

**INDEX**

12 week

08 week

04 week

**ARCHITECTURE AND PLANNING**

Environmental Impact Assessment	9
Structure, Form, and Architecture: The Synergy	10
Disaster Recovery and Build Back Better	11
Engineering/Architectural Graphics - part I - Orthographic projection	12
Introduction to History of Architecture in India	13
User Interface Design	14
Engineering/Architectural Graphics – part II – Isometric and Axonometric Drawings	15

**CIVIL ENGINEERING**

Rural Water Resources Management	17
Hydraulic Engineering	18
Geosynthetics And Reinforced Soil Structures	19
Maintenance and Repair of Concrete Structures	20
Modern Construction Materials	21
Structural Dynamics	22
Applied Environmental Microbiology	23
Microwave Remote Sensing in Hydrology	24
Geographic Information Systems	25
Mineral Resources: Geology Exploration Economics And Environment	26
Soil Structure Interaction	27
Surface Water Hydrology	28
Traffic Engineering	29
Mechanics of Solids	30
Mechanical Characterization of Bituminous Materials	31
Concrete Technology	32
Groundwater hydrology and management	33
Geotechnical Engineering II Foundation Engineering	34
Geology and Soil Mechanics	35
Geotechnical Engineering - 1	36
Geomorphology	37
Water Supply Engineering	38
Remote Sensing Essentials	39
Environmental Remediation of Contaminated Sites	40
Engineering Hydrology	41
Retrofitting and Rehabilitation of Civil Infrastructure	42
Air pollution and Control	43
Remote Sensing: Principles and Applications	44
Advanced Soil Mechanics	45
Water and waste water treatment	46
Rock Engineering	47
Structural Analysis-I	48
Probability Methods in Civil Engineering	49
Advanced Foundation Engineering	50
Urban Transportation Systems Planning	51
Basic construction materials	52
Geomorphic Processes: Landforms And Landscapes	53
Introduction to Accounting and Finance for Civil Engineers	54

Development and Applications of Special Concretes	55
Expansive Soil	56
Introduction to Civil Engineering Profession	57
Natural Hazards	58
Digital Land Surveying And Mapping (DLS&M)	59
Safety in Construction	60
Electronic Waste Management - Issues And Challenges	61
Advanced Topics in the Science and Technology of Concrete	62
Scheduling Techniques in Projects	63
Introduction to Lean Construction (Module 1 Lean Basics)	64

**COMPUTER SCIENCE AND ENGINEERING**

Arithmetic Circuit Complexity	66
Artificial Intelligence: Knowledge Representation And Reasoning	67
Foundations of Cryptography	68
Data Analytics with Python	69
Ethical Hacking	70
Compiler Design	71
Computer Networks and Internet Protocol	72
Deep Learning (IIT KGP)	73
Model Checking	74
The Joy of Computing using Python	75
Reinforcement Learning	76
Online Privacy	77
Computational Geometry	78
Programming in Modern C++	79
Blockchain and its Applications	80
Problem Solving Through Programming In C	81
Discrete Structures	82
Introduction To Internet Of Things	83
Object Oriented System Development Using UML, Java And Patterns	84
Introduction to Database Systems	85
Getting Started with Competitive Programming	86
Discrete Mathematics - IIITB	87
GPU Architectures and Programming	88
Computer Architecture	89
Cloud computing	90
Introduction to Machine Learning	91
Social Networks	92
Discrete Mathematics	93
Deep Learning - IIT Ropar	94
An Introduction to Programming Through C++	95
Embedded Systems Design	96
Programming In Java	97
Hardware Security	98

**INDEX**

12 week

08 week

04 week

VLSI Physical Design	99
Introduction To Industry 4.0 And Industrial Internet Of Things	100
An Introduction to Artificial Intelligence	101
AI:Constraint Satisfaction	102
User-centric Computing for Human-Computer Interaction	103
Cloud Computing and Distributed Systems	104
Introduction to parallel programming with OpenMP and MPI	105
Information Security - 5 - Secure Systems Engineering	106
Programming, Data Structures And Algorithms Using Python	107
Design and analysis of algorithms	108
Data Science for Engineers	109
Design and Engineering of Computer Systems	110
Data Base Management System	111
Introduction To Soft Computing	112
Data Mining	113
Advanced Graph Theory	114
Introduction To Programming In C	115
Advanced Computer Architecture	116
Machine Learning, ML	117
Software Testing	118
Python for Data Science	119
Introduction to Machine Learning (Tamil)	120
Systems and Usable Security	121
Fundamental Algorithms: Design and Analysis	122
Software Conceptual Design	123

Optical Fiber Sensors	144
Design and Analysis of VLSI Subsystems	145
Biophotonics	146
Fundamental of Power Electronics	147
Principles of Signals and Systems	148
Principles of Communication Systems - I	149
Network Analysis	150
Analog Electronic Circuits	151
Fundamentals of semiconductor devices	152
Power System Engineering	153
Power System Dynamics, Control and Monitoring	154
Spread Spectrum Communications and Jamming	155
Circuit Analysis for Analog Designers	156
Operation and Planning of Power Distribution Systems	157
Analog Ic Design	158
Digital IC Design	159
Nonlinear System Analysis	160
Power Management Integrated Circuits	161
Signals and Systems	162
Transmission lines and electromagnetic waves	163
Sensors and Actuators	164
Deep Learning for Visual Computing	165
Communication Networks	166
Signal Processing Techniques And Its Applications	167
CMOS Digital VLSI Design	168
Microwave Integrated Circuits	169
Analog Circuits	170
Optimal control	171
Electronics equipment integration and Prototype building	172
Discrete Time Signal Processing	173
Power Quality Improvement Technique	174
Linear Dynamical Systems	175
Digital Protection of Power System	176
An Introduction to Information Theory	177
Basic Building Blocks of Microwave Engineering & Design Principles of RF And Microwave Filters And Amplifiers	178
Fundamentals of MIMO Wireless Communication	179
Electronics Enclosures Thermal issues	180
Design of Power Electronic Converters	181
Evolution Of Air Interface Towards 5G	182
Analysis and Design Principles of Microwave Antennas	183
Electromagnetic Waves in Guided and Wireless Media	184
VLSI Signal Processing	185
Nonlinear and Adaptive Control	186
Recent Advances in Transmission Insulators	187
A brief introduction of Micro - Sensors	188
Electric Vehicles - Part 1	189
Medical Image Analysis	190

## ELECTRICAL AND ELECTRONICS ENGINEERING

Statistical Signal Processing	125
Electrical Machines - II	126
Microprocessors and Interfacing	127
Principles of Digital Communications	128
Microprocessors And Microcontrollers	129
High Power Multilevel Converters - Analysis, design and operational issues	130
Biomedical Signal Processing	131
Fuzzy Sets, Logic and Systems & Applications	132
Antennas	133
Integrated Circuits, Mosfets, OP-Amps and their Applications	134
Control engineering	135
Multirate DSP	136
Digital System Design	137
Physics of Nanoscale Devices	138
Computer Vision and Image Processing – Fundamentals and Applications	139
Photonic integrated circuit	140
Digital Electronic Circuits	141
Architectural Design of Digital Integrated Circuits	142
Applied Linear Algebra	143

## OCEAN ENGINEERING

Offshore Structures Under Special Environmental Loads Including Fire Resistance	192
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# ARITHMETIC CIRCUIT COMPLEXITY

**PROF. NITIN SAXENA**

Department of Computer Science and Engineering  
IIT Kanpur

**TYPE OF COURSE** : Rerun I Elective I UG/PG

**COURSE DURATION** : 12 weeks (24 Jan' 22 - 15 Apr' 22)

**EXAM DATE** : 23 Apr 2022

**PRE-REQUISITES** : Preferable (but not necessary)-- Theory of Computation, Algorithms, Algebra

**INTENDED AUDIENCE** : Interested students

**INDUSTRIES APPLICABLE TO** : Cryptography, Coding theory, Symbolic Computing Software, Learning Software

**COURSE OUTLINE :**

In this course we will study computation by primarily algebraic models, and use, or in many cases extend, the related tools that mathematics provides. We will start with some positive examples-- fast polynomial multiplication, matrix multiplication, determinant, matching, linear/algebraic independence, etc. The related tools are FFT (fast fourier transform), tensor rank, Newtons identity, ABP (algebraic branching program), PIT (polynomial identity testing), Wronskian, Jacobian, etc. We then move on to proofs, or attempts to prove, that certain problems are hard and impossible to express as a small circuit (i.e. hard to solve in real life too).

**ABOUT INSTRUCTOR :**

Prof. Nitin Saxena completed my Bachelors in Computer Science from the Indian Institute of Technology, Kanpur in 2002 and completed his PhD under Manindra Agrawal in 2006. He is broadly interested in Computational Complexity Theory, Algebra, Geometry and Number Theory. He has been a visiting graduate student in Princeton University (2003-2004) and National University of Singapore (2004-2005); a postdoc at CWI, Amsterdam (2006-2008) and a Bonn Junior Fellow (W2 Professor) at Hausdorff Center for Mathematics, Bonn (2008-2013). Since April 2013, He has a faculty position in the department of CSE, IIT Kanpur.

**COURSE PLAN :**

**Week 1:** Turing machines. Arithmetic circuits.

**Week 2:** Newton's identity. Arithmetic branching program. Iterated matrix multiplication.

**Week 3:** Arithmetic branching program vs. Determinant.

**Week 4:** Circuit Depth Reduction.

**Week 5:** Nontrivial reduction to constant-depth.

**Week 6:** Width reduction.

**Week 7:** Depth-3 over finite fields. Grigoriev-Karpinski measure.

**Week 8:** Raz-Yehudayoff measure for multilinear depth-3.

**Week 9:** Shifted partials of degree-restricted depth-4.

**Week 10:** Exponential lower bound for homogeneous depth-4.

**Week 11:** Polynomial Identity Testing (PIT) and exponential lower bounds are equivalent

**Week 12:** PIT for tiny depth-3 (or many other tiny models) suffices.



# ARTIFICIAL INTELLIGENCE: KNOWLEDGE REPRESENTATION AND REASONING

## PROF. DEEPAK KHEMANI

Department of Computer Science and Engineering  
IIT Madras

**TYPE OF COURSE** : Rerun I Elective I UG/PG

**COURSE DURATION** : 12 weeks (24 Jan' 22 - 15 Apr' 22)  
**EXAM DATE** : 23 Apr 2022

**PRE-REQUISITES** : Some exposure to formal languages, logic and programming

**INTENDED AUDIENCE** : BE/ME/MS/MSc/PhD students

**INDUSTRIES APPLICABLE TO** : Software companies dealing with knowledge and reasoning, including the semantic web and semantic search

## COURSE OUTLINE :

An intelligent agent needs to be able to solve problems in its world. The ability to create representations of the domain of interest and reason with these representations is a key to intelligence. In this course we explore a variety of representation formalisms and the associated algorithms for reasoning. We start with a simple language of propositions, and move on to first order logic, and then to representations for reasoning about action, change, situations, and about other agents in incomplete information situations. This course is a companion to the course Artificial Intelligence: Search Methods for Problem Solving that was offered recently and the lectures for which are available online.

## ABOUT INSTRUCTOR :

Prof. Deepak Khemani is Professor at Department of Computer Science and Engineering, IIT Madras. He completed his B.Tech. (1980) in Mechanical Engineering, and M.Tech. (1983) and PhD. (1989) in Computer Science from IIT Bombay, and has been with IIT Madras since then. In between he spent a year at Tata Research Development and Design Centre, Pune and another at IIT, Mandi. He has had shorter stays at several Computing departments in Europe. Prof Khemani's long-term goals are to build articulate problem solving systems using AI that can interact with human beings. His research interests include Memory Based Reasoning, Knowledge Representation and Reasoning, Planning and Constraint Satisfaction, Qualitative Reasoning and Natural Language Processing.

## COURSE PLAN :

**Week 1:** Introduction, Propositional Logic, Syntax and Semantics

**Week 2:** Proof Systems, Natural Deduction, Tableau Method, Resolution Method

**Week 3:** First Order Logic (FOL), Syntax and Semantics, Unification, Forward Chaining

**Week 4:** The Rete Algorithm, Rete example, Programming Rule Based Systems

**Week 5:** Representation in FOL, Categories and Properties, Reification, Event Calculus

**Week 6:** Deductive Retrieval, Backward Chaining, Logic Programming with Prolog

**Week 7:** Resolution Refutation in FOL, FOL with Equality, Complexity of Theorem Proving

**Week 8:** Description Logic (DL), Structure Matching, Classification

**Week 9:** Extensions of DL, The ALC Language, Inheritance in Taxonomies

**Week 10:** Default Reasoning, Circumscription, The Event Calculus Revisited

**Week 11:** Default Logic, Autoepistemic Logic, Epistemic Logic, Multi Agent Scenarios

**Week 12:** Optional Topics A: Conceptual Dependency (CD) Theory, Understanding Natural Language

Optional Topics B: Semantic Nets, Frames, Scripts, Goals and Plans



# FOUNDATIONS OF CRYPTOGRAPHY

**PROF. ASHISH CHOUDHURY**

Department of Computer Science  
IIIT Bangalore

**TYPE OF COURSE** : Rerun I Elective I UG/PG

**COURSE DURATION** : 12 weeks (24 Jan' 22 - 15 Apr' 22)

**EXAM DATE** : 23 Apr 2022

**PRE-REQUISITES :** There are no pre-requisites for this course. However it is expected that the students who are interested to take this course have had some exposure to a basic course on discrete mathematics, algorithms, or theory of computation.

**INTENDED AUDIENCE :** Computer Science and Mathematics students

**INDUSTRIES APPLICABLE TO :** The course will be relevant for any IT related company

**COURSE OUTLINE :**

The course provides the basic paradigm and principles of modern cryptography. The focus of this course will be on definitions and constructions of various cryptographic objects. We will try to understand what security properties are desirable in such objects, how to formally define these properties, and how to design objects that satisfy the definitions. The aim is that at the end of this course, the students are able to understand a significant portion of current cryptography research papers and standards.

**ABOUT INSTRUCTOR :**

Prof. Ashish Choudhury is currently an Assistant Professor at IIIT Bangalore. He did his MS and PhD in Computer science from IIT Madras, followed by postdoc at ISI Kolkata and University of Bristol. His research work is focused on the foundation of cryptographic protocols for real-world problems. His current projects aim to design efficient protocols in the asynchronous network model which can be realized in practice.

**COURSE PLAN :**

**Week 1:** Course Overview, Symmetric-key Encryption, Historical Ciphers

**Week 2:** Computational Security, Semantic Security and Pseudorandom Generators (PRGs)

**Week 3:** Stream Ciphers, Provably-secure Instantiation of PRG, Practical Instantiation of PRG

**Week 4:** CPA-Secure Ciphers from PRF, Modes of Operations of Block Ciphers

**Week 5:** DES, AES and Message Authentication Codes (MAC)

**Week 6:** Information-theoretic Secure MAC, Cryptographic Hash Functions

**Week 7:** Birthday Attacks on Cryptographic Hash Functions, Applications of Hash Functions

**Week 8:** Generic Constructions of Authenticated Encryption Schemes

**Week 9:** Discrete-Logarithm Problem, Computational Diffie-Hellman Problem, Decisional Diffie-Hellman Problem, Elliptic-Curve Based Cryptography and Public-Key Encryption

**Week 10:** El Gamal Encryption Scheme, RSA Assumption

**Week 11:** CCA-secure Public-key Hybrid Ciphers Based on Diffie-Hellman Problems and RSA-assumption, Digital Signatures

**Week 12:** Schnorr Signature, Overview of TLS/SSL, Number Theory, Interactive Protocols and Farewell



# DATA ANALYTICS WITH PYTHON

**PROF. A RAMESH**

Department of Management Studies  
IIT Roorkee

**TYPE OF COURSE**

: Rerun I Elective I UG/PG

**COURSE DURATION**

: 12 weeks (24 Jan' 22 - 15 Apr' 22)

**EXAM DATE**

: 23 Apr 2022

**INTENDED AUDIENCE :** Management, Industrial Engineering and Computer Science Engineering Students

**INDUSTRIES APPLICABLE TO :** Any analytics company

**COURSE OUTLINE :**

This course includes examples of analytics in a wide variety of industries, and we hope that students will learn how one can use analytics in their career and life. One of the most important aspects of this course is that hands-on experience creating analytics models will be shared.

**ABOUT INSTRUCTOR :**

Prof. Ramesh Anbanandam graduated in Production Engineering from Madras University, Chennai. He did his post-graduation from National Institute of Technology, Trichy. He later earned his Ph.D. in Supply Chain Management from Indian Institute of Technology Delhi. His professional interest includes Humanitarian Supply Chain Management, Operations Management, Operations Research, Healthcare Waste Management, Sustainable Multi-model and Freight Transportation, Transportation Asset Management and Advanced Data Analytics using Python and R-programming. He has published various research articles in reputed journals. He was also awarded Emerald Literati Award for Excellence under "Highly Commended Research Paper in the Year 2011 and 2016" in the field of Supply Chain Management.

**COURSE PLAN :**

- Week 1:** Introduction to data analytics and Python fundamentals
- Week 2:** Introduction to probability
- Week 3:** Sampling and sampling distributions
- Week 4:** Hypothesis testing
- Week 5:** Two sample testing and introduction to ANOVA
- Week 6:** Two way ANOVA and linear regression
- Week 7:** Linear regression and multiple regression
- Week 8:** Concepts of MLE and Logistic regression
- Week 9:** ROC and Regression Analysis Model Building
- Week 10:**  $\chi^2$  Test and introduction to cluster analysis
- Week 11:** Clustering analysis
- Week 12:** Classification and Regression Trees (CART)



# ETHICAL HACKING

## PROF. INDRANIL SENGUPTA

Dept. of Computer Science and Engineering  
IIT Kharagpur

**TYPE OF COURSE** : Rerun | Elective | UG/PG

**COURSE DURATION** : 12 Weeks (24 Jan' 22 - 15 Apr' 22)

**EXAM DATE** : 23 Apr 2022

**INTENDED AUDIENCE :** Computer Science and Engineering

/ Information Technology / Electronics and Communication Engineering / Electrical Engineering

**PREREQUISITES :** Basic concepts in programming and networking

**INDUSTRIES APPLICABLE TO :** TCS, Wipro, CTS, Google, Microsoft, Qualcomm

## COURSE OUTLINE

Ethical hacking is a subject that has become very important in present-day context, and can help individuals and organizations to adopt safe practices and usage of their IT infrastructure. Starting from the basic topics like networking, network security and cryptography, the course will cover various attacks and vulnerabilities and ways to secure them. There will be hands-on demonstrations that will be helpful to the participants.

## ABOUT INSTRUCTOR

Prof. Indranil Sengupta has obtained his B.Tech., M.Tech. and Ph.D. degrees in Computer Science from the University of Calcutta. He joined the Indian Institute of Technology, Kharagpur, as a faculty member in 1988, in the Department of CSE, where he is presently a full Professor. He had been the former Heads of the Department of Computer Science and Engineering and also the School of Information Technology of the Institute. He was also the Managing Director of Science and Technology Entrepreneurship Park (STEP), and the Professor-in-Charge of a Centre of Excellence in Information Assurance funded by the Ministry of Defense.

## COURSE PLAN

**Week 1** : Introduction to ethical hacking. Fundamentals of computer networking. TCP/IP protocol stack.

**Week 2** : IP addressing and routing. Routing protocols.

**Week 3** : Introduction to network security. Information gathering: reconnaissance, scanning, etc.

**Week 4** : Vulnerability assessment: OpenVAS, Nessus, etc. System hacking: password cracking, penetration testing, etc.

**Week 5** : Social engineering attacks. Malware threats, penetration testing by creating backdoors.

**Week 6** : Introduction to cryptography, private-key encryption, public-key encryption.

**Week 7** : Key exchange protocols, cryptographic hash functions, applications.

**Week 8** : Steganography, biometric authentication, lightweight cryptographic algorithms.

**Week 9** : Sniffing: Wireshark, ARP poisoning, DNS poisoning. Hacking wireless networks, Denial of service attacks.

**Week 10** : Elements of hardware security: side-channel attacks, physical unclonable functions.

**Week 11** : Hacking web applications: vulnerability assessment, SQL injection, cross-site scripting.

**Week 12** : Case studies: various attacks scenarios and their remedies.



# COMPILER DESIGN

**PROF. SANTANU CHATTOPADHYAY**

Department of Electrical Engineering  
IIT Kharagpur

**TYPE OF COURSE** : Rerun I Core I UG

**COURSE DURATION** : 12 weeks (24 Jan' 22 - 15 Apr' 22)  
**EXAM DATE** : 23 Apr 2022

**INTENDED AUDIENCE :** Undergraduate students of CSE, IT, B.Sc (Computer Science), MCA, MS (Computer Science)

**INDUSTRIES APPLICABLE TO :** All software industries

**COURSE OUTLINE :**

Compilers have become part and parcel of today's computer systems. They are responsible for making the user's computing requirements, specified as a piece of program, understandable to the underlying machine. These tools work as interface between the entities of two different domains – the human being and the machine. The actual process involved in this transformation is quite complex. Automata Theory provides the base of the course on which several automated tools can be designed to be used at various phases of a compiler. Advances in computer architecture, memory management and operating systems provide the compiler designer large number of options to try out for efficient code generation. This course on compiler design is to address all these issues, starting from the theoretical foundations to the architectural issues to automated tools. Being primarily targeted to a one-semester course for the undergraduate students, the course will follow the current GATE syllabus, enabling the students to prepare well for the same. It can also help all other participants looking for an introduction to the domain of compiler designs and code translators.

**ABOUT INSTRUCTOR :**

Prof. Santanu Chattopadhyay received his BE degree in Computer Science and Technology from Calcutta University (B.E. College) in 1990. He received M.Tech in Computer and Information Technology and PhD in Computer Science and Engineering from Indian Institute of Technology Kharagpur in 1992 and 1996, respectively. He is currently a Professor in the Department of Electronics and Electrical Communication Engineering, IIT Kharagpur. Prior to this, he had been a faculty member in the IEST Sibpur and IIT Guwahati in the departments of Computer Science and Engineering. In both these places he has taught the subject of Compiler Design several times. His research interests include Digital Design, Embedded Systems, System-on-Chip (SoC) and Network-on-Chip (NoC) Design and Test, Power- and Thermal-aware Testing of VLSI Circuits and Systems. He has published more than 150 papers in reputed international journals and conferences. He has published several text and reference books on Compiler Design, Embedded Systems and other related areas. He is a senior member of the IEEE and an Associate Editor of IET Circuits Devices and Systems journal.

**COURSE PLAN :**

**Week 1:** Introduction

**Week 2:** Lexical Analysis

**Week 3:** Parsing – Part I

**Week 4:** Parsing – Part II

**Week 5:** Parsing – Part III

**Week 6:** Syntax Directed Translation

**Week 7:** Type Checking and Symbol Tables

**Week 8:** Runtime Environment Management – Part I

**Week 9:** Runtime Environment Management – Part II

**Week 10:** Intermediate Code Generation – Part I

**Week 11:** Intermediate Code Generation – Part II

**Week 12:** Intermediate Code Generation – Part III



# COMPUTER NETWORKS AND INTERNET PROTOCOL

## PROF. SOUMYA KANTI GHOSH

Department of Computer Science and Engineering  
IIT Kharagpur

**TYPE OF COURSE** : Rerun I Core I UG/PG

**COURSE DURATION** : 12 weeks (24 Jan' 22 - 15 Apr' 22)  
**EXAM DATE** : 23 Apr 2022

## PROF. SANDIP CHAKRABORTY

Department of Computer Science and Engineering  
IIT Kharagpur

**INTENDED AUDIENCE :** CSE, ECE, EE students

**INDUSTRIES APPLICABLE TO :** IT industries

## COURSE OUTLINE :

The domain of Internet has grown in a rapid pace from traditional circuit switched and packet switched small scale networks to modern high-speed mobile and wireless Internet. A large number of methods, architectures and designs came up at every protocol level to cope up with the demands for developing a secure and highly dependable information technology infrastructure. The broad objective of the course is to understand - (i) the architecture and principles of today's computer networks, (ii) the protocols and their functionalities, (iii) the requirements for the future Internet and its impact on the computer network architecture. In this course, we'll broadly cover the basic TCP/IP protocol stack and touch on the next generation computer networks. We'll take a top-down approach to cover different protocols at the TCP/IP protocol stack.

## ABOUT INSTRUCTOR :

Prof. Soumya K. Ghosh received Ph.D. and M.Tech. degrees from Department of Computer Science and Engineering, Indian Institute of Technology (IIT), Kharagpur. Presently, he is a Professor with Department of Computer Science and Engineering, IIT Kharagpur. Before joining IIT Kharagpur, he worked for the Indian Space Research Organization in the area of satellite remote sensing and geographic information systems. He has more than 200 research papers in reputed journals and conference proceedings. His research interests include spatial data science, spatial web services and cloud computing.

Prof. Sandip Chakraborty received Ph.D. and M.Tech. degrees from Department of Computer Science and Engineering, Indian Institute of Technology (IIT), Guwahati. Presently, he is an Assistant Professor with Department of Computer Science and Engineering, IIT Kharagpur. He has around 100 research papers in reputed journals and conference proceedings. His research interests include computer systems, distributed systems and mobile computing.

## COURSE PLAN :

**Week 1 :** Introduction to Computer Networks History, Circuit Switching and Packet Switching

**Week 2 :** TCP/IP Protocol Stack – Basic Overview

**Week 3 :** Application Layer Services (HTTP, FTP, Email, DNS)

**Week 4 :** Transport Layer Primitives – Connection Establishment and Closure

**Week 5 :** Flow Control and Congestion Control at the Transport Layer

**Week 6 :** Transmission Control Protocol – Basic Features, TCP Congestion Control

**Week 7 :** Network Layer Primitives – IP Addressing

**Week 8 :** IP Routing – Intra Domain Routing Protocols, Inter Domain Routing Protocols (BGP)

**Week 9 :** IP Services – SNMP, ARP

**Week 10 :** Data Link Layer Service Primitives – Forwarding, Flow Control, Error Control

**Week 11 :** Media Access Control - Channel Access Protocols, Framing

**Week 12 :** End to End Principles of Computer Networks



# DEEP LEARNING (IITKGP)

**PROF. PRABIR KUMAR BISWAS**

Department of Computer Science and Engineering  
IIT Kharagpur

**TYPE OF COURSE** : Rerun I Elective I UG/PG

**COURSE DURATION** : 12 weeks (24 Jan' 22 - 15 Apr' 22)

**EXAM DATE** : 23 Apr 2022

**PRE-REQUISITES :** Knowledge of Linear Algebra, DSP, PDE will be helpful.

**INTENDED AUDIENCE :** Electronics and Communication Engineering, Computer Science, Electrical Engineering

**INDUSTRIES APPLICABLE TO :** Google, Adobe, TCS, DRDO etc.

**COURSE OUTLINE :**

The availability of huge volume of Image and Video data over the internet has made the problem of data analysis and interpretation a really challenging task. Deep Learning has proved itself to be a possible solution to such Computer Vision tasks. Not only in Computer Vision, Deep Learning techniques are also widely applied in Natural Language Processing tasks. In this course we will start with traditional Machine Learning approaches, e.g. Bayesian Classification, Multilayer Perceptron etc. and then move to modern Deep Learning architectures like Convolutional Neural Networks, Autoencoders etc. On completion of the course students will acquire the knowledge of applying Deep Learning techniques to solve various real life problems.

**ABOUT INSTRUCTOR :**

Prof. Prabir Kumar Biswas completed his B.Tech(Hons), M.Tech and Ph.D from the Department of Electronics and Electrical Communication Engineering, IIT Kharagpur, India in the year 1985, 1989 and 1991 respectively. From 1985 to 1987 he was with Bharat Electronics Ltd. Ghaziabad as a deputy engineer. Since 1991 he has been working as a faculty member in the department of Electronics and Electrical Communication Engineering, IIT Kharagpur, where he is currently holding the position of Professor and Head of the Department. Prof. Biswas visited University of Kaiserslautern, Germany under the Alexander von Humboldt Research Fellowship during March 2002 to February 2003.

**COURSE PLAN :**

**Week 1:** Introduction to Deep Learning, Bayesian Learning, Decision Surfaces

**Week 2:** Linear Classifiers, Linear Machines with Hinge Loss

**Week 3:** Optimization Techniques, Gradient Descent, Batch Optimization

**Week 4:** Introduction to Neural Network, Multilayer Perceptron, Back Propagation Learning

**Week 5:** Unsupervised Learning with Deep Network, Autoencoders

**Week 6:** Convolutional Neural Network, Building blocks of CNN, Transfer Learning

**Week 7:** Revisiting Gradient Descent, Momentum Optimizer, RMSProp, Adam

**Week 8:** Effective training in Deep Net- early stopping, Dropout, Batch Normalization, Instance Normalization, Group Normalization

**Week 9:** Recent Trends in Deep Learning Architectures, Residual Network, Skip Connection Network

**Week 10:** Classical Supervised Tasks with Deep Learning, Image Denoising, Semanticd Segmentation

**Week 11:** LSTM Networks

**Week 12:** Generative Modeling with DL, Variational Autoencoder, Generative Adversarial Network Revisiting Gradient Descent



# MODEL CHECKING

**PROF. SRIVATHSAN.B**

Department of Computer Science and Engineering  
Chennai Matematical Institute

**TYPE OF COURSE**

: Rerun I Elective I UG

**COURSE DURATION**

: 12 weeks (24 Jan' 22 - 15 Apr' 22)

**EXAM DATE**

: 23 Apr 2022

**PRE-REQUISITES :** Familiarity with basic algorithms and finite-state machines preferable

**INTENDED AUDIENCE :** This course would be relevant to CSE/EE/ECE/IT students. It would also cater to engineers in the industry who are looking forward to rigorous design and testing methods.

**COURSE OUTLINE :**

Embedded software control many of the safety-critical systems that we deal with in everyday life: for instance, modern cars are equipped with software to automatically change gears; pacemakers come with a software controller to regulate heart beat; aircrafts have flight control software, and so on. Typically, these (software) controllers have to make decisions based on inputs coming from multiple interacting components. As the size and the number of interacting components increase, the design and verification of controllers becomes increasingly complex.

**ABOUT INSTRUCTOR :**

Prof. B. Srivathsan obtained his B. Tech and M. Tech (CSE) from IIT Bombay; and Ph.D from the University of Bordeaux, France. He worked as a post-doctoral researcher at RWTH university - Aachen, Germany. He has been a faculty member at CMI since 2013. His main research interest is in the formal verification of real-time systems.

**COURSE PLAN :**

**Week 1:** Modeling systems as Finite-state machines

**Week 2:** Using the model-checker NuSMV

**Week 3:** Linear-time properties for verification

**Week 4:** Regular properties - automata over finite words

**Week 5:** Omega-regular properties - automata over infinite words

**Week 6:** Model checking omega-regular properties

**Week 7:** Linear Temporal Logic (LTL)

**Week 8:** Algorithms for LTL

**Week 9:** Computation Tree Logic (CTL)

**Week 10:** Algorithms for CTL

**Week 11:** Binary Decision Diagrams (BDDs)

**Week 12:** Models with timing constraints - timed automata Regular properties - automata over finite words



# THE JOY OF COMPUTING USING PYTHON

**PROF. SUDARSHAN IYENGAR**

Department of Computer Science and Engineering  
IIT Ropar

**TYPE OF COURSE** : Rerun | Elective | UG/PG

**COURSE DURATION** : 12 weeks (24 Jan' 22 - 15 Apr' 22)

**EXAM DATE** : 23 Apr 2022

**INTENDED AUDIENCE** : Any interested audience

**PREREQUISITES** : 10th standard/high school

**INDUSTRY SUPPORT** : Every software company is aware of the potential of a first course in computer science. Especially of a first course in computing, done right.

**COURSE OUTLINE** : A fun filled whirlwind tour of 30 hrs, covering everything you need to know to fall in love with the most sought after skill of the 21st century. The course brings programming to your desk with anecdotes, analogies and illustrious examples. Turning abstractions to insights and engineering to art, the course focuses primarily to inspire the learner's mind to think logically and arrive at a solution programmatically. As part of the course, you will be learning how to practice and culture the art of programming with Python as a language. At the end of the course, we introduce some of the current advances in computing to motivate the enthusiastic learner to pursue further directions.

## ABOUT INSTRUCTOR :

Prof. Sudarshan Iyengar, Associate Professor at the CSE at IIT Ropar has a Ph.D. from the Indian Institute of Science (IISc). An exemplary teacher who has delivered over 350 popular science talks to students of high school and advanced graduate programmes. Prof. Sudarshan has offered more than 100 hours of online lectures with novel teaching methodologies that have reached lakhs of Students. His research interests include Data Sciences, Social Computing, Social Networks, Collective Intelligence, Crowdsourced Technologies and Secure Computation.

## COURSE PLAN :

**Week 1:** Motivation for Computing

**Week 2:** Welcome to Programming!!

**Week 3:** Variables and Expressions : Design your own calculator

**Week 4:** Loops and Conditionals : Hopscotch once again

**Week 5:** Lists, Tuples and Conditionals : Lets go on a trip

**Week 6:** Abstraction Everywhere : Apps in your phone

**Week 7:** Counting Candies : Crowd to the rescue

**Week 8:** Birthday Paradox : Find your twin

**Week 9:** Google Translate : Speak in any Language

**Week 10:** Currency Converter : Count your foreign trip expenses

**Week 11:** Monte Hall : 3 doors and a twist

**Week 12:** Sorting : Arrange the books



# REINFORCEMENT LEARNING

**PROF. BALARAMAN RAVINDRAN**

Department of Computer Science  
IIT Madras

**TYPE OF COURSE** : Rerun I Elective I UG / PG

**COURSE DURATION** : 12 weeks (24 Jan' 22 - 15 Apr' 22)

**EXAM DATE** : 23 Apr 2022

**INTENDED AUDIENCE :** Any interested learner

**INDUSTRIES APPLICABLE TO :** Data analytics/data science/robotics

**COURSE OUTLINE :**

Reinforcement learning is a paradigm that aims to model the trial-and-error learning process that is needed in many problem situations where explicit instructive signals are not available. It has roots in operations research, behavioral psychology and AI. The goal of the course is to introduce the basic mathematical foundations of reinforcement learning, as well as highlight some of the recent directions of research.

**ABOUT INSTRUCTOR :**

Prof. Balaraman Ravindran is currently an Professor in Computer Science at IIT Madras and Mindtree Faculty Fellow . He has nearly two decades of research experience in machine learning and specifically reinforcement learning. Currently his research interests are centered on learning from and through interactions and span the areas of data mining, social network analysis, and reinforcement learning.

**COURSE PLAN :**

**Week 1:** Introduction

**Week 2:** Bandit algorithms - UCB, PAC

**Week 3:** Bandit algorithms - Median Elimination, Policy Gradient

**Week 4:** Full RL & MDPs

**Week 5:** Bellman Optimality

**Week 6:** Dynamic Programming & TD Methods

**Week 7:** Eligibility Traces

**Week 8:** Function Approximation

**Week 9:** Least Squares Methods

**Week 10:** Fitted Q, DQN & Policy Gradient for Full RL

**Week 11:** Hierarchical RL

**Week 12:** POMDPs



# ONLINE PRIVACY

**PROF. PONNURANGAM KUMARAGURU**  
Department of Computer Science  
IIIT Hyderabad

**TYPE OF COURSE** : New I Elective I UG/PG  
**COURSE DURATION** : 12 Weeks (24 Jan' 22 - 15 Apr' 22)  
**EXAM DATE** : April 23, 2022

**PRE-REQUISITES :** Any student from 5th semester UG B.Tech. should be able to understand the content of the course.

**INTENDED AUDIENCE :** Anybody interested in the area of Privacy, including industry professionals and students

**INDUSTRIES APPLICABLE TO :** TCS, Wipro, Microsoft to name a few, any company involved in online business will be interested

## COURSE OUTLINE :

With increase in the usage of the Internet, there has been an exponential increase in the use of online platforms, including social media (Facebook, Twitter, Koo, Tinder), e-commerce (Amazon, Flipkart), gaming (Roblox), video streaming (Netflix, Amazon Prime, Twitch), and messaging (WhatsApp, Signal, Telegram) services. These platforms have changed our way of living, and information that we share with or consume from these platforms. However, widely used, there is a lack of understanding of privacy on these online platforms. Popularity of study of Online privacy as a topic of study is very recent. Online Privacy needs to be investigated, studied and characterized from various perspectives (computational, cultural, psychological, theoretical, etc.). It is critical to understand the threats and defend privacy through real-time and scalable systems. Since there are no logical boundaries for the online space, it is important to study the problem from an international perspective too.

## ABOUT INSTRUCTOR :

Prof. Ponnurangam Kumaraguru (&quot;PK&quot;) is a Professor of Computer Science at IIIT-Hyderabad. He is a Visiting Faculty at IIT Kanpur and an Adjunct faculty at IIIT Delhi. PK is an ACM India Council Member, and Chair of the Publicity & Membership Committee of ACM India. PK is a TEDx and an ACM Distinguished & ACM India Eminent Speaker. PK received his Ph.D. from the School of Computer Science at Carnegie Mellon University (CMU).

## COURSE PLAN :

**Week 1:** Introduction; Various Privacy breaches, and its effects

**Week 2:** Definition & forms of Privacy; Difference between data security & data privacy

**Week 3:** Privacy Attitudes & Awareness

**Week 4:** Social Media Privacy

**Week 5:** Social Media Privacy

**Week 6:** Data anonymity:K-anonymity, L-diversity, T-closeness, Differential privacy

**Week 7:** Image & Location privacy; Ethics about studying online privacy

**Week 8:** Image & Location privacy; Ethics about studying online privacy

**Week 9:** User behaviour & Usable privacy; Privacy in National projects like Aadhaar, NATGRID

**Week 10:** User behaviour & Usable privacy; Privacy in National projects like Aadhaar, NATGRID

**Week 11:** Privacy policies:Length, readability, legality, cost of reading privacy polcies

**Week 12:** Privacy policies:Length, readability, legality, cost of reading privacy polcies



# COMPUTATIONAL GEOMETRY

**PROF. AMIT KUMAR**

Department of Computer Science and Engineering  
IIT Delhi

**TYPE OF COURSE**

: Rerun | Elective | UG

**COURSE DURATION**

: 12 weeks (24 Jan' 22 - 15 Apr' 22)

**EXAM DATE**

: 23 Apr 2022

**PRE-REQUISITES :** Data Structures and Algorithms

**INTENDED AUDIENCE :** 4 th year undergraduate or beginning graduate students

**COURSE OUTLINE :**

The course covers lessons in Introduction using Basic Visibility Problems , The Maximal Points Problem, The Plane Sweep Technique and applications ,Convex Hull Different Paradigms and Quickhull , Dual Transformation and Applications , Lower Bounds on Algebraic tree model , Point Location and Triangulation , Voronoi Diagram and Delaunay Triangulation , Randomized Incremental Construction and Random Sampling , Arrangements and Levels , Range Searching , Clustering Point Sets using Quadtrees and Applications , Epsilon-Nets VC Dimension and Applications , Shape Analysis and Shape Comparison.

**ABOUT INSTRUCTOR :**

Prof. Amit Kumar is Tarwinder and Jaswinder Chadha Chair Professor in the Dept. of Computer Science and Engineering at IIT Delhi. He obtained B.Tech. degree from IIT Kanpur in 1997 and Ph.D. from Cornell University in 2002. He works in the area of combinatorial optimization, with emphasis on problems arising in scheduling, graph theory and clustering. He received IBM Faculty Award in 2005, INAE (Indian National Academy of Engineering) Young Engineer Award in 2006 and INSA (Indian National Science Academy) Medal for Young Scientists in 2011. He was a Max Planck-India partner group research fellow during 2005-09. He received the prestigious Shanti Swarup Bhatnagar Award for Mathematical Sciences in 2018, and was elected Fellow of Indian Academy of Sciences in 2019.

**COURSE PLAN :**

- Week 1:** Introduction and Basic Problems
- Week 2:** Plane Sweep Technique
- Week 3:** Convex Hull and Algorithm
- Week 4:** Duality Transform and Application
- Week 5:** Lower Bound Techniques
- Week 6:** Point Location and Triangulation
- Week 7:** Voronoi Diagram and Delaunay Triangulation
- Week 8:** Arrangements and Levels
- Week 9:** Range Search
- Week 10:** Clustering Point sets using Quadtrees and Applications
- Week 11:** Epsilon-nets and VC Dimension
- Week 12:** Shape Analysis



# PROGRAMMING IN MODERN C++

## PROF. PARTHA PRATIM DAS

Department of Computer Science and Engineering  
IIT Kharagpur

**TYPE OF COURSE** : New I Core I UG/PG

**COURSE DURATION** : 12 weeks (24 Jan' 22 - 15 Apr' 22)

**EXAM DATE** : April 23, 2022

**PRE-REQUISITES :** Programming & Data Structure (mandatory), Programming in C (optional). Design and Analysis of Algorithms (optional)

**INDUSTRIES APPLICABLE TO :** Programming in C++ is so fundamental that all companies dealing with systems as well as application development (including web, IoT, embedded systems) have a need for the same. These include – Microsoft, Samsung, Xerox, Yahoo, Oracle, Google, IBM, TCS, Infosys, Amazon, Flipkart, etc. This course would help industry developers to be up-to-date with the advances in C++ so that they can remain at the state-of-the-art

## COURSE OUTLINE :

There has been a continual debate on which programming language/s to learn, to use. As the latest TIOBE Programming Community Index for August 2021 indicates – C (13%), Python (12%), C++ (7%), Java (10%), and C#(5%) together control nearly half the programming activities worldwide. Further, C Programming Language Family (C, C++, C#, Objective C etc.) dominate more than 25% of activities. Hence, learning C++ is important as one learns about the entire family, about Object-Oriented Programming and gets a solid foundation to also migrate to Java and Python as needed. C++ is the mother of most general purpose of languages. It is multi-paradigm encompassing procedural, object-oriented, generic, and even functional programming. C++ has primarily been the systems language till C++03 which punches efficiency of the code with the efficacy of OOP. Then, why should I learn it if my primary focus is on applications? This is where the recent updates of C++, namely, C++11 and several later offer excellent depths and flexibility for C++ that no language can match.

## ABOUT INSTRUCTOR :

Prof. Partha Pratim Das is a Professor at the Department of Computer Science and Engineering, IIT Kharagpur, India. He is also the Joint Principal Investigator of National Digital Library of India project of Ministry of Education and leads the initiative to integrate the Digital Repositories of various Institutions. Prof. Das received his BTech, MTech and PhD degrees in 1984, 1985 and 1988 respectively from IIT Kharagpur. He served as a faculty in Department of Computer Science and Engineering, IIT Kharagpur from 1988 to 1998. In 1998, he moved to the industry and served in director positions till 2011.

## COURSE PLAN :

**Week 1:** Programming in C++ is Fun.

**Week 2:** C++ as Better C.

**Week 3:** OOP in C++.

**Week 4:** OOP in C++.

**Week 5:** Inheritance.

**Week 6:** Polymorphism.

**Week 7:** Type Casting.

**Week 8:** Exceptions and Templates.

**Week 9:** Streams and STL.

**Week 10:** Modern C++.

**Week 11:** Lambda and Concurrency.

**Week 12:** Move, Rvalue and STL Containers.



# BLOCKCHAIN AND ITS APPLICATIONS

**PROF. SANDIP CHAKRABORTY**

Department of Computer Science and Engineering IIT Kharagpur

**PROF. SHAMIK SURAL**

Department of Computer Science and Engineering IIT Kharagpur

**TYPE OF COURSE** : New | Elective | UG/PG

**COURSE DURATION** : 12 weeks (24 Jan' 22 - 15 Apr' 22)

**EXAM DATE** : April 23, 2022

**PRE-REQUISITES :** Computer Networks; Operating Systems; Cryptography and Network Security

**INTENDED AUDIENCE :** Undergraduate Students, Postgraduate Students, Industry Associates

**INDUSTRIES APPLICABLE TO :** IBM; HPE; Intel; Any startups working on Blockchain

**COURSE OUTLINE :**

In the last few years, Blockchain technology has generated massive interest among governments, enterprises, and academics, because of its capability of providing a transparent, secured, tamper-proof solution for interconnecting different stakeholders in a trustless setup. In January 2021, the Ministry of Electronics and Information Technology (MeITY), Government of India, published the first draft of the "National Strategy on Blockchain" that highlights 17 potential applications that are of national interest. Against this backdrop, this subject will cover the basic design principles of Blockchain technology and its applications over different sectors. Additionally, the course also provides tutorials on setting up blockchain applications using one of the well-adopted permissionless blockchain platforms - Ethereum, and one permissioned blockchain platform - Hyperledger.

**ABOUT INSTRUCTOR :**

Prof. Sandip Chakraborty is working as an Associate Professor in the Department of Computer Science and Engineering at the Indian Institute of Technology (IIT) Kharagpur. He obtained his Bachelor of Engineering (BE) degree from Jadavpur University, Kolkata in 2009 and Master of Technology (M Tech) and Doctor of Philosophy (Ph.D.), both from IIT Guwahati, in 2011 and 2014, respectively. The primary research interests of Dr. Chakraborty is in the intersection of Computer Systems, Pervasive Computing, and Human-Computer Interaction.

Prof. Shamik Sural is a full professor in the Department of Computer Science and Engineering, Indian Institute of Technology (IIT) Kharagpur. He received the Ph.D. degree from Jadavpur University, Kolkata, India in the year 2000. Before joining IIT Kharagpur in 2002, he spent more than a decade in the Information Technology industry working in India as well as in Michigan, USA. Prof. Sural was a recipient of the Alexander von Humboldt Fellowship for Experienced Researchers in 2009, which enabled him to carry out collaborative research at the Technical University of Munich, Germany.

**COURSE PLAN :**

**Week 1:** Introduction to Blockchain Technology and its Importance

**Week 2:** Basic Crypto Primitives I – Cryptographic Hash

**Week 3:** Basic Crypto Primitives II – Digital Signature

**Week 4:** Evolution of the Blockchain Technology

**Week 5:** Elements of a Blockchain

**Week 6:** Blockchain Consensus I – Permissionless Models

**Week 7:** Blockchain Consensus II – Permissioned Models

**Week 8:** Smart Contract Hands On I – Ethereum Smart Contracts (Permissionless Model) **Week 9:** Smart Contract Hand On II – Hyperledger Fabric (Permissioned Model)

**Week 10:** Decentralized Identity Management

**Week 11:** Blockchain Interoperability

**Week 12:** Blockchain Applications



# PROBLEM SOLVING THROUGH PROGRAMMING IN C

**PROF. ANUPAM BASU**

Department of Computer Science and  
Engineering IIT Kharagpur

**TYPE OF COURSE**

: Rerun I Elective I UG/PG

**COURSE DURATION**

: 12 weeks (24 Jan' 22 - 15 Apr' 22)

**EXAM DATE**

: 23 Apr 2022

**INTENDED AUDIENCE :** BE/BTech in all disciplines BCA/MCA/M. Sc

**INDUSTRIES APPLICABLE TO :** All IT Industries

**COURSE OUTLINE :**

This course is aimed at enabling the students to

- Formulate simple algorithms for arithmetic and logical problems
- Translate the algorithms to programs (in C language)
- Test and execute the programs and correct syntax and logical errors
- Implement conditional branching, iteration and recursion
- Decompose a problem into functions and synthesize a complete program using divide and conquer approach
- Use arrays, pointers and structures to formulate algorithms and programs
- Apply programming to solve matrix addition and multiplication problems and searching and sorting problems
- Apply programming to solve simple numerical method problems, namely rot finding of function, differentiation of function and simple integration

**ABOUT INSTRUCTOR :**

Prof. Anupam Basu is Professor in the Dept. of Computer Science Engineering, IIT Kharagpur, and has been an active researcher in the areas of Cognitive and Intelligent Systems, Embedded Systems and Language Processing. Presently he is acting as the Chairman and Head of the Center for Educational Technology, IIT Kharagpur. He has developed several embedded system based tools empowering the physically challenged and has led several national projects in the area. He has taught at the University of California, Irvine at the Center for Embedded Systems. He is an Alexander von Humboldt Fellow and a Fellow of the Indian National Academy of Engineering. The awards won by him include the State Award for the Best Contribution to the Cause of Empowerment of the Disabled (2014), Universal Design Award 2011, for contributions in design for the disabled, by National Council for Promotion of Employment of Disabled Persons, India, the National Award for the Best Technology Innovation for the Physically Disabled (2007) and the Da-Vinci Award 2004 from the Engineering Society of Detroit.

**COURSE PLAN :**

**Week 1:** Introduction to Problem Solving through programs, Flowcharts/Pseudo codes, the compilation process, Syntax and Semantic errors, Variables and Data Types

**Week 2:** Arithmetic expressions, Relational Operations, Logical expressions; Introduction to Conditional Branching

**Week 3:** Conditional Branching and Iterative Loops

**Week 4:** Arranging things : Arrays

**Week 5:** 2-D arrays, Character Arrays and Strings

**Week 6:** Basic Algorithms including Numerical Algorithms

**Week 7:** Functions and Parameter Passing by Value

**Week 8:** Passing Arrays to Functions, Call by Reference

**Week 9:** Recursion

**Week 10:** Structures and Pointers

**Week 11:** Self-Referential Structures and Introduction to Lists

**Week 12:** Advanced Topics



# DISCRETE STRUCTURES

**PROF. DIPANWITA ROYCHOWDHURY**

Department of Computer Science and Engineering  
IIT Kharagpur

**TYPE OF COURSE** : Rerun I Core I UG

**COURSE DURATION** : 12 Weeks (24 Jan' 22 - 15 Apr' 22)  
**EXAM DATE** : 23 Apr 2022

**PRE-REQUISITES** : Knowledge of Class 12 Mathematics and basics Computer Programming

**INTENDED AUDIENCE** : Computer Science, Mathematics

**INDUSTRIES APPLICABLE TO** : All companies that work on research problems

**COURSE OUTLINE :**

This course builds the mathematical foundation of computer science. It introduces the elements of mathematics like sets, functions, relations that form the basics of almost the entirety of computer science. It gives a clear understanding about the formal statements and their proofs and the counting techniques. The course develops the concept of algebraic structures and how they are used in defining mathematical applications. All the topics are illustrated with a handful of problems to make the course interesting as well as easy to understand.

**ABOUT INSTRUCTOR :**

Prof. Dipanwita Roy Chowdhury has received her B.Tech and M.Tech degrees in Computer Science from University of Calcutta and the PhD degree from the Department of Computer Science and Engineering, Indian Institute of Technology, Kharagpur. She is a Professor in the Department of Computer Science and Engineering, IIT Kharagpur, India. Currently, she is also the Chairman of Kalpana Chawla Space Technology Cell at IIT Kharagpur. Her current research interests are in the field of Cryptography, Error Correcting Code, Cellular Automata, and VLSI Design and Testing. She has guided 15 PhD students and published more than 150 technical papers in International Journals and Conferences. Prof. Roy Chowdhury is the recipient of INSA Young Scientist Award and Associate of Indian Academy of Science. She is a Senior Member of IEEE and the fellow of Indian National Academy of Engineers (INAE).

**COURSE PLAN :**

**Week 1:** Introduction to Propositional Logic

**Week 2:** Predicate Logic

**Week 3:** Methods of Proofs and Induction

**Week 4:** Sets and Functions

**Week 5:** Relations and their Properties

**Week 6:** Recursion

**Week 7:** Recurrence Relations

**Week 8:** Counting Techniques and Pigeonhole Principle

**Week 9:** Combinatorics

**Week 10:** Algebraic Structures

**Week 11:** Rings and Modular Arithmetic

**Week 12:** Finite Fields and Applications



# INTRODUCTION TO INTERNET OF THINGS

**PROF. SUDIP MISRA**

Department of Computer Science and Engineering  
IIT Kharagpur

**TYPE OF COURSE** : Rerun I Elective I UG

**COURSE DURATION** : 12 weeks (24 Jul' 22 - 15 Apr' 22)  
**EXAM DATE** : 23 Apr 2022

**PRE-REQUISITES :** Basic programming knowledge

**INTENDED AUDIENCE :** CSE, IT, ECE, EE, Instrumentation Engg, Industrial Engineering

**COURSE OUTLINE :**

Internet of Things (IoT) is presently a hot technology worldwide. Government, academia, and industry are involved in different aspects of research, implementation, and business with IoT. IoT cuts across different application domain verticals ranging from civilian to defence sectors. These domains include agriculture, space, healthcare, manufacturing, construction, water, and mining, which are presently transitioning their legacy infrastructure to support IoT. Today it is possible to envision pervasive connectivity, storage, and computation, which, in turn, gives rise to building different IoT solutions. IoT-based applications such as innovative shopping system, infrastructure management in both urban and rural areas, remote health monitoring and emergency notification systems, and transportation systems, are gradually relying on IoT based systems. Therefore, it is very important to learn the fundamentals of this emerging technology.

**ABOUT INSTRUCTOR :**

Prof. Sudip Misra is a Professor in the Department of Computer Science and Engineering at the Indian Institute of Technology Kharagpur. Prior to this he was associated with Cornell University (USA), Yale University (USA), Nortel Networks (Canada) and the Government of Ontario (Canada). He received his Ph.D. degree in Computer Science from Carleton University, in Ottawa, Canada. He has several years of experience working in the academia, government, and the private sectors in research, teaching, consulting, project management, architecture, software design and product engineering roles. His current research interests include Wireless Ad Hoc and Sensor Networks, Internet of Things (IoT), Computer Networks, Learning Systems, and algorithm design for emerging communication networks. Dr. Misra is the author of over 260 scholarly research papers, including 140+ reputed journal papers. He has won seven research paper awards in different conferences.

**COURSE PLAN :**

**Week 1:** Introduction to IoT: Part I, Part II, Sensing, Actuation, Basics of Networking: Part-I

**Week 2:** Basics of Networking: Part-II, Part III, Part IV, Communication Protocols: Part I, Part II

**Week 3:** Communication Protocols: Part III, Part IV, Part V, Sensor Networks: Part I, Part II

**Week 4:** Sensor Networks: Part III, Part IV, Part V, Part VI, Machine-to-Machine Communications

**Week 5:** Interoperability in IoT, Introduction to Arduino Programming: Part I, Part II, Integration of Sensors and Actuators with Arduino: Part I, Part II

**Week 6:** Introduction to Python programming, Introduction to Raspberry Pi, Implementation of IoT with Raspberry Pi

**Week 7:** Implementation of IoT with Raspberry Pi (contd), Introduction to SDN, SDN for IoT

**Week 8:** SDN for IoT (contd), Data Handling and Analytics, Cloud Computing

**Week 9:** Cloud Computing(contd), Sensor-Cloud

**Week 10:** Fog Computing, Smart Cities and Smart Homes

**Week 11:** Connected Vehicles, Smart Grid, Industrial IoT

**Week 12:** Industrial IoT (contd), Case Study: Agriculture, Healthcare, Activity Monitoring



# OBJECT ORIENTED SYSTEM DEVELOPMENT USING UML, JAVA AND PATTERNS

## PROF. RAJIB MALL

Department of Computer Science and Engineering  
IIT Kharagpur

**TYPE OF COURSE** : Rerun I Elective I PG

**COURSE DURATION** : 12 weeks (24 Jan' 22 - 15 Apr' 22)

**EXAM DATE** : 23 Apr 2022

**PRE-REQUISITES :** Programming Using Java, Software Engineering

**INTENDED AUDIENCE :** CSE, IT

## COURSE OUTLINE :

Object-oriented software development has become very popular. Also, UML has been accepted as the standard design language. We discuss use of UML to arrive at a design solution. Skeletal java code generation from UML diagrams will be discussed. Design patterns are reusable solutions. These are good solutions to typical programming problems, that can be understood and applied in a specific design situation to improve the overall design and reduce design iterations.

## ABOUT INSTRUCTOR :

Prof. Rajib Mall is Professor, Department of Computer Science and Engineering, Indian Institute of Technology Kharagpur, West Bengal. He has more than a two decades of teaching experience in the areas of real-time systems, program analysis and testing. He has written five text books and over 150 refereed research papers.

## COURSE PLAN :

**Week 1:** Introduction

**Week 2:** Life Cycle Models for OO Development

**Week 3:** Use Case Diagram

**Week 4:** Class Diagram I

**Week 5:** Class Diagram II

**Week 6:** Sequence Diagram

**Week 7:** State chart diagram

**Week 8:** Design process

**Week 9:** Introduction to design patterns

**Week 10:** GRASP patterns

**Week 11:** GoF pattern I

**Week 12:** GoF Pattern II



# INTRODUCTION TO DATABASE SYSTEMS

**PROF. SREENIVASA KUMAR**

Department of Computer Science and Engineering  
IIT Madras

**TYPE OF COURSE** : Rerun I Core I UG

**COURSE DURATION** : 12 weeks ( 24 Jan' 22 - 15 Apr' 22 )

**EXAM DATE** : 23 Apr 2022

**PRE-REQUISITES :** Studying B Tech (computer science) 3rd year Discrete Mathematics and Data Structures

**INTENDED AUDIENCE :** Any Interested Learners

**COURSE OUTLINE :**

Databases are the backbone of almost all the digital services and e-governance solutions. Modern businesses and financial systems heavily depend on databases systems and transaction processing for their successful operation. This course introduces the students to the various theoretical and practical principles involved in the design and use of databases systems with the help of database management systems (DBMS) and the SQL Standard.

**ABOUT INSTRUCTOR :**

Prof. P Sreenivasa Kumar has been a member of the faculty of the CSE Dept for the past two decades. His research interests are: databases, semi-structured data and XML, theory and applications of ontologies. He completed his Masters and PhD from the Department of Computer Science and Automation of Indian Institute of Science, Bangalore.

**COURSE PLAN :**

**Week 1:** Introduction and part of E/R Model Module

**Week 2:** ER Model Module

**Week 3:** Relational Model Module

**Week 4:** Relational Model Module

**Week 5:** TRC Module and part of SQL Module

**Week 6:** SQL Module

**Week 7:** Indexes Module

**Week 8:** Indexes Module + Query Processing Module

**Week 9:** Normal Forms Module

**Week 10:** Normal Forms Module

**Week 11:** Transaction Processing Module

**Week 12:** Transaction Processing Module



# GETTING STARTED WITH COMPETITIVE PROGRAMMING

## PROF. NEELDHARA MISRA

Department of Computer Science  
IIT Gandhinagar

**TYPE OF COURSE :** Rerun I Elective I UG

**COURSE DURATION :** 12 Weeks (24 Jan'22 - 15 Apr'22)

**EXAM DATE :** 23 Apr 2022

**PREREQUISITES :** Data Structures and Algorithms, Familiarity with a programming language (ideally C++ or Python)

**INTENDED AUDIENCE :** Undergraduate students who have already done a basic data structures/algorithms course.

**INDUSTRIES APPLICABLE TO :** Most technology-based companies typically hire based on a test of coding competence and this course will prepare students for this. Notable examples include: Facebook, Google, Amazon, Apple, Microsoft, etc.

### COURSE OUTLINE :

This is a course on algorithm design with a focus on issues of modeling and implementation. Each lecture will be focused entirely on one or two problems that reveal the use of a specific algorithmic technique. The techniques themselves are chosen to be in line with those covered in existing NPTEL courses on data structures and algorithms, so that students who complete those courses can find in this course a natural follow up. This course is intended for anyone who wants to deepen their appreciation for algorithmic techniques that they have learned in a foundational course and/or would like to take a first step towards preparing for coding competitions such as the ICPC.

### ABOUT INSTRUCTOR :

Prof. Neeldhara Misra is an Assistant Professor of Computer Science and Engineering at the Indian Institute of Technology, Gandhinagar. Her primary research interest involves the design and analysis of efficient algorithms for “hard” problems in general, and parameterized algorithms in particular. The problems considered are typically concerned with combinatorial optimization, frequently in the context of graph theory, social choice, games, geometry, and constraint satisfaction.

### COURSE PLAN :

**Week 1:** Sorting and Searching Algorithms

**Week 2:** Greedy Algorithms - I

**Week 3:** Greedy Algorithms - II

**Week 4:** Disjoint Set Union with Path Compression

**Week 5:** Minimum Spanning Tree

**Week 6:** Shortest Paths: Dijkstra and Beyond

**Week 7:** Network Flows - I

**Week 8:** Network Flows - II, Divide and Conquer

**Week 9:** Dynamic programming - I

**Week 10:** Dynamic programming - II

**Week 11:** Dynamic programming - III

**Week 12:** Dynamic programming - IV



# DISCRETE MATHEMATICS - IIIT B

## PROF. ASHISH CHOUDHURY

Department of Computer Science  
IIIT Bangalore

TYPE OF COURSE : Rerun I Core I UG/PG

COURSE DURATION : 12 Weeks (24 Jan' 22 - 15 Apr' 22)

EXAM DATE : 24 Apr 2022

**INTENDED AUDIENCE :** The course is intended for any student from the computer science discipline

### COURSE OUTLINE :

Discrete mathematics is the study of mathematical structures that are discrete in the sense that they assume only distinct, separate values, rather than in a range of values. It deals with the mathematical objects that are widely used in all most all fields of computer science, such as programming languages, data structures and algorithms, cryptography, operating systems, compilers, computer networks, artificial intelligence, image processing, computer vision, natural language processing, etc. The subject enables the students to formulate problems precisely, solve the problems, apply formal proof techniques and explain their reasoning clearly.

### ABOUT INSTRUCTOR :

Prof. Ashish Choudhury is currently an Associate Professor at IIIT Bangalore. He did his MS and PhD in Computer science from IIT Madras, followed by postdoc at ISI Kolkata and University of Bristol. His research work is focused on the foundation of cryptographic protocols for real-world problems. His current projects aim to design efficient protocols in the asynchronous network model which can be realized in practice. In general he is interested in secure distributed computing and all areas of theoretical computer science.

### COURSE PLAN :

**Week 1:** Logic: Proposition and Predicate Logic, introduction to proof techniques

**Week 2:** Advanced proof techniques, resolution, induction

**Week 3:** Set theory and relations

**Week 4:** Various types of relations and functions

**Week 5:** Combinatorics Part I: permutations, combinations, sum rule, product rule, pigeon-hole principle, Ramsey numbers

**Week 6:** Combinatorics Part II: Combinatorial proofs, Catalan numbers, counting using recursion, principle of inclusion-exclusion, advanced counting techniques

**Week 7:** Recurrence equations and various methods of solving recurrence equations

**Week 8:** Cardinality theory, countable and uncountable sets, Cantors diagonalization, uncomputable functions

**Week 9:** Graph theory Part I: basic definitions, Eulers theorem, bipartite graphs and matching, Halls marriage theorem, various operations on graphs

**Week 10:** Graph theory part II: isomorphism, vertex-connectivity, edge-connectivity, Euler graphs and Hamiltonian graphs, various characterizations, vertex and edge coloring

**Week 11:** Abstract algebra: groups, rings, fields

**Week 12:** Basic number theory: modular arithmetic, prime numbers and properties, GCD, Chinese remainder theorem, Fermats little theorem, RSA cryptosystem



# GPU ARCHITECTURES AND PROGRAMMING

**PROF. SOUMYAJIT DEY**

Department of Computer Science and Engineering  
IIT Kharagpur

**TYPE OF COURSE** : Rerun I Elective I UG/PG

**COURSE DURATION** : 12 weeks (24 Jan' 22 - 15 Apr' 22)

**EXAM DATE** : 24 Apr 2022

**PRE-REQUISITES :** Programming and Data Structure, Digital Logic, Computer architecture

**INTENDED AUDIENCE :** Computer Science, Electronics, Electrical Engg students

**INDUSTRIES APPLICABLE TO :** NVIDIA, AMD, Google, Amazon and most big-data companies

**COURSE OUTLINE :**

The course covers basics of conventional CPU architectures, their extensions for single instruction multiple data processing (SIMD) and finally the generalization of this concept in the form of single instruction multiple thread processing (SIMT) as is done in modern GPUs. We cover GPU architecture basics in terms of functional units and then dive into the popular CUDA programming model commonly used for GPU programming. In this context, architecture specific details like memory access coalescing, shared memory usage, GPU thread scheduling etc which primarily effect program performance are also covered in detail. We next switch to a different SIMD programming language called OpenCL which can be used for programming both CPUs and GPUs in a generic manner. Throughout the course we provide different architecture-aware optimization techniques relevant to both CUDA and OpenCL. Finally, we provide the students with detail application development examples in two well-known GPU computing scenarios.

**ABOUT INSTRUCTOR :**

Prof. Dey joined the Dept. of CSE, IIT Kgp in May 2013. He worked at IIT Patna as Assistant Professor in CSE Dept. from 2012 to 2013. He received a B.E. degree in Electronics and Telecommunication Engg. from Jadavpur University, Kolkata in 2004. and an M.S. followed by PhD degree in Computer Science from Indian Institute of Technology, Kharagpur in 2007 and 2011 respectively. His research interests include 1) Synthesis and Verification of Safe, Secure and Intelligent Cyber Physical Systems, 2) Runtime Systems for Heterogeneous Platforms.

**COURSE PLAN :**

**Week 1:** Review of Traditional Computer Architecture – Basic five stage RISC Pipeline, Cache Memory, Register File, SIMD instructions

**Week 2:** GPU architectures - Streaming Multi Processors, Cache Hierarchy, The Graphics Pipeline

**Week 3:** Introduction to CUDA programming

**Week 4:** Multi-dimensional mapping of dataspace, Synchronization

**Week 5:** Warp Scheduling, Divergence

**Week 6:** Memory Access Coalescing

**Week 7:** Optimization examples : optimizing Reduction Kernels

**Week 8:** Optimization examples : Kernel Fusion, Thread and Block Coarsening

**Week 9:** OpenCL basics

**Week 10:** CPU GPU Program Partitioning

**Week 11:** Application Design : Efficient Neural Network Training/Inferencing

**Week 12:** Application Design : Efficient Neural Network Training/Inferencing, cont'd



# COMPUTER ARCHITECTURE

**PROF. SMRUTI RANJAN SARANGI**

Department of Computer Science and Engineering  
IIT Delhi

**TYPE OF COURSE**

: Rerun I Core I UG

**COURSE DURATION**

: 12 weeks (24 Jan' 22 - 15 Apr' 22)

**EXAM DATE**

: 24 Apr 2022

**PRE-REQUISITES :** C programming

**INTENDED AUDIENCE :** 2nd year UG students

**INDUSTRIES APPLICABLE TO :** Intel, AMD, IBM, Oracle, NVidia, Fujitsu

## **COURSE OUTLINE :**

This is an introductory computer architecture course for beginners. We will start out with a discussion on binary representations, and a discussion on number systems (1s complement and 2 complement). Then, the course will move on to discuss assembly languages, and computer arithmetic. Once, we are done with the fundamentals, we shall look at the design of a simple processor, concepts of pipelining, and the design of a modern memory system.

## **ABOUT INSTRUCTOR :**

Prof. Smruti R. Sarangi is an Associate Professor in the Computer Science and Engineering department at IIT Delhi. He has a Ph.D in computer science from the University of Illinois at Urbana Champaign, USA, and a B.Tech from IIT Kharagpur. Prior to his appointment as a faculty member in IIT Delhi in 2011, he spent 5 years working for IBM Research Labs, and Synopsys Research. He has published 60 papers in prestigious international conferences and journals, and holds 5 US patents. He is a member of the IEEE and ACM.

## **COURSE PLAN :**

**Week 1:** Introduction to Computing

**Week 2:** Number Systems

**Week 3:** Floating Point Numbers

**Week 4:** Assembly Language - I

**Week 5:** Assembly Language - II

**Week 6:** Algorithms for Binary Addition

**Week 7:** Algorithms for Multiplication and Division

**Week 8:** Processor Design

**Week 9:** Pipelining - I

**Week 10:** Pipelining - II

**Week 11:** Memory Systems - Caches

**Week 12:** Virtual Memory



# CLOUD COMPUTING

**PROF. SOUMYA KANTI GHOSH**

Department of Computer Science and Engineering  
IIT Kharagpur

**TYPE OF COURSE**

: Rerun I Elective I UG

**COURSE DURATION**

: 12 weeks (24 Jan' 22 - 15 Apr' 22)

**EXAM DATE**

: 24 Apr 2022

**PRE-REQUISITES :** Basics of Computer Architecture and Organization, Networking

**INTENDED AUDIENCE :** CSE, ECE, EE

**INDUSTRIES APPLICABLE TO :** IT industries

**COURSE OUTLINE :**

Cloud computing is a scalable services consumption and delivery platform that provides on-demand computing service for shared pool of resources, namely servers, storage, networking, software, database, applications etc., over the Internet. It is a model for enabling ubiquitous, on-demand access to a shared pool of configurable computing resources, which can be rapidly provisioned and released with minimal management effort. This course will introduce various aspects of cloud computing, including fundamentals, management issues, security challenges and future research trends. This will help students (both UG and PG levels) and researchers to use and explore the cloud computing platforms.

**ABOUT INSTRUCTOR :**

Prof. Soumya K. Ghosh received the Ph.D. and M.Tech. degrees from Department of Computer Science and Engineering, Indian Institute of Technology (IIT), Kharagpur, India. Presently, he is a Professor with Department of Computer Science and Engineering, IIT Kharagpur. Before joining IIT Kharagpur, he worked for the Indian Space Research Organization in the area of satellite remote sensing and geographic information systems. He has more than 200 research papers in reputed journals and conference proceedings. His research interests include spatial data science, spatial web services and cloud computing.

**COURSE PLAN :**

**Week 1:** Introduction to Cloud Computing

**Week 2:** Cloud Computing Architecture

**Week 3:** Service Management in Cloud Computing

**Week 4:** Data Management in Cloud Computing

**Week 5:** Resource Management in Cloud

**Week 6:** Cloud Security

**Week 7:** Open Source and Commercial Clouds, Cloud Simulator

**Week 8:** Research trend in Cloud Computing, Fog Computing

**Week 9:** VM Resource Allocation, Management and Monitoring

**Week 10:** Cloud-Fog-Edge enabled Analytics

**Week 11:** Serverless Computing and FaaS Model

**Week 12:** Case Studies and Recent Advancements



# INTRODUCTION TO MACHINE LEARNING

**PROF. BALARAMAN RAVINDRAN**

Department of Computer Science IIT Madras

**TYPE OF COURSE** : Rerun I Elective I UG/PG

**COURSE DURATION** : 12 weeks (24 Jan' 22 - 15 Apr' 22)

**EXAM DATE** : 24 Apr 2022

**PRE-REQUISITES :** We will assume that the students know programming for some of the assignments. If the students have done introductory courses on probability theory and linear algebra it would be helpful. We will review some of the basic topics in the first two weeks as well.

**INTENDED AUDIENCE :** This is an elective course. Intended for senior UG/PG students. BE/ME/MS/PhD

**INDUSTRIES APPLICABLE TO :** Any company in the data analytics/data science/big data domain would value this course

## COURSE OUTLINE :

With the increased availability of data from varied sources there has been increasing attention paid to the various data driven disciplines such as analytics and machine learning. In this course we intend to introduce some of the basic concepts of machine learning from a mathematically well motivated perspective. We will cover the different learning paradigms and some of the more popular algorithms and architectures used in each of these paradigms.

## ABOUT INSTRUCTOR :

Prof. Balaraman Ravindran is currently an Professor in Computer Science at IIT Madras and Mindtree Faculty Fellow . He has nearly two decades of research experience in machine learning and specifically reinforcement learning. Currently his research interests are centered on learning from and through interactions and span the areas of data mining, social network analysis, and reinforcement learning.

## COURSE PLAN :

**Week 0:** Probability Theory, Linear Algebra, Convex Optimization - (Recap)

**Week 1:** Introduction: Statistical Decision Theory - Regression, Classification, Bias Variance

**Week 2:** Linear Regression, Multivariate Regression, Subset Selection, Shrinkage Methods, Principal Component Regression, Partial Least squares

**Week 3:** Linear Classification, Logistic Regression, Linear Discriminant Analysis

**Week 4:** Perceptron, Support Vector Machines

**Week 5:** Neural Networks - Introduction, Early Models, Perceptron Learning, Backpropagation, Initialization, Training & Validation, Parameter Estimation - MLE, MAP, Bayesian Estimation

**Week 6:** Decision Trees, Regression Trees, Stopping Criterion & Pruning loss functions, Categorical Attributes, Multiway Splits, Missing Values, Decision Trees - Instability Evaluation Measures

**Week 7:** Bootstrapping & Cross Validation, Class Evaluation Measures, ROC curve, MDL, Ensemble Methods - Bagging, Committee Machines and Stacking, Boosting

**Week 8:** Gradient Boosting, Random Forests, Multi-class Classification, Naive Bayes, Bayesian Networks

**Week 9:** Undirected Graphical Models, HMM, Variable Elimination, Belief Propagation

**Week 10:** Partitional Clustering, Hierarchical Clustering, Birch Algorithm, CURE Algorithm, Density-based Clustering

**Week 11:** Gaussian Mixture Models, Expectation Maximization

**Week 12:** Learning Theory, Introduction to Reinforcement Learning, Optional videos (RL framework, TD learning, Solution Methods, Applications)



# SOCIAL NETWORKS

## Prof. Sudarshan Iyengar

Department of Computer Science and Engineering  
IIT Ropar

**TYPE OF COURSE** : Rerun I Elective I UG

**COURSE DURATION** : 12 weeks (24 Jan' 22 - 15 Apr' 22)

**EXAM DATE** : 24 Apr 2022

## Prof. Yayati Gupta

Department of Computer Science and Engineering  
Mahindra University, Hyderabad

**INTENDED AUDIENCE :** Any Interested Learners

### COURSE OUTLINE :

The world has become highly interconnected and hence more complex than ever before. We are surrounded by a multitude of networks in our daily life, for example, friendship networks, online social networks, world wide web, road networks etc. All these networks are today available online in the form of graphs which hold a whole lot of hidden information. They encompass surprising secrets which have been time and again revealed with the help of tools like graph theory, sociology, game theory etc. The study of these graphs and revelation of their properties with these tools have been termed as Social Network Analysis.

### ABOUT INSTRUCTOR :

Prof. Sudarshan Iyengar, Associate Professor at the CSE at IIT Ropar has a Ph.D. from the Indian Institute of Science (IISc). An exemplary teacher who has delivered over 350 popular science talks to students of high school and advanced graduate programmes. Prof. Sudarshan has offered more than 100 hours of online lectures with novel teaching methodologies that have reached lakhs of Students. His research interests include Data Sciences, Social Computing, Social Networks, Collective Intelligence, Crowdsourced Technologies and Secure Computation.

Prof. Yayati Gupta is an Assistant Professor in the Computer Science & Engineering Department at Mahindra University École Centrale School of Engineering. She is also an instructor for a couple of NPTEL/SWAYAM courses (Social Networks, Joy of Computing). She holds a Ph.D. in Computer Science and Engineering from Indian Institute of Technology Ropar (November 2017). Her research primarily focuses on Social Network Analysis and Complex Networks. The major research projects include "Modeling Information Diffusion" and "Understanding Virality of Internet Memes" in online social networks.

### COURSE PLAN :

**Week 1:** Introduction

**Week 2:** Handling Real-world Network Datasets

**Week 3:** Strength of Weak Ties

**Week 4:** Strong and Weak Relationships (Continued) & Homophily

**Week 5:** Homophily Continued and +Ve / -Ve Relationships

**Week 6:** Link Analysis

**Week 7:** Cascading Behaviour in Networks

**Week 8:** Link Analysis (Continued)

**Week 9:** Power Laws and Rich-Get-Richer Phenomena

**Week 10:** Power law (contd..) and Epidemics

**Week 11:** Small World Phenomenon

**Week 12:** Pseudocore (How to go viral on web)



# DISCRETE MATHEMATICS

## PROF. SUDARSHAN IYENGAR

Department of Computer Science and Engineering  
IIT Ropar

## PROF. PRABUCHANDRAN K.J.

Department of Computer Science and Automation  
IIT Dharwad

**TYPE OF COURSE** : Rerun | Core | UG

**COURSE DURATION** : 12 weeks (24 Jan'22 - 15 Apr'22)

**EXAM DATE** : 24 Apr 2022

**INTENDED AUDIENCE** : Any Interested Learners

**INDUSTRIES APPLICABLE TO** : Every industry expects candidates to have good aptitude. This course sharpens the overall Quant skills.

## COURSE OUTLINE :

The course will be an introduction to Discrete Mathematics which comprises of the essentials for a computer science student to go ahead and study any other topics in the subject. The emphasis will be on problem solving as well as proofs. We will be providing motivational illustrations and applications through out the course. The course doesn't assume any pre-requisites except for high school level arithmetic and algebra.

## ABOUT INSTRUCTOR :

Prof. Sudarshan Iyengar, Associate Professor at the CSE at IIT Ropar has a Ph.D. from the Indian Institute of Science (IISc). An exemplary teacher who has delivered over 350 popular science talks to students of high school and advanced graduate programmes. Prof. Sudarshan has offered more than 100 hours of online lectures with novel teaching methodologies that have reached lakhs of Students. His research interests include Data Sciences, Social Computing, Social Networks, Collective Intelligence, Crowdsourced Technologies and Secure Computation.

Prof. Prabuchandran K.J. is an Assistant Professor at IIT Dharwad. He completed Ph.D. from the Department of Computer Science and Automation, IISc in the area of Reinforcement Learning. Post his PhD, Prabuchandran worked as Research Scientist at IBM Research Labs, India for a year and half on change detection algorithms for multivariate compositional data. After that he pursued his postdoctoral research at IISc, Bangalore as an Amazon-IISc Postdoctoral scholar for a year and half on Multi-agent Reinforcement Learning and Stochastic Optimization algorithms.

## COURSE PLAN :

**Week 1:** Counting

**Week 2:** Set Theory

**Week 3:** Logic

**Week 4:** Relations

**Week 5:** Functions

**Week 6:** Mathematical Induction and Pigeonhole Principle

**Week 7:** Graph Theory - 01

**Week 8:** Graph Theory - 02

**Week 9:** Graph Theory - 03 and Generating Functions

**Week 10:** Principle of Inclusion-Exclusion

**Week 11:** Recurrence relations

**Week 12:** Advanced Topics



# Deep learning - IIT Ropar

## Prof. Sudarshan Iyengar

Department of Computer Science and Engineering  
IIT Ropar

**TYPE OF COURSE** : Rerun I Elective I UG/PG  
**COURSE DURATION** : 12 weeks (24 Jan' 22 - 15 Apr 22)  
**EXAM DATE** : 24 Apr 2022

## Prof. Sanatan Sukhija

Department of Computer Science and Engineering  
Mahindra University, Hyderabad

**PRE-REQUISITES :** Working knowledge of Linear Algebra, Probability Theory. It would be beneficial if the participants have done a course on Machine Learning.

## COURSE OUTLINE :

Deep Learning has received a lot of attention over the past few years and has been employed successfully by companies like Google, Microsoft, IBM, Facebook, Twitter etc. to solve a wide range of problems in Computer Vision and Natural Language Processing. In this course we will learn about the building blocks used in these Deep Learning based solutions. Specifically, we will learn about feedforward neural networks, convolutional neural networks, recurrent neural networks and attention mechanisms. We will also look at various optimization algorithms such as Gradient Descent, Nesterov Accelerated Gradient Descent, Adam, AdaGrad and RMSProp which are used for training such deep neural networks. At the end of this course students would have knowledge of deep architectures used for solving various Vision and NLP tasks

## ABOUT INSTRUCTOR :

Prof. Sudarshan Iyengar, Associate Professor at the CSE at IIT Ropar has a Ph.D. from the Indian Institute of Science (IISc). An exemplary teacher who has delivered over 350 popular science talks to students of high school and advanced graduate programmes. Prof. Sudarshan has offered more than 100 hours of online lectures with novel teaching methodologies that have reached lakhs of Students. His research interests include Data Sciences, Social Computing, Social Networks, Collective Intelligence, Crowdsourced Technologies and Secure Computation.

Prof. Sanatan Sukhija is currently working as an Assistant Professor in the Department of Computer Science and Engineering at Mahindra University, Hyderabad. He earned his Doctorate from the Department of Computer Science and Engineering at Indian Institute of Technology Ropar. Prior to joining Mahindra University, his varied career includes stints at several industries and academic institutions, including, Amazon, Intel, Siemens, HCL, Punjab Engineering College, and the NorthCap University.

## COURSE PLAN :

**Week 1:** History of Deep Learning, Deep Learning Success Stories, McCulloch Pitts Neuron

**Week 2:** Multilayer Perceptrons (MLPs), Representation Power of MLPs, Sigmoid Neurons, Gradient Descent

**Week 3:** Feed Forward Neural Networks, Back propagation

**Week 4:** Gradient Descent (GD), Momentum Based GD, Nesterov Accelerated GD, Stochastic GD

**Week 5:** Principal Component Analysis and its interpretations, Singular Value Decomposition

**Week 6:** Auto encoders and relation to PCA, Regularization in auto encoders, Denoising auto encoders, Sparse auto encoders

**Week 7:** Regularization: Bias Variance Tradeoff, L2 regularization, Early stopping, Dataset augmentation

**Week 8:** Greedy Layerwise Pre-training, Better activation functions, Better weight initialization methods, Batch Normalization

**Week 9:** Learning Vectorial Representations Of Words

**Week 10:** Convolutional Neural Networks, LeNet, AlexNet, ZF-Net, VGGNet, GoogLeNet, ResNet

**Week 11:** Recurrent Neural Networks, Back propagation through time (BPTT), Vanishing and Exploding Gradients, Truncated BPTT, GRU, LSTMs

**Week 12:** Encoder Decoder Models, Attention Mechanism, Attention over images



# AN INTRODUCTION TO PROGRAMMING THROUGH C++

## PROF. ABHIRAM G. RANADE

Department of Computer Science  
IIT Bombay

TYPE OF COURSE : Rerun I Core I UG

COURSE DURATION : 12 weeks (24 Jan' 22 - 15 Apr' 22)

EXAM DATE : 24 Apr 2022

**PRE-REQUISITES :** Standard XII in the Science stream.

**INTENDED AUDIENCE :** First and second year students in degree programs including Engineering and Science degree programs.

**INDUSTRIES APPLICABLE TO :** Basic programming is of value to all. C++ allows you to design very fast programs and access low level machine features, but at the same time its libraries provide a very high level programming model. It can be considered a modern, safer version of the C language.

## COURSE OUTLINE :

This course provides an introduction to problem solving and programming using the C++ programming language. The topics include: Basic programming notions. Control flow, variables and assignments statements, conditional execution, looping, function calls including recursion. Arrays and structures. Elementary aspects of classes. Heap memory. Program design. How human beings solve problems manually. Strategies for translating manual strategies to computer programs. Organizing large programs into units such as functions and classes. Introduction to assertions and invariant. Programming applications. Arithmetic on polynomials, matrices. Root finding. Sorting and searching. Design of editors and simulators, including graphical editors. Elementary animation. A rudimentary graphics system will be discussed. Standard Library of C++. The string, vector and map classes.

## ABOUT INSTRUCTOR :

Prof. Abhiram G. Ranade is a Professor of Computer Science and Engineering at IIT Bombay. He obtained a B. Tech. degree in Electrical Engineering from IIT Bombay in 1981. In 1988 he obtained a Ph.D. in Computer Science from Yale University, USA. He was an Assistant Professor of Electrical Engineering and Computer Science at the University of California, Berkeley, USA during 1988-94. Since 1995 he has been a faculty member in IIT Bombay. His research interests are Algorithms, Combinatorial Optimization, Scheduling in Transportation Systems, and Programming Education. He has won Excellence in Teaching Awards of IIT Bombay in 2006-7 and 2010-11.

## COURSE PLAN :

**Week 1:** Introduction to computers using graphics. Notions of program organization, control flow.

**Week 2:** Basic data types. Variables. Assignment statement. Introduction to program design using examples such as summing infinite series.

**Week 3:** Statements of C++ for conditional execution and looping.

**Week 4:** Applications such as computing mathematical functions, root finding.

**Week 5:** Functions. Parameter passing. Recursion. Correctness issues.

**Week 6:** Recursive algorithms and recursive drawings. Breaking larger programs into functions.

**Week 7:** Arrays. Basic array processing strategies including passing arrays to functions. Pointers. Applications illustrating use of arrays to store sets and sequences. Iterating over pairs of objects from an array, Selection sort.

**Week 8:** Use of arrays to represent textual data. Multidimensional arrays. Command line arguments. Binary search. Merge sort.

**Week 9:** Structures. Pointers with structures. Structure examples.

**Week 10:** Dynamic memory allocation. Basic mechanisms and pitfalls.

**Week 11:** Use of the standard library in designing programs. Design of medium size programs.

**Week 12:** A program for designing and solving resistive circuits with a graphical user interface.



# EMBEDDED SYSTEMS DESIGN

**PROF. ANUPAM BASU**

Department of Computer Science & Engineering  
IIT Kharagpur

**TYPE OF COURSE** : Rerun I Core I UG

**COURSE DURATION** : 12 weeks (24 Jan' 22 - 15 Apr' 22)  
**EXAM DATE** : 24 Apr 2022

**PRE-REQUISITES :** Computer Organization, Basic of Microprocessors

**INTENDED AUDIENCE :** Environmental engineering professionals and students pursuing a degree with emphasis in Environmental engineering.

**INDUSTRIES APPLICABLE TO :** Any industry working in the area of Embedded Systems

**COURSE OUTLINE :**

This course on Embedded systems will first introduce the students to the fundamental requirements of embedded systems and the interaction between hardware and software in such systems. Next the course will discuss some basic steps of hardware design, introduce the students to ASIPs, ASICs and FPGAs. Next, the students will be exposed to the very important issue of designing for less power consumption and introduce them to the techniques that are adopted to this end. Since many of the embedded systems will have real time constraints, basic issues of real time operating systems will be discussed. This will be followed by formal specification models and languages, mapping the specification to hardware and software components along with decisions on design tradeoffs and hardware software partitioning. Next, synthesis of hardware and software along with a few of the optimization techniques will be presented. The course will end with a brief overview of design verification methods that are adopted for embedded system design.

**ABOUT INSTRUCTOR :**

Prof. Anupam Basu is Professor in the Dept. of Computer Science Engineering, IIT Kharagpur, and has been an active researcher in the areas of Cognitive and Intelligent Systems, Embedded Systems and Language Processing. Presently he is acting as the Chairman and Head of the Center for Educational Technology, IIT Kharagpur. He has developed several embedded system based tools empowering the physically challenged and has led several national projects in the area.

**COURSE PLAN :**

**Week 1:** Introduction to Embedded System, ASICs and ASIPs

**Week 2:** Designing Single Purpose Processors and Optimization

**Week 3:** Introduction to FPGAs and Synthesis

**Week 4:** Verilog Hardware Description Language (Verilog HDL)

**Week 5:** Microcontrollers and Power Aware Embedded System Design

**Week 6:** Real Time Operating System

**Week 7:** Real Time Scheduling Algorithms

**Week 8:** Modelling and Specification

**Week 9:** Design Synthesis

**Week 10:** Digital Camera Design and Hardware Software Partitioning

**Week 11:** Design Optimization

**Week 12:** Simulation and Verification



# PROGRAMMING IN JAVA

**PROF. DEBASIS SAMANTA**

Department of Computer Science and Engineering  
IIT Kharagpur

**TYPE OF COURSE** : Rerun I Elective I UG

**COURSE DURATION** : 12 weeks (24 Jan' 22 - 15 Apr' 22)

**EXAM DATE** : 24 Apr 2022

**PRE-REQUISITES :** This course requires that the students are familiar with programming language such as C/C++ and data structures, algorithms.

**INTENDED AUDIENCE :** The undergraduate students from the engineering disciplines namely CSE, IT, EE, ECE, etc. might be interested for this course.

**INDUSTRIES APPLICABLE TO :** All IT companies.

**COURSE OUTLINE :**

With the growth of Information and Communication Technology, there is a need to develop large and complex software. Further, those software should be platform independent, Internet enabled, easy to modify, secure, and robust. To meet this requirement object-oriented paradigm has been developed and based on this paradigm the Java programming language emerges as the best programming environment. Now, Java programming language is being used for mobile programming, Internet programming, and many other applications compatible to distributed systems. This course aims to cover the essential topics of Java programming so that the participants can improve their skills to cope with the current demand of IT industries and solve many problems in their own field of studies.

**ABOUT INSTRUCTOR :**

Prof. Debasis Samanta holds a Ph.D. in Computer Science and Engineering from Indian Institute of Technology Kharagpur. His research interests and work experience spans the areas of Computational Intelligence, Data Analytics, Human Computer Interaction, Brain Computing and Biometric Systems. Dr. Samanta currently works as a faculty member at the Department of Computer Science Engineering at IIT Kharagpur.

**COURSE PLAN :**

**Week 1:** Overview of Object-Oriented Programming and Java

**Week 2:** Java Programming Elements

**Week 3:** Input-Output Handling in Java

**Week 4:** Encapsulation

**Week 5:** Inheritance

**Week 6:** Exception Handling

**Week 7:** Multithreaded Programming

**Week 8:** Java Applets and Servlets

**Week 9:** Java Swing and Abstract Windowing Toolkit (AWT)

**Week 10:** Networking with Java

**Week 11:** Java Object Database Connectivity (ODBC)

**Week 12:** Interface and Packages for Software Development



# HARDWARE SECURITY

**PROF. DEBDEEP MUKHOPADHYAY**

Department of Computer Science and Engineering  
IIT Kharagpur

**TYPE OF COURSE**

: Rerun I Elective I PG

**COURSE DURATION**

: 12 Weeks (24 Jan' 22 - 15 Apr' 22)

**EXAM DATE**

: 24 Apr 2022

**PRE-REQUISITES :** Cryptography

**INTENDED AUDIENCE :** Post-graduate students, and final year undergraduate students

**INDUSTRIES APPLICABLE TO :** TexasInstruments/BOSCH/DRDO/HAL/Wipro/CDAC/ISRO/Rambus/Inte  
l/Qualcomm/Synopsys/IBM/Microsoft/Cadence/SecureIC/Riscure/Mento  
r Graphics/Xilinx/Nvidia

**COURSE OUTLINE :**

This course will focus on the importance of addressing different security threats on modern hardware design, manufacturing, installation, and operating practices. In particular, the threats would be shown to be relevant at scales ranging from a single user to an entire nation's public infrastructure. Through theoretical analyses and relevant practical world case studies, the threats would be demonstrated, and then state-of-the-art defense techniques would be described. The course would borrow concepts from diverse fields of study such as cryptography, hardware design, circuit testing, algorithms, and machine learning.

**ABOUT INSTRUCTOR :**

Prof. Debdeep Mukhopadhyay is currently a full Professor at the Department of Computer Science and Engineering, IIT-Kharagpur, India. At IIT Kharagpur he initiated the Secured Embedded Architecture Laboratory (SEAL), with a focus on Embedded Security and Side Channel Attacks( [ <http://cse.iitkgp.ac.in/resgrp/seal/> | <http://cse.iitkgp.ac.in/resgrp/seal/> ] ). Prior to this he worked as Associate Professor at IIT Kharagpur, visiting scientist at NTU Singapore, a visiting Associate Professor of NYU-Shanghai, Assistant Professor at IIT-Madras, and as Visiting Researcher at NYU Tandon-School-of-Engineering, USA. He holds a PhD, an MS, and a B. Tech from IIT Kharagpur, India.

**COURSE PLAN :**

**Week 1:** Introduction, Finite Fields, AES Hardware, S-Box

**Week 2:** Algorithm to Hardware, Case Study on ECC, Intro to ECC

**Week 3:** Implementation of ECC, Hardware Design of ECC

**Week 4:** Introduction to Side Channel Analysis

**Week 5:** Advanced SCA, Introduction to Fault Attacks

**Week 6:** Advanced Fault Attacks, Algebraic Fault Analysis

**Week 7:** Countermeasures-I

**Week 8:** Countermeasures-II

**Week 9:** Introduction to PUFs, Designs on FPGAs, Machine Learning of PUFs

**Week 10:** Design-for-Testability for Cryptographic Designs

**Week 11:** Protocols, Challenges, Introduction to Micro-architectural attacks

**Week 12:** Advanced Micro-architectural attacks, Hardware monitoring for malwares using Hardware Performance Counters



# VLSI PHYSICAL DESIGN

**PROF. INDRANIL SENGUPTA**

Department of Computer Science and Engineering  
IIT Kharagpur

**TYPE OF COURSE**

: Rerun I Elective I UG/PG

**COURSE DURATION**

: 12 weeks (24 Jan' 22 - 15 Apr' 22)

**EXAM DATE**

: 24 Apr 2022

**PRE-REQUISITES :** Basic concepts in digital circuit design

**INTENDED AUDIENCE :** Computer Science and Engineering / Electronics and Communication Engineering / Electrical Engineering

**INDUSTRIES APPLICABLE TO :** Intel, Cadence, Mentor Graphics, Synopsys, Xilinx

**COURSE OUTLINE :**

The course will introduce the participants to the basic design flow in VLSI physical design automation, the basic data structures and algorithms used for implementing the same. The course will also provide examples and assignments to help the participants to understand the concepts involved, and appreciate the main challenges therein.

**ABOUT INSTRUCTOR :**

Prof. Indranil Sengupta has obtained his B.Tech., M.Tech. and Ph.D. degrees in Computer Science and Engineering from the University of Calcutta. He joined the Indian Institute of Technology, Kharagpur, as a faculty member in 1988, in the Department of Computer Science and Engineering, where he is presently a full Professor. He had been the former Heads of the Department of Computer Science and Engineering and also the School of Information Technology of the Institute. He has over 28 years of teaching and research experience. He has guided 22 PhD students, and has more than 200 publications to his credit in international journals and conferences. His research interests include cryptography and network security, VLSI design and testing, and mobile computing.

**COURSE PLAN :**

**Week 1:** Introduction to physical design automation

**Week 2:** Partitioning, Floorplanning and Placement

**Week 3:** Grid Routing and Global Routing

**Week 4:** Detailed Routing and Clock Design

**Week 5:** Clock Routing and Power/Ground

**Week 6:** Static Timing Analysis and Timing Closure

**Week 7:** Physical Synthesis and Performance Driven Design Flow

**Week 8:** Interconnect Modeling and Layout Compaction

**Week 9:** Introduction to Testing, Fault Modeling and Simulation

**Week 10:** Test Pattern Generation, DFT and BIST

**Week 11:** Low Power Design Techniques

**Week 12:** Low Power Design Techniques (contd.)



# INTRODUCTION TO INDUSTRY 4.0 AND INDUSTRIAL INTERNET OF THINGS

## PROF. SUDIP MISRA

Department of Computer Science and Engineering  
IIT Kharagpur

TYPE OF COURSE : Rerun I Core I PG

COURSE DURATION : 12 weeks (24 Jan' 22 - 15 Apr' 22)  
EXAM DATE : 24 Apr 2022

**PRE-REQUISITES :** Basic knowledge of computer and internet

**INTENDED AUDIENCE :** CSE, IT, ECE, EE, Instrumentation Engg, Industrial Engineering, Industry Professionals

**INDUSTRIES APPLICABLE TO :** All Industrial Sectors

## COURSE OUTLINE :

Industry 4.0 concerns the transformation of industrial processes through the integration of modern technologies such as sensors, communication, and computational processing. Technologies such as Cyber Physical Systems (CPS), Internet of Things (IoT), Cloud Computing, Machine Learning, and Data Analytics are considered to be the different drivers necessary for the transformation. Industrial Internet of Things (IIoT) is an application of IoT in industries to modify the various existing industrial systems. IIoT links the automation system with enterprise, planning and product lifecycle. This course has been organized into the modules below:

## ABOUT INSTRUCTOR :

Prof. Sudip Misra is a Professor in the Department of Computer Science and Engineering at the Indian Institute of Technology Kharagpur. Prior to this he was associated with Cornell University (USA), Yale University (USA), Nortel Networks (Canada) and the Government of Ontario (Canada). He received his Ph.D. degree in Computer Science from Carleton University, in Ottawa, Canada. He has several years of experience working in the academia, government, and the private sectors in research, teaching, consulting, project management, architecture, software design and product engineering roles. His current research interests include Wireless Ad Hoc and Sensor Networks, Internet of Things (IoT), Computer Networks, Learning Systems, and algorithm design for emerging communication networks.

## COURSE PLAN :

**Week 1:** Introduction: Sensing & actuation, Communication-Part I, Part II, Networking-Part I, Part II

**Week 2:** Industry 4.0: Globalization, The Fourth Revolution, LEAN Production Systems,

**Week 3:** Industry 4.0: Cyber Physical Systems and Next Generation Sensors, Collaborative Platform and Product Lifecycle Management

**Week 4:** Cybersecurity in Industry 4.0, Basics of Industrial IoT: Industrial Processes-Part I, Part II, Industrial Sensing & Actuation

**Week 5:** IIoT-Introduction, Industrial IoT: Business Model and Reference Architecture: IIoT-Business Models-Part I, Part II, IIoT Reference Architecture-Part I, Part II.

**Week 6:** Industrial IoT- Layers: IIoT Sensing-Part I, Part II, IIoT Processing-Part I, Part II, IIoT Communication-Part I.

**Week 7:** Industrial IoT- Layers: IIoT Communication , IIoT Networking-Part I, Part II, Part III.

**Week 8:** Industrial IoT: Big Data Analytics and Software Defined Networks: IIoT Analytics - Introduction, Machine Learning and Data Science Part I, Part II

**Week 9:** Industrial IoT: Big Data Analytics and Software Defined Networks: SDN in IIoT-Part I, Part II, Data Center Networks, Industrial IoT

**Week 10:** Industrial IoT: Security and Fog Computing - Fog Computing in IIoT, Security in IIoT-Part I, Part II, Industrial IoT- Application Domains

**Week 11:** Industrial IoT- Application Domains: Healthcare, Power Plants, Inventory Management & Quality Control, Plant Safety and Security (Including AR and VR safety applications), Facility Management.

**Week 12:** Industrial IoT- Application Domains: Oil, chemical and pharmaceutical industry, Applications of UAVs in Industries, Real case studies



# AN INTRODUCTION TO ARTIFICIAL INTELLIGENCE

## PROF. MAUSAM

Department of Computer Science and Engineering  
IIT Delhi

## TYPE OF COURSE

: Rerun I Elective I UG

## COURSE DURATION

: 12 weeks (24 Jan' 22 - 15 Apr' 22)

## EXAM DATE

: 24 Apr 2022

**PRE-REQUISITES :** Data Structures, Probability

**INTENDED AUDIENCE :** Undergraduate students in computer science

**INDUSTRIES APPLICABLE TO :** Most software companies

## COURSE OUTLINE :

The course introduces a variety of concepts in the field of artificial intelligence. It discusses the philosophy of AI, and how to model a new problem as an AI problem. It describes a variety of models such as search, logic, Bayes nets, and MDPs, which can be used to model a new problem. It also teaches many first algorithms to solve each formulation. The course prepares a student to take a variety of focused, advanced courses in various subfields of AI.

## ABOUT INSTRUCTOR :

Prof. Mausam is an Associate Professor of Computer Science department at IIT Delhi, and an affiliate faculty member at University of Washington, Seattle. His research explores several threads in artificial intelligence, including scaling probabilistic planning algorithms, large-scale information extraction over the Web, and enabling complex computation over crowdsourced platforms. He received his PhD from University of Washington in 2007 and a B.Tech. from IIT Delhi in 2001. ArnetMiner, a global citation aggregator, has rated Mausam as the 25th most influential scholar in AI for 2019. He was recently awarded the AAAI Senior Member status for his long-term participation in AAAI and distinction in the field of artificial intelligence.

## COURSE PLAN :

**Week 1:** Introduction: Philosophy of AI, Definitions

**Week 2:** Modeling a Problem as Search Problem, Uninformed Search

**Week 3:** Heuristic Search, Domain Relaxations

**Week 4:** Local Search, Genetic Algorithms

**Week 5:** Adversarial Search

**Week 6:** Constraint Satisfaction

**Week 7:** Propositional Logic & Satisfiability

**Week 8:** Uncertainty in AI, Bayesian Networks

**Week 9:** Bayesian Networks Learning & Inference, Decision Theory

**Week 10:** Markov Decision Processes

**Week 11:** Reinforcement Learning

**Week 12:** Introduction to Deep Learning & Deep RL



# AI: CONSTRAINT SATISFACTION

## PROF. DEEPAK KHEMANI

Department of Computer Science and Engineering  
IIT Madras

**TYPE OF COURSE :** Rerun I Elective I UG/PG

**COURSE DURATION :** 8 Weeks (24 Jan' 22 - 18 Mar' 22)  
**EXAM DATE :** 27 Mar 2022

**PRE-REQUISITES :** Exposure to AI: Search Methods for Problem Solving and AI: Knowledge Representation & Reasoning helps, but is not necessary.

**INTENDED AUDIENCE :** Both UG and PG students studying Computer Science (any degree) can take it.

**INDUSTRIES APPLICABLE TO :** Software companies dealing with artificial intelligence applications

## COURSE OUTLINE :

Human beings solve problems in many different ways. Problem solving in artificial intelligence (AI) is inspired from these diverse approaches. AI problem solvers may be based on search, on memory, or on knowledge representation and reasoning. An approach to problem solving is to pose problems as constraint satisfaction problems (CSP), and employ general methods to solve them. The task of a user then is only to pose a problem as a CSP, and then call an off-the-shelf solver. CSPs are amenable to combining search based methods with reasoning. In this 2 credit course we will look at general approaches to solving finite domain CSPs, and explore how search can be combined with constraint propagation to find solutions.

## ABOUT INSTRUCTOR :

Prof. Deepak Khemani is Professor at Department of Computer Science and Engineering, IIT Madras. He completed his B.Tech. (1980) in Mechanical Engineering, and M.Tech. (1983) and PhD. (1989) in Computer Science from IIT Bombay, and has been with IIT Madras since then. In between he spent a year at Tata Research Development and Design Centre, Pune and another at the youngest IIT at Mandi. He has had shorter stays at several Computing departments in Europe. Prof. Khemani's long-term goals are to build articulate problem solving systems using AI that can interact with human beings. His research interests include Memory Based Reasoning, Knowledge Representation and Reasoning, Planning and Constraint Satisfaction, Qualitative Reasoning and Natural Language Processing.

## COURSE PLAN :

**Module 1:** Constraint satisfaction problems (CSP), examples.

**Module 2:** Constraint networks, equivalent and projection networks.

**Module 3:** Constraint propagation, arc consistency, path consistency, i-consistency.

**Module 4:** Directional consistency and graph ordering, backtrack free search, adaptive consistency.

**Module 5:** Search methods for solving CSPs, lookahead methods, dynamic variable and value ordering.

**Module 6:** Lookback methods, Gaschnig's backjumping, graph based backjumping, conflict directed back jumping. Combing lookahead with lookback, learning.

**Module 7:** Model based systems, model based diagnosis, truth maintenance systems, planning as CSP. Wrapping up.



# USER-CENTRIC COMPUTING FOR HUMAN-COMPUTER INTERACTION

## PROF. SAMIT BHATTACHARYA

Department of Computer Science and Engineering  
IIT Guwahati

TYPE OF COURSE : Rerun I Elective I UG/PG

COURSE DURATION : 8 weeks (24 Jan' 22 - 18 Mar' 22)

EXAM DATE : 27 Mar 2022

**PRE-REQUISITES :** None. However, knowledge in basic subjects of Computer Science and Engineering/IT (Data structures, Algorithms, FLAT, Software Engg, Operating Systems, Databases, Computer Architecture) preferable.

**INTENDED AUDIENCE :** UG/PG/PhD students (also people from industry may benefit)

**INDUSTRIES APPLICABLE TO :** Industry/companies that deal with consumer electronics and user-interface design and development.

## COURSE OUTLINE :

Human-computer interaction is an emerging field of study at present, due to the proliferation of large number of consumer electronic products. The key issue in this field is to make the products usable to lay-persons. In order to do that, we need to take care of the (creative) design aspects (the look-and-feel of the interface) and also the system design aspect (both software and hardware). The field is interdisciplinary with inputs required from various other fields. However, the computer science and engineering plays the central role in the design of such systems (as per SIGCHI of ACM). In this course, we will introduce the engineering and computational issues in the design of human-computer interfaces for laypersons. The topics covered in the course includes the engineering life cycles for design of interactive systems, computational design framework (as part of the life cycle), components of the framework including the computational models of users and systems, and evaluation of such systems (with or without users).

## ABOUT INSTRUCTOR :

Prof. Samit Bhattacharya is an associate professor in the Dept of Computer Science and Engineering, IIT Guwahati, with more than 12 years of teaching and research experience. He has taught numerous courses including those related to the proposed course, to both the PG and UG level students of Computer Science and Engineering. He also has more than five dozen publications as books, book chapters, patents, peer-reviewed journals and conference proceedings under his credit. Most of his publications are related to the topics covered in this course. He has already graduated four PhD students (with another five at various stages of their research) and guided about a dozen MTech projects and more than two dozen BTech projects in this area. He is also involved in various sponsored projects (funded by the Govt and private agencies) as principal investigator/co principal investigator having close relations to the topics covered.

## COURSE PLAN :

**Week 1:** Introduction to user-centric design – case studies, historical evolution, issues and challenges and current trend

**Week 2:** Engineering user-centric systems – relation with software engineering, iterative life-cycle, prototyping, guidelines, case studies

**Week 3:** User-centric computing – framework, introduction to models, model taxonomy

**Week 4:** Computational user models (classical) – GOMS, KLM, Fitts' law, Hick-Hymans law

**Week 5:** Computational user models (contemporary) 2D and 3D pointing, constrained navigation, mobile typing, touch interaction

**Week 6:** Formal models – case study with matrix algebra, specification and verification of properties, formal dialog modeling

**Week 7:** Empirical research – research question formulation, experiment design, data analysis, statistical significance test

**Week 8:** User-centric design evaluation – overview of evaluation techniques, expert evaluation, user evaluation, model-based evaluation with case studies



# CLOUD COMPUTING AND DISTRIBUTED SYSTEMS

## PROF. RAJIV MISRA

Department of Computer Science and Engineering  
IIT Patna

**TYPE OF COURSE** : Rerun I Elective I UG/PG

**COURSE DURATION** : 8 weeks (24 Jan' 22 - 18 Mar' 22)

**EXAM DATE** : 27 Mar 2022

**PRE-REQUISITES :** Minimum: Data Structures and Algorithms; Ideal: Computer Architecture, Basic OS and Networking concepts

**INDUSTRIES SUPPORT :** Companies like Amazon, Microsoft, Google, IBM, Facebook and start-ups working on this field.

## COURSE OUTLINE :

Cloud computing is the on-demand delivery of computations, storage, applications, and other IT resources through a cloud services platform over the internet with pay-as-you-go business model. Today's Cloud computing systems are built using fundamental principles and models of distributed systems. This course provides an in-depth understanding of distributed computing "concepts", distributed algorithms, and the techniques, that underlie today's cloud computing technologies. The cloud computing and distributed systems concepts and models covered in course includes: virtualization, cloud storage: key-value/NoSQL stores, cloud networking,fault-tolerance cloud using PAXOS, peer-to-peer systems, classical distributed algorithms such as leader election, time, ordering in distributed systems, distributed mutual exclusion, distributed algorithms for failures and recovery approaches, emerging areas of big data and many more. And while discussing the concepts and techniques, we will also look at aspects of industry systems such as Apache Spark, Google's Chubby, Apache Zookeeper, HBase, MapReduce, Apache Cassandra, Google's B4, Microsoft's Swan and many others. Upon completing this course, students will have intimate knowledge about the internals of cloud computing and how the distributed systems concepts work inside clouds.

## ABOUT INSTRUCTOR :

Prof. Rajiv Misra is an Associate Professor in Department of Computer Science and Engineering at Indian Institute of Technology Patna, India. He obtained his Ph.D degree from IIT Kharagpur, M.Tech degree in Computer Science and Engineering from the Indian Institute of Technology (IIT) Bombay, and Bachelors of engineering degree in Computer Science from MNIT Allahabad. His research interests spanned a design of distributed algorithms for Mobile, Adhoc and Sensor Networks, Cloud Computing and Wireless Networks. He has contributed significantly to these areas and published more than 70 papers in high quality journals and conferences, and 2 book chapters. His h-index is 10 with more than 590 citations. He has authored papers in IEEE Transactions on Mobile Computing, IEEE Transaction on Parallel and Distributed Systems, Adhoc Networks, Journal of Parallel and Distributed Computing.

## COURSE PLAN :

**Week 1:** Introduction to Clouds, Virtualization and Virtual Machine

**Week 2:** Network Virtualization and Geo-distributed Clouds

**Week 3:** Leader Election in Cloud, Distributed Systems and Industry Systems

**Week 4:** Classical Distributed Algorithms and the Industry Systems

**Week 5:** Consensus, Paxos and Recovery in Clouds

**Week 6:** Cloud Storage: Key-value stores/NoSQL

**Week 7:** P2P Systems and their use in Industry Systems

**Week 8:** Cloud Applications: MapReduce, Spark and Apache Kafka



# INTRODUCTION TO PARALLEL PROGRAMMING IN OPENMP AND MPI

## PROF. YOGISH SABHARWAL

Department of Computer Science and Engineering  
IIT Delhi

TYPE OF COURSE : Rerun I Elective I UG/PG

COURSE DURATION : 8 Weeks (24 Jan' 22 - 18 Mar' 22)  
EXAM DATE : 27 Mar 2022

**PRE-REQUISITES :** Students enrolling for this course should be comfortable with programming in C.

**INTENDED AUDIENCE :** Computer Science and non-Computer Science Students with interest in parallel programming for HPC applications.

**INDUSTRIES APPLICABLE TO :** IBM, Intel, Amazon, Google, Microsoft, Cray.

## COURSE OUTLINE :

This course focuses on the shared memory programming paradigm. It covers concepts & programming principles involved in developing scalable parallel applications. Assignments focus on writing scalable programs for multi-core architectures using OpenMP and C. This is an introductory course in shared memory parallel programming suitable for computer science as well as non-computer science students working on parallel/HPC applications and interested in parallel programming.

## ABOUT INSTRUCTOR :

Prof. Yogish Sabharwal is a researcher at IBM Research and serves as an adjunct faculty at IIT Delhi. At IBM, he manages the high performance computing group, that ensures that real-world applications are able to extract the best performance out of HPC systems. He has 70+ papers including 3 best paper awards, 2 best paper nominations and a Gordon Bell finalist. His work has won several competitions organized in the HPC community.

## COURSE PLAN :

**Week 1:** Single Processor Architecture and Basic OpenMP constructs & functions

**Week 2:** More OpenMP constructs & functions

**Week 3:** Basic Linear Algebra using OpenMP and OpenMP tasks

**Week 4:** Critical Sections, locks and Matrix Factorization using OpenMP

**Week 5:** Distributed Memory programming and Message Passing Interface (MPI)

**Week 6:** MPI Collectives and Interconnection architectures

**Week 7:** Some applications on distributed memory architectures

**Week 8:** Applications to Graph Algorithms



# INFORMATION SECURITY - 5 - SECURE SYSTEMS ENGINEERING

**PROF. CHESTER REBEIRO**

Department of Computer Science and Engineering  
IIT Madras

**TYPE OF COURSE** : Rerun I Elective I UG/PG

**COURSE DURATION** : 8 weeks (24 Jan' 22 - 18 Mar' 22)

**EXAM DATE** : 27 Mar 2022

**PRE-REQUISITES :** C programming must be strong. Minimum understanding of digital logic/ operating systems/computer organization

**INTENDED AUDIENCE :** BTech/BE/ME/MTech/MS/MCA/BCA students in computer science/information technology/electrical engineering / electronics engineering /instrumentation engineering

**INDUSTRIES APPLICABLE TO :** All companies developing embedded products /IoT etc.

**COURSE OUTLINE :**

With the increase in the threat of cyber-security attacks, it is important to develop computer systems that are not only efficient but also secure. This course will discuss various vulnerabilities in systems and mechanisms by which these vulnerabilities can be mitigated. The first part of the course will discuss various security vulnerabilities in software code that, if left unfixed, can potentially lead to major cyber-attacks. We will see how these vulnerabilities can arise from simple programming flaws like a buffer that overflows, to complex application runtime characteristics that get manifested through side-channels such as the execution time and power consumption of the device. We will look at some recent cyber-attacks such as Meltdown and Spectre, Heartbleed, and Stagefright. The pre-requisites are a good understanding of C and a basic understanding of computer organization and operating systems.

**ABOUT INSTRUCTOR :**

Prof. Chester Rebeiro is an Assistant Professor at IIT Madras. He completed his PhD from IIT Kharagpur and a post-doc from Columbia University. His research interests are in cryptography, system security, especially hardware and operating system security.

**COURSE PLAN :**

**Week 1:** Introduction / gdb / buffer overflow

**Week 2:** Preventing buffer overflow based malware

**Week 3:** Integer overflow and buffer overread and heap overflow

**Week 4:** More on heap overflow; Access Control

**Week 5:** Confinement

**Week 6:** SGX and Trustzone

**Week 7:** Micro-architectural Attacks

**Week 8:** Hardware Security.



# PROGRAMMING, DATA STRUCTURES AND ALGORITHMS USING PYTHON

## PROF. MADHAVAN MUKUND

Department of Computer Science and Engineering  
Chennai Mathematical Institute

**TYPE OF COURSE** : Rerun | Elective | UG

**COURSE DURATION** : 8 weeks (24 Jan'22 - 18 Mar'22)

**EXAM DATE** : 27 Mar 2022

**INTENDED AUDIENCE** : Students in any branch of mathematics/science/engineering, 1st year

**PRE-REQUISITES** : School level mathematics.

**INDUSTRIES APPLICABLE TO** : This course should be of value to any company requiring programming skills.

## COURSE OUTLINE :

This course is an introduction to programming and problem solving in Python. It does not assume any prior knowledge of programming. Using some motivating examples, the course quickly builds up basic concepts such as conditionals, loops, functions, lists, strings and tuples. It goes on to cover searching and sorting algorithms, dynamic programming and backtracking, as well as topics such as exception handling and using files. As far as data structures are concerned, the course covers Python dictionaries as well as classes and objects for defining user defined datatypes such as linked lists and binary search trees.

## ABOUT INSTRUCTOR :

Prof. Madhavan Mukund studied at IIT Bombay (B.Tech) and Aarhus University (PhD). He has been a faculty member at Chennai Mathematical Institute since 1992, where he is presently Professor and Dean of Studies. His main research area is formal verification. In addition to the NPTEL MOOC programme, he has been involved in organizing IARCS Instructional Courses for college teachers. He is a member of ACM India's Education Committee. He has contributed lectures on algorithms to the Massively Empowered Classroom (MEC) project of Microsoft Research and the QEEE programme of MHRD.

## COURSE PLAN :

- Week 01** : Informal introduction to programming, algorithms and data structures via gcd, Downloading and installing Python, gcd in Python: variables, operations, control flow - assignments, conditionals, loops, functions.
- Week 02** : Python: types, expressions, strings, lists, tuples | Python memory model: names, mutable and immutable values | List operations: slices etc| Binary search | Inductive function definitions: numerical and structural induction | Elementary inductive sorting: selection and insertion sort | In-place sorting.
- Week 03** : Basic algorithmic analysis: input size, asymptotic, complexity,O() notation | Arrays vs lists | Merge sort | Quicksort | Stable sorting.
- Week 04** : Dictionaries | More on Python functions: optional arguments, default values | Passing functions as arguments | Higher order functions on lists: map, iter, list comprehension.
- Week 05** : Exception handling | Basic input/output | Handling files | String processing.
- Week 06** : Backtracking: N Queens, recording all solutions | Scope in Python: local, global, nonlocal names | Nested functions | Data structures: stack, queue | Heaps.
- Week 07** : Abstract datatypes | Classes and objects in Python | "Linked" lists: find, insert, delete | Binary search trees: find, insert, delete | Height-balanced binary search trees.
- Week 08** : Efficient evaluation of recursive definitions: memoization | Dynamic programming: examples | Other programming languages: C and manual memory management | Other programming paradigms: functional programming.



# DESIGN AND ANALYSIS OF ALGORITHMS

**PROF. MADHAVAN MUKUND**

Department of Computer Science and Engineering  
Chennai Mathematical Institute

**TYPE OF COURSE** : Rerun I Elective I UG

**COURSE DURATION** : 8 weeks (24 Jan' 22 - 18 Mar' 22)

**EXAM DATE** : 27 Mar 2022

**INTENDED AUDIENCE:** Students in BE/BTech Computer Science, 2nd/3rd year.

**PRE-REQUISITES:** Exposure to introductory courses on programming and data structures.

**INDUSTRY SUPPORT:** This course should be of value to any company working in the area of software services and products.

**COURSE OUTLINE:**

This course will cover basic concepts in the design and analysis of algorithms. Asymptotic complexity, O() notation Sorting and search. Algorithms on graphs: exploration, connectivity, shortest paths, directed acyclic graphs, spanning trees. Design techniques: divide and conquer, greedy, dynamic programming. Data structures: heaps, union of disjoint sets, search trees. Intractability.

**ABOUT INSTRUCTOR :**

Prof. Madhavan Mukund studied at IIT Bombay (BTech) and Aarhus University (PhD). He has been a faculty member at Chennai Mathematical Institute since 1992, where he is presently Professor and Director. His main research area is formal verification. He has active research collaborations within and outside India and serves on international conference programme committees and editorial boards of journals.

**COURSEPLAN:**

**Week 1** Module 1: Introduction | Module 2: Examples and motivation | Module 3: Examples and motivation | Module 4: Asymptotic complexity: informal concepts | Module 5: Asymptotic complexity: formal notation | Module 6: Asymptotic complexity: examples | Assignments MCQ/Fill in blanks (unique answer)

**Week 2** Module 1: Searching in list: binary search | Module 2: Sorting: insertion sort | Module 3: Sorting: selection sort | Module 4: Sorting: merge sort | Module 5: Sorting: quicksort | Module 6: Sorting: stability and other issues | Assignments MCQ/Fill in blanks, programming assignment

**Week 3** Module 1: Graphs: Motivation | Module 2: Graph exploration: BFS | Module 3: Graph exploration: DFS | Module 4: DFS numbering and applications | Module 5: Directed acyclic graphs | Module 6: Directed acyclic graphs | Assignments MCQ/Fill in blanks, programming assignment

**Week 4** Module 1: Shortest paths: unweighted and weighted | Module 2: Single source shortest paths: Dijkstra | Module 3: Single source shortest paths: Dijkstra | Module 4: Minimum cost spanning trees: Prim's algorithm | Module 5: Minimum cost spanning trees: Kruskal's Algorithm | Module 6: Union-Find data structure | Assignments MCQ/Fill in blanks, programming assignment

**Week 5** Module 1: Divide and conquer: counting inversions | Module 2: Divide and conquer: nearest pair of points | Module 3: Priority queues, heaps | Module 4: Priority queues, heaps | Module 5: Dijkstra/Prims revisited using heaps | Module 6: Search Trees: Introduction | Assignments MCQ/Fill in blanks, programming assignment

**Week 6** Module 1: Search Trees: Traversals, insertions, deletions | Module 2: Search Trees: Balancing | Module 3: Greedy : Interval scheduling | Module 4: Greedy : Proof strategies | Module 5: Greedy : Huffman coding | Module 6: Dynamic Programming: weighted interval scheduling | Assignments MCQ/Fill in blanks, programming assignment

**Week 7** Module 1: Dynamic Programming: memoization | Module 2: Dynamic Programming: edit distance | Module 3: Dynamic Programming: longest ascending subsequence | Module 4: Dynamic Programming: matrix multiplication | Module 5: Dynamic Programming: shortest paths: Bellman Ford | Module 6: Dynamic Programming: shortest paths: Floyd Warshall | Assignments MCQ/Fill in blanks, programming assignment

**Week 8** Module 1: Intractability: NP completeness | Module 2: Intractability: reductions | Module 3: Intractability: examples | Module 4: Intractability: more examples | Module 5: Misc topics | Module 6: Misc topics | Assignments MCQ/Fill in blanks



# DATA SCIENCE FOR ENGINEERS

## PROF. RAGHUNATHAN RENGASAMY

Department of Chemical Engineering  
IIT Madras

**TYPE OF COURSE :** Rerun I Elective I UG/PG  
**COURSE DURATION:** 8 weeks (24 Jan' 22 - 18 Mar' 22)  
**EXAM DATE :** 27 Mar 2022

## PROF. SHANKAR NARASIMHAN

Department of Chemical Engineering  
IIT Madras

**PRE-REQUISITES :** 10 hrs of pre-course material will be provided, learners need to practise this to be ready to take the course.

**INTENDED AUDIENCE :** Any interested learner

**INDUSTRIES APPLICABLE TO :** HONEYWELL, ABB, FORD, GYAN DATA PVT. LTD.

### COURSE OUTLINE :

This course will Introduce: R as a programming language, mathematical foundations required for data science, the first level data science algorithms, data analytics problem solving framework, practical capstone case study Course will also describe a flow process for data science problems (Remembering) , Classify data science problems into standard typology (Comprehension), Develop R codes for data science solutions (Application) , Correlate results to the solution approach followed (Analysis), Assess the solution approach (Evaluation) , Construct use cases to validate approach and identify modifications required (Creating).

### ABOUT INSTRUCTOR :

Prof.Rengaswamy was a professor of Chemical Engineering before joining at IIT Madras as a professor and Co-Director of the Process Control and Optimization Consortium at Texas Tech University, Lubbock, USA. He was also a Professor at Clarkson University, USA and Assistant Professor at IIT Bombay. His major research interests are in the areas of fault detection and diagnosis and development of data science algorithms for manufacturing industries.

Prof. Shankar Narasimhan is currently a professor in the department of Chemical Engineering at IIT Madras. His major research interests are in the areas of data mining, process design and optimization, fault detection and diagnosis and fault tolerant control. He has co-authored several important papers and a book titled Data Reconciliation and Gross Error Detection: An Intelligent Use of Process Data which has received critical appreciation in India and abroad.

### COURSE PLAN :

**Week 1:** Course philosophy and introduction to R

**Week 2:** Linear algebra for data science

**Week 3:** Statistics

**Week 4:** Optimization

**Week 5:** Typology of data science problems and a solution framework

**Week 6:** Simple linear regression and verifying assumptions used in linear regression, Multivariate linear regression, model assessment, assessing importance of different variables, subset selection

**Week 7:** Classification using logistic regression

**Week 8:** Classification using kNN and k-means clustering



# DESIGN AND ENGINEERING OF COMPUTER SYSTEMS

## PROF. MYTHILI VUTUKURU

Department of Computer Science and Engineering  
IIT Bombay

**TYPE OF COURSE** : New I Elective I UG/PG

**COURSE DURATION** : 8 Weeks (24 Jan' 22 - 18 Mar' 22)

**EXAM DATE** : March 27, 2022

**PRE-REQUISITES :** Introduction to programming. A previous course in operating systems or computer networks can be helpful, but not necessary.

**INTENDED AUDIENCE :** Senior UG students or PG students in Computer Science. Working professionals

**INDUSTRIES APPLICABLE TO :** Computer Systems, Operating Systems, Computer Networking, Distributed Systems

## COURSE OUTLINE :

In this course, we will understand how to design and engineer real-world computer systems, covering important concepts cutting across multiple topics such as operating systems, computer networks, computer architecture, virtualization, cloud computing, performance analysis, and distributed systems. The course is accessible to anyone who has a basic introduction to computer programming; no other prior knowledge is assumed.

The course concepts will be covered in a bottom-up manner, beginning with a discussion of the building blocks of computer systems, and ending with case studies and examples of end-to-end design of real-world computer systems. We start with an overview of computer systems hardware. We then understand how the operating system manages the hardware, and how user applications are built over the operating system. We will also understand how user applications communicate over the Internet. We will then study how a computer system is assembled from various sub-components, using examples from real life. Next, we will learn how to measure the performance of computer systems, and how to optimize for good performance. Finally, we will study some techniques to improve the fault tolerance and reliability of computer systems. The course will not be tied to any specific programming language or framework, but will focus on the best practices and principles for designing and engineering computer systems. It is expected that by the end of the course, students will get a good understanding of how real-world computer systems work, and will be able to apply the concepts learnt in the course to design systems on their own.

## ABOUT INSTRUCTOR :

Prof. Mythili Vutukuru is an Associate Professor in the Department of Computer Science and Engineering at IIT Bombay. She works in the areas of computer networking, operating systems, and networked systems. She completed her B.Tech. from IIT Madras in 2004, and M.S. and PhD. from Massachusetts Institute of Technology (MIT) in 2006 and 2010 respectively, all in Computer Science. She has been teaching at IIT Bombay since 2013. For more information, please visit: <https://www.cse.iitb.ac.in/~mythili/>

## COURSE PLAN :

**Week 1:** Introduction to computer systems.

**Week 2:** Process management and CPU virtualization.

**Week 3:** Memory management.

**Week 4:** Disk and network I/O

**Week 5:** Computer networking

**Week 6:** End-to-end application design.

**Week 7:** Performance engineering.

**Week 8:** Reliability engineering.



# DATA BASE MANAGEMENT SYSTEM

## PROF. PARTHA PRATIM DAS

Department of Computer Science and Engineering  
IIT Kharagpur

**TYPE OF COURSE** : Rerun I Core I UG/PG

**COURSE DURATION** : 8 weeks (24 Jan' 22 - 18 Mar' 22)

**EXAM DATE** : 27 Mar 2022

## PROF. SAMIRAN CHATTOPADHYAY

Department of Computer Science and Engineering  
IIT Kharagpur

**PRE-REQUISITES :** Procedural and / or Object-Oriented Programming (C / C++ / Java / Python), Data Structures, Algorithms

**INTENDED AUDIENCE :** Students from all disciplines can enroll for this course.

**INDUSTRIES APPLICABLE TO :** DBMS is so fundamental that all companies dealing with systems as well as application development (including web, IoT, embedded systems, data mining, machine learning) have a need for the same. These include – Microsoft, Samsung, Xerox, Yahoo, Google, IBM, TCS, Infosys, Amazon, Flipkart, etc.

## COURSE OUTLINE :

Databases form the backbone of all major applications today – tightly or loosely coupled, intranet or internet based, financial, social, administrative, and so on. Structured Database Management Systems (DBMS) based on relational and other models have long formed the basis for such databases. Consequently, Oracle, Microsoft SQL Server, Sybase etc. have emerged as leading commercial systems while MySQL, PostgreSQL etc. lead in open source and free domain. While DBMS's differ in details, they share a common set of models, design paradigms and a Structured Query Language (SQL).

## ABOUT INSTRUCTOR :

Prof. Partha Pratim Das received his BTech, MTech and PhD degrees in 1984, 1985 and 1988 respectively from IIT Kharagpur. He served as a faculty in Department of Computer Science and Engineering, IIT Kharagpur from 1988 to 1998. In 1998, he joined Alumnus Software Ltd as a Business Development Manager. From 2001 to 2011, he worked for Interra Systems, Inc. as a Senior Director and headed its Kolkata Center. In 2011, he joined back to Department of Computer Science and Engineering, IIT Kharagpur as Professor. Dr. Das has also served as a Visiting Professor with Institute of Radio Physics and Electronics, Calcutta University from 2003 to 2013.

Prof. Samiran Chattopadhyay received his B.Tech and M.Tech degrees in 1987, and 1989 respectively from IIT Kharagpur. He received his PhD in 1993 from Jadavpur University. He served as a faculty in Department of Computer Science and Engineering, Jadavpur University from 1989 to 1993 and 1997 to 2001 before joining the department of Information Technology. He has two decades of experience in serving reputed Industry houses such as Computer Associates, Interra Systems India, Agilent, Motorola as Technical consultants. Dr. Chattopadhyay has also served as an Adjunct faculty at IIT Kharagpur.

## COURSE PLAN :

**Week 1:** Course Overview, Introduction to RDBMS

**Week 2:** Structured Query Language (SQL)

**Week 3:** Relational Algebra, Entity-Relationship Model

**Week 4:** Relational Database Design

**Week 5:** Application Development, Case Studies, Storage and File Structure

**Week 6:** Indexing and Hashing, Query Processing

**Week 7:** Query Optimization, Transactions (Serializability and Recoverability)

**Week 8:** Concurrency Control, Recovery Systems, Course Summarization



# INTRODUCTION TO SOFT COMPUTING

**PROF. DEBASIS SAMANTA**

Department of Computer Science and Engineering  
IIT Kharagpur

**TYPE OF COURSE** : Rerun I Elective I UG/PG

**COURSE DURATION** : 8 weeks (24 Jan' 22 - 18 Mar' 22)

**EXAM DATE** : 27 Mar 2022

**INTENDED AUDIENCE :** The course is of interdisciplinary nature and students from CSE ,IT,EE,ECE,CE,ME, etc. can take this course.

**INDUSTRIES APPLICABLE TO :** All IT companies, in general.

**COURSE OUTLINE :**

Soft computing is an emerging approach to computing which parallel the remarkable ability of the human mind to reason and learn in an environment of uncertainty and imprecision. Soft computing is based on some biological inspired methodologies such as genetics, evolution, ant's behaviors, particles swarming, human nervous systems, etc. Now, soft computing is the only solution when we don't have any mathematical modeling of problem solving (i.e., algorithm), need a solution to a complex problem in real time, easy to adapt with changed scenario and can be implemented with parallel computing. It has enormous applications in many application areas such as medical diagnosis, computer vision, hand written character recondition, pattern recognition, machine intelligence, weather forecasting, network optimization, VLSI design, etc.

**ABOUT INSTRUCTOR :**

Prof. Debasis Samanta holds a Ph.D. in Computer Science and Engineering from Indian Institute of Technology Kharagpur. His research interests and work experience spans the areas of Computational Intelligence, Data Analytics, Human Computer Interaction, Brain Computing and Biometric Systems. Dr. Samanta currently works as a faculty member at the Department of Computer Science & Engineering at IIT Kharagpur.

**COURSE PLAN :**

**Week 1:** Introduction to Soft Computing, Introduction to Fuzzy logic,Fuzzy membership functions, Operations on Fuzzy sets

**Week 2:** Fuzzy relations, Fuzzy propositions, Fuzzy implications, Fuzzy inferences

**Week 3:** Defuzzification Techniques-I, Defuzzification Techniques-II, Fuzzy logic controller-I, Fuzzy logic controller-II

**Week 4:** Solving optimization problems, Concept of GA, GA Operators: Encoding,GA Operators: Selection-I

**Week 5:** GA Operators: Selection-II, GA Operators: Crossover-I, GA Operators: Crossover-II, GA Operators: Mutation

**Week 6:** Introduction to EC-I, Introduction to EC-II, MOEA Approaches: Non-Pareto, MOEA Approaches: Pareto-I

**Week 7:** MOEA Approaches: Pareto-II, Introduction to ANN, ANN Architecture

**Week 8:** ANN Training-I, ANN Training-II, ANN Training-III, Applications of ANN



# DATA MINING

**PROF. PABITRA MITRA**

Department of Computer Science and Engineering  
IIT Kharagpur

**TYPE OF COURSE**

: Rerun I Elective I UG

**COURSE DURATION**

: 8 weeks (21 Feb' 22 - 15 Apr' 22)

**EXAM DATE**

: 23 Apr 2022

**INTENDED AUDIENCE :** Any engineering discipline and mathematics, physics.

**INDUSTRIES APPLICABLE TO :** TCS, Infosys, CTS, Accenture

**COURSE OUTLINE :**

Data mining is study of algorithms for finding patterns in large data sets. It is an integral part of modern industry, where data from its operations and customers are mined for gaining business insight. It is also important in modern scientific endeavors. Data mining is an interdisciplinary topic involving, databases, machine learning and algorithms. The course will cover the fundamentals of data mining. It will explain the basic algorithms like data preprocessing, association rules, classification, clustering, sequence mining and visualization. It will also explain implementations in open source software. Finally, case studies on industrial problems will be demonstrated.

**ABOUT INSTRUCTOR :**

Prof.Pabitra Mitra is an Associate Professor of Computer Science and Engineering at Indian Institute of Technology Kharagpur. He did his BTech in Electrical Engineering from IIT Kharagpur and PhD from ISI Calcutta. He was a Scientist at Centre for Artificial Intelligence and Robotics, Bangalore and an Assistant Professor at IIT Kanpur. He received the INAE Young engineer Award, IBM Faculty Award and Yahoo Faculty Award. He has authored a book on Data mining and about 50 papers in international journals.

**COURSE PLAN :**

**Week 1:** Introduction, Data Preprocessing

**Week 2:** Association Rule Mining, Classification Basics

**Week 3:** Decision Tree, Bayes Classifier, K nearest neighbor

**Week 4:** Support Vector Machine, Kernel Machine

**Week 5:** Clustering, Outlier detection

**Week 6:** Sequence mining

**Week 7:** Evaluation, Visualization

**Week 8:** Case studies



# ADVANCED GRAPH THEORY

**PROF. RAJIV MISRA**

Department of Computer Science and Engineering  
IIT Patna

**TYPE OF COURSE :** Rerun I Elective I UG/PG

**COURSE DURATION :** 8 Weeks (21 Feb' 22 - 15 Apr' 22)

**EXAM DATE :** 23 Apr 2022

**PRE-REQUISITES :** Discrete Mathematics

**INTENDED AUDIENCE :** UG & PG (both)

**INDUSTRIES APPLICABLE TO :** Companies like Microsoft Research, Google, Facebook, LinkedIn and also start-ups are most eager to apply graph technology.

**COURSE OUTLINE :**

Advanced Graph Theory focuses on problem solving using the most important notions of graph theory with an in-depth study of concepts on the applications in the field of computer science. This course provides an in-depth understanding of Graphs and fundamental principles and models underlying the theory, algorithms, and proof techniques in the field of Graph Theory. Emerging applications of Graph Theory in Computer Science domain will be covered for significant impact. Upon completing this course, students will have intimate knowledge about how the graph theory play an important role to solve the technology driven and research oriented problems.

**ABOUT INSTRUCTOR :**

Prof. Rajiv Misra is an Associate Professor in Department of Computer Science and Engineering at Indian Institute of Technology Patna, India. He obtained his Ph.D degree from IIT Kharagpur, M.Tech degree in Computer Science and Engineering from the Indian Institute of Technology (IIT) Bombay, and Bachelors of engineering degree in Computer Science from MNIT Allahabad. His research interests spanned a design of distributed algorithms for Mobile, Adhoc and Sensor Networks, Distributed Cloud Computing and Wireless Networks. He has contributed significantly to these areas and published more than 60 papers in high quality journals and conferences, and 2 book chapters. He has authored papers in IEEE Transactions on Mobile Computing, IEEE Transaction on Parallel and Distributed Systems, Adhoc Networks, Journal of Parallel and Distributed Computing. He is currently editing a book titled as Smart Techniques for a Smarter Planet: Towards Smarter Algorithms for the Studies in Fuzziness and Soft Computing book series, Springer (2017).

**COURSE PLAN :**

**Week 1:** Introduction to Graphs & its Applications, Basics of Paths, Cycles, and Trails, Connection, Bipartite Graphs, Eulerian Circuits, Vertex Degrees and Counting, Degree-sum formula, The Chinese Postman Problem and Graphic Sequences.

**Week 2:** Trees and Distance, Properties of Trees, Spanning Trees and Enumeration, Matrix-tree computation, Cayley's Formula, Prüfer code.

**Week 3:** Matchings and Covers, Hall's Condition, Min-Max Theorem, Independent Sets, Covers and Maximum Bipartite Matching, Augmenting Path Algorithm, Weighted Bipartite Matching, Hungarian Algorithm.

**Week 4:** Stable Matchings and Faster Bipartite Matching, Factors & Perfect Matching in General Graphs, Matching in General Graphs: Edmonds Blossom Algorithm

**Week 5:** Connectivity and Paths: Cuts and Connectivity, k-Connected Graphs, Network Flow Ford-Fulkerson Labeling Algorithm, Max-Flow Min-cut Theorem, Menger's Proof using Max-Flow Min-Cut Theorem.

**Week 6:** Vertex Coloring and Upper Bounds, Brooks Theorem and Color-Critical Graphs, Counting Proper Colorings.

**Week 7:** Planar Graphs, Characterization of Planar Graphs, Kuratowski's Theorem, Wagner's Theorem.

**Week 8:** Line Graphs and Edge-coloring, Hamiltonian Graph, Traveling Salesman Problem and NP-Completeness, Dominating Sets.



# INTRODUCTION TO PROGRAMMING IN C

## PROF. SATYADEV NANDAKUMAR

Dept. of Computer Science and Engineering  
IIT Kanpur

**TYPE OF COURSE** : Rerun | Elective | UG | PG

**COURSE DURATION** : 8 weeks (21 Feb'22 - 15 Apr'22)

**EXAM DATE** : 23 Apr 2022

**INTENDED AUDIENCE** : Anyone can learn

**PRE-REQUISITES** : Prior programming not required; mathematical maturity of a second level UG student in science or engineering

## COURSE OUTLINE :

This is a course in programming in C. No prior programming experience is assumed; however, mathematical maturity at the level of a second year science or engineering undergraduate is assumed. We emphasize solving problems using the language, and introduce standard programming techniques like alternation, iteration and recursion. We will briefly glimpse the basics of software engineering practices like modularization, commenting, and naming conventions which help in collaborating and programming in teams.

## ABOUT INSTRUCTOR :

Prof. Satyadev Nandakumar is an Assistant Professor at the Department of Computer Science & Engineering, IIT Kanpur. He is specialized in Computable Analysis, Algorithmic Information Theory, Symbolic Dynamics. His research interests lies in the areas of:

- \* Algorithmic Information Theory, Kolmogorov complexity, and effective fractal dimension.
- \* Effective symbolic measure-theoretic and topological dynamical systems.
- \* Normal numbers, continued fractions, finite-state dimension.
- \* Computability and complexity in analysis.
- \* Computational complexity theory, pseudorandomness.

## COURSE PLAN :

**Week 01** : Introduction. Straight-Line Code. Variables, Operators, Expressions and Conditionals.

**Week 02** : Loops.

**Week 03** : Functions.

**Week 04** : One-Dimensional Arrays and Pointers.

**Week 05** : Recursion.

**Week 06** : Multi-dimensional Arrays, Linked Lists.

**Week 07** : Operating on Files.

**Week 08** : Organizing C projects, working with multiple source directories, makefiles.



# ADVANCED COMPUTER ARCHITECTURE

**PROF.JOHN JOSE**

Department of Computer Science and Engineering  
IIT Guwahati

**TYPE OF COURSE** : Rerun I Elective I PG

**COURSE DURATION** : 8 weeks (21 Feb'22 - 15 Apr'22)

**EXAM DATE** : 24 Apr 2022

**PRE-REQUISITES :** A basic understanding of Computer Organisation & Architecture or Microprocessors

**INTENDED AUDIENCE :** Anyone in CSE and related fields (like ECE, EEE, IT etc.) with an interest of exploring Computer Architecture

**INDUSTRIES APPLICABLE TO :** Intel, AMD, IBM, Nvidia etc

**COURSE OUTLINE :**

Applications and handheld devices play a major role in ensuring comfort in our day- today life. These applications run on handheld electronic gadgets with high-end microprocessor support. Modern CPU designers handle challenges imposed by these applications with cost effective architectural enhancements. This course provides a deeper insight into the design of high-end microprocessors that will support the future applications.

**ABOUT INSTRUCTOR :**

Prof. John Jose is an Assistant Professor in Department of Computer Science and Engineering, Indian Institute of Technology, Guwahati. Prior to this he worked as faculty in Rajagiri School of Engineering and Technology and Viswajyothi College of Engineering and Technology, Kerala for 7 years. He completed his Ph.D degree in Department of Computer Science and Engineering, Indian Institute of Technology, Madras. He has guided over 8 M.Tech thesis and is currently supervising 6 PhD thesis and 2 M.Tech thesis. His area of interest is in on-chip interconnection networks and cache management techniques for large multicore systems. He is the principal investigator of two sponsored R&D projects funded by DST, Govt of India. He is having active research collaboration with University of Catania-Italy, ITRI Taiwan, and BITS Pilani-Dubai Campus.

**COURSE PLAN :**

**Week 1:** Review of Basic Computer Organization, Performance Evaluation Methods, Introduction to RISC Instruction Pipeline, Instruction Pipeline and Performance.

**Week 2:** Pipeline Hazards and Analysis, Branch Prediction, MIPS Pipeline for Multi-Cycle Operations.

**Week 3:** Compiler Techniques to Explore Instruction Level Parallelism, Dynamic Scheduling with Tomasulo's Algorithm and Speculative Execution.

**Week 4:** Advanced Pipelining and Superscalar Processors, Exploiting Data Level Parallelism: Vector and GPU Architectures, Architectural Simulation using gem5.

**Week 5:** Introduction to Cache Memory, Block Replacement Techniques and Write Strategy, Design Concepts in Cache Memory.

**Week 6:** Basic and Advanced Optimization Techniques in Cache Memory, Cache Optimization using gem5.

**Week 7:** Introduction to DRAM System, DRAM Controllers and Address Mapping, Secondary Storage Systems, Design Concepts in DRAM and Hard Disk.

**Week 8:** Tiled Chip Multicore Processors(TCMP), Routing Techniques in Network on Chip(NoC), NoC Router Microarchitecture, TCMP and NoC: Design and Analysis, Future Trends in Computer Architecture Research.



# MACHINE LEARNING, ML

**PROF. CARL GUSTAF JANSSON**

School of Electrical Engineering and Computer Science  
KTH, The Royal Institute Of Technology

**TYPE OF COURSE** : Rerun I Elective I PG

**COURSE DURATION** : 8 weeks (21 Feb' 22 - 15 Apr' 22)  
**EXAM DATE** : 24 Apr 2022

**PRE-REQUISITES :** Relevant applied math and statistics, core computer science

**INTENDED AUDIENCE :** Interested students

**INDUSTRIES APPLICABLE TO :** Broad industrial interest at present, i.e. for autonomous vehicles, robots, intelligent assistants and general datamining

## **COURSE OUTLINE :**

The scientific discipline of Machine Learning focuses on developing algorithms to find patterns or make predictions from empirical data. It is a classical sub-discipline within Artificial Intelligence (AI). The discipline is increasingly used by many professions and industries to optimize processes and implement adaptive systems. The course places machine learning in its context within AI and gives an introduction to the most important core techniques such as decision tree based inductive learning, inductive logic programming, reinforcement learning and deep learning through decision trees.

## **ABOUT INSTRUCTOR :**

Prof. Carl Gustaf Jansson is tenured Professor in Artificial Intelligence at the School of Electrical Engineering and Computer Science, KTH Royal Institute of Technology, Stockholm, Sweden. His research contributions are mostly in artificial intelligence, in particular Knowledge Representation and Machine Learning. Particular research interests are intelligent interfaces and ubiquitous computing.

## **COURSE PLAN :**

**Week 1:** Introduction to the Machine Learning course

**Week 2:** Characterization of Learning Problems

**Week 3:** Forms of Representation

**Week 4:** Inductive Learning based on Symbolic Representations and Weak Theories

**Week 5:** Learning enabled by Prior Theories

**Week 6:** Machine Learning based Artificial Neural Networks

**Week 7:** Tools and Resources + Cognitive Science influences

**Week 8:** Examples, demos and exam preparations



# SOFTWARE TESTING

**PROF. RAJIB MALL**

Department of Computer Science and Engineering  
IIT Kharagpur

**TYPE OF COURSE**

: Rerun I Elective I UG / PG

**COURSE DURATION**

: 4 weeks (24 Jan' 22 - 18 Feb' 22)

**EXAM DATE**

: 27 Mar 2022

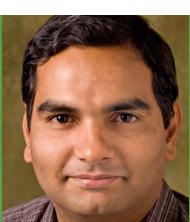
**PRE-REQUISITES :** Basic Knowledge of Programming**INTENDED AUDIENCE :** Elective Course, PG Course, M.Tech**INDUSTRIES APPLICABLE TO :** All software development/testing companies**COURSE OUTLINE :**

Over the years program several testing techniques have developed and tools have become available. Also, testing has been acknowledged as the primary technique for ensuring software reliability. The course would provide a brief introduction to test process and techniques available for black box and white box test case design. Integration, system and regression testing would also be discussed. A few of the test tools would be discussed and the participants would be encouraged to use.

**ABOUT INSTRUCTOR :**

Prof. Rajib Mall is a Professor from Department of Computer Science and Engineering, Indian Institute of Technology Kharagpur, West Bengal. He has more than a two decades of teaching experience in the areas of program analysis and testing. He has written five text books and over 150 referred research papers.

**COURSE PLAN :****Week 1:** Introduction to software testing and test process**Week 2:** Black box testing**Week 3:** White box testing**Week 4:** Integration, regression and system testing, test automation



# PYTHON FOR DATA SCIENCE

**PROF. RAGHUNATHAN RENGASAMY**

Department of Chemical Engineering  
IIT Madras

**TYPE OF COURSE**

: Rerun I Elective I UG

**COURSE DURATION**

: 4 weeks (24 Jan' 22 - 18 Feb' 22)

**EXAM DATE**

: 27 Mar 2022

**PRE-REQUISITES :** Knowledge of basic data science algorithms

**INTENDED AUDIENCE :** Final Year Undergraduates

## **COURSE OUTLINE :**

The course aims at equipping participants to be able to use python programming for solving data science problems

## **ABOUT INSTRUCTOR :**

Prof.Rengaswamy was a professor of Chemical Engineering before joining at IIT Madras as a professor and Co-Director of the Process Control and Optimization Consortium at Texas Tech University, Lubbock, USA. He was also a professor and associate professor at Clarkson University, USA and an assistant professor at IIT Bombay. His major research interests are in the areas of fault detection and diagnosis and development of data science algorithms for manufacturing industries.

## **COURSE PLAN :**

**Week 1:** Basics Of Python Spyder (Tool)

**Week 2:** Sequence data types and associated operations

**Week 3:** Pandas data frame and data frame related operations on Toyota Corolla dataset  
Data visualization on Toyoto Corolla dataset using matplotlib and seaborn libraries Control structures using Toyota Corolla dataset

**Week 4:** CASE STUDY-Regression,Classification



# INTRODUCTION TO MACHINE LEARNING (TAMIL)

**PROF. ARUN RAJKUMAR**

Department of Computer Science  
IIT Madras

**TYPE OF COURSE** : New I Elective I UG/PG

**COURSE DURATION** : 4 weeks (24 Jan' 22 - 18 Feb' 22)

**EXAM DATE** : March 27, 2022

**PRE-REQUISITES :** A basic course in linear algebra/probability/programming/algorithms would be a big plus. These are not strong pre-requisites.

**INTENDED AUDIENCE :** Native Tamil speaking audience (Teachers/ Undergraduate Students)

**INDUSTRIES APPLICABLE TO :** All Data centric companies including those that have core business in search/e-commerce/social-media

**COURSE OUTLINE :**

A short course introducing the main ideas and algorithms of Machine Learning. The goal of the course is to cover the topics at a high level so that it would act as a first course for a full fledged Machine Learning course. The course will be delivered in spoken Tamil while the technical terms discussed/exams/assignments will be in English.

**ABOUT INSTRUCTOR :**

Prof. Arun Rajkumar is currently an assistant professor in the department of CSE at IIT Madras. His PhD thesis was in the area of Machine Learning and his broad research interests are in the areas of Machine Learning, sequential decision making.

**COURSE PLAN :**

**Week 1:** Introduction to Supervised Learning - Regression; Topics - Linear Regression; Ridge Regression; LASSO;

**Week 2:** Supervised Learning - Classification; Topics: K-NN, Decision Tree, Naive Bayes, Logistic Regression

**Week 3:** Supervised Learning - Classification; Topics: Perceptron, Support-Vector Machines, Introduction to Neural Networks

**Week 4:** Unsupervised Learning - K-means Clustering, PCA



# SYSTEMS AND USABLE SECURITY

**PROF. NEMINATH HUBBALLI**

Department of Computer Science and Engineering  
Indian Institute of Technology Indore

**TYPE OF COURSE** : New I Elective I UG/PG

**COURSE DURATION** : 4 Weeks (21 Feb' 22 - 18 Mar' 22)

**EXAM DATE** : April 23, 2022

**PRE-REQUISITES :** Computer Networks, Operating Systems, Discrete Mathematics

**INTENDED AUDIENCE :** Final year undergraduate students of Computer Science and Engineering discipline.

**INDUSTRIES APPLICABLE TO :** Cyber Security is an important aspect for every organization currently.

Having knowledge about the threats and possible countermeasures will immensely benefit any organization in todays world.

**COURSE OUTLINE :**

This course will give an understanding of the principles of systems security from application viewpoint. Student will obtain hands-on experience on security threats and counter-measures. Goal is to study various types of threats, operating systems security, advanced topics on network security, web security and usable security. After the completion of the course, the student will have understanding of practical aspects of security and will be able to analyze and design the secure systems.

**ABOUT INSTRUCTOR :**

Prof. Neminath Hubballi received the Ph.D. degree from the Department of Computer Science and Engineering, IIT Guwahati, India. He is currently an Associate Professor in the Discipline of Computer Science, IIT Indore, India. Prior to the current role, he was with corporate research and development centers of Samsung, Infosys Lab. He has also worked with Hewlett-Packard. He has several publications in the areas of security. His areas of interests include networks and system security. He has served as a TPC member and the chair of several conferences. He is a regular reviewer of many security journals and conferences.

**COURSE PLAN :**

**Week 1:** Introduction: Computer security concepts, threats, attacks Malicious Software: Types of Malicious Software (Malware), Vulnerability, Exploits, Social Engineering–SPAM E-mail, Zombie, Bots, Keyloggers, Phishing, Spyware.

**Week 2:** Operating System Security: System Security Planning, Application Security, Linux/Unix Security, Windows Security, Virtualization Security

**Week 3:** Web Security: Secure E-mail and S/MIME, Domain Keys Identified Mail, Secure Sockets Layer (SSL) and Transport Layer Security (TLS), HTTPS, IPv4 and IPv6 Security, Public-Key Infrastructure and Federated Identity Management.

**Week 4:** Usable Security: Introduction to Privacy, Trust and Semantic Security, Visualizing Privacy, Web Browser Security and Privacy, Authentication and Text Passwords, Biometrics and Graphical Passwords.



# FUNDAMENTAL ALGORITHMS: DESIGN AND ANALYSIS

**PROF. SOURAV MUKHOPADHYAY**  
Department of Computer Science  
IIT Kharagpur

**TYPE OF COURSE** : Rerun I Core I UG/PG  
**COURSE DURATION** : 4 Weeks (21 Feb' 22 - 18 Mar' 22)  
**EXAM DATE** : 24 Apr 2022

**INDUSTRIES APPLICABLE TO :** IT companies

## **COURSE OUTLINE :**

This course provides an introduction to mathematical modeling of computational problems. It covers the common algorithms, algorithmic paradigms, and data structures used to solve these problems. The course emphasizes the relationship between algorithms and programming, and introduces basic performance measures and analysis techniques for these problems.

## **ABOUT INSTRUCTOR :**

Prof. Sourav Mukhopadhyay is an associate professor at Indian Institute of Technology Kharagpur. He has completed his B.Sc (Honours in Mathematics) in 1997 from University of Calcutta, India. He has done M.Stat (in statistics) and M.Tech (in computer science) from Indian Statistical Institute, India, in 1999 and 2001 respectively. He worked with Cryptology Research Group at Indian Statistical Institute as a PhD student and received his Ph.D. degree in Computer Science from there in 2007. He was a Research Assistant at the Computer Science department of School of Computing, National University of Singapore (NUS). He visited Inria Rocquencourt, project CODES, France and worked as a post-doctoral research fellows at the School of Computer Engineering, Nanyang Technological University (NTU), Singapore. He was a post-doctoral research fellows and a part time Lecturer with School of Electronic Engineering, Dublin City University (DCU), Ireland.

## **COURSE PLAN :**

**Week 1:** Insertion Sort, Asymptotic Notation, Merge Sort, QuickSort, Divide and Conquer

**Week 2:** Heap Sort, Linear-time Sorting, Order Statistics

**Week 3:** Hashing, BST Sort, Augmenting Data Structures, Dynamic Programming

**Week 4:** Graphs : BFS, DFS, Prim's, Shortest Paths

# SOFTWARE CONCEPTUAL DESIGN

## MULTI FACULTY

<b>TYPE OF COURSE</b>	: New I Elective I UG
<b>COURSE DURATION</b>	: 4 weeks (21 Feb' 22 - 18 Mar' 22)
<b>EXAM DATE</b>	: 24 Apr 2022

**PRE-REQUISITES :** Learners should have undergone a basic course in programming in any language, should be familiar with basic programming constructs

**INDUSTRIES APPLICABLE TO :** This course can be useful for graduates who wish to be employed in Software/IT companies in software engineering positions.

### COURSE OUTLINE :

This course will provide learners with an overview of what all is involved in creating conceptual software designs. Specifically, it will take learners through different aspects of understanding, creating and evaluating software conceptual designs.

After going through the course, learners will be able to:

1. Think of software in terms of sub-systems, and understand what issues have to be considered in order to design these sub-systems
2. Create a software conceptual design for a given design problem, and model them using Unified Modeling Language (UML) diagrams
3. Evaluate their designs for functional and non-functional quality attributes

### ABOUT INSTRUCTOR :

Prof. Sridhar Iyer is a Professor in the Dept of Computer Science & Engg, and the Head of the Interdisciplinary Programme on Educational Technology, at IIT Bombay. He is also the Head of the Centre for Distance Engineering Education and the Principal Investigator of the National Programme on Technology Enhanced Learning at IIT Bombay. His current research interests are in the field of Educational Technology.

Prof. Prajish Prasad completed his PhD from the Interdisciplinary Programme in Educational Technology at IIT Bombay. His bachelor and master degrees are in Computer Science. He is a computing education researcher, and specializes in designing technology-enhanced learning environments for topics in computer science. The focus of his doctoral research was on fostering software design evaluation skills in students. Prior to joining his PhD, he worked as a software developer in an EdTech startup, and as an engineering instructor, teaching courses for computer science undergraduates.

Prof. T.G.Lakshmi completed her PhD from the Interdisciplinary Programme in Educational Technology at IIT Bombay. She has completed her bachelor and master degrees in computer science engineering. Her doctoral research focuses on fostering software conceptual design using the Function-Behaviour-Structure design framework. She is a computing education and learning science researcher. Her interests also include designing and implementing technology-enhanced learning environments for learners. Prior to joining her PhD she was a software developer and a lecturer teaching undergraduate computer engineering students for several years.

### COURSE PLAN :

**Week 1:** Deconstructing the software design process

**Week 2:** Designing Software using the FBS Framework

**Week 3:** Comprehending and Evaluating Software Designs

**Week 4:** The Next Steps - Where does one go from here