



Department of Computer Science and Engineering

Ph.D. Course Work

(Applicable for the scholars admitted from the AY: 2025-26)

The credit requirement for the Ph.D. course work is a minimum of 12 credits including the courses on ‘Research Methodology’ and ‘Research and Publication Ethics’ for 2 credits each. The candidate must complete two domain-specific courses of 3 credits each, recommended by the respective Department Research Committee (DRC). These courses can be completed through MOOCs.

The candidate must present two research seminars before the completion of course work, typically within the first year. The first research seminar shall be before the end of first semester on introduction to the proposed research work, and the second seminar shall be before the end of the second semester or after the completion of course work on the research proposal, as per the format provided. Each research seminar will have one credit weightage. The course structure is presented in Table 1 and list of domain-specific courses is presented in Table 2.

Table 1: Course Structure

S.No.	Course Code	Name of the Course	Credit (s)
1	2517UC01	Research Seminar -I	1
2	2517UC02	Research Seminar -II	1
3	2517UC03	Research Methodology	2
4	2517UC04	Research and Publication Ethics	2
5	-	Domain Specific Course -I	3
6	-	Domain Specific Course -II	3
Total			12

Table 2: Domain Specific Courses

S.No.	Course Code	Name of the Course
1	2517CS01	Data Science Fundamentals
2	2517CS02	Artificial Cognitive Systems
3	2517CS03	Fog and Edge Computing
4	2517CS04	Secure Cloud Computing
5	2517CS05	AI for Cyber Security
6	2517CS06	AI for Language and Text Processing
7	2517CS07	Block Chain Technology
8	2517CS08	Quantum Computational Methods
9	2517CS09	Introduction to Machine Learning
10	2517CS10	Machine Learning for Engineering and Science Applications
11	2517CS11	Computer Networks and Internet Protocol
12	2517CS12	Natural language processing
13	2517CS13	Advanced Computer Networks
14	2517CS14	Computer Vision and Image processing - Fundamentals and Applications
15	2517CS15	Introduction to Soft Computing
16	2517CS16	Introduction to Internet of Things
17	2517CS17	Cryptography and Network Security
18	2517CS18	Data analytics with Python
19	2517CS19	Deep Learning
20	2517CS20	Machine Learning and Deep Learning - Fundamentals and Applications

Research Methodology

Course Code: 2517UC03

UNIT -I:

Research Design

Overview of research process and design, Use of Secondary and exploratory data to answer the research question, Qualitative research, Observation studies, Experiments and Surveys. Case Studies.

UNIT-II:

Data Collection and Sources

Measurements, Measurement Scales, Questionnaires and Instruments, Sampling and methods. Data - Preparing, Exploring, examining and displaying.

UNIT-III:

Data Analysis and Reporting

Overview of Multivariate analysis, Hypotheses testing and Measures of Association. Presenting Insights and findings using written reports and oral presentation.

UNIT-IV:

Intellectual Property Rights

Intellectual Property – The concept of IPR, Evolution and development of concept of IPR, IPR development process, Trade secrets, utility Models, IPR & Bio diversity, Role of WIPO and WTO in IPR establishments, Right of Property, Common rules of IPR practices, Types and Features of IPR Agreement, Trademark, Functions of UNESCO in IPR maintenance.

UNIT-V:

Patents

Patents – objectives and benefits of patent, Concept, features of patent, Inventive step, Specification, Types of patent application, process E-filing, Examination of patent, Grant of patent, Revocation, Equitable Assignments, Licenses, Licensing of related patents, patent agents, Registration of patent agents.

Text Books:

1. Research Methodology: A Step-by-Step Guide for Beginners, Ranjit Kumar, Sage Publications, 4th Edition, 2015.
2. Intellectual Property: A Very Short Introduction, Siva Vaidhyanathan, Oxford University Press, 2017.
3. Intellectual Property: The Law of Trademarks, Copyrights, Patents, and Trade Secrets" Deborah E. Bouchoux, Cengage India, 4th Edition, 2013.

Reference Books:

1. Research methodology: an introduction for science & engineering students, Stuart Melville and Wayne Goddard, Juta Academic, 2nd Edition, 2014.
2. Research design: Qualitative, quantitative, and mixed methods approaches, Creswell, J.W. and Creswell, J.D., Sage publications, 2017.
3. Intellectual Property in New Technological Age, Robert P. Merges, Peter S. Menell, Mark A. Lemley, Clause 8 Publishing; Volume I: Perspectives, Trade Secrets & Patents; 2023.

Weblinks:

1. <https://archive.nptel.ac.in/courses/121/106/121106007/#>
2. https://onlinecourses.swayam2.ac.in/ntr24_ed08/preview

Research and Publication Ethics

Course Code: 2517UC04

Unit-I:

Philosophy & Ethics

Introduction to Philosophy:

Definition, Nature & Scope, Concept, Branches

Ethics:

Definition, Moral Philosophy, Nature of Moral Judgements & Reactions

Unit-II:

Scientific Conducts

Ethics with respect to Science and Research, Intellectual Honesty & Research Integrity

Scientific Misconducts:

Falsification, Fabrication & Plagiarism

Redundant Publications:

Duplicate & Overlapping Publication, Salami Slicing, Selective Reporting & Misrepresentation of Data

Unit-III:

Publication Ethics:

Definition, Introduction and Importance

Best Practices/ Standard Setting Initiatives and Guidelines:

COPE, WAVE, etc., Conflicts of Interest

Publication Misconduct:

Definition, Concept, Problems that lead to unethical behaviour and vice-versa, types, Violation of Publication Ethics, Authorship and Contributorship, Identification of Publication Misconduct, Complaints and Appeals, Predatory Publishers and Journals

Unit-IV:

Open Access Publishing

Open Access publications and Initiatives, SHERPA/ RoMEO online resource to check publisher copyright and self-achieving policies, Software tool to identify predatory publications developed by SPPU, Journal Finder/ Journal Suggestion tools viz. JANE, ELSEVIER, SPINGER, Journal suggester etc.

Unit-V:

Publication Misconduct Group Discussions:

Subject-specific Ethical issues, FFP, Authorship, Conflicts of Interest, Complaints and Appeals: Examples and fraud from India and Abroad

Software tools:

Use of Plagiarism software like Turnitin, Urkund and other open source software tools

Database and Research Metrics:

Database:

Indexing database, Citation database: web of science, Scopus etc.

Impact factor of journal as per journal citation report, SNIP, SJR, IPP, cite score

Metrics:

h-index, g-index, i-10 index, AL metrics etc.

Text Books:

1. Philosophy in Science, Bird A, Routledge, 2006.
2. A Short History of Ethics, MacIntyre, London, 1967.

Reference Book:

1. Ethics in Science, Education and Governance, Indian National Science Academy, 2019.

Weblinks:

1. www.niehs.nih.gov/research/resources/bioethics/whatis
2. https://onlinecourses.swayam2.ac.in/nou22_ge73/preview

Data Science Fundamentals

Course Code: 2517CS01

UNIT – I

Introduction to Data Science:

Need for Data Science – What is Data Science - Data Science Process – Business Intelligence and Data Science – Prerequisites for a Data Scientist – Tools and Skills required.

NumPy Basics:

The NumPy ndarray: A Multidimensional Array Object, Creating ndarrays, Data Types for ndarrays, Operations between Arrays and Scalars, Basic Indexing and Slicing, Boolean Indexing, Fancy Indexing, Data Processing Using Arrays, Expressing Conditional Logic as Array Operations, Methods for Boolean Arrays, Sorting, Unique.

UNIT – II

Getting Started with pandas:

Introduction to pandas, Library Architecture, Features, Applications, Data Structures, Series, Data Frame, Index Objects, Essential Functionality (Reindexing, Dropping entries from an axis, Indexing, selection, and filtering), Sorting and ranking, Summarizing and Computing Descriptive Statistics, Unique Values, Value Counts, Handling Missing Data, filtering out missing data.

UNIT – III

Plotting and Visualization:

A Brief matplotlib API Primer, Figures and Subplots, Colors, Markers, and Line Styles, Ticks, Labels, and Legends, Annotations and Drawing on a Subplot, Saving Plots to File, Plotting Functions in pandas, Line Plots, Bar Plots, Histograms and Density Plots, Scatter Plots.

UNIT – IV

Data Loading, Storage, and File Formats:

Reading and Writing Data in Text Format, Reading Text Files in Pieces, Writing Data Out to Text Format, Manually Working with Delimited Formats, JSON Data, XML and HTML: Web Scraping, Binary Data Formats, Using HDF5 Format, Reading Microsoft Excel Files, Interacting with Databases, Storing and Loading Data in Mongo DB.

UNIT – V

Data Wrangling:

Combining and Merging Data Sets, Database style DataFrame Merges, Merging on Index, Concatenating Along an Axis, Combining Data with Overlap, Reshaping and Pivoting, Reshaping with Hierarchical Indexing, Data Transformation, Removing Duplicates, Replacing Values.

Machine Learning Fundamentals: Supervised Learning: Regression and Classification, Unsupervised Learning: Clustering and Dimensionality Reduction, Evaluation Metrics for Machine Learning, Overfitting and Underfitting, Model Selection and Hyper parameter Tuning

Text Books:

- 1 Python for Data Analysis, O'REILLY, Wes McKinney, ISBN: 978-1-449-31979-3, 1st edition.
- 2 Doing Data Science, Rachel Schutt & O'neil, O'REILLY, ISBN: 978-1-449-35865-5, 1st edition

Reference Books:

- 1 Data Science from Scratch: First Principles with Python", Joel Grus, O'Reilly Media.
- 2 Learning the Pandas Library: Python Tools for Data Munging, Analysis, and Visualization, Matt Harrison, O'Reilly.
- 3 Introduction to Machine Learning with Python: A Guide for Data Scientists" by Andreas Müller and Sarah Guido.

Web Links:

- 1 https://en.m.wikipedia.org/wiki/Data_Science_and_Predictive_Analytics/

Artificial Cognitive Systems

Course Code: 2517CS02

UNIT – I

Introduction to Cognitive Science:

Understanding Cognition, Design for Human Cognition, Augmented Intelligence, Cognition Modeling Paradigms: Declarative/ logic-based computational cognitive modeling, connectionist models of cognition, Bayesian models of cognition, a dynamical systems approach to cognition

UNIT – II

Cognitive Models of memory and language, computational models of episodic and semantic memory, modeling psycholinguistics

UNIT – III

Cognitive Modeling:

Modeling the interaction of language, memory and learning, Modeling select aspects of cognition classical models of rationality, symbolic reasoning and decision making.

UNIT – IV

Formal models of inductive generalization, causality, categorization and similarity, the role of analogy in problem solving, Cognitive Development Child concept acquisition. Cognition and Artificial cognitive architectures such as ACT-R, SOAR, OpenCog, CopyCat, Memory Networks

UNIT – V

DeepQA Architecture, Unstructured Information Management Architecture (UIMA), Structured Knowledge, Business Implications, Building Cognitive Applications, Application of Cognitive Computing and Systems

Text Books:

- 1 The Cambridge Handbook of Computational Psychology by Ron Sun (ed.), Cambridge University Press.
- 2 Learning IBM Watson Analytics, James D Miller, Packt Publications

Reference Books:

- 1 Formal Approaches in Categorization by Emmanuel M. Pothos, Andy J. Wills, Cambridge University Press.
- 2 Cognition, Brain and Consciousness: Introduction to Cognitive Neuroscience by Bernard J. Bears, Nicole M. Gage, Academic Press.
- 3 Cognitive Computing and Big Data Analytics by Hurwitz, Kaufman, and Bowles, Wiley.

Web Links:

1. <https://www.techtarget.com/searchenterpriseai/definition/cognitive-modeling/>
2. <https://www.slideshare.net/slideshow/cognitive-modeling-92473833/92473833/>

Fog and Edge Computing

Course Code: 2517CS03

UNIT – I

Internet of Things (IoT) and New Computing Paradigm:

Introduction, Relevant Technologies, Fog and Edge Computing Completing the Cloud, Hierarchy of Fog and Edge Computing, Business Models, Edge Computing Platforms, Opportunities and Challenges, Methodology, Integrated C2F2T Literature by Modeling Technique, Integrated C2F2T Literature by Use, Case Scenarios , Integrated C2F2T Literature by Metrics – Threads , Standards.

UNIT – II

Orchestration of Network Slices in Fog, Edge, and Clouds:

Introduction, Background, Network Slicing, Network Slicing in Software, Defined Clouds Network Slicing Management in Edge and Fog, Internet of Vehicles (IoV): Architecture, Protocols and Seven-layer security model architecture for Internet of Vehicles, IoV: Network Models, Challenges and future aspects

UNIT – III

Optimization Problems in Fog and Edge Computing:

Preliminaries, The Case for Optimization in Fog Computing, Formal Modeling Framework for Fog Computing – Metrics, Further Quality Attributes, Optimization Opportunities along the Fog Architecture, Optimization Opportunities along the Service Life Cycle, Toward a Taxonomy of Optimization Problems in Fog Computing.

UNIT – IV

Middleware for Fog and Edge Computing:

Need for Fog and Edge Computing Middleware, Design Goals, State of the, Art Middleware Infrastructures, System Model, Case Study, Technologies, Fog Data Management, Smart Building , Predictive Analysis with FogTorch , Machine Learning in Fog Computing , Data Analytics in the Fog , Data Analytics in the Fog Architecture

UNIT – V

Applications of Fog and Edge Computing:

Exploiting Fog Computing in Health Monitoring, Smart Surveillance Video Stream Processing at the Edge for Real, Time Human Objects Tracking, Fog Computing Model for Evolving Smart Transportation Applications, Testing Perspectives of Fog , Based IoT Applications , Legal Aspects of Operating IoT Applications in the Fog.

Text Books:

- 1 Fog and Edge computing: Principles and Paradigms, Buyya, Rajkumar, and Satish Narayana Srirama, 2019, 1st edition, John Wiley & Sons, USA.
- 2 Fog Computing: Theory and Practice by Assad Abbas, Samee U. Khan, Albert Y. Zomaya
- 3 IoT and Edge Computing for Architects, Second Edition, by Perry Lea, Publisher: Packt Publishing, 2020, ISBN: 9781839214806

Reference Books:

- 1 Cloud computing: A hands-on approach, Bahga, Arshdeep, and Vijay Madiseti, 2nd edition, CreateSpace Independent Publishing Platform, USA.
- 2 Internet of Things –From Research and Innovation to Market Deployment, Ovidiu Vermesan, Peter Friess, 1st edition, River Publishers, India.

Web Links:

- 1 https://onlinecourses.nptel.ac.in/noc24_cs66/preview/

Secure Cloud Computing

Course Code: 2517CS04

UNIT – I

Cloud Computing Fundamentals- Definition, Evolution, Essential characteristics, Cloud Deployment Models, Cloud Service Models, Benefits, Cloud Architecture, Virtualization in Cloud, Cloud Data Centre, SLA, Cloud Applications.

UNIT – II

Cloud Security Challenges, Cloud Information Security Objectives, Cloud Security Services, Secure Cloud Software Requirements, Cloud Security Policy Implementation, Infrastructure Security, Data Security and Storage.

UNIT – III

Threats and Vulnerabilities to Infrastructure, Data, and Access Control; Risk Management and Risk Assessment in Cloud, Cloud Service Provider Risks, Virtualization Security Management in the Cloud.

UNIT – IV

Cloud Computing and Business Continuity Planning/Disaster Recovery, Cloud Audit and Compliance: Internal Policy Compliance, Regulatory/External Compliance.

UNIT – V

Standards for Security: SAML OAuth, OpenID, SSL/TLS, Encrypting Data and Key Management, Creating a Cloud Security Strategy.

Text Books:

- 1 Ronald L. Krutz, Russell Dean Vines, "Cloud Security: A Comprehensive Guide to Secure Cloud Computing", Wiley Publishing.

Reference Books:

- 1 Tim Mather, Subra Kumaraswamy, and Shahed Latif," Cloud Security and Privacy", Published by O'Reilly Media, Inc..

Web Links:

- 1 https://onlinecourses.nptel.ac.in/noc21_cs14/preview/
- 2 <https://nptel.ac.in/courses/106105167/>

AI for Cyber Security

Course Code: 2517CS05

UNIT – I

Introduction: Understanding Cyber security, Looking at the Various Aspects of Cyber security, Social engineering and phishing , Introducing ransom ware, Malware intrusion, Non-malware intrusion, Detect, Respond, and Mitigate, Responding to and Recovering From Cyber attacks and Security Events, Meeting the Challenges of Cyber security.

UNIT – II

Understanding Artificial Intelligence: Teaching Machines to be Smarter, Learning Algorithms, Supervised learning, Unsupervised learning, Being Smarter, Interacting with Humans, Natural Language Processing.

UNIT – III

Discovering Machine Learning and Deep Learning: Deep Learning and Deeply Layered Neural Networks, Introducing cognitive computing, Structured and Unstructured Data.

UNIT – IV

Applying Machine Learning and Deep Learning to Cyber security: Predictive Analytics, Taught Not Programmed, Uncovering the needle in the haystack, introducing cognitive computing, Identifying root cause, A Smarter Adversary.

UNIT – V

Using the Cognitive Capabilities to Investigate Security Incidents, Taking Intelligent Action, Understand, Reason and Learn, Detecting spam with Perceptron, Malware threat detection, Responding to Ransomware, Network anomaly detection with AI, Fraud prevention with cloud AI solutions, GANs - Attacks and Defenses.

Text Books:

- 1 Hands-On Artificial Intelligence for Cybersecurity, Implement smart AI systems for preventing cyber attacks and detecting threats and network anomalies by Alessandro Parisi.
- 2 AI in Cybersecurity by Leslie F. Sikos, Springer, Cham.

Reference Books:

- 1 Artificial Intelligence & Cyber security For Dummies, IBM Limited Edition.
- 2 Machine Learning for Computer and Cyber Security Principle, Algorithms, and Practices, By Brij B. Gupta, Quan Z. Sheng, CRC Press, 1st Ed..
- 3 Artificial Intelligence for Security by Archie Addo, Srini Centhala, Muthu Shanmugam, Publisher(s): Business Expert Press ISBN: 9781951527273.

Web Links:

1. https://onlinecourses.nptel.ac.in/noc24_cs121/preview/
2. https://onlinecourses.nptel.ac.in/noc22_cs56/preview/

AI for Language and Text Processing

Course Code: 2517CS06

UNIT – I

Introduction to NLP:

Introduction to NLP - Various stages of NLP –The Ambiguity of Language: Why NLP Is Difficult Parts of Speech: Nouns and Pronouns, Words: Determiners and adjectives, verbs, Phrase Structure. Statistics Essential Information Theory: Entropy, perplexity, The relation to language, Cross entropy.

UNIT – II

Text Preprocessing

Tokenization, Stemming, Text Preprocessing & Feature Representation Introduction to Corpora, Sentence Segmentation, Stemming: Porter Stemmer, Bag of words and Vector Space Model, Topic Modelling, N-gram Language Model, Smoothing.

UNIT – III

Language Modelling

Words: Collocations- Frequency-Mean and Variance –Hypothesis testing: The t test, Hypothesis testing of differences, Pearson's chi-square test, Likelihood ratios. Statistical Inference: n -gram Models over Sparse Data: Bins: Forming Equivalence Classes- N gram model - Statistical Estimators- Combining Estimators

UNIT – IV

Morphology:

Sequence Labeling for Parts of Speech and Named Entities, Part of Speech Tagging, Named Entities and Named Entity Tagging , HMM Part of Speech Tagging , Conditional Random Fields (CRFs), Evaluation of Named Entity Recognition Applications of NLP Machine Translation Encoder & Decoder Model, Attention Models, Question Answering Knowledge based Q&A Chatbots & Dialogue Systems, Automatic Speech Recognition and Text to Speech

UNIT – V

Markov Model and POS Tagging:

Markov Model: Hidden Markov model, Fundamentals, Probability of properties, Parameter estimation, Variants, Multiple input observation. The Information Sources in Tagging: Markov model taggers, Viterbi algorithm, Applying HMMs to POS tagging, Applications of Tagging

Text Books:

1. Foundations of Natural Language Processing , Christopher D. Manning and Hinrich Schutze, 6 th Edition, The MIT Press Cambridge, Massachusetts London, England.
2. Speech and Language Processing, Daniel Jurafsky and James H. Martin ,3rd edition, Prentice Hall

Reference Books:

1. Handbook of Natural Language Processing, Nitin Indurkha, Fred J. Damerau Second Edition, CRC Press.
2. Natural language processing in action, Hobson lane, Cole Howard, Hannes Hapke Manning Publications.

Block Chain Technology

Course Code: 2517CS07

UNIT – I

Introduction:

Introduction to Blockchain, Scenarios, Challenges Articulated, Blockchain, Blockchain Characteristics, Opportunities Using Blockchain, History of Blockchain.

Evolution of Blockchain :

Evolution of Computer Applications, Centralized Applications, Decentralized Applications, Stages in Blockchain Evolution Public Blockchain Environments

UNIT – II

Blockchain Concepts:

Introduction, Changing of Blocks, Hashing, Consensus, Mining and Finalizing Blocks, security on blockchain, data storage on blockchain, wallets, Coding on Blockchain: Smart contracts, peer-to-peer network, types of blockchain nodes, risk associated with blockchain solutions, life cycle of blockchain transaction.

UNIT – III

Architecting Blockchain solutions:

Introduction, Obstacles for Use of Blockchain, Blockchain Relevance Evaluation Framework, Blockchain Solutions Reference Architecture, and Types of Blockchain Applications.

Crypto currency and Wallet:

Types of Wallet, Desktop Wallet, App based Wallet, Browser based wallet, Metamask, Creating an account in Metamask, transfer of crypto currency in metamask.

UNIT – IV

Ethereum Blockchain Implementation:

Introduction, Tuna Fish Tracking Use Case, Ethereum Ecosystem, Ethereum Development, Ethereum Tool Stack, Ethereum Virtual Machine, Smart Contract Programming, Integrated Development Environment, Truffle Framework, Ethereum Accounts, MyEtherWallet, Ethereum Networks/Environments, Ethereum Clients, Decentralized Application.

UNIT – V

Hyperledger Blockchain Implementation, Introduction, Use Case – Car Ownership Tracking, Hyperledger Fabric, Hyperledger Fabric Transaction Flow, Invoking Chaincode Functions Using Client Application. Advanced Concepts in Blockchain: Introduction, InterPlanetary File System (IPFS), Blockchain Cloud Offerings, Blockchain and its Future Potential.

Text Books:

- 1 Blockchain: Blueprint for a New Economy, Melanie Swan, O'Reilly
- 2 Mastering Blockchain: Deeper insights into decentralization, cryptography, Bitcoin, and popular Blockchain frameworks by Imran Bashier, Packt publishing

Reference Books:

- 1 Mastering Ethereum: Building Smart Contracts and DApps by Andrews
- 2 Mastering Bitcoin: Programming the Open Blockchain, by Andreas M. Antonopoulos, O'Reilly

Web Links:

- 1 https://onlinecourses.swayam2.ac.in/aic21_ge01/
- 2 <https://github.com/blockchainedindia/resources/>
- 3 <https://github.com/HyperledgerHandsOn/trade-finance-logistics/>

Quantum Computational Methods

Course Code: 2517CS08

UNIT – I

Overview of classical vs. quantum computing, Quantum superposition, and entanglement (entangled states and their properties, Bell's theorem and the violation of Bell inequalities, Applications of entanglement in quantum information tasks.) Quantum Measurement, Quantum Teleportation, Quantum bits (qubits) and quantum gates, Quantum Computing Hardware, physical implementations of qubits (Superconducting, Trapped Ion, Photonic Qubits).

UNIT – II

Quantum gates and their operations: Hadamard Gate, Pauli-X Gate, Pauli-Y Gate, Pauli-Z Gate, CNOT Gate, Toffoli Gate, SWAP Gate, Rabi Gate Quantum circuits and circuit diagrams and notation, Quantum circuits for everyday operations.

UNIT – III

Shor's factoring algorithms, Grover's search algorithm, the adiabatic algorithms, Quantum oracle and its use in Grover's algorithm, Analysing the time complexity of quantum algorithms, Quantum parallelism, Quantum error correction, and its importance.

UNIT – IV

Quantum Programming Languages and Tools, Introduction to quantum programming languages (Qiskit, Cirq), Writing simple quantum programs, Debugging and simulating quantum circuits, Accessing and using quantum hardware.

UNIT – V

Quantum Applications, Quantum cryptography, Quantum machine learning, Quantum chemistry and simulations, Quantum optimization, Open problems and ongoing research.

Text Books:

- 1 Quantum Computation and Quantum, Michael A. Nielsen and Isaac L. Chuang, Information, Cambridge University Press
- 2 Quantum Computing: A Gentle Introduction, Eleanor Rieffel and Wolfgang Polak, MIT Press.

Reference Books:

- 1 Programming Quantum Computers, Eric R. Johnston, Nic Harrigan, and Mercedes Gimeno-Segovia, O'Reilly
- 2 An Open-source Framework for Quantum Computing, Qiskit contributors, IBM, doi = 10.5281/zenodo.2573505

Web Links:

- 1 <https://nptel.ac.in/courses/106106232/>
- 2 <https://learn-xpro.mit.edu/quantum-computing/>

Introduction to Machine Learning

Course Code: 2517CS09

UNIT – I

Probability Theory, Linear Algebra, Convex Optimization - (Recap)-Introduction: Statistical Decision Theory - Regression, Classification, Bias Variance-Linear Regression, Multivariate Regression, Subset Selection, Shrinkage Methods, Principal Component Regression, Partial Least squares

UNIT-II

Linear Classification, Logistic Regression, Linear Discriminant Analysis-Perceptron, Support Vector Machines-Neural Networks - Introduction, Early Models, Perceptron Learning, Backpropagation, Initialization, Training & Validation, Parameter Estimation - MLE, MAP, Bayesian Estimation

UNIT-III

Decision Trees, Regression Trees, Stopping Criterion & Pruning loss functions, Categorical Attributes, Multiway Splits, Missing Values, Decision Trees - Instability Evaluation Measures Bootstrapping & Cross Validation, Class Evaluation Measures, ROC curve, MDL, Ensemble Methods - Bagging, Committee Machines and Stacking, Boosting

UNIT-IV

Gradient Boosting, Random Forests, Multi-class Classification, Naive Bayes, Bayesian Networks Undirected Graphical Models, HMM, Variable Elimination, Belief Propagation

UNIT-V

Partitional Clustering, Hierarchical Clustering, Birch Algorithm, CURE Algorithm, Density-based Clustering-Gaussian Mixture Models, Expectation Maximization-Learning Theory, Introduction to Reinforcement Learning, Optional videos (RL framework, TD learning, Solution Methods, Applications)

Textbooks:

1. The Elements of Statistical Learning, by Trevor Hastie, Robert Tibshirani, Jerome H. Friedman (freely available online)
2. Pattern Recognition and Machine Learning, by Christopher Bishop (optional)

Reference Books:

- 1 “Machine Learning”, Tom M.Mitchel McGrawHill publication,2017
- 2 “Machine Learning in Action “, Peter Harrington ,Dream Tech

Web links:

1. https://onlinecourses.nptel.ac.in/noc25_cs46/course

Machine Learning for Engineering and Science Applications

Course Code: 2517CS10

UNIT – I

Mathematical Basics 1 – Introduction to Machine Learning, Linear Algebra

Mathematical Basics 2 – Probability

Computational Basics – Numerical computation and optimization, Introduction to Machine learning packages

UNIT – II

Linear and Logistic Regression – Bias/Variance Tradeoff, Regularization, Variants of Gradient Descent, MLE, MAP, Applications Neural Networks – Multilayer Perceptron, Backpropagation, Applications

UNIT – III

Convolutional Neural Networks 1 – CNN Operations, CNN architectures

Convolutional Neural Networks 2 – Training, Transfer Learning, Applications

Recurrent Neural Networks RNN, LSTM, GRU, Applications

UNIT – IV

Classical Techniques 1 – Bayesian Regression, Binary Trees, Random Forests, SVM, Naïve Bayes, Applications Classical Techniques 2 – k-Means, kNN, GMM, Expectation Maximization, Applications

UNIT – V

Advanced Techniques 1 – Structured Probabilistic Models, Monte Carlo Methods

Advanced Techniques 2 – Autoencoders, Generative Adversarial Network

Textbooks:

1. Deep Learning, Goodfellow et al, MIT Press, 2017.
2. Pattern Recognition and Machine Learning, Christopher Bishop, Springer, 2009.

Reference Books:

- 1 “Machine Learning”, Tom M. Mitchell McGrawHill publication, 2017
- 2 “Machine Learning in Action”, Peter Harrington, Dream Tech

Web links:

1. https://onlinecourses.nptel.ac.in/noc25_cs49/course
2. https://www.youtube.com/watch?v=_M-nDb0MIa4

Computer Networks and Internet Protocol

Course Code: 2517CS11

UNIT – I

Introduction to Computer Networks – History, Circuit Switching and Packet Switching, TCP/IP Protocol Stack – Basic Overview, Application Layer Services (HTTP, FTP, Email, DNS).

UNIT – II

Transport Layer Primitives – Connection Establishment and Closure, Flow Control and Congestion Control at the Transport Layer

UNIT – III

Transmission Control Protocol – Basic Features, TCP Congestion Control, Network Layer Primitives – IP Addressing

UNIT – IV

IP Routing – Intra Domain Routing Protocols, Inter Domain Routing Protocols (BGP), IP Services – SNMP, ARP, Data Link Layer Service Primitives – Forwarding, Flow Control, Error Control

UNIT – V

Media Access Control - Channel Access Protocols, Framing, End to End Principles of Computer Networks

Textbooks:

1. Computer Networking: A Top - Down Approach, by Ames Kurose, Keith Ross
2. Computer Networks - Andrew S Tanenbaum
3. Computer Networks: A Systems Approach Book by Bruce S. Davie and Larry L. Peterson

Reference Books:

- 1 “Machine Learning”, Tom M.Mitchel McGrawHill publication,2017
- 2 “Machine Learning in Action “, Peter Harrington, Dream Tech

Web links:

1. https://onlinecourses.nptel.ac.in/noc25_cs15/preview
2. <http://www.redbooks.ibm.com/abstracts/gg243376.html>
3. <http://www.tcpipguide.com/>
4. <http://www.ietf.org/rfc.html>

Natural Language Processing

Course Code: 2517CS12

UNIT – I

Introduction and Basic Text Processing, Spelling Correction, Language Modeling

UNIT – II

Advanced smoothing for language modeling, POS tagging, Models for Sequential tagging – MaxEnt, CRF

UNIT – III

Syntax – Constituency Parsing, Dependency Parsing

UNIT – IV

Distributional Semantics, Lexical Semantics, Topic Models

UNIT – V

Entity Linking, Information Extraction, Text Summarization, Text Classification, Sentiment Analysis and Opinion Mining

Textbooks:

1. Speech and Language Processing: An Introduction to Natural Language Processing, Computational Linguistics and Speech Recognition, Dan Jurafsky and James Martin. Prentice Hall, Second Edition, 2009.
2. Foundations of Statistical Natural Language Processing., Chris Manning and Hinrich Schütze MIT Press, Cambridge, MA: May 1999.

Reference Books:

- 1 Natural Language Processing and Information Retrieval: Tanvier Siddiqui, U.S.Tiwary
- 2 Understanding Natural Language Processing (Machine Learning and Deep Learning Perspectives) by T.V.Geetha– Pearson,2024

Web links:

1. https://onlinecourses.nptel.ac.in/noc25_cs51/preview

Advanced Computer Networks

Course Code: 2517CS13

UNIT – I

High Performance Switching and Routing: Introduction, performance considerations, IP address lookup, Algorithms for IP address lookup and optimization, hardware implementation of address lookup.

UNIT – II

Packet Classification: Need for packet classification and methods for packet classification, Differentiated Service, Quality of Service, Traffic Polishing, Traffic Shaping, Network Softwarization – Introduction

UNIT – III

Software Defined Networking (SDN) - Deep Dive (Northbound and Southbound interface) , Working with Mininet + Lab Exercises with Minine, Network Function Virtualization (NFV) - Architecture and Concepts

UNIT – IV

Programmable Networks - Introduction to P4, SmartNICS and P4 switches. + Lab Exercise with Mininet and BMV2 switches, Data Center Networking (DCN) – Introduction.

UNIT – V

DCN - Deep Dive (Network topologies, Container Network Interfaces), Content Distribution on the Internet, Architectures for Information Centric Networking, Content Naming, Routing and Caching, Security in Named Data Networking

Textbooks:

1. High Performance Switches and Routers, H. Jonathan Chao, Bin Liu, 2007, John Wiley & Sons, Inc. ISBN-10: 0-470-05367-4
2. Information-Centric Networks: A New Paradigm for the Internet (Focus Series in Networks and Telecommunications), Gabriel M. de Brito, Pedro B. Velloso, Igor M. Moraes, Wiley-ISTE; 1st edition, 2013, ISBN: 9781848214491
3. Information-Centric Networking (ICN): Content Centric Networking (CCNx) and Named Data Networking (NDN) Terminology, B. Wissingh, C. Wood, A. Afanasyev, L. Zhang, D. Oran and C. Tschudin, RFC 8793, June 2020

Reference Books:

- 1 Cloud Networking: Understanding Cloud-based Data Centre Networks, Gary Lee (Author), Morgan Kaufmann (Publisher), 2014, ISBN-139780128007280
- 2 Understanding communications and Networks, 3rd Edition, W. A. Shay, Cengage Learning.

Web links:

1. https://onlinecourses.nptel.ac.in/noc25_cs02/preview
2. <https://sdn.systemsapproach.org/index.html>

Computer Vision and Image Processing -Fundamentals and Applications

Course Code: 2517CS14

UNIT – I

Introduction to Computer Vision and Basic Concepts of Image Formation: Introduction and Goals of Computer Vision and Image Processing, Image Formation Concepts, Fundamental Concepts of Image Formation: Radiometry, Geometric Transformations, Geometric Camera Models

UNIT – II

Fundamental Concepts of Image Formation: Camera Calibration, Image Formation in a Stereo Vision Setup, Image Reconstruction from a Series of Projections, Image Processing Concepts: Image Transforms, Image Transforms, Image Enhancement. Syllabus:

UNIT – III

Image Processing Concepts: Image Filtering, Colour Image Processing, Image Segmentation. Image Descriptors and Features: Texture Descriptors, Colour Features, Edges/Boundaries, Object Boundary and Shape Representations

UNIT – IV

Image Descriptors and Features: Interest or Corner Point Detectors, Histogram of Oriented Gradients, Scale Invariant Feature Transform, Speeded up Robust Features, Saliency Fundamentals of Machine Learning: Linear Regression, Basic Concepts of Decision Functions, Elementary Statistical Decision Theory, Parameter Estimation, Clustering for Knowledge Representation, Dimension Reduction, Linear Discriminant Analysis.

UNIT – V

Applications of Computer Vision: Artificial Neural Network for Pattern Classification, Convolutional Neural Networks, Autoencoders. Gesture Recognition, Motion Estimation and Object Tracking, Programming Assignments.

Textbooks:

1. Computer Vision-A Modern Approach, Forsyth & Ponce, Pearson Education.
2. Computer Vision and Image Processing: Fundamentals and Applications, M.K. Bhuyan

Reference Books:

- 1 Computer Vision- Algorithms & Applications, Richard Szeliski, Springer.
- 2 Computer Vision Principles, algorithms, Applications, Learning 5th Edition by E.R. Davies Academic Press, Elsevier 2018 ISBN 978-0-12-809284-2

Web links:

1. https://onlinecourses.nptel.ac.in/noc25_ee13/course

Introduction to Soft Computing

Course Code: 2517CS15

UNIT – I

Introduction to Soft Computing, Introduction to Fuzzy logic, Fuzzy membership functions, Operations on Fuzzy sets, Fuzzy relations, Fuzzy propositions, Fuzzy implications, Fuzzy inferences

UNIT – II

Defuzzification Techniques-I, Defuzzification Techniques-II, Fuzzy logic controller-I, Fuzzy logic controller-II

UNIT – III

Solving optimization problems, Concept of GA, GA Operators: Encoding, GA Operators: Selection-I, GA Operators: Selection-II, GA Operators: Crossover-I, GA Operators: Crossover-II, GA Operators: Mutation

UNIT – IV

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

UNIT – V

MOEA Approaches: Pareto-II, Introduction to ANN, ANN Architecture, ANN Training-I, ANN Training-II, ANN Training-III, Applications of ANN

Textbooks:

1. An Introduction to Genetic Algorithm Melanic Mitchell (MIT Press)
2. Evolutionary Algorithm for Solving Multi-objective, Optimization Problems (2nd Edition), Collelo, Lament, Veldhnizer (Springer)

Reference Books:

- 1 Fuzzy Logic with Engineering Applications Timothy J. Ross (Wiley)
- 2 Neural Networks and Learning Machines Simon Haykin (PHI)

Web links:

1. https://onlinecourses.nptel.ac.in/noc25_cs48/preview

Introduction to Internet of Things

Course Code: 2517CS16

UNIT – I

Introduction to IoT: Part I, Part II, Sensing, Actuation, Basics of Networking: Part-I, Basics of Networking: Part-II, Part III, Part IV, Communication Protocols: Part I, Part II, Communication Protocols: Part III, Part IV, Part V, Sensor Networks: Part I, Part II.

UNIT – II

Sensor Networks: Part III, Part IV, Part V, Part VI, Machine-to-Machine Communications, Interoperability in IoT, Introduction to Arduino Programming: Part I, Part II, Integration of Sensors and Actuators with Arduino: Part I, Part II.

UNIT – III

Introduction to Python programming, Introduction to Raspberry Pi, Implementation of IoT with Raspberry Pi, Implementation of IoT with Raspberry Pi (contd), Introduction to SDN, SDN for IoT.

UNIT – IV

SDN for IoT (contd), Data Handling and Analytics, Cloud Computing, Cloud Computing(contd), Sensor-Cloud

UNIT – V

Fog Computing, Smart Cities and Smart Homes, Connected Vehicles, Smart Grid, Industrial IoT, Industrial IoT (contd), Case Study: Agriculture, Healthcare, Activity Monitoring.

Textbooks:

1. Introduction to IoT, S. Misra, A. Mukherjee, and A. Roy, 2020, Cambridge University Press.
2. Introduction to Industrial Internet of Things and Industry 4.0, S. Misra, C. Roy, and A. Mukherjee, 2020, CRC Press.

Reference Books:

- 1 The Internet of Things – Key applications and Protocols, Olivier Hersent, David Boswarthick, Omar Elloumi and Wiley, 2012
- 2 Recipes to Begin, Expand, and Enhance Your Projects, 2nd Edition, Michael Margolis, Arduino Cookbook and O'Reilly Media, 2011.

Web links:

1. https://onlinecourses.nptel.ac.in/noc25_cs44/preview

Cryptography and Network Security

Course Code: 2517CS17

UNIT – I

Introduction to cryptography, Classical Cryptosystem, Block Cipher, Data Encryption Standard (DES), Triple DES, Modes of Operation, Stream Cipher, LFSR based Stream Cipher, Mathematical background, Abstract algebra, Number Theory.

UNIT – II

Modular Inverse, Extended Euclid Algorithm, Fermat's Little Theorem, Euler Phi-Function, Euler's theorem, Advanced Encryption Standard (AES), Introduction to Public Key Cryptosystem, Diffie-Hellman Key Exchange, Knapsack Cryptosystem, RSA Cryptosystem.

UNIT – III

Primarily Testing, ElGamal Cryptosystem, Elliptic Curve over the Reals, Elliptic curve Modulo a Prime, Generalized ElGamal Public Key Cryptosystem, Rabin Cryptosystem, Message Authentication, Digital Signature, Key Management, Key Exchange, Hash Function

UNIT – IV

Cryptographic Hash Function, Secure Hash Algorithm (SHA), Digital Signature Standard (DSS), Cryptanalysis, Time-Memory Trade-off Attack, Differential and Linear Cryptanalysis.

UNIT – V

Cryptanalysis on Stream Cipher, Modern Stream Ciphers, Shamir's secret sharing and BE, Identity-based Encryption (IBE), Attribute-based Encryption (ABE), Side-channel attack, The Secure Sockets Layer (SSL), Pretty Good Privacy (PGP), Introduction to Quantum Cryptography, Blockchain, Bitcoin and Cryptocurrency.

Textbooks:

1. Cryptography and Network Security Principles and Practice, William Stallings, 8th Edition – Pearson by
2. Software-Defined Networks: A Systems Approach, Peterson, Cascone, O'Connor, Vachuska, and Davie

Reference books:

1. Foundations of Cryptography (Basic Tools), Oded Goldreich Cambridge 2001
2. Cloud Networking: Understanding Cloud-based Data Centre Networks, Gary Lee (Author), Morgan Kaufmann (Publisher), 2014, ISBN-139780128007280

Web links:

1. https://onlinecourses.nptel.ac.in/noc25_cs16/preview

Data Analytics with Python

Course Code: 2517CS18

UNIT – I

Introduction to data analytics and Python fundamentals, Introduction to probability, Sampling and sampling distributions

UNIT – II

Hypothesis testing, two sample testing and introduction to ANOVA.

UNIT – III

Two way ANOVA and linear regression, Linear regression and multiple regression, Concepts of MLE and Logistic regression

UNIT – IV

ROC and Regression Analysis Model Building, c^2 Test and introduction to cluster analysis.

UNIT – V

Clustering analysis, Classification and Regression Trees (CART).

Textbooks:

1. Python for data analysis: Data wrangling with Pandas, NumPy, and IPython, McKinney, W. (2012). O'Reilly Media, Inc."
2. A Byte of Python. Python Tutorial, Swaroop, C. H. (2003).
3. Business Statistics for Contemporary Decision Making, Ken Black, sixth Editing, John Wiley & Sons, Inc”.

Reference Books:

- 1 Applied logistic regression (Wiley Series in probability and statistics), David W. Hosmer, Stanley Lemeshow (2000). Wiley-Interscience Publication
- 2 Data Mining: Concepts and Techniques, Jiawei Han and Micheline Kamber (2006).

Web links:

1. https://onlinecourses.nptel.ac.in/noc25_cs17/preview

Deep Learning

Course Code: 2517CS19

UNIT I

Foundations of Neural Networks:

History of Deep Learning, Deep Learning Success Stories, McCulloch Pitts Neuron, Thresholding Logic, Perceptrons, Perceptron Learning Algorithm, Multilayer Perceptrons (MLPs), Representation Power of MLPs, Sigmoid Neurons, Gradient Descent, Feed forward Neural Networks, Representation Power of Feed forward Neural Networks, Back propagation

UNIT II

Optimization and Linear Algebra for Deep Learning:

Gradient Descent (GD), Momentum Based Gradient Descent, Nesterov Accelerated GD, Stochastic Gradient Descent, AdaGrad, RMSProp, Adam, Eigen values and Eigenvectors, Eigenvalue Decomposition, Basis, Principal Component Analysis and its interpretations, Singular Value Decomposition.

UNIT III

Auto encoders and Regularization:

Auto encoders and relation to PCA, Regularization in auto encoders, Denoising auto encoders, Sparse auto encoders, Contractive auto encoders, Regularization, Bias Variance Tradeoff, L2 regularization, Early stopping, Dataset augmentation, Parameter sharing and tying, Injecting noise at input, Ensemble methods, Dropout.

UNIT IV

Deep Architectures and Word Representations:

Greedy Layer wise Pre-training, Better activation functions, Better weight initialization methods, Batch Normalization, Learning Vectorial Representations Of Words, Convolution Neural Networks, LeNet, Alex Net, ZF-Net, VGGNet, Google Net, ResNet, Visualizing Convolution Neural Networks, Guided Back propagation, Deep Dream, Deep Art, Fooling Convolution Neural Networks.

UNIT V

Sequence Models and Attention Mechanisms:

Recurrent Neural Networks, Back propagation through time (BPTT), Vanishing and Exploding Gradients, Truncated BPTT, GRU, LSTMs, Encoder Decoder Models, Attention Mechanism, Additive and Multiplicative Attention, Attention over images, Visual Attention, Image Captioning with Attention, Transformers (Basic Introduction).

Text books

1. Deep Learning, Ian Goodfellow, Yoshua Bengio, Aaron Courville, MIT Press, First Edition, 9780262035613
2. Neural Networks and Deep Learning, Charu C. Aggarwal, Springer, First Edition, 9783319944623

Reference books

1. Natural Language Processing with PyTorch, Delip Rao, Brian McMahan, O'Reilly Media, First Edition, 9781491978238
2. Natural Language Processing with PyTorch, Delip Rao, Brian McMahan, O'Reilly Media, First Edition, 9781491978238

Web links:

1. <https://jalammar.github.io/illustrated-transformer/>
2. <https://arxiv.org/abs/1502.03044>

Machine Learning and Deep Learning - Fundamentals and Applications

Course Code: 2517CS20

UNIT – I

Introduction:

Introduction to ML, Performance Measures, Bias-Variance Trade off, Linear Regression.

Bayes Decision Theory:

Bayes Decision Theory, Normal Density and Discriminate Function, Bayes Decision Theory - Binary Features, Bayesian Belief Network

Parametric and Non- Parametric Density Estimation:

Parametric and Non- Parametric Density Estimation – ML and Bayesian Estimation, Parzen Window and KNN

UNIT – II

Perceptron Criteria and Discriminative Models:

Perceptron Criteria, Discriminative models, Support Vector Machines (SVM)

Logistic Regression, Decision Trees and Hidden Markov Model:

Logistic Regression, Decision trees, Hidden Markov Model (HMM)

UNIT – III

Ensemble methods: Ensemble methods:

Ensemble strategies, boosting and bagging, Random Forest

Dimensionality Problem:

Dimensionality Problem, Principal Component Analysis (PCA), Linear Discriminant Analysis (LDA)

UNIT – IV

Mixture Model and Clustering:

Concept of mixture model, Gaussian mixture model, Expectation Maximization Algorithm, K-means clustering.

Clustering:

Fuzzy K-means clustering, Hierarchical Agglomerative Clustering, Mean-shift is clustering.

Neural Network:

Neural network: Perceptron, multilayer network, back propagation, RBF Neural Network, Applications

UNIT – V

Introduction to Deep Neural Networks:

Introduction to Deep Learning, Convolution Neural Networks (CNN), Vanishing and Exploding Gradients in Deep Neural Networks, Le Net - 5, Alex Net, VGG Net, Google Net, and Res Net.

Recent Trends in Deep Learning:

Generative Adversarial Networks (GAN), Auto Encoders and Relation to PCA, Recurrent Neural Networks, U-Net, Applications and Case studies

Text books

1. Introduction to Machine Learning, E. Alpaydin, 3rd Edition, Prentice Hall (India) 2015
2. Pattern Classification, R. O. Duda, P. E. Hart and D. G. Stork, 2nd Edn., Wiley India, 2007.

Reference books

1. Pattern Recognition and Machine Learning (Information Science and Statistics), C. M. Bishop, Springer, 2006.
2. Computer Vision and Image Processing: Fundamentals and Applications, M.K. Bhuyan, published by CRC press, USA, 2019.
3. Neural Networks and Learning Machines, S. O. Haykin, 3rd Edition, Pearson Education (India), 2016.
4. Neural Networks and Deep Learning, Michael A. Nielsen, Determination Press, 2015
5. Learning Deep Architectures for AI, Yoshua Bengio, now Publishers Inc., 2009

Web links:

1. https://onlinecourses.nptel.ac.in/noc25_ee181/preview