertext: Concept, Open Document Architecture (ODA), Multimedia and Hypermedia Coding Expert Group (MHEG), Standard Generalized Markup Language (SGML), Document Type Definition (DTD), Hypertext Markup Language (HTML) in Web Publishing. Case study of Applications.	13 L
6	**Multimedia Applications:** Interactive television, Video-on-demand, Video Conferencing, Educational Applications, Industrial Applications, Multimedia archives and digital libraries, media editors	3L
Total		**36L**

Course Outcomes:	
After completion of the course, students will be able to:	
1	Understand the concepts, principles and theories of Multimedia Applications and Virtual environments.
2	Demonstrate knowledge and understanding the various aspects and issues involved with development and deployment of multimedia system.
3	Analyze and solve problems related to their expertise in Multimedia Applications and Virtual Environments.
4	Demonstrate their ability to extend their basic knowledge to encompass new principles and practice.

Learning Resources:	
1	"Multimedia: Computing, Communications & Applications" by Ralf Steinmetz and Klara Nahrstedt, Pearson Ed.
2	"Multimedia and Animation" by V.K. Jain, Khanna Publishing House, 2019.
3	"Multimedia Information System" by Nalin K. Sharda , PHI.
4	"Multimedia Communications" by Fred Halsall, Pearson Ed.
5	"Multimedia Systems" by Koegel Buford, Pearson Ed.
6	"Multimedia Literacy" by Fred Hoffstetter, McGraw Hill.
7	"Multimedia Fundamentals: Vol. 1- Media Coding and Content Processing" by Ralf Steinmetz and Klara Nahrstedt, PHI.
8	"Multimedia in Practice: Technology and Application" by J. Jeffcoate , PHI.

Course Name:	**Operations Research and Optimizing Technique**		
Course Code:	OE-M701A	**Category:**	Optional Elective Courses
Semester:	Seventh	**Credit:**	3
L-T-P:	3-0-0	**Pre-Requisites:**	School mathematics, BS-M101, BS-M201
Full Marks:	100		
Examination Scheme:	Semester Examination: 70	Continuous Assessment: 25	Attendance: 05

Course Objectives:	
1	To impart knowledge in concepts and tools of Operations Research
2	To understand mathematical models used in Operations Research
3	To apply these techniques constructively to make effective business decisions

Course Contents:		
Module No.	**Description of Topic**	**Contact Hrs.**
1	**Solving Linear Programming Problems :** Formulation, Solving LPP: Using Simultaneous Equations and Graphical Method; Simplex, Duality, Big-M method, Transportation& Assignment, Travelling Salesman problem	**11L**
2	**Game Theory** : Introduction ; 2- person Zero – sum Game; Saddle Point; Mini-Max and Maxi-Min Theorems (statement only); Games without saddle point ; Graphical Method ; Principle of Dominance	**7L**
3	**Queuing Theory :** Introduction ; Basic Definitions and Notations ; Axiomatic Derivation of the 7L Arrival & Departure (Poisson Queue). Pure Birth and Death Models; Poisson Queue Models : M/M/1 : ∞/FIFO and M/M/1: N/ FIFO.	**6L**
4	.**Network Analysis :** Shortest Path : Floyd Algorithm ; Maximal Flow Problem (Ford-Fulkerson); PERT-CPM (Cost Analysis, Crashing, Resource Allocation excluded).	**6L**
5	**Non-Linear Programming:** Integer Programming, Dynamic Programming.	**6L**
Total		**36L**

Course Outcomes:	
After completion of the course, students will be able to:	
1	Solve linear programming problems using appropriate techniques and optimization solvers, interpret the results obtained.
2	Determine optimal strategy for Minimization of Cost of shipping of products from source to Destination/ Maximization of profits of shipping products using various methods, Finding initial basic feasible and optimal solution of the Transportation problems.
3	Optimize the allocation of resources to Demand points in the best possible way using various techniques and minimize the cost or time of completion of number of jobs by number of persons.
4	Extract the Optimum value in constrained and unconstrained situations.
5	Acquire skills in analyzing queueing models.

Learning Resources:	
1	H. A. Taha, "Operations Research", Pearson
2	P. M. Karak – "Linear Programming and Theory of Games", ABS Publishing House
3	Ghosh and Chakraborty, "Linear Programming and Theory of Games", Central Book Agency
4	Ravindran, Philips and Solberg - "Operations Research", WILEY INDIA
5	Kanti Swaroop — "Operations Research", Sultan Chand & Sons
6	Rathindra P. Sen—"Operations Research: Algorithms and Applications", PHI
7	R. Panneerselvam - "Operations Research", PHI
8	A.M. Natarajan, P. Balasubramani and A. Tamilarasi - "Operations Research", Pearson
9	M. V. Durga Prasad – "Operations Research", CENGAGE Learning
10	J. K. Sharma - "Operations Research", Macmillan Publishing Company

Open Elective -II

Subject Code	Subject Name	Offered by
OE-HU701B	Human Resource Development and Organizational Behavior	MSH Department
OE-HU701D	Time Series Analysis and Forecasting	MSH Department
OE-IT701A	Introduction to Bioinformatics	IT Department
OE-IT701B	Cyber Law and Security Policy	IT Department

Course Name:	**Human Resource Development and Organizational Behaviour**		
Course Code:	OE-HU 701B	**Category:**	Open Elective Courses
Semester:	7th	**Credit:**	3
L-T-P:	3-0-0	**Pre-Requisites:**	To know the existence of an organization as a place for human livelihood
Full Marks:	100		
Examination Scheme:	Semester Examination: 70	Continuous Assessment: 25	Attendance: 05

Course Objectives:	
1	To help the students to develop cognizance of the importance of human behavior and how to align it with basic organizational theories.
2	To enable students to describe how people behave under different conditions and understand why people behave as they do.
3	To provide the students to analyze specific strategic human resources demands for future action.
4	To enable students to synthesize related information and evaluate options for the most logical and optimal solution such that they would be able to predict and control human behaviour and improve results.

Course Contents:		
Module No.	**Description of Topic**	**Contact Hrs.**
1.	**Introduction of Human Resource Development:** Human aspect of management, Human Relations; Human Resource Management- Concept, Scope and Importance; Competencies of HR Manager, Human Resource Planning, Job Analysis, and Job Design: Job analysis; Job description and specifications; Job design; Job characteristic approach to job design.	5
2.	**Recruitment, Selection, Training, and Development:** Factors affecting recruitment; Sources of recruitment (internal and external); Basic selection model; Psychological tests for selection; Interviewing; Placement and Induction; Job Changes- Transfers, Promotions, and Separations; An overview of Training and Development; Emerging trends in Recruitment, Selection, and development.	5

3.	**Performance Appraisal, and Audit: Performance Appraisal:** Concept, Objectives and Methods; Traditional and Modern Methods- MBO, 360 Degree Appraisal, Behaviourally Anchored Rating Scale, Potential Appraisal, Human Resource Audit.	4
4.	**Introduction of Organizational Behavior** : Introduction, definition, historical development, An OB model; contributing disciplines, challenges and opportunities. Personality: Meaning, formation, determinants, traits of personality, big five and MBTI, personality attributes influencing OB. Attitude: Formation, components of attitudes, relation between attitude and behavior. Learning; Perception: Process of perception, factors influencing perception, link between perception and individual decision-making; Transactional Analysis: An Introduction to Transactional Analysis; Johari window.	6
5	**Group Dynamics and Team Development**: Group dynamics -definition and importance, types of groups, group formation, group development, group composition, group performance factors; Principle-centered-approach to team development	4
6.	**Motivation**: Meaning, theories of motivation-needs theory, two factor theory, Theory X and Y, application of motivational theories. Job satisfaction. Case Study analysis. **Leadership**: Meaning, styles of leadership, leadership theories, trait theory, behavioral theories, managerial grid, situational theories.	6
7.	**Power and Authority**: Definition of Power –Types of Power; Power and Politics in Organization; Organizational Stress; Conflict: Nature of Conflict & Conflict Resolution; Case Study Analysis	3
8.	**Organizational Change and Development**: Planned Change & OB Techniques; Organizational Development; Organizational Culture: Meaning & Definition, Contemporary Models of Culture and Organizational Effectiveness; Cross Cultural Management	3
		36L

Course Outcomes:	
After completion of the course, students will be able to:	
1	Demonstrate the applicability of the concept of organizational behavior to understand the behavior of people in the organization
2	Demonstrate the applicability of analyzing the complexities associated with management of individual behavior in the organization.
3	Analyze the complexities associated with management of the group behavior in the organization
4	Demonstrate how the organizational behavior can integrate in understanding the motivation (why) behind behavior of people in the organization.

Learning Resources:	
1.	D'Cenzo, David A., Stephen P. Robbins, and Susan L. Verhulst, Human Resource Management, John Wiley and Sons, New Delhi
2.	Saiyadain, Mirza S., Human Resource Management, Tata McGraw-Hill Pub. Co. Ltd., New Delhi.
3.	Robbins, S.P. Judge, T.A. & Sanghi, S.: Organizational Behaviour, Pearson
4.	Luthans, Fred: Organizational Behaviour, McGraw Hill
5.	Newstrom J.W. &Devis K.: Organizational Behavior, McGraw Hill
6.	Aswathappa, K : Organisational Behaviour ,Himalaya Publishing House
7.	Shukla, Madhukar : Understanding Organizations – Organizational Theory & Practice in India, Prentice Hall
8.	Sekharan, Uma: Organisational Behaviour , The McGraw –Hill Companies

Course Name:	**Time Series Analysis and Forecasting**		
Course Code:	OE-HU701D	**Category:**	Business Analytics
Semester:	7th	**Credit:**	3
L-T-P:	3-0-0	**Pre-Requisites:**	Statistics & Quantitative Techniques
Full Marks:	100		
Examination Scheme:	Semester Examination: 70	Continuous Assessment: 25	Attendance: 05

Course Objectives:	
1.	Students master the framework of business forecasting
2.	Students master the use of Excel & SPSS for analyzing the data
3.	Students apply the forecasting methods to evaluate the variables of interest
4.	Students use the result to make the suggestion in the business and economic contexts

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1	Introduction to Business Forecasting, Overview of the forecast, Review of Statistics, Linear Regression Model; Experiment	4
2	Introduction to Forecasting with Regression Methods, RMSE and Coefficient of Determination,Introduction to Multiple Regression , Statistical Inference in Multiple Regression;)Multiple Linear Regression Model ii)Time Series Regression experiment	7
3	Comparative Analysis Using Regression ,Variable Selection in Multiple Regression, Model Selection in Regression, Checking Regression Models ,Autocorrelation in Regression	5
4	Introduction of Time Series : Some representative Time series, Terminology, Objective of Time Series, Approaches to Time Series, Types of Variation, Trend and Seasonal Variation;i)Modeling and Forecasting Trend experiment ii)Modeling and Forecasting Seasonality experiment	7
5	Time-Series Decomposition and Box-Jenkins (ARIMA)Types of Forecasting Models Concept of Auto correlation and correlogram ,Stationary process ; Decomposition of Different Time Series Component with some example. Checking the Stationary with Different methods [Dicky Fuller Test, Kwiatkowski–Phillips–Schmidt– and etc]	7
6	Identification of ARMA models, ARIMA Models, ARIMA Models Identification, Building better models from ARIMA Concept of Unit root test and Inevertibilty.	4

7	Parameter Estimation and Diagnostic checking, Forecast using ARIMA models, Modeling Seasonal Data ,Intervention Analysis	4
Total		**38L**

Course Outcomes:	
After completion of the course, students will be able to:	
1.	Organize Relevant data with Statistical methods and Experimentation.
2.	Implement the forecasting methods using Time Series, Regression analysis for stationary and non-stationary observations.
3.	Implement the Forecasting using ARIMA and ARMA model formulation.
4.	Infer the different results obtained from modelling and experimentation valid for parametric and non-parametric estimation techniques.

Learning Resources:	
1	"Forecasting and Time Series", 4th Edition, by Bowerman and O'Connell, Duxbury
2	Francis X. Diebold, *Elements of Forecasting,* 4th Edition, South-western Cengage Learning, 2007
3	J. Holton Wilson and Barry Keating, *Business Forecasting with ForecastX™,* 6th Edition McGraw Irwin, John Galt Solutions, Inc.
4	Introductory Time Series PAUL S.P. Cowpertwait . Andrew V. Metcalfe Springer
5	The Analysis of Time Series An Introduction[Sixth Edition] Chris Chatfield CHAPMAN & HALL/CRC
6	Shumway, R.H. and D.S. Stoffer, Time Series Analysis and Its Applications, SpringerVerlag, New York, 2000.
7	West, M. and J. Harrison, Baysian Forecasting and Dynamic Models, Second Edition, Springer-Verlag, New York, 1997.

Course Name:	**Introduction to Bioinformatics**		
Course Code:	OE-IT701A	**Category:**	Open Elective Courses
Semester:	7th	**Credit:**	3
L-T-P:	3-0-0	**Pre-Requisites:**	Basic Knowledge of Biology & Database
Full Marks:	100		
Examination Scheme:	Semester Examination: 70	Continuous Assessment: 25	Attendance: 05

Course Objectives:	
1	To exposed to the need for Bioinformatics technologies.
2	To be familiar with the modeling techniques.
3	To exposed to Pattern Matching and Visualization.

Course Contents:		
Module No.	**Description of Topic**	**Contact Hrs.**
1	**Introduction:** Need for Bioinformatics technologies – Overview of Bioinformatics technologies Structural bioinformatics – Data format and processing – Secondary resources and applications – Role of Structural bioinformatics – Biological Data Integration System.	8L
2	**Introduction to Molecular Biology:** Concepts of Cell, tissue, types of cell, components of cell, organelle. Functions of different organelles. Concepts of DNA: Basic Structure of DNA; Double Helix structure; Watson and crick model. Exons and Introns and Gene Concept. Concepts of RNA : Basic structure, Difference between RNA and DNA. Types of RNA. Concept of Protein: Basic components and structure. Introduction to Central Dogma: Transcription and Translation Introduction to Metabolic Pathways	12L
3	**Sequence Databases:** Introduction to Bioinformatics. Recent challenges in Bioinformatics. Protein Sequence Databases, DNA sequence databases. sequence database search programs like BLAST and FASTA. NCBI different modules: GenBank; OMIM, Taxonomy browser, PubMed.	12L
4	**DNA Mapping and Assembly:** Size of Human DNA, Copying DNA: Polymerase Chain Reaction (PCR), Hybridization and Microarrays, Cutting DNA into Fragments, Sequencing Short DNA Molecules, Mapping Long DNA Molecules. DeBruijn Graph. Sequence Alignment: Introduction, local and global alignment, pair wise and multiple alignment, Dynamic Programming Concept. Alignment algorithms: Needleman and Wunsch algorithm, Smith-Waterman.	6L
Total		**38L**

Course Outcomes:	
After completion of the course, students will be able to:	
1	Develop models for biological data
2	Apply pattern matching techniques to bioinformatics data – protein data genomic data
3	Apply microarray technology for genomic expression study

Learning Resources:	
1	Bioinformatics Technologies by Yi-Ping Phoebe Chen (Ed). First Indian Reprint, Springer Verlag, 2007
2	Bio Informatics Computing by Bryan Bergeron, Pearson Education
3	Introduction to Bioinformatics by Arthur M Lesk Oxford University Press
4	Bioinformatics for Beginners by Supratim Chaudhury Elsevier.
5	Bioinformatics Algorithms: An Active Learning Approach, Volume 1 by Phillip Campeau Active Learning Publishers
6	Algorithms in Bioinformatics: A Practical Introduction by Wing-Kin Sung CRC Press

Course Name:	**Cyber Law and Security Policy**		
Course Code:	OE-IT 701B	**Category:**	Open Elective-II
Semester:	7th	**Credit:**	3
L-T-P:	3-0-0	**Pre-Requisites:**	
Full Marks:	100		
Examination Scheme:	Semester Examination: 70	Continuous Assessment: 25	Attendance: 05

Course Objectives:	
1	To familiarize with the basic terminology related to cybercrime and cyber security.
2	To familiarize with the security challenges faced by mobile devices.
3	To describe the Tools and Methods used in cybercrime.
4	To impart knowledge of cyber forensic evidence gathering and report generation
5	To motivate to analyze cybercrime, its ethical issues and apply different sections of Indian IT Act on it.

Course Contents:		
Module No.	**Description of Topic**	**Contact Hrs.**
1	1A: Introduction of Cybercrime & Cyber Security: Importance and challenges Cyberspace, Cyber threats, Hacking, Types of cybercrime and cyber criminals. 1B: Steps and categories of Cybercrime: Planning of attacks, social engineering, passive attack, Active attacks, cyber-stalking, Phishing methods, ID Theft and consequences.	5 5
2	Cybercrime Mobile & Wireless devices: Security challenges posted by mobile devices, cryptographic security for mobile devices, Attacks on mobile/cell phones, Different viruses, Worms, Trojans, Backdoor attacks on laptops and other devices.	5
3	Tools and Methods used in Cyber crime: Proxy servers, password checking, Random checking, Trojan Horses and Backdoors, DOS & DDOS attacks, SQL injection, buffer over flow.	5
4	Cyber Forensics: Introduction to Cyber Forensics, Computer Equipment and associated storage media, Role of forensics Investigator, Forensics Investigation Process and Collecting Network based Evidence. Writing Computer Forensics Reports.	8
5	Cyber Laws: Legal aspects, Indian IT Act, its subsections and case studies, Computer Offences and its penalty under IT Act 2000. Cyber Ethics, Software piracy, Intellectual Property Rights in Cyberspace.	6 2
Total		**36L**

Course Outcomes:	
After completion of the course, students will be able to:	
1	Recall the basic terminology related to cybercrime and cyber security.
2	Identify the security challenges faced by mobile devices.
3	Describe the tools and methods used in cybercrime.
4	Explain steps of cyber forensic evidence gathering and report generation.
5	Use different sections of Indian IT Act on cybercrimes.

Learning Resources:	
1	Cyber Security, Nina Gobole & Sunit Belapune; Pub: Wiley India.
2	Information Security and Cyber Laws, Pankaj Agarwal
3	Information Security & Cyber Laws, Gupta & Gupta, Khanna Publishing House, (AICTE Recommended Textbook- 2018)
4	Computer and Cyber Security ,Principles, Algorithm, Applications, and Perspectives Edited by Brij B. Gupta , Taylor & Francis Group , 2019