Indian Institute of Technology Jodhpur

# 2nd year B.Tech Computer Science & Engineering
# Curriculum Structure
# August 2020

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## 1. Introduction

Traditional curriculum in Computer Science and Engineering (CSE) has focused on two major areas, i.e., theory and systems (database, computer hardware, and operating systems). With the advent of the era of Edge Computing, Cloud Computing, Security, AI and Big Data, the discipline is being transformed by the incorporation of new emerging technologies. The discipline is becoming instrumental in solving major real-world problems faced by modern society such as healthcare, security, sustainability, and socio-economic challenges. There is a need to revamp the B.Tech program in CSE so as to prepare students to tackle problems which are fundamentally multidisciplinary in nature. This would improve IIT Jodhpur's participation and contribution towards providing solutions for global challenges. IIT Jodhpur can become a leading source of technology solutions for self-reliant India.

## 2. Objectives of the Program

The objective of the B.Tech. program in Computer Science and Engineering (CSE) at IIT Jodhpur is to equip students to undertake careers involving challenges of working on real-world problems, while innovating with their core competency in computer science. The curriculum gives due importance to the foundational aspects of computer science, as well as develops in students the necessary engineering skills for addressing emerging technological challenges. The program offers flexibility in choosing elective courses for widening the understanding of emerging concepts and processes in different domains. Students can opt for specializations which provide a coherent and increasingly sophisticated understanding so as to enable them to pursue preferred career opportunities. The program will produce a well prepared and well-motivated workforce to undertake careers in research and industry involving innovation, knowledge creation, engineering, and entrepreneurship.

## 3. Expected Graduate Attributes

After completing this program, a student will be able to develop an ability to:

1. Apply appropriate knowledge in Computer Science and Engineering to identify, formulate, analyze, and solve complex engineering problems in order to reach substantive conclusions.
2. Self-learn and engage in use of advanced computing tools.
3. Develop sustainable computing solutions in broader economic, societal and environmental contexts.
4. Think critically, creatively and analytically as a computer scientist, whilst being able to work effectively, independently and collaboratively as part of a team in research, technology development and entrepreneurial ventures.
5. Apply evolving ethics and privacy laws across various domains and territories.
6. Effectively communicate engineering concepts and ideas to peers in written or oral forms.
7. Be motivated to engage in independent and life-long learning in the broadest context of evolving technological challenges.

## 4. Learning Outcomes

The student will have the ability to:

1. Abstract out computational models based on mathematical rigor.
2. Critically analyse and appreciate emerging and applied fields of computer science owing to deeper understanding and strong foundations in theoretical computer science.
3. Develop robust, secure, and efficient software systems that would involve software engineering, data structures, and algorithm design paradigms.
4. Apply different concepts including digital design, computer architecture, operating systems, databases, networking, and applications for building solutions for real-world problems.
5. Design and implement smart, intelligent, and user friendly interfaces for computer applications.
6. Analyse, design, develop and deploy computer based systems in collaboration with domain experts for meeting societal needs in areas such as healthcare, safety, environment, law enforcement, transportation, etc., by exploiting tools and techniques of Big data, AI and project management.
7. Become proficient in some of the specialized areas such as Computer Vision, Augmented Reality, Internet of Things, Natural Language Understanding, and Intelligent Communication.

8. Communicate effectively by comprehending, documenting, making effective presentations and exchanging clear instructions.

## 5. New Skill Sets Targeted

1. Designing user-centric human-machine interfaces
2. Designing end-to-end socio-digital reality systems
3. Developing sustainable computing solutions
4. Building secure, intelligent, and trustable systems
5. Designing and synthesizing digital systems for solving industrial problems

## 6. Topic Clouds and Mapping of Topic Clouds with Proposed Courses

**Table 1**. Topics and Mapping of Topic with Courses

| **Area** | **Topics** | **Category (Core/ Techniques Technology/ Systems)** | **Course (IE/IS/ PC/PE)** |
|---|---|---|---|
| Theory and Algorithms | Computing Paradigms, Syntax, Semantics Specification, Attribute Grammar, Imperative Programming, Procedures, Modules, Object-oriented Programming, Abstraction, Encapsulation, Reuse, Functional Programming, Polymorphic Data Types, Recursion, Lambda Calculus, Logic Programming, Horn Clauses, Backtracking, Concurrent Programming, Synchronization, Multithreads | Core | Principles of Programming Languages (PC) |
| | Abstract Data Types, Linear Data Structures, Non Linear Data Structures, Stack, Queue, Link List, Heap, Sorting, Hashing, Algorithm Analysis, Graph, Tree | Core | Data Structures and Algorithms (PC) |
| | Complexity Analysis, Divide-and-conquer, Greedy Algorithms, Dynamic Programming, Linear Programming, Universal Hashing, Approximation Algorithms, Randomized Algorithms | Core | Design and Analysis of Algorithms (PC) |
| | Discrete Structures, Logics, Set, Graph and Trees, Deterministic Finite Automata, Non-deterministic Finite Automata, PushDown Automata, Context Free Grammar, Turing Machine, Lexical and Syntax Analysis, Parsing | Core | Maths for Computing (PC) |
| | Computability, Decision Trees and Communication Complexity, Time Complexity, Space Complexity, Complexity of Counting and Randomization | Core | Theory of Computation (PE) |
| | Graph algorithms, Directed and Undirected graph, Planar graph, Graph coloring, Hamiltonion and Eulorian graph, Bipartite graphs, Trees. | Core | Graph Theoretic Algorithms (PC Bouquet) |
| | NP-Hard problems, Bounded Search Tree, Iterative Compression, Randomized Methods, Kernelization, Sunflower Lemma, Crown Decomposition, Expansion Lemma, Intractability | Core | Parameterized Complexity (PC Bouquet) |

| | | | |
|---|---|---|---|
| | Persistence DS, Retroactive DS, Geometric DS, DS for Moving Data, Dynamic Optimality, Cache-oblivious DS, van Emde Boas, Sketching, String DS, Low Memory DS, Dynamic Graphs | Core and Techniques | Advanced Data Structures (PE) |
| | Euclidean TSP, Metric TSP, FPTAS, PTAS, Primal-Dual Schema, Dual Fitting, Embeddings, Sparsest Cut, Random Hyperplanes, Hashing, Makespan | Techniques | Approximatio n Algorithms (PE) |
| | Randomized Complexity Classes, Probabilistic Analysis, Markov Chain, Random Walk, Randomized Graph Algorithms, Randomized Sorting and Searching, Markov, Chebyshev, Chernoff | Techniques | Randomized Algorithms (PE) |
| | Computational Model and Complexity Classes, NP, NP Completeness, Complexity Issues in Cryptography, Lower Bounds, Algebraic Computational Model, Levin's Theory, Hardness Amplification, Logic in complexity theory, Circuit Lower Bounds | Core | Complexity Theory (PE) |
| | Complex Numbers, Complex Vector Spaces, Quantum Algorithms, Quantum Programming Languages, Quantum Cryptography, Quantum Information Theory, Deutsch's Algorithm, Simon's Periodicity Algorithm, Grover's Search Algorithm, The Deutsch–Jozsa Algorithm, Shor's Factoring Algorithm, Quantum Assembly Programming, Quantum Key Exchange, Quantum Teleportation, von Neumann Entropy | Core | Quantum Computing (PE) |
| | Streaming Algorithms, Stream mining using Clustering, Massive Data Clustering, Data Stream Classification, Distributed Mining of Streaming Data, Change Diagnosis, Forecasting on Stream, Dimensionality Reduction for Streaming data. | Core and Technique | Stream Analytics (PE) |
| Hardware | Introduction to HDL, Design flow, Number representation, Arithmetic circuits, Design and Analysis of Synchronous circuits, Design of Finite State Machines, CMOS Technology, Programmable Logic Devices, CAD | Core | Digital Design (PC) |
| | CPU, Memory, Processor, Instruction set Architecture, I/O, ALU, Bus Architecture, Cache management, Performance | Core | Computer Architecture (PC) |
| | Embedded system design, Architectures of embedded processors, Hardware-Software Co-design, ARM Cortex M3, Programming for Embedded Systems, Real time OS, Distributed Embedded Architectures, Real time scheduling algorithms, Multi-rate systems | Systems | Embedded Systems (PC Bouquet) |
| | VLSI design flow, hardware modelling principles, hardware description, Behavioural synthesis, logic optimization and synthesis, Chip architectures, standard cells and FPGA, Synthesis tools, layout synthesis | Technique | High-level Synthesis (PE) |

| | | | |
|---|---|---|---|
| Systems | Processes Management, Process Coordination, Deadlock, Memory Management, Storage Management, Protection and Security | Core | Operating Systems (PC) |
| | Database Architectures, Data Granularity, ER Model, EER Model, Relational Model, Relational Algebra, Relational Calculus, SQL, Schema, Query, Data Definition, Data Manipulation, Data Retrieval, Views, Normalization, Functional Dependency, Transactions, Schedules, ACID Properties, Concurrency Control, Recoverability, Serializability, Deadlock Prevention, Locking Protocols, Timestamp Protocols, Deadlock Detection, Recovery Protocols, Query Optimization, Hashing, Indexing | Core | Database Systems (PC) |
| | Software Development Life Cycle, Software Engineering Process Model, Software Design, UML, Design Pattern, Project Management, Cost Analysis, UI Design, Service Oriented Architecture, Software Quality, Risk Analysis, Agile Methodologies, Software Architecture | Core | Software Engineering (PC) |
| | Software Testing, Quality Engineering, Testing Process, Automatic Testing, Unit Testing, Defect Prevention, Process Improvement, Quantifiable Quality Improvement, Quality Model and Measurements, Defect Classification, Reliability Engineering | Techniques | Software Testing and Quality Assurance (PE) |
| | Distributed Systems, Centralized Systems, Data Transparency, Data Fragmentation, Data Allocation, Security, Semantic Integrity, Query Decomposition, Query Localization, Query Ordering, Query Optimization, Transaction Management, Concurrency Control, Deadlock Management, Reliability, Recovery Protocols | Systems | Distributed Database Systems (PE) |
| | Fog Computing, Internet of Things and Analytics, Edge Computing, Distributed computing and system design, architecture, contemporary cloud framework, distributed data & processing management, middleware design issues and challenges, Edge & Fog for AI-driven applications | Systems | Edge and Fog Computing (PE) |
| | Concurrency, events & ordering, distributed file systems, distributed disk management, fault tolerance, microkernel, operating system kernel | Systems | Distributed Systems (PE) |
| | Understanding Software & Evolution, Software Maintenance, Software Reuse, Reverse engineering levels & techniques | Systems | Software Maintenance (PE) |
| Network and Security | Cyber Security Vulnerabilities and Cyber Security Safeguards, Securing Web Application, Services and Servers, Intrusion Detection and Prevention, Firewalls, Cyberspace and the Law, Cyber Forensics | Core | Cyber Security (PC) |
| | OSI reference model, Packet switching techniques, Performance metrics, Socket programming, Email, FTP, Telnet, SSH, DNS, TCP, UDP, Transmission, Flow and Congestion Control, Tunneling, Internet Protocol and its operation, Routing algorithms, ICMP, ARP, RARP, DHCP, IPv6, RIP, | Core | Computer Networks (PC) |

| | | | |
|---|---|---|---|
| | OSPF, Advanced Internetworking, Multicast routing, framing, medium access mechanism, Public key and private key cryptography, Firewalls, SDN Overview. | | |
| | Overview about MANETs, VANETs, WSNs and WMNs, Modulation techniques at PHY layer, Fading mitigation techniques, MAC protocols for MANETs, Error correcting codes, distributed wireless routing algorithms, transport level mobility management, 5G overview, LPWAN, Bluetooth | Systems | Introduction to Wireless Ad hoc Network (PE) |
| | Digital Trust, Digital Asset, Digital Transactions, Distributed Ledger Technology, Digital Signature, Cryptocurrency, Bitcoin, Hyperledger, Ethereum Interaction, Blockchain-as-a-service, Blockchain Use Cases, Blockchain Security | Technology | Introduction to Blockchain (PE) |
| | Cooperative Vehicular Safety Applications, Vehicular Mobility Modeling, Physical Layer Considerations for Vehicular Communications, MAC Layer of Vehicular Communication Networks, VANET Routing protocols, Emerging VANET Applications, Standards and Regulations | Systems | Vehicular Ad-Hoc Networks (PE) |
| | Overview of wireless systems, Multiplexing, Link adaptation, Multihop routing protocols, Mobility and Handoff management, Cellular Technologies, Overview of LTE and 5G Cellular Networks, 5G Architecture, RAN and dynamic CRAN, Mobility management and Network slicing in 5G, Pervasive computing, Context aware sensor networks, Localization, Android architecture and Overview, Body area networks | Technology | Mobile and Pervasive Computing (PE) |
| | 4G LTE networks, From 4G to 5G, 5G overview, core, signalling, 5G mobile edge and fog computing, application, 5G vs mm-wave WiFi, India's 5G policy and vision, 6G vision, paper discussions | Technology | 5G Mobile Networks (PE) |
| | Networking basics, switching architecture, SDN architectures, OpenFlow, Network function virtualization, Emerging SDN models, Data center networking | Core | Software Defined Networks (PE) |
| | Basic symmetric-key encryption, Message integrity, Public key cryptography, Digital signatures ,Protocols | Core | Cryptography and Network security (PE) |
| Applications | Bayes Decision Theory, Regression, Bias variance, Maximum Likelihood Estimation, Bayesian Parameter Estimation, Decision Tree, Random Forest, Artificial Neural Network, Clustering, k-means, SVM, Feature Selection, Dimensionality Reduction | Core and Technique | Pattern Recognition and Machine Learning (PC) |
| | Uninformed Search Strategies, Informed Search Strategies, Local Search Algorithms, Hill Climbing, Constraint Satisfaction Problems, Backtracking, Adversarial Search, Min-Max algorithms, Propositional Logic, Reasoning Patterns, First-order logic, Syntax, Semantics, Q-value, Policy, | Technique | Artificial Intelligence (PE) |

| | | | |
|---|---|---|---|
| | Search Engine Architecture, Retrieval Models, Performance Evaluation, Text Categorization, Text Clustering, Web Information Retrieval, Structured Document Retrieval | Techniques | Information Retrieval (PE) |
| | Visual World, Geometry, Lights and Optics, Tracking, Motion, Depth, Devices and tools | Technique | Introduction to AR and VR (PE) |
| | Geometric primitives, Clipping, Viewing, Rendering, Animation, Shading, Coloring, OpenGL | Technique | Computer Graphics (PE) |
| | Eye and early vision, Reasoning systems, Late vision, visual attention, Cognitive architectures, Knowledge representation and learning, Neural networks for vision, Applications in vision tasks | Technique | Principles of Biological Vision and Applications (PE) |
| | Image formation and transformations, Camera calibration, Image restoration, Spatial and Wavelet-based processing, Epipolar Geometry, SfM, Optical flow, Key-point detection, Feature description and matching, Deep learning for vision, Applications | Technique | Computer Vision (PE) |
| | Data storage methods, data access methods, analysis, representation, visualization, visual storytelling, Dashboard, Infographics | Technique | Data Visualization (PE) |
| | Neural Networks, Gradient Descent, Optimization, Regularization, Autoencoder, Convolutional Neural Network, Recurrent Neural Network, LSTM, Deep Generative Models, Generative Adversarial Network (GAN), Deep Belief Network, Deep Convolutional GAN, Variational Autoencoder, Representation Learning, Unsupervised Pre-training, Transfer Learning, Distributed Representation, Domain Adaptation, Neural Language Model, Adversarial Learning | Technique | Deep Learning (PE) |
| | Kernel Machines, Variants of Support Vector Machines, PAC Theory, Boosting, Graphical Models, Structural Predictions, Deep Reinforcement Learning, Space Coding | Core and Technique | Advanced Machine Learning (PE) |
| | Decision-making, Utility Theory, Utility Functions, Decision Networks, Sequential Decision Problems, Partially Observable MDP, Game Theory, Reinforcement Learning, Generalization, Policy Search, Hidden Markov Model, Kalman Filter, Knowledge Representation, Ontological Engineering, Situation Calculus, Semantic Networks, Description Logic, Planning graphs, Partial-order Planning, Conditional Planning, Continuous Planning, Multi-agent Planning, Hierarchical Task Network Planning, Non-deterministic Domains | Core | Advanced Artificial Intelligence (PE) |
| | Neuromorphic Engineering, Neuroanatomy of human brain, Neuron models, Plasticity rules, Learning rules, Spiking Neural Networks (SNN), Nanodevices for Neuron Implementation, Synaptic emulation, Electronic synapses, Digital/Analog neuromorphic VLSI, Hardware implementation of synaptic circuits, Synaptic programming | Technique | Neuromorphic Design and Computing (PE) |

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|---|---|---|---|
| | Accuracy-explainability tradeoff, Interpretability problem, Predictability, Transparency, Traceability, Causality, Reasoning, Attention and Saliency, Interpretable AI, Prediction Consistency, Adversarial Robustness, Trustworthy AI, Integrity, Reproducibility, Accountability, Bias-free AI, Ethics in AI | Technique | Dependable Artificial Intelligence (PE) |
| | Fuzzy Computing, Fuzzy Systems, Neural Computing, Genetic Algorithms, Rough Sets, Knowledge Representations, Fuzzification, Defuzzification, Swarm Intelligence, Hybrid Models, Neuro-fuzzy systems, Rough-neural computing | Technique | Soft Computing Techniques (PE) |
| | Biological Signals, Biomedical Imaging Modalities, ECG, NMR spectroscopy, electron microscopy, MRI, and X-Ray Images, Visualization, Reconstruction, Restoration, Clustering, Graph Partitioning, Deep Learning for Bio-image | Technique | Bio-image Computing (PE) |
| | Biometric Devices, Biometric System Design, Biometric Data Analysis, Face Recognition, Fingerprint Matching, Signature Authentication, Biometric | Technique | Advanced Biometrics (PE) |
| | Computational complexity of AI models, Prediction accuracy, Numeric accuracy, Precision, Memory footprints, Edge AI, Memory Optimization of Models, Hardware accelerators for Edge AI, Vision Processing Unit, Streaming Hybrid Architecture Vector Engine, Open Neural Network Exchange | Systems and Technique | Resource-Constrained Artificial Intelligence (PE) |
| | Word representation, NLP tasks, Seq2Seq model, Question Answering, Sentiment Analysis, Dialogue system, Machine Translation, natural language generation Interpretability, Knowledge Graphs. | Technique | Natural Language Understanding (PE) |
| | Spoken language technology, dialog and conversational systems, automatic speech recognition, speech synthesis, affect detection, dialogue management. | Techniques | Speech Understanding (PE) |
| | Graphs, Network Models, Network Data Generation, Structural Properties, Link Prediction, Community Detection, Information Cascade, Small World Phenomenon, Homophily, Structural Balance, Components, Network Evolution, Multi-layer network | Technique | Social Networks (PE) |

## 7. Course Categories, Credit Distribution and Credit Structure of B.Tech. Programmes

**Table 2.** Proposed Course Categories and credit distribution in the proposed B.Tech. Programmes

| S.N. | Course Type | Course Category | Regular B.Tech. | | Double B.Tech. | |
|---|---|---|---|---|---|---|
| | | | Credit | Total | Credit | Total |
| 1 | Institute Core (I) | Engineering (IE) | 34 | 69 | 34 | 59 |
| | | Science (IS) | 16 | | 16 | |
| | | Humanities (IH) | 12 | | 9 | |
| 2 | Programme Linked (L) | Science (LS) | 7 | | 0 | |
| 3 | Programme Core (P) | Programme Compulsory (PC) | 51 | 71 | 51 | 71 |
| | | Programme Electives (PE) | 17 | | 17 | |
| | | B.Tech. Project (PP) | 3 | | 3 | |
| 4 | Open (O) | Open Electives (OE) | 10 | 10 | 0 | 0 |
| 5 | Engineering Science (E) | Engineering Science Core (EC) | 0 | 0 | 22 | 22 |
| | | Engineering Science Elective (EE) | 0 | 0 | 8 | 8 |
| **Total Graded** | | | | **150** | | **160** |
| 6 | Non-Graded (N) | Humanities (NH) | 6 | 15 | 6 | 15 |
| | | Engineering (NE) | 3 | | 3 | |
| | | Design/Practical Experience (ND) | 6 | | 6 | |
| **Total Graded + Non-Graded** | | | | **165** | | **175** |

## 8. Credit Structure of B.Tech. Programmes

**Table 3.** Credit Structure for B.Tech. Programmes (Up 6000 Level)

| Type | L-T-P | Distribution of contact and beyond contact hours | | | Total Credits (TC=TH/3) |
|---|---|---|---|---|---|
| | | Contact Hours (CH) | Beyond Contact Hours (BCH) | Total Hours (TH) | |
| 1 hour of Lecture | 1-0-0 | 1 hr | 2 hr | 3 hr | 1 |
| 1 hour of Tutorial | 0-1-0 | 1 hr | 2 hr | 3hr | 1 |
| 1 hour of Lab/Project | 0-0-1 | 1 hr | 0.5 hr | 1.5 hr | 0.5 |

#Contact hour for a project refers to the involvement of students in the laboratory, discussion, etc.

## 9. List of Programme Compulsory Courses

**Table 4**. Programme Compulsory Courses

| Sr. No | Course Name | LTP | Contact Hours | Credit |
|---|---|---|---|---|
| 1 | Data Structure and Algorithms | 3-0-2 | 5 | 4 |
| 2 | Maths for Computing | 3-1-0 | 4 | 4 |
| 3 | Digital Design | 2-0-2 | 4 | 3 |
| 4 | Human-Machine Interaction | 0-0-4 | 4 | 2 |
| 5 | Software Engineering | 3-0-2 | 5 | 4 |
| 6 | Operating Systems | 3-0-2 | 5 | 4 |
| 7 | Design and Analysis of Algorithms | 3-1-0 | 4 | 4 |
| 8 | Computer Architecture | 3-0-0 | 3 | 3 |
| 9 | Database Systems | 3-0-2 | 5 | 4 |
| 10 | Cyber Security | 3-0-2 | 5 | 4 |
| 11 | Computer Networks | 3-0-3 | 5 | 4.5 |
| 12 | Digital Systems LAB | 0-0-3 | 3 | 1.5 |
| 13 | Principles of Programming Languages | 3-0-0 | 3 | 3 |
| 14a | Randomized Algorithms (B1) | 3-0-0 | 3 | 3 |
| 14b | Approximation Algorithms (B1) | 3-0-0 | 3 | 3 |
| 14c | Distributed Algorithms (B1) | 3-0-0 | 3 | 3 |
| 14d | Optimization (B1) | 3-0-2 | 5 | 4 |
| 15a | VLSI Design (B2) | 3-0-0 | 3 | 3 |
| 15b | High-Level Synthesis (B2) | 3-0-0 | 3 | 3 |
| 15c | Embedded Systems (B2) | 3-0-0 | 3 | 3 |
| | | | **Total** | **51/52** |

## 10. Area-wise Programme Elective Courses

**Table 5**. Stream-wise Programme Electives Courses

| S. No. | Stream | Courses | L-T-P |
|---|---|---|---|
| 1 | Theory and Algorithms | 1. Randomized Algorithms (700)<br>2. Approximation Algorithms (700)<br>3. Complexity Theory (400)<br>4. Advanced Data Structures (400)<br>5. Quantum Computing (400)<br>6. Graph-theoretic Algorithms (700)<br>7. Parameterized Complexity (700)<br>8. Optimization (Math) (400) | 3-0-0 |
| 2 | Hardware | 1. High-level Synthesis (EE/CS)(700)<br>2. Embedded Systems (EE)<br>3. VLSI Design (EE)<br>4. Hardware Software Co-Design (CS) (700) | 3-0-0 |
| 3 | Systems | 1. Software Testing and Quality Assurance (700)<br>2. Distributed Database Systems (700)<br>3. Distributed Systems (2-0-0) (400)<br>4. Mobile and Pervasive Computing (700)<br>5. Virtualization and Cloud Computing (700)<br>6. Compiler Design (700)<br>7. Software Maintenance (400) | 3-0-0<br><br><br><br><br><br>2-0-2 |
| 4 | Network and Security | 1. Introduction to Wireless Ad hoc Network (700)<br>2. 5G Mobile Networks(CS)(700)<br>3. Software Defined Networks (CS)(700)<br>4. Intelligent Radio Networks (EE) (700)<br>5. Data Communication Networks (EE) (300)<br>6. Cryptography and Network Security (CS/EE) (400)<br>7. Introduction to Blockchain (700) | 3-0-0<br><br>2-0-0<br>3-0-2 |
| 5 | AI-ML | 1. Deep Learning (400)<br>2. Artificial Intelligence (400)<br>3. Advanced Machine Learning<br>4. Dependable Artificial Intelligence (400)<br>5. Information Retrieval (700)<br>6. Autonomous Systems (IDRP) (400)<br>7. Ethics, Policy, Law and Regulation in AI (700)<br>8. Planning and Decision making for Robots (IDRP)(700) | 3-0-0 |
| 6 | Speech,Text, and Vision | 1. Natural Language Understanding (700)<br>2. Digital Image Processing (400)<br>3. Computer Vision (400)<br>4. Computer Graphics (400)<br>5. Speech Understanding (700) | 3-0-0 |

| | | | |
|---|---|---|---|
| 7 | Social Computing | 1. Social Computing | 3-0-0 |
| | | 2. Sustainable Computing | 3-0-0 |
| | | 3. ICT for Development | 2-0-0 |
| | | 4. Machine Learning for Epidemiology | 3-0-0 |
| | | 5. Health Informatics | 3-0-0 |
| | | 6. Computational Social Choice | 3-0-0 |
| | | 7. Computational Cognition & Behavior Modelling | 3-0-0 |
| | | 8. Social Networks | 3-0-0 |
| | | 9. Ethics, policy, law and regulations in AI | 0-0-2 |
| | | 10. Crowd-sourcing and human computing | 3-0-0 |
| | | 11. Environmental Informatics | 3-0-0 |
| | | 12. Computational Microeconomics | 3-0-0 |

## 11. Specializations Offered by the Department

**Table 6**. Specializations and courses

| S. No. | Name of Specialization | Specialization Core (8 Credits) | Specialization Elective (12 Credits) |
|---|---|---|---|
| 1. | Visual Computing (CSE, AIDE, EE) | Jointly with EE and AIDE | Jointly with EE and AIDE |
| 2. | Socio-Digital Reality (CS, AIDE, EE) | Jointly with EE and AIDE | Jointly with EE and AIDE |
| 3. | Advanced Algorithms | Advanced Data Structures (3-0-0), Complexity Theory (3-0-0), Algorithms for Big Data (from M.Tech, 2-0-0) | Randomized Algorithms, Approximation Algorithms, Theory of Computation, Distributed Algorithms, Quantum Computing (IDRP), Optimization, Graph Theory and Applications, Parameterized Complexity |
| 4. | Social and Sustainable Computing | Social Computing (3-0-0), Sustainable Computing (3-0-0), ICT for Development (2-0-0) | Machine Learning for Epidemiology (3-0-0), Health Informatics (3-0-0), Computational Social Choice (3-0-0), Computational Cognition & Behavior Modelling (3-0-0), Social Networks (3-0-0), Ethics, Policy, Law and regulations in AI(0-0-2), Crowd-sourcing and human computing (3-0-0), Environmental Informatics (3-0-0), Computational Microeconomics (3-0-0), Project (0-0-6) |
| 5. | Intelligent Communication and Networking (CS, AIDE, EE) | Jointly with EE | Jointly with EE |
| 6. | VLSI Systems (EE, CS) | Jointly with EE | Jointly with EE |

## 12. Curriculum of B.Tech. in Computer Science and Engineering (Direct Entry)

**Table 7.** Curriculum of B.Tech. (Computer Science and Engineering)

| *Cat* | *Course* | *LTP* | *CH* | *NC* | *GC* | *Cat* | *Course* | *LTP* | *CH* | *NC* | *GC* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **I Semester** | | | | | | **II Semester** | | | | |
| IE | Introduction to Electrical Engineering | 3-0-2 | 5 | - | 4 | IE | Engineering Mechanics | 2-1-0 | 3 | - | 3 |
| IE | Introduction to Computer Science | 3-0-2 | 5 | - | 4 | IS | Chemistry | 3-0-0 | 3 | - | 3 |
| IE | Introduction to Bioengineering | 3-0-2 | 5 | - | 4 | IS | Physics | 3-0-0 | 3 | - | 3 |
| | | | | | | IS | Chemistry Lab | 0-0-2 | 2 | - | 1 |
| | | | | | | IS | Physics Lab | 0-0-2 | 2 | - | 1 |
| IS | Mathematics I | 3-1-0 | 4 | - | 4 | IS | Mathematics II | 3-1-0 | 4 | - | 4 |
| IE | Engineering Visualization | 0-0-2 | 2 | - | 1 | IE | Engineering Realization | 0-0-2 | 1 | - | 1 |
| NE | Engineering Design I | 0-0-2 | 2 | 1 | - | NE | Engineering Design II | 0-0-2 | 2 | 1 | - |
| NH | Communication Skill I | 0-0-2 | 2 | 1 | - | NH | Communication Skill II | 0-0-2 | 2 | 1 | - |
| NH | Social Connect and responsibilities I | 0-0-1 | 1 | 0.5 | - | NH | Social Connect and responsibilities II | 0-0-1 | 1 | 0.5 | - |
| NH | Performing Arts I /Sports I | 0-0-1 | 1 | 0.5 | - | NH | Performing Arts II/Sports II | 0-0-1 | 1 | 0.5 | - |
| | **Total** | **12-1-14** | **27** | **3** | **17** | | **Total** | **11-2-12** | **24** | **3** | **16** |
| | **III Semester** | | | | | | **IV Semester** | | | | |
| IS | Probability, Statistics and Stochastic Processes | 3-1-0 | 4 | - | 4 | IE | Materials Science & Engineering (Electronic materials) | 1-0-0 | 1 | - | 1 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| IE | MSE -<br>(i) Energy materials<br>(ii) Computational Material Design | 2X 1-0-0 | 2 | - | 2 | IE | Thermodynamics | 3-1-0 | 4 | - | 4 |
| IE | Signals and Systems | 3-1-0 | 4 | - | 4 | IE | Pattern Recognition and Machine Learning | 3-0-2 | 5 | - | 4 |
| PC | Maths for Computing | 3-1-0 | 4 | | 4 | PC | Software Engineering | 3-0-2 | 5 | | 4 |
| PC | Data Structures and Algorithms | 3-0-2 | 5 | - | 4 | PC | Human-Machine Interaction | 0-0-4 | 4 | | 2 |
| LS | Foundations of Quantum Information Processing (Program Linked Science Elective) | 3-0-0 | 3 | - | 3 | PC | Digital Design | 2-0-2 | 4 | | 3 |
| NE | Intro. To Profession | 0-0-2 | 2 | 1 | | IH | Humanities I | 3-0-0 | 3 | | 3 |
| | **Total** | **17-3-4** | **24** | **1** | **21** | | **Total** | **15-1-10** | **23** | **-** | **21** |
| | **V Semester** | | | | | | **VI Semester** | | | | |
| PC | Design and Analysis of Algorithms | 3-1-0 | 4 | | 4 | PC | Cyber Security | 3-0-2 | 5 | | 4 |
| PC | Computer Architecture | 3-0-0 | 3 | | 3 | PC | Computer Networks | 3-0-3 | 6 | | 4.5 |
| PC | Operating Systems | 3-0-2 | 5 | | 4 | PC | Digital Systems Lab | 0-0-3 | 3 | | 1.5 |
| PC | Principles of Programming Languages | 3-0-0 | 3 | | 3 | PC | **CS Core Bouquet -1 (Algorithms)/ 2 (Hardware)** | 3-0-0 | 3 | | 3 |
| PC | Database Systems | 3-0-2 | 5 | | 4 | | | | | | |
| IH | Humanities II | 3-0-0 | 3 | - | 3 | PE | Programme/Open Elective | 6-0-0 | 6 | | 6 |
| NH | Professional Ethics I | 0-1-0 | | 1 | - | NH | Professional Ethics II | 0-0-2 | | 1 | - |
| | **Total** | **18-2-4** | **23** | **1** | **21** | | **Total** | **15-1-8** | **23** | **1** | **19** |
| | **VII Semester** | | | | | | **VIII Semester** | | | | |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| PP | B. Tech. Project | 0-0-6 | 6 | - | 3 | IH | Humanities IV | 3-0-0 | 3 | - | 3 |
| PC | **CS Core Bouquet-1 (Algorithms)/2 (Hardware)** | 3-0-0 | 3 | | 3 | | | | | | |
| PE / OE | Programme/Open Electives | 6-0-0 | 6 | - | 6 | PE / OE | Programme/Open Electives | 15-0-0 | 15 | - | 15 |
| IH | Humanities III | 3-0-0 | 3 | - | 3 | | | | | | |
| IS | Environmental Science | 2-0-0 | 2 | - | 2 | | | | | | |
| | **Total** | **14-0-6** | **20** | **-** | **17** | | **Total** | **18-0-0** | **18** | **-** | **18** |
| | | | | | | | | | | **Total of Graded Credits** | **-** **150** |
| | | | | | | | | | | **Total of Non-Graded Credits** | **9** **-** |
| | | | | | | | | | | **Non-Graded Design Credits** | **6** **-** |
| | | | | | | | | | | **Grand Total** | **165** |

## 13. Curriculum of Double B.Tech.: B.Tech. in Computer Science and Engineering and B.Tech. in Engineering Science

**Table 8.** Programme structure of Double B.Tech.

| *Cat* | *Course* | *LTP* | *CH* | *NC* | *GC* | *Cat* | *Course* | *LTP* | *CH* | *NC* | *GC* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **I Semester** | | | | | | **II Semester** | | | | |
| **First two semesters same as Table 8a or 8 b<br>33 Graded and 6 non graded credits** | | | | | | | | | | | |
| | **III Semester** | | | | | | **IV Semester** | | | | |
| ES | Probability, Statistics, and Stochastic Processes | 3-1-0 | 4 | - | 4 | IE | Materials Science & Engineering | 3 × 1-0-0 | 3 | - | 3 |
| ES | Modern Physics | 3-0-0 | 3 | - | 3 | ES | Embedded Systems and IoT | 3-0-2 | 5 | - | 4 |
| IE | Thermodynamics | 3-1-0 | 4 | - | 4 | IE | Pattern Recognition and Machine Learning | 3-0-2 | 5 | - | 4 |
| ES | Data Structures and Algorithms | 3-0-2 | 5 | - | 4 | ES | Design of Experiments | 3-0-0 | 3 | - | 3 |
| IE | Signals and Systems | 3-1-0 | 4 | - | 4 | ES | Control Systems | 3-0-2 | 5 | - | 4 |
| NE | Intro. To Profession | 0-0-2 | 2 | 1 | | IH | Humanities I | 3-0-0 | 3 | - | 3 |
| | **Total** | **15-3-4** | **22** | **1** | **19** | | **Total** | **18-0-6** | **24** | **-** | **21** |
| | **V Semester** | | | | | | **VI Semester** | | | | |
| PC | Design and Analysis of Algorithms | 3-1-0 | 4 | | 4 | PC | Cyber Security | 3-0-2 | 5 | | 4 |
| PC | Principles of Programming Languages | 3-0-0 | 3 | | 3 | PC | Computer Networks | 3-0-3 | 6 | | 4.5 |
| PC | Operating Systems | 3-0-2 | 5 | | 4 | PC | Software Engineering | 3-0-2 | 5 | | 4 |
| PC | Database Systems | 3-0-2 | 5 | | 4 | PC | Human-Machine Interaction | 0-0-4 | 4 | | 2 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| PC | Maths for Computing | 3-1-0 | 4 | | 4 | PC | Digital Design | 2-0-2 | 4 | | 3 |
| | | | | | | PC | **CS Core Bouquet - 1 (Algorithms)/ 2 (Hardware)** | 3-0-0 | 3 | | 3 |
| IH | Humanities II | 3-0-0 | 3 | - | 3 | | | | | | |
| N H | Professional Ethics I | 0-1-0 | | 1 | - | N H | Professional Ethics II | 0-1-0 | | 1 | - |
| | **Total** | **18-3-4** | **24** | **1** | **22** | | **Total** | **15-1-14** | **29** | **1** | **20.5** |
| | **VII Semester** | | | | | | **VIII Semester** | | | | |
| PP | B. Tech. Project | 0-0-6 | 6 | - | 3 | PE / ES | Programme/Engineering Science Electives | 17-0-0 | 17 | - | 17 |
| PC | **CS Core Bouquet - 1 (Algorithms)/ 2 (Hardware)** | 3-0-0 | 3 | | 3 | IH | Humanities III | 3-0-0 | 3 | - | 3 |
| PE / OE | Programme/ Engineering Science Electives | 12-0-0 | 12 | - | 12 | PC | Digital Systems Lab | 0-0-3 | 3 | | 1.5 |
| PC | Computer Architecture | 3-0-0 | 3 | | 3 | | | | | | |
| IS | Environmental Science | 2-0-0 | 2 | - | 2 | | | | | | |
| | **Total** | **20-0-6** | **26** | **-** | **23** | | **Total** | **20-0-0** | **20** | **-** | **21.5** |
| | | | | | | | | | **Total Graded Credits** | **-** | **160** |
| | | | | | | | | | **Total of Non-Graded Credits** | **9** | **-** |
| | | | | | | | | | **Non-Graded Design Credits** | **6** | **-** |
| | | | | | | | | | **Grand Total** | **175** | |

**Note:** ES are proposed Engineering Science compulsory courses