
Indian Institute of Technology Jodhpur

PG Course Booklet
Indian Institute of Technology Jodhpur
July 2019



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Indian Institute of Technology Jodhpur

Course Booklet

for

M.Tech. (CSE)

and

Dual degree M.Tech. (CSE) + PhD

Programs

offered by the

**Department of Computer Science and
Engineering**

July 2019

1. Introduction

Traditionally Computer Science and Engineering (CSE) teaching were focusing on two major areas, i.e., theories and systems (database, computer hardware, and operating systems). With the advent of the era of Cloud Computing, Edge Computing, AI and Big Data, the discipline is being transformed by incorporation of new emerging technologies. It is becoming an instrumental tool in solving major problems faced by modern society such as energy, natural disasters, pollution, and water. Through this newly revamped M.Tech and M.Tech-Ph.D dual degree programs in CSE, IIT Jodhpur is making a conscious effort to divulge from the traditional path and planning to reposition itself to become a leading institute in this new genre of Computer Science education.

2. Objectives

This M.Tech and M.Tech-Ph.D dual degree programs in CSE will offer students with deep knowledge of core and applied computer science. Through this programme, a student will learn niche subject areas which are of paramount importance in the modern big data era, such as Computer Systems and Security. This programme is aiming at imparting the necessary breadth and depth to the students for pursuing careers in academics as well as in industry. This programme is aiming at extending undergraduate computing skills with up-to-date and in-depth expertise in specialized areas of Computer Systems and Security.

3. Expected Graduate Attributes

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

1. Understand fundamental concepts and hands-on knowledge of emerging fields in Computer Science.
2. Conceive, Design and Develop state-of-the-art scalable parallel and distributed systems
3. Solve Big data problems through the knowledge of advanced data structures, distributed algorithmic design, analysis, and applications.
4. Design and develop network protocols for Wireless, Sensor, Mobile, and Vehicular networks.
5. Ideate, Implement and Integrate cryptographic, fault tolerant algorithms for large scale distributed systems
6. Understand state-of-the-art hardware platforms for running compute intensive distributed algorithms
7. Ability to understand and apply evolving ethics and privacy laws across various domains and territories.
8. Plan and manage technical projects

4. Learning Outcome

1. Understand the fundamentals of algorithmic complexity, advanced computer architecture, advanced network, and security protocols.
2. Apply appropriate design principles, framework and protocols to develop dependable systems.
3. Demonstrate hands-on knowledge of cutting edge simulation, synthesizing, programming tools.
4. Ability to design and develop system architecture for mobile, cloud, fog, and edge computing.
5. Demonstrate hands-on knowledge of virtualization, data center design and management, and software defined networking.
6. Skills to comprehend and communicate effectively.
7. Apply appropriate project and business management principles and tools for real-world problems.

5. Course Structure for the M.Tech. (CSE) Program and Dual Degree M.Tech. (CSE)+Ph.D. Program

Cat	Code	Course Title	L-T-P	Cr	Cat	Code	Course Title	L-T-P	Cr
I Semester					II Semester				
MC	MAL7xx0	Statistics I Matrix Computation Optimization	1-0-0 1-0-0 1-0-0	3	MC	CSL7xx0	Computer Architecture	3-0-0	3
MC	CSL7xx0	Algorithms for Big Data	2-0-0	2	MC	CSL7xx0	Software and Data Engineering	3-0-0	3
MC	CSL7xx0	Machine Learning I	3-0-0	3	MC	CSL7xx0	Security and its applications	3-0-0	3
MC	CSP7xx0	Data Structures and Practices	0-0-2	1	ME	xxxxx	Program Elective 3	3-0-0	3
ME	xxxxx	Program Elective 1	3-0-0	3	MO	xxxxx	Open Elective 1	3-0-0	3
ME	xxxxx	Program Elective 2	3-0-0	3	NG	xxxxx	Ethics and Professional Life	1-0-0	1
NG		Technical Communication	1-0-0	1					
Total Credits: 16					Total Credits: 16				

*Maths Fractals: Linear Algebra, Probability and Random Processes, Optimization

Cat	Code	Course Title	L-T-P	Cr	Cat	Code	Course Title	L-T-P	Cr
III Semester					IV Semester				
MP	CSD7xx0	Major Project – Part 1	0-0-10	5	MP	CSD8xx0	Major Project – Part 2	0-0-22	11
ME	xxxxx	Program Elective 4	3-0-0	3	ME	xxxxx	Program Elective 6	3-0-0	3
ME	xxxxx	Program Elective 5	3-0-0	3	NG	xxxxx	Intellectual Property	1-0-0	1
MO	xxxxx	Open Elective – 2	3-0-0	3					
NG	xxxxx	System Design	1-0-0	1					
Total Credits: 15					Total Credits: 15				

Credit Distribution		
1	Program Core	18 credits
2	Program Electives	18 credits
3	Open Electives	6 credits
4	Project	16 credits
5	Non-graded	4 credits
Total		62 credits

6. Program Electives for M.Tech. (CSE) and Dual Degree M.Tech. (CSE)+Ph.D. Program

Courses offered by Department of Computer Science and Engineering

1. Advanced Computer Graphics
2. AI for Finance
3. Artificial Intelligence I
4. Artificial Intelligence II
5. Bio-image computing
6. Block chain
7. Computer Vision
8. Computational Optimization
9. Data Visualization
10. Dependable AI
11. Digital Image Analysis
12. Edge and Fog Computing
13. Embedded Systems
14. GPU Programming
15. Graph Theory and Applications
16. Human Machine Interface
17. Information Retrieval and Web Mining
18. Introduction to Augmented Reality and Virtual Reality
19. Machine Learning II
20. Machine Learning with Big Data
21. Natural Language Processing
22. Neuromorphic Computing and Design
23. Real time Autonomous Systems
24. Ad hoc Wireless Networks
25. Selected Topics in Artificial Intelligence - I
26. Selected Topics in Artificial Intelligence - II
27. Selected Topics in Artificial Intelligence - III
28. Selected Topics in Computer Science - I
29. Selected Topics in Computer Science - II
30. Selected Topics in Computer Science - III
31. Social Network Analysis
32. Speech processing
33. Stream Analytics
34. Vehicular Ad-hoc Networks (VANETs)

Courses offered by Department of Electrical Engineering

1. Adaptive Signal Processing
2. Advanced Control System
3. Advanced Digital Communication
4. Advanced Signal Processing
5. Analog and Interfacing Circuits
6. Antenna Engineering
7. Applied Optimization for Wireless Communication
8. Backhaul Networks for Wireless Systems
9. Coding Theory
10. Compressive Sensing
11. Computational Imaging
12. Cyber Physical System Modelling Laboratory

13. Data Compression
14. Digital image and Video Processing Lab
15. Digital Image Processing and Applications
16. Digital Signal Processing
17. Digital Video Processing
18. Digital VLSI Design
19. Embedded System Design
20. Embedded System Design Lab
21. Flexible and Printed Electronics
22. Free Space Optical Communications
23. GNSS Signal Processing
24. Image Sensor Design and Applications
25. Introduction to Cyber-Physical Systems
26. Machine Learning for Communication
27. Mathematical Modelling and Simulation
28. Microfluidics Technology
29. Microsystems Fabrication Technology
30. Millimeter Wave Technology
31. Multi-rate Digital Signal Processing
32. Nanosensors
33. Network Information Theory
34. Neuromorphic computing and design
35. Optical Fiber Communications
36. Optimal Filtering
37. Physical Layer Security
38. Principles of Data and System Security
39. Real Time Communications
40. Resource Constrained AI
41. RF IC Design
42. RF IC Design Lab
43. Selected Topics in Communication I
44. Selected Topics in Communication I
45. Selected Topics in Communication II
46. Selected Topics in Communication III
47. Selected Topics in Sensors & IoT I
48. Selected Topics in Sensors & IoT II
49. Selected Topics in Sensors & IoT III
50. Selected Topics in Signal Processing I
51. Selected Topics in Signal Processing II
52. Selected Topics in Signal Processing III
53. Sensors and IoT Lab
54. Sensors and Measurement
55. Smart Grid
56. Speech and Audio Signal Processing
57. Statistical Decision Theory
58. Systems-on-Chips Design
59. VLSI Design Lab
60. Wavelets
61. Wireless Communication
62. Wireless Networks

Courses offered by Department of Mechanical Engineering

1. Robotics

Courses offered by Department of Bioscience and Bioengineering

1. Bioinformatics
2. Computational Biology

Courses offered by Department of Mathematics

1. Financial Engineering
2. Computational finance
3. Computational Game Theory
4. Advanced topics in computational PDE
5. Dynamical Systems
6. Stochastic Processes
7. Representation of Finite Groups

Courses offered by Department of Physics

1. Quantum Computing
2. Quantum Information Processing
3. Quantum Cryptography and Coding

Courses offered by IDRP Digital Humanities

1. Digital Humanities

Title	Algorithms for Big Data	Number	CSL7XX0
Department	Computer Science and Engineering	L-T-P [C]	2-0-0 [2]
Offered for	M.Tech. 1 st Year, Ph.D. 1 st Year	Type	Compulsory
Prerequisite	None		

Objectives

The Instructor will:

1. Introduce some algorithmic techniques developed for handling large amounts of data.
2. Emphasize on both theoretical as well as practical aspects of such algorithms.

Learning Outcomes

The students are expected to have the ability to:

Analyze existing algorithms as well as design novel algorithms pertaining to big data.

Contents

Sketching and Streaming: Extremely small-space data structures (4 lectures)

Numerical linear algebra: Algorithms for big matrices, Regression, Low-rank approximation, Matrix completion (8 lectures)

Compressed Sensing: Sparse signals, Linear measurements, Signal recovery (8 lectures)

External memory and cache-obliviousness: Minimizing I/O for large datasets, Algorithms and data structures such as B-trees, Buffer trees, Multiway mergesort (8 lectures)

Reference Books

Markovsky I, (2014), *Low Rank Approximation: Algorithms, Implementation, Applications*, Springer

Eldar Y C., Kutyniok G. (2012), *Compressed Sensing: Theory and Applications*, Cambridge University Press.

Self Learning Material

Department of Computer Science, Harvard University, [Algorithms for Big Data](#)

Title	Data structures and practices	Number	CSP7XX0
Department	Computer Science and Engineering	L-T-P [C]	0-0-2 [1]
Offered for	M.Tech. (CSE) 1 st Year	Type	Compulsory
Prerequisite	Computer Programming		

Objectives

The Instructor will:

Explain various data structures and provide details to implement and use them in different algorithms

Learning Outcomes

The students are expected to have the ability to:

1. Write, debug and rectify the programs using different data structures
2. Expertise in transforming coding skills into algorithm design and implementation

Contents

Laboratory Experiments

Exercises based on

Abstract Data Types: Arrays, link-list/list, hash tables, dictionaries, structures, *stack, queues* (4 labs)

Data Structures: Heap, Sets, Sparse matrix, Binary Search Tree, B-Tree/ B+ Tree, Graph (4 labs)

Algorithm implementation: Quick or Merge sort, Breadth or Depth first search or Dijkstra's Shortest Path First algorithm, Dynamic programming (6 labs)

Textbook

1. Weiss, M. A. (2007), Data Structures and Algorithm Analysis in C++, Addison-Wesley.
2. Lipschutz, S. (2017), Data Structures with C, McGraw Hill Education.
3. Cormen, T. H., Leiserson, C. E., Rivest, R. L. and Stein, C., (2009), Introduction to Algorithms, MIT Press

Online Course Material

Department of Computer Science and Engineering, IIT Delhi, <http://www.nptelvideos.in/2012/11/data-structures-and-algorithms.html>

Title	Software and Data Engineering	Number	CSL7XX0
Department	Computer Science and Engineering	L-T-P [C]	3-0-0 [3]
Offered for	M.Tech.	Type	Compulsory
Prerequisite			

Objectives

The Instructor will:

1. Discuss techniques to manage a large amount of data
2. Provide mechanisms to design and develop data-intensive computing systems

Learning Outcomes

The students are expected to have the ability to:

1. Design complex end-to-end data pipeline for data processing
2. Critically identify and use the tools for data handling and management
3. Use modern software technologies to design and develop data analytical systems

Contents

CSL7XX1 Cloud Computing and Virtualization 1-0-0 [1]

Basics of complex software design: Concept of modular software, microservices, communication, 4+1 architectural views and patterns (5 lectures)

Cloud Computing: Architecture of cluster computing, design of data centers, open data center platforms, fault-tolerant system design (5 lectures)

Virtualization: Type-1 and Type-2 virtualization, virtual machine, containers, dockers (4 lectures)

CSL7XX2 Data Management 1-0-0 [1]

Data Management: Structured data, relational database management, unstructured data, semi-structured data, Nosql database management (mongodb), column database, graph database, XML, JSON, HDFS, Handling drift in data, sensor data reliability at software and algorithmic level, sensor data analysis techniques (14 lectures)

CSL7XX3 Data Intensive Processing Systems 1-0-0 [1]

Data Intensive Processing Systems: Architecture of large scale data processing systems, Hadoop, Apache Spark, Storm, parallel data processing concepts such as map-reduce, directed acyclic graph, resilient distributed datasets, dynamic resource allocation, partial & shared computation, storage architecture (14 lectures)

Textbook

1. Bass L., Clements P., Kazman R., (2012), *Software Architecture in Practice*, 3rd edition, Addison-Wesley Professional
2. Martin K., (2017), *Designing Data-Intensive Applications: The Big Ideas Behind Reliable, Scalable, and Maintainable Systems*, 1st Edition, O'Reilly Media

Self Learning Material

Taylor,R.N., Medvidovic,N. and Dashofy,E.M., (2014), *Software Architecture Foundation: Theory and Practice*, Wiley

Preparatory Course Material

1. IEEE Transactions on Knowledge and Data Engineering
2. International Conference on Data Engineering

Title	Computer Architecture	Number	CSL7XX0
Department	Computer Science and Engineering	L-T-P [C]	3-0-0 [3]
Offered for	M.Tech. 2 nd Year	Type	Compulsory
Prerequisite	Computer Organization		

Objectives

The Instructor will:

Provide background to understand various components of a modern computer system, its interconnections, and performance issue

Learning Outcomes

The students are expected to have the ability to:

1. Explain the working principles of various components of modern computer systems
2. Compare between systems using benchmark data
3. Write, execute and debug parallel programs on GPU

Contents

CSL7XX1 Multi System Architecture 1-0-0 [1]

Introduction: Defining Computer Architecture, Flynn's Classification of Computers, Metrics for Performance Measurement. (4 lectures)

Memory Hierarchy: Introduction, Advanced Optimizations of Cache Performance, Memory Technology and Optimizations, Virtual Memory and Virtual Machines, The Design of Memory Hierarchies, Introduction to Pin Instrumentation and Cache grind, Case Study: Intel Core i7 (10 lectures)

CSL7XX2 Multicore Processing 1-0-0 [1]

Instruction-Level Parallelism: Instruction-level Parallelism: Concepts and Challenges, Basic Compiler Techniques for Exposing ILP, Reducing Branch Costs with Advanced Branch Prediction, Dynamic Scheduling, Superscalar, Limitations of ILP, Case Study: Dynamic Scheduling in Intel Core i7. (9 lectures)

Multicore Processor: Introduction, CPU Interconnections, Network on Chip (NoC), Routing Protocols, Quality of Service on NoC. (5 lectures)

CSL7XX3 Fundamentals of Parallel Programming 1-0-0 [1]

Data Level Parallelism: Introduction, Vector Architecture, SIMD Instruction Set Extensions for Multimedia, Graphics Processing Units, GPU Memory Hierarchy, Detecting and Enhancing Loop- Level Parallelism, CUDA Programming, Case Study: Nvidia Maxwell. (14 lectures)

Textbook

1. Hennessy, J.L. and Patterson, D.A., (2012), *Computer Architecture: A Quantitative Approach*, 5th Edition, Morgan Kaufmann Publishers
2. Shen, J.P. and Lipasti, M.H., (2005), *Modern Processor Design: Fundamentals of Superscalar Processors*, McGraw-Hill Publishers

Self-Learning Material

1. CUDA: <https://developer.nvidia.com/cuda-zone>
2. OpenMP: <https://www.openmp.org/>

Preparatory Course Material

Department of Computer Science and Engineering, Indian Institute of Technology Madras, <https://nptel.ac.in/courses/106106134/>

Title	Machine Learning-1	Number	CSL7XX0
Department	Computer Science and Engineering	L-T-P [C]	3-0-0 [3]
Offered for	M.Tech. 1 st Year, Ph.D. 1 st Year	Type	Compulsory
Prerequisite	None		

Objectives

The Instructor will:

1. Provide motivation and understanding of the need and importance of Machine Learning in today's world
2. Provide details about various algorithms in Machine Learning

Learning Outcomes

The students are expected to have the ability to:

1. Develop a sense of Machine Learning in the modern context, and independently work on problems relating to Machine Learning
2. Design and program efficient algorithms related to Machine Learning, train models, conduct experiments, and deliver ML-based applications

Contents

CSL7XX1: Introduction to Machine Learning: Supervised Learning 1-0-0[1]

Introduction: Motivation, Different types of learning, Linear regression, Logistic regression (2 lectures)

Gradient Descent: Introduction, Stochastic Gradient Descent, Subgradients, Stochastic Gradient Descent for risk minimization (2 lectures)

Support Vector Machines: Hard SVM, Soft SVM, Optimality conditions, Duality, Kernel trick, Implementing Soft SVM with Kernels (4 lectures)

Decision Trees: Decision Tree algorithms, Random forests (2 lectures)

Neural Networks: Feedforward neural networks, Expressive power of neural networks, SGD and Backpropagation (3 lectures)

Model selection and validation: Validation for model selection, k-fold cross-validation, Training-Validation-Testing split, Regularized loss minimization (1 lectures)

CSL7XX2: Introduction to Machine Learning: Unsupervised Learning and Generative Models 1-0-0[1]

Nearest Neighbour: k-nearest neighbour, Curse of dimensionality (1 lecture)

Clustering: Linkage-based clustering algorithms, k-means algorithm, Spectral clustering (3 lectures)

Dimensionality reduction: Principal Component Analysis, Random projections, Compressed sensing (2 lectures)

Generative Models: Maximum likelihood estimator, Naive Bayes, Linear Discriminant Analysis, Latent variables and Expectation-maximization algorithm, Bayesian learning (5 lectures)

Feature Selection and Generation: Feature selection, Feature transformations, Feature learning (3 lectures)

CSL7XX3: Introduction to Machine Learning: Computational Learning Theory and Deep Learning 1-0-0[1]

Statistical Learning Framework: PAC learning, Agnostic PAC learning, Bias-complexity tradeoff, No free lunch theorem, VC dimension, Structural risk minimization, Adaboost (7 lectures)

Foundations of Deep Learning: DNN, CNN, RNN, Autoencoders (7 lectures)

Textbook

Shalev-Shwartz,S., Ben-David,S., (2014), *Understanding Machine Learning: From Theory to Algorithms*, Cambridge University Press

Reference Books

Mitchell Tom (1997). *Machine Learning*, Tata McGraw-Hill

Self Learning Material

Department of Computer Science, Stanford University,

<https://see.stanford.edu/Course/CS229>

Title	Security and Its Application	Number	CSL7XX0
Department	Computer Science and Engineering	L-T-P [C]	3-0-0 [3]
Offered for	M.Tech.	Type	Elective
Prerequisite	Networks		

Objectives

The Instructor will:

1. Provide the fundamental principles of access control models and techniques, authentication and secure system design
2. Introduce a strong understanding of different cryptographic protocols and techniques and be able to use them
3. Provide methods for authentication, access control, intrusion detection and prevention

Learning Outcomes

The students are expected to have the ability to:

1. Understand cryptography and network security concepts and application
2. Identify and investigate network security threat
3. Analyze and design network security protocols

Contents

Shannon's Approach to Cryptography: Measures of security, Perfect secrecy, Definition of entropy, One-time pad (3 lectures)

Symmetric Key Cryptography: The notion of a symmetric key cryptography, The Data Encryption Standard (DES) and differential cryptanalysis, The Advanced Encryption Standard (AES) (4)

Cryptographic Hash Functions: Definition of hash functions and properties, Unkeyed hash functions, Keyed hash functions, Message Authentication Codes (MAC), The Random Oracle Model (ROM) (4 lectures)

Authentication: Definition of authentication, A simple authentication protocol and possible attacks, Strong password protocols, BM Encrypted Key Exchange (EKE), Key Distribution Centers (KDC), Certification authorities and certificate revocation, KDC based authentication protocols (6 lectures)

Public Key Cryptosystems: Fundamentals of Public-key Cryptography, Background on number theory, The RSA public key cryptosystem, The ElGamal public key cryptosystem and discrete logs

Digital Signatures: An RSA based signature scheme, The ElGamal based signature scheme, The Schnorr signature scheme, The Digital Signature Algorithm (DSA) (8 lectures)

Key Distribution and Key Agreement Protocols: Key Predistribution: Diffie-Hellman key Exchange, The MTI key Exchange (4 lectures)

Network Security: TCP/IP threats, The IPSEC protocol, The SSL and TLS protocols, Firewalls and Virtual Private Networks (VPNs), Electronic mail security, Worms, DDoS attacks, BGB and security considerations (5 lectures)

Cyber-physical security: IoT security, sensor actuator network security (4 lectures)

Block Chain: Introduction to Blockchain, Blockchain Architecture and Design, Consensus, Permissioned Blockchains (4 lectures)

Laboratory Experiments

Programming exercises using Exata and AVISPA Tools

Textbook

1. Stallings, W. (2017). *Cryptography and network security*, 7/E. Pearson Education India
2. Douglas R. Stinson, Maura B. Paterson (2018). *Cryptography: theory and practice*. 4/E Chapman and Hall/CRC

Reference Books

1. Mao, W. (2004). *Modern cryptography: theory and practice*. Pearson Education India
2. Pfleeger, C. P., & Pfleeger, S. L. (2018). *Security in computing*. 5/E, Prentice Hall Professional Technical Reference
3. Goldreich, O. (2009). *Foundations of cryptography: volume 2, basic applications*. Cambridge university press
4. Forouzan, B. A. (2015). *Cryptography & network security*. 3/E, McGraw-Hill, Inc.

Self Learning Material

1. Network and Computer Security - MIT OpenCourseWare
<https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-857-network-and-computer-security-spring-2014/>
2. Cryptography I, Coursera, Stanford University, <https://www.coursera.org/learn/crypto>