Shirpur Education Society's

R. C. Patel Institute of Technology, Shirpur

(An Autonomous Institute)

Course Structure and Syllabus

Final Year B. Tech

Computer Science and Engineering (Data Science)

With effect from Year 2025-26

Shahada Road, Near Nimzari Naka, Shirpur, Maharashtra 425405
Ph: 02563 259 802, Web: www.rcpit.ac.in

R. C. PATEL
INSTITUTE OF TECHNOLOGY
An Autonomous Institute

R. C. Patel Institute of Technology, Shirpur

Institute Vision

To become a leading Institute in Technical education fostering innovation, research, ethical values, and sustainable development for the betterment of society.

Institute Mission

To impart high quality Technical Education through:

M1: Innovative and Interactive learning process and high quality, globally recognized instructional programs.

M2: Fostering a collaborative scientific temper among students with ethical responsibility towards the society.

M3: Preparing students from diverse backgrounds to have aptitude for employment, entrepreneurship and research with a spirit of professionalism.

M4: To contribute to nation's sustainable development.

Department of Computer Science & Engineering (Data Science)

Department Vision

To provide cutting-edge Computer Engineering education in Data Science while instilling socio-moral values.

Department Mission

M1: To deliver state-of-the-art, ICT-enabled teaching and learning to achieve excellence in Data Science education.

M2: To develop professionally competent Data Science Engineers, meeting evolving industrial and societal needs.

M3: To prepare employable professionals with ethical values and a commitment to professional and social responsibility.

Program Educational Objectives (PEOs) of the Department

PEO1: Graduates will achieve proficiency in Data Science and pursue lifelong learning to advance as professionals, entrepreneurs, and leaders.

PEO2: Graduates will operate effectively in diverse, dynamic professional and cultural environments, respecting societal perspectives.

PEO3: Graduates will demonstrate ethical values and social responsibility in their professional and personal lives.

Program Specific Outcomes (PSOs) of the Department

PSO1: Apply programming concepts, algorithms, and data structures to develop data-driven software and web solutions.

PSO2: Develop intelligent solutions using machine learning, data analysis, and cloud technologies for practical problem-solving.

Final Year B. Tech Computer Science and Engineering (Data Science) Semester-VII (w.e.f. 2025-26)														
Sr	Course Category	Course Code	Course Title	Teaching Scheme			Evaluation Scheme					Total	Credit	
							Continuous Assessment (CA)							
				L	T	P	TA [A]	Term Test 1 (TT1)	Term Test 2 (TT2)	Average of (TT1 & TT2) [B]	ESE [C]	[A+B+C]		
1	PC	22PCCS7010T	Language Models	3			25	10	10	10	65	100	3	4
	PC	22PCCS7010L	Language Models Laboratory			2	25					25	1	
2	PC	22PCCS7020T	Information Security	3			25	10	10	10	65	100	3	4
	PC	22PCCS7020L	Information Security Laboratory			2	25				25	50	1	
3	PC	22PCCS7030L	Applied Data Science Laboratory	1		2	50					50	2	2
4@	PE	22PECS7041T	Parallel Computing	3			25	10	10	10	65	100	3	4
		22PECS7041L	Parallel Computing Laboratory			2	25					25	1	
		22PECS7042T	Geo-Spatial Data Science	3			25	10	10	10	65	100	3	
		22PECS7042L	Geo-Spatial Data Science Laboratory			2	25					25	1	
		22PECS7043T	Advanced Internet of Things	3			25	10	10	10	65	100	3	
		22PECS7043L	Advanced Internet of Things Laboratory			2	25					25	1	
		22PECS7044T	Adversarial Machine Learning	3			25	10	10	10	65	100	3	
		22PECS7044L	Adversarial Machine Learning Laboratory			2	25					25	1	
5#	OE	22OECS7051T	Product Life Cycle Management	3			25	10	10	10	65	100	3	3
		22OECS7052T	Management Information System	3			25	10	10	10	65	100	3	
		22OECS7053T	Operations Research	3			25	10	10	10	65	100	3	
		22OECS7054T	Cyber Security and Laws	3			25	10	10	10	65	100	3	
		22OECS7055T	Personal Finance Management	3			25	10	10	10	65	100	3	
		22OECS7056T	Energy Audit and Management	3			25	10	10	10	65	100	3	
		22OECS7057T	Public Systems and Policies	3			25	10	10	10	65	100	3	
		22OECS7058T	Science of Well-being	3			25	10	10	10	65	100	3	
		22OECS7059T	Research Methodology	3			25	10	10	10	65	100	3	
6	PJ	22PJCS7060L	Project Stage-II			8	25				25	50	4	4
7	HM	22HMCS7070L	Employability Skill Development Program-III			2	25				25	50	1	1
			Total	13		18	275			40	335	650	22	

@Any 1 Professional Elective Course
#Any 1 Open Elective Course

Prepared by:
Dr. P. S. Sanjekar

Checked by:
Prof. S. P. Salunkhe

Prof. Dr. U. M. Patil
BOS Chairman

Prof. S. P. Shukla
C.O.E.

Prof. Dr. P. J. Deore
Dean Academics/Dy. Director

Prof. Dr. J.B. Patil
Director

R. C. Patel Institute of Technology, Shirpur
SES
AUTONOMOUS

Semester-VIII(w.e.f. 2025-26)

Sr	Course Category	Course Code	Course Title	Teaching Scheme			Evaluation Scheme					Total	Credit	
							Continuous Assessment (CA)							
							TA	Term Test 1 (TT1)	Term Test 2 (TT2)	Average of (TT1 &TT2)	ESE			
				L	T	P	[A]			[B]	[C]	[A+B+C]		
1@	PE1	22PECS8011T	High Performance Computing*	3			25	10	10	10	65	100	3	3
		22PECS8012T	Data Ethics*	3			25	10	10	10	65	100	3	
		22PECS8013T	Introduction to Quantum Computing*	3			25	10	10	10	65	100	3	
			NPTEL/Swayam Course#	3			25	10	10	10	65	100	3	
2@	PE2	22PECS8021T	Social Network Analysis*	3			25	10	10	10	65	100	3	3
		22PECS8022T	Applied Game Theory*	3			25	10	10	10	65	100	3	
		22PECS8023T	Robotics and AI*	3			25	10	10	10	65	100	3	
			NPTEL/Swayam Course#	3			25	10	10	10	65	100	3	
3	INT	22INTCS8030L	Internship			20	150				150	300	10	
4	MC	22MCCS8040T	Disaster Management and Preparedness	2									Audit Course	
			Total	8		20	200			20	280	500	16	

1. @ Any 1 Elective Course.
2. * Professional Elective Courses offered for the students doing Internship at institute level.
3. # Professional Elective Courses offered for the students doing Internship at Industry. These courses are to be studied in self study mode using NPTEL/Swayam platform.
4. Students doing internship at industry shall submit certificate of NPTEL examination OR They have to appear examinations conducted by institute like TT1,TT2 and ESE.
5. Students undergoing internship have the option to appear for both the NPTEL examination and the End Semester Examination (ESE) conducted by the institute for the respective course. In such cases, the better of the two scores (NPTEL or ESE) shall be considered for final grading.
6. List of NPTEL courses will be declared by concerned BOS at the beginning of the semester-VIII.

Prepared by:
Dr. M. S. Patil

Checked by:
Dr. P. S. Sanjekar

Prof. Dr. U. M. Patil
BOS Chairman

Prof. S. P. Shukla
C.O.E.

Prof. Dr. P. J. Deore
Dean Academics/Dy. Director

Prof. Dr. J. B. Patil
Director

Semester - VII

Program: Computer Science & Engineering (Data Science)	Final Year B.Tech	Semester: VII
Language Models (22PCCS7010T)		
Language Models Laboratory (22PCCS7010L)		

Prerequisite: Machine Learning-I, Machine Learning-II, Foundations of Data Analysis, Statistics for Data Science, Natural Language Text Processing

Course Objective(s): To introduce the fundamentals of neural language models, pre-training, fine-tuning, and evaluation techniques. The course aims to provide hands-on experience in developing and deploying large language models (LLMs) while addressing ethical concerns and safety measures.

Course Outcomes:

On completion of the course, the learner will be able to:

CO	Course Outcomes	Blooms Level	Blooms Description
CO1	Explain the architecture and working principles of modern language models such as Transformers, BERT, and GPT.	L2	Understand
CO2	Apply pre-training and fine-tuning techniques to optimize language models for real-world applications.	L3	Apply
CO3	Analyze various evaluation metrics to assess the performance and reliability of language models.	L4	Analyze
CO4	Develop applications using large language models for tasks such as text generation, question answering, and multimodal AI.	L6	Design

Language Models (22PCCS7010T)
Course Contents

Unit-I 06 Hrs.

Natural Language Generation:

Limitations of RNNs & LSTMs in Language Modeling, Encoder-Decoder Models, Attention Mechanism: Motivation & Evolution, Seq2Seq with Attention.

Transformers:

Self-Attention Mechanism: Query-Key-Value Representation ,Scaled Dot-Product Attention , Multi-Head Attention, Positional Encoding, Transformer-based Encoder-Decoder Architectures..

Unit-II 08 Hrs.

Large Language Models Architectures:

Encoder Models: BERT architecture and working, BERT variants: RoBERTa, ALBERT, DistilBERT, Applications: Text Classification, Named Entity Recognition (NER).

Decoder Models (Autoregressive LLMs): GPT Family (GPT-3, GPT-4, GPT-4 Turbo).

Open-source model: LLaMA.

Unit-III 09 Hrs.

Pre-training & Fine-tuning of LLMs:

Pre-training Strategies: Self-Supervised Learning in LLMs, Next Token Prediction (Auto-regressive) vs.Masked Language Models (Auto-encoding), Pre-training Methods: Causal LM, Prefix LM, Sequence-to-Sequence Pre-training.

Fine-tuning Techniques: Supervised Fine-tuning & Transfer Learning, Parameter-efficient Fine-tuning (LoRA, Adapter Layers), gradient accumulation, fine-tuning, gradient check pointing, quantization, Few-shot, Zero-shot, and Multi-Task Learning

Prompt Engineering & Adaptation: Instruction Tuning, Chain-of-Thought (CoT) Prompting ,Self-consistency & ReAct (Reasoning + Acting) ,Prompt-aware Training Methods.

Unit-IV 05 Hrs.

Evaluation Metrics:

Traditional Evaluation Metrics BLEU, ROUGE, METEOR, BERTScore, GLUE, SQuAD, MMLU (Massive Multitask Language Understanding), LLM-Specific Evaluation Methods, Embedding-based Metrics, GPT-Score, AI Arena, HELM(Holistic Evaluation of Language Models), TruthfulQA for Factual Accuracy.

Unit-V 05 Hrs.

Real-World Applications & Future Trends:

Question Answering Systems:IR-based vs. Knowledge-based QA, Retrieval-Augmented Generation (RAG) using Langchain, LLMs for Legal & Medical NLP.

AI Agents & Autonomous LLMs: OpenAI's AutoGPT, BabyAGI, Agentic Workflows & Planning LLMs

Unit-VI 09 Hrs.

Reinforcement Learning with Human Feedback (RLHF) & Safety:

RLHF Process in Modern LLMs: Reward Modelling for LLM Alignment, Reinforcement Learning Techniques: Proximal Policy Optimization (PPO), Comparative Ranking & Preference Learning, Group Relative Policy Optimization (GRPO).

RLAF: Reinforcement Learning through Agent Feedback (RLAF), How RLAF works, Difference between RLAF and RLHF.

LLM Alignment & Bias Mitigation:

Ethical Risks: Bias, Misinformation, Hallucinations, Adversarial Attacks on LLMs, Safety in Large Models: Constitutional AI, Red-teaming.

Language Models Laboratory (22PCCS7010L)

List of Laboratory Experiments

Suggested Experiments (Any 08):

1. Implementing Sequence-to-Sequence (Seq2Seq) Models for performing language translation.
2. Implementing Transformer Models for Natural language Processing Tasks.
3. Fine-Tuning BERT for performing Natural language Processing Tasks.
4. Implement LoRA and Adapter Layers for Fine-Tuning Pre-trained language Models.
5. Implement techniques to elicit desired behaviours from LLMs using prompts.
6. Implementing and Comparing Evaluation Metrics for LLMs.
7. Developing Question Answering System using Information Extraction.
8. Developing Retrieval-Augmented Generation (RAG) Systems using Langchain.
9. Using GRPO to Train a Model for Reasoning.
10. Building Autonomous AI Agents with LLMs.
11. Efficient Inference and Deployment of Large Language Models.

12. Mini Project

Text Books:

1. Jurafsky and Martin, "Speech and Language Processing", 3rd Edition, Prentice Hall, 2020.
2. Uday Kamath, "Deep Learning for NLP and Speech Recognition", 1st Edition, 2019.

Reference Books:

1. Jelinek, F., "Statistical Methods for Speech Recognition", The MIT Press, 2022.
2. Yuli Vasiliev "Natural Language Processing with Python and spaCy - A Practical Introduction", No Starch Press, 2022.
3. Sowmya Vajjala, Bodhisattwa Majumder, Anuj Gupta, Harshit Surana, "Practical Natural Language Processing: A Comprehensive Guide to Building Real-World NLP Systems", 1st Edition, O'Reilly, 2020.

Web Links:

1. NPTEL link: Introduction to Large Language Models (LLMs) - - Announcements
2. NPTEL Course: https://cse.iitm.ac.in/~miteshk/llm-course.html
3. NPTEL Course: https://onlinecourses.swayam2.ac.in/imb24_mg116/preview

Program: Computer Science and Engineering (Data Science)	Final Year B.Tech	Semester: VII
Information Security (22PCCS7020T)		
Information Security Laboratory (22PCCS7020L)		

Prerequisite: Computer Communication and Networks.

Course Objective(s):

1. Gain a comprehensive understanding of cyber threats, defence strategies, cryptographic principles, and modern security practices to safeguard digital assets.
2. Learn symmetric and asymmetric cryptography, key management, hashing techniques, and authentication protocols to ensure data confidentiality, integrity, and authentication.
3. Examine various network attacks, security mechanisms like firewalls, IDS, IPS, and encryption protocols to design and implement robust network defence strategies.

Course Outcomes:

On completion of the course, the learner will be able to:

CO	Course Outcomes	Blooms Level	Blooms Description
CO1	Analyze different types of cyber threats, cryptographic techniques, and their role in securing data and communication systems.	L4	Analyze
CO2	Apply cryptographic algorithms like AES, RSA, and Diffie-Hellman for secure key management and data encryption.	L4	Analyze
CO3	Describe the effectiveness of authentication methods, including Kerberos, biometrics, and digital certificates, in ensuring system integrity.	L2	Understand
CO4	Design and implement security solutions using firewalls, IDS, IPSec, and SSL protocols to mitigate network-based cyber threats.	L4	Analyze

Information Security (22PCCS7020T)
Course Contents

Unit-I 04 Hrs.

Introduction:

Cyber Attacks, Defense, Strategies and Techniques, Guiding Principles of Modern Security Practices. OSI security model.

Unit-II 07 Hrs.

Number Theory:

Modulo Arithmetic, Euclid's Algorithm, Fermat's and Euler's Theorem, Chinese Remainder Theorem, Cipher Properties, Substitution Ciphers – Mono-alphabetic Ciphers, Polyalphabetic Ciphers, Transposition Ciphers.

Unit-III 08 Hrs.

Symmetric Cryptography:

Block Cipher, Fiestel Structure, Block Cipher Modes of Operation, S-DES, Double DES, Triple DES, AES Algorithm.

Unit-IV 07 Hrs.

Asymmetric Cryptography:

Private Key and Public Key Cryptography, The RSA algorithm, Key Management, Diffie-Hellman Key Exchange, Key Exchange Algorithm.

Unit-V 08 Hrs.

Integrity and Authentication:

Hashing: Properties of cryptographic hash, message digest, MD-5, SHA-1. Public Key Infrastructure (PKI), One way and mutual authentication, Needham- Schroeder Protocol, Authentication methods, Kerberos Authentication Protocol, Biometrics, Digital Certificates: X.509.

Unit-VI 08 Hrs.

Network Security:

Network attacks, DoS and DDoS attack, Sniffing, Session hijacking, Spoofing, Phishing, Cross-site Scripting (XSS), IPSec Protocol, SSL Handshake Protocol, Firewalls, IDS Prevention and Detection.

Information Security Laboratory (22PCCS7020L)

List of Laboratory Experiments

Suggested Experiments: (Any 08)

1. Implement Playfair Cipher with key entered by user.
2. Implement polyalphabetic Cipher.
3. Implement Simple and Advanced Columner Transposition technique.
4. Implement Simplified DES.
5. Implement Simple RSA Algorithm with small numbers..
6. Implement Diffie-Hellman Key Exchange.
7. Implement DoS and DDoS attack using Hping.
8. Implement phishing attack using HTTrack Website Cloning.
9. Implement static code analysis using Flawfinder Python Distribution.
10. Implement packet sniffing using Wireshark and TCP Dump.
11. Implement cross site request forgery in a controlled virtual environment using DVWA Web Server.
12. Implement firewalls using IP tables.
13. Implement Network Intrusion Detection System (NIDS).
14. Implement Host based Intrusion Detection System (HIDS).

Any other experiment based on syllabus may be included which would help the learner to understand topic/concept.

Oral examination will be based on the entire syllabus including, the practicals performed during laboratory sessions.

Text Books:

1. William Stallings, "Cryptography and Network Security Principles and Practices", 8th Edition, Pearson/PHI, 2023.
2. Behrouz A. Forouzan, Debdeep Mukhopadhyay, "Cryptography and Network Security", 3rd Edition, McGraw Hill, 2017.

Reference Books:

1. Charles P. Pfleeger, Shari Lawrence Pfleeger – Security in Computing – Prentice Hall of India, 5th Edition, 2015.
2. Atul Kahate, Cryptography and Network Security, McGraw Hill, 3rd Edition, 2013.

3. Bernard Menezes, Network Security and Cryptography, Cengage Learning, 2nd Edition, 2011.

4. Wade Trappe, Lawrence C. Washington, Introduction to Cryptography with Coding Theory, Pearson, 2nd Edition, 2006.

5. W. Mao, Modern Cryptography – Theory and Practice, Pearson Education, 1st Edition, 2003.

Web Links:

1. Damn Vulnerable Web Application (DVWA): http://dvwa.co.uk

2. Open Web Application Security Project: https://owasp.org

3. Web penetration testing: https://pentesterlab.com

4. Penetration Testing: https://kali.org

Program: Computer Science and Engineering (Data Science)	Final Year B.Tech	Semester: VII
Applied Data Science Laboratory (22PCCS7030L)		

Prerequisite: Machine Learning, Data Engineering.

Course Objective(s): To bridge the gaps between industry and academia. Give the exposure of production system and applied data science.

Course Outcomes:

On completion of the course, the learner will be able to:

CO	Course Outcomes	Blooms Level	Blooms Description
CO1	Evaluate production systems available in the industry.	L5	Evaluate
CO2	Analyze various problems occurring in a data science production system.	L4	Analyze

Applied Data Science Laboratory (22PCCS7030L) Course Contents

Unit-I 01 Hrs.

Converting Business problem into Data Science Problem:

- Bridging the Qualitative-to-Quantitative Gap in Data Science
- Right Data Available with the Right Level of Granularity
- Repeatability and Reproducibility: Consistency in Labelled Data for Accurate AI Systems

Unit-II 02 Hrs.

Agile Methodology:

- Work Breakdown structure for Agile Models
- Scrum/XP modelling of Data Science Projects
- Agile Tools for Project Management

Unit-III 01 Hrs.

Data Preparation Best Practice:

- Gathering suitable data for Data Science problem
- Determine all Key Performance Indicators (KPIs)
- Business stakeholders POC Dashboard

Unit-IV 02 Hrs.

Data Modelling:

- Selection of appropriate tool
- Data Modelling with Incremental Data
- Robust model design.
- Data Modelling with different data formats

Unit-V 01 Hrs.

Model Building Best Practice:

- One hot encoding
- Selecting right metrics to evaluate the model
- SHAP and LIME for interpretability of model.

Unit-VI 01 Hrs.

Model Compression:

- Quantization
- Pruning
- Knowledge Distillation

Unit-VII 02 Hrs.

Modelling and Optimization Trade-off:

- Need of Optimization

- Different methods of Optimization
- Development
- Rest APIs

Unit-VIII 01 Hrs.

Data Science Project Architecture:

- Functions of MLOps/DevOps
- Difference between MLOps and DevOps
- Collaboration, Scalability and Reusability

Unit-IX 02 Hrs.

Project Deployment:

- Flask
- Docker
- Kubernetes

Unit-X 01 Hrs.

A/B Testing:

- Formulate Hypothesis
- Create Test Group
- Compare Results

Text Books:

1. Probyto Data Science and Consulting Pvt. Ltd, "Data Science for Business Professionals", bpb publications, 2020.
2. Emmanuel Ameisen, "Building Machine Learning Powered Applications", O'Reilly, 2020.

Reference Books:

1. Valliappa Lakshmanan, Sara Robinson and Michael Munn, "Machine Learning Design Patterns", O'Reilly, 2021.
2. Emily Robinson and Jacqueline Nolis, "Build a career in Data Science", Manning, 2020.
3. Andriy Burkov, "Machine Learning Engineering", True Positive Inc, 2020.

Web References:

1. Coursera course: IBM Data Science Professional Certificate — Coursera
2. https://www.coursera.org/specializations/data-science-python?msockid=0a3d4df1db7a6b8909345878dac86aa5
3. https://onlinecourses.nptel.ac.in/noc21_cs23/preview

Program: Computer Science and Engineering (Data Science)	Final Year B.Tech	Semester: VII
Parallel Computing (22PECS7041T)		
Parallel Computing Laboratory (22PECS7041L)		

Prerequisite: System Fundamentals

Course Objective(s): To familiarize students with the fundamental concepts, techniques and tools of parallel computing.

Course Outcomes:

On completion of the course, the learner will be able to:

CO	Course Outcomes	Blooms Level	Blooms Description
CO1	Explain different structures of Parallel Computers.	L2	Understand
CO2	Apply parallel algorithms in problem solving.	L3	Apply
CO3	Evaluate the performance of parallel computing models and algorithms.	L5	Evaluate

Parallel Computing (22PECS7041T)
Course Contents

Unit-I 08 Hrs.

Introduction:

Introduction to Parallel computing, Abstract model of serial & parallel computation,pipelining, data parallelism, control parallelism, scalability, topologies in processor organization, parallel computing design consideration, parallel algorithms & parallel architectures, speedup and efficiency, supercomputers.

Unit-II 07 Hrs.

System Architecture:

Shared memory multiprocessors (UMA-Uniform memory Access), Distributed memory multiprocessors (NUMA- Non-Uniform memory Access), SIMD, Systolic processor, Cluster computing, Grid computing, Multicore Systems.

Unit-III 06 Hrs.

Parallel Algorithms:

Introduction to parallel algorithms, parallel algorithm models, Decomposition Techniques, characteristics of tasks & interactions, mapping techniques for load balancing, methods for containing interaction overheads.

Unit-IV 08 Hrs.

Parallel Algorithm Applications:

Matrix multiplication, parallel reduction, parallel sorting (Bubble sort, Quick sort), Graph algorithm (Minimum Spanning Tree - Prim's Algorithm), Fast Fourier Transform (serial and transpose algorithm).

Unit-V 08 Hrs.

Parallel Programming:

Parallel programming models, point to point communication, synchronous and asynchronous communication, shared memory programming, message passing programming, MPI, PVM, Threads.

Unit-VI 05 Hrs.

Applications of Parallel Programming:

Issues and challenges, scope of parallel computing, applications in data mining, computer security and cryptography, medicine and human organ modelling.

Parallel Computing Laboratory (22PECS7041L)

List of Laboratory Experiments

Suggested Experiments: (Any 08)

1. To implement the parallel construct in OpenMP that creates a parallel region in a C++ code.
2. To write an OpenMP program for illustrating the Fork Join model.
3. To implement SIMD (Single Instruction Multiple Data) parallel program in OpenMP.
4. To write a simple OpenMP program to demonstrate the sharing of loop iteration by a number of threads. (Take chunk size of 10).
5. To write an OpenMP program for finding prime numbers.
6. To write an OpenMP program to demonstrate sharing of section work by performing arithmetic operations on a one-dimensional array.
7. To write an OpenMP program to perform dot product of two one-dimensional arrays.
8. To implement the program for Matrix addition and Matrix multiplication using OpenMP.
9. To implement the program for sorting algorithms (Bubble sort, Quick sort) in OpenMP.
10. To implement the program to create a Minimum Spanning Tree using Prim's algorithm.

Any other experiment based on syllabus may be included which would help the learner to understand topic/concept.

Text Books:

1. Thomas Rouber, Gudula Rünger, "Parallel Programming for Multicore and Cluster Systems", 2^{nd} Edition, Springer, 2020.
2. Steven Brawer, "Introduction to Parallel Programming", 1^{st} Edition, Academic Press Inc, 2000.
3. M.Sasikumar, Dinesh Shikhare, P. Ravi Prakash, "Introduction to Parallel Processing", 2^{nd} Edition, Prentice Hall, 2014.

Reference Books:

1. David Bader, " Handbook of Parallel Computing: Models, Algorithms and Applications", 1^{st} Edition, CRC Press, 2023.
2. Fayez Gebali , "Algorithms and Parallel Computing", 1^{st} Edition, Wiley Series, 2011.

3. Ananth Grama, Anshul Gupta, George Karypis, Vipin Kumar, "An Introduction to Parallel Computing: Design and Analysis of Algorithms", 2^{nd} Edition, Pearson Publication, 2004.

Web Links:

1. NPTEL course: https://archive.nptel.ac.in/courses/106/102/106102163/
2. Parallel Programming:Introduction to Parallel Computing Tutorial — HPC @ LLNL

Program: Computer Science & Engineering (Data Science)	T. Y. B.Tech.	Semester: V
Geo-Spatial Data Science (22PECS7042T)		
Geo-Spatial Data Science Laboratory (22PECS7042L)		

Prerequisite: Data Visualization, Machine Learning and Artificial Intelligence.

Course Objective(s):

1. To understand geospatial data sources, students will explore satellite imagery, GPS, and open datasets.
2. To effectively work with spatial data, they will learn pre-processing, cleaning, and geocoding techniques for seamless integration.

Course Outcomes:

On completion of the course, the learner will be able to:

CO	Course Outcomes	Blooms Level	Blooms Description
CO1	Apply tools and techniques used to analyze and visualize geospatial data.	L3	Apply
CO2	Apply data science methods to solve real-world problems with geospatial data.	L3	Apply
CO3	Analyze geospatial large data models and ethical issues.	L4	Analyze

Geo-Spatial Data Science (22PECS7042T)
Course Contents

Unit-I 06 Hrs.

Introduction to Geospatial Data:

Introduction to Geographic Information Systems (GIS), Data Collection and Sources, Remote sensing and satellite imagery, GPS data and tracking, Coordinate systems and projections, Overview of geospatial data: Coordinates, attributes, temporal information; static and dynamic data, Spatial Data Types: vector and raster data, network data and Spatial Data Formats: shape files, geodatabases, Spatial data structures: Geometric objects (Points, lines and polygon), qualitative binary relation between geometrics and GSD applications.

Unit-II 08 Hrs.

Geospatial Data Modeling:

Feature based approach: point, curve, surface, geometry collection; Algebra and calculi of qualitative spatial relations, topological relations, RCC-8, cardinal directions, Field based approach. Spatial regression, clustering, and optimization, Geo statistics and spatial modeling, Predictive modeling with geospatial data, Case study: Predicting property values, Spatial Analysis, Buffer analysis, spatial joins, spatial econometrics and geographically weighted regression (GWR).

Unit-III 09 Hrs.

Linked Geospatial Data:

Visualizing Linked Geospatial Data, Querying Geospatial Data Expressed in RDF, Transforming Geospatial Data into RDF, SPARQL, Interlinking Geospatial Data Sources, Incomplete Geospatial Information, Geospatial RDF stores, Geospatial Knowledge Graphs, Question Answering Engines for Geospatial Knowledge Graphs, choropleth mapping.

Unit-IV 06 Hrs.

Geospatial Visualization:

Introduction to data visualization libraries (e.g., Matplotlib, Folium, Plotly), Creating basic maps and charts, customizing geospatial visualizations, creating maps and charts, Customizing geospatial visualizations Python toolkits Geospatial Visualization. Spatial Data, GIS, Geospatial Data, Geospatial Analysis, Data Visualization

Unit-V 07 Hrs.

Data Ingestion & Big Data:

web scraping and APIs, distributed computing frameworks (e.g., Google Earth Engine, Hadoop GIS,

GeoSpark, and Dask for geospatial data), and Google BigQuery GIS for scalable processing; Streaming Geospatial Data: IoT devices, GPS tracking, weather stations, and OpenStreetMap live updates.

Spatial Analysis:

Spatial queries and operations; Spatial Data Indexing: Quadtrees, R-trees, and Hilbert Curves to optimize geospatial queries. Spatial Relationships & Topology: topological consistency (e.g., via OGC Simple Features Specification). Spatial Statistics: spatial autocorrelation (Moran's I, Geary's C), and spatial interpolation techniques (Kriging, IDW).

Unit-VI 06 Hrs.

GIS Softwares

Introduction to web mapping tools (e.g., Leaflet), Exploring GIS software (e.g., QGIS, ArcGIS), Introduction to geospatial libraries (e.g., Geopandas, Fiona, Shapely), Building interactive web maps, Geospatial big data and distributed computing, Machine learning for geospatial data, Geo Spatial Data Ethics, Ethical considerations in geospatial data analysis.

Geo-Spatial Data Science Laboratory (22PECS7042L)

List of Laboratory Experiments

Suggested Experiments:(Any 08)

1. Apply cyberGIS techniques to analyze and visualize big geospatial data in Python using advanced cyberinfrastructure and high-performance computing.
2. Apply Python tools for developing high-performance geospatial computing. solutions. Optimize and speed up geospatial computation using Python libraries like Numba, Cython and Dask, Ray, or PySpark for large-scale geospatial processing.
3. Implement open source mapping and large-scale geospatial visualization libraries such as Leaflet, D3,Plotly Kepler.gl, Deck.gl and Cesium.js for 3D geospatial applications and mash up these libraries to create interactive and dynamic visualization tools and GIS applications.
4. Apply tools to investigate and identify patterns, clusters, classes, and anomalies based on various types of geospatial data and apply these techniques to a variety of geospatial applications.
5. Apply advanced techniques of spatial analysis, including spatial autocorrelation, trend surface analysis, grouping and regionalization procedures, and point pattern analysis to solve geospatial problems. spatial clustering methods (e.g., DBSCAN, K- Means with spatial constraints, HDBSCAN) and spatial econometrics modeling(spatial lag and spatial error models)
6. Solve given geospatial problem using ESRI ArcGIS solutions stack.
7. Identify right tool to interlink dataset to transform unlinked geospatial data into linked data using geospatial semantic technologies (geospatial ontologies, stRDF, stSPARQL, GeoSPARQL,

OBDA mappings techniques. thing (e.g., a dataset containing information about roads in Crete can be interlinked with a dataset containing land cover information about Crete).

8. Analyze and visualize the data with the help of appropriate linked data tools using a sequence of GeoSPARQL queries.

9. Geospatial science in forestry and watershed management
   Geospatial science in urban planning and resource management

10. Use geospatial libraries for Geospatial Data Analysis with Python (e.g., Geopandas, Fiona, Shapely for Analyzing and visualizing geospatial data in Python.

11. Demonstrate the use of Apache, Jena and Stardog for managing large-scale geospatial knowledge graphs.

Any other experiment based on syllabus may be included which would help the learner to understand topic/concept.

Text Books:

1. "Geospatial Data Science: A Hands-on Approach for Building Geospatial Applications Using Linked Data Technologies", June 2023.

2. David S. Jordan, "Applied Geospatial Data Science with Python", Feb 2023.

3. Janahan Gnanachandran, "Geospatial data analysis on AWS", ACM Publisher, 2023.

4. Paul A. Zandbergen,"Geospatial Data Science Techniques and Applications", 2020.

5. Kang-Tsung Chang, "Introduction to Geographic Information Systems", McGraw-Hill Education, 2019.

Reference Books:

1. Chris Garrard, "Geoprocessing with Python", Manning Publisher, 2016.

2. Michael J. de Smith, Michael F. Goodchild, and Paul A. Longley, "Geospatial Analysis: A Comprehensive Guide", Winchelsea Press, 2018.

3. "The Ultimate Guide to Geospatial Data Science, Geospatial Data Science Explained: A Full Guide", Aya Data

Web Links:

1. The Ultimate Guide to Geospatial Data Science, Geospatial Data Science Explained: A Full Guide - Aya Data
   https://www.ayadata.ai/the-ultimate-guide-to-geospatial-data-science/

2. https://www.safegraph.com/guides/geospatial-data

Program: Computer Science & Engineering (Data Science)	B.Tech.	Semester: V
Advanced Internet of Things (22PECS7043T)		
Advanced Internet of Things Laboratory (22PECS7043L)		

Prerequisite: Basic Programming Knowledge, Networking Fundamentals, Microcontrollers & Embedded Systems Basics.

Course Objective(s):

1. To Introduce Advanced IoT Concepts and Architectures.
2. To Provide In-Depth Knowledge of IoT Communication Protocols.
3. To Develop Skills in IoT Hardware and Software Integration.
4. To Address IoT Security, Privacy, and Ethical Issues.
5. To Design and Develop Industrial IoT (IIoT) and Smart Applications.

Course Outcomes:

On completion of the course, the learner will be able to:

CO	Course Outcomes	Blooms Level	Blooms Description
CO1	Describe Advanced IoT Architectures & Communication Protocols.	L2	Understand
CO2	Design and develop IoT systems.	L6	Create
CO3	Use Cloud, Edge, and Fog computing technologies in IoT applications.	L3	Apply
CO4	Apply Big Data Analytics and AI/ML techniques in IoT.	L3	Apply

Advanced Internet of Things (22PECS7043T) Course Contents

Unit-I 09 Hrs.

Introduction to Advanced IoT Evolution from traditional IoT to Advanced IoT, IoT ecosystem overview

IoT Architecture and Design Drivers behind new network architecture , comparing IoT architectures: The oneM2M IoT Standardized Architecture, The core IOT functional stack

IoT Data Management and Compute Stack: Fog and Edge Computing in IoT.

Smart objects: The Things in IoT Sensors, Actuators, Microelectro Mechanical system

Connecting Smart Objects: Communication criteria, IoT access technologies: IEEE 802.15.4, physical Layer ,MAC Layer, Topolgy, Security

Unit-II 05 Hrs.

Sensors, Endpoints and Power system

Sensors, Actuators, PIR sensors and Smart Objects, Thermocouples and temperature sensing, LiDAR an active sensing system, MEMS sensors, Smart IoT endpoints, Sensor fusion, functional examples, Energy sources and power management

Communication and Information Theory: Communication theory, Information Theory, radio structure

Unit-III 05 Hrs.

Cloud and Fog Topologies:

Cloud service Model ,Public ,private and hybrid cloud Openstack cloud architecture constraints of cloud architecture for IoT Fog computing.

IoT edge to cloud protocols: MQTT,MQTT-SN, Constrained Application protocol, other protocols.

Unit-IV 10 Hrs.

Power Line communication Technology:

Overview of PLC technologies ans standards, Architecture for home network technologies, IoT using PLC Technology.

IoT Security: Common challenges in OT Security,Cyber security vernacular, Anatomy of IoT cyber atttacks, Physical and hardware security, blockchains and cryptocurrencies in IoT.

IP as IoT Network Layer: The Business case for IP,The need for optimization, optimizing IP for IOT,Formal risk analysis structures: OCTAVE and FAIR,The phased application of security in an operational environment.

Public safety: Overview, An IoT Blueprint for Public Safety,IoT Public safety Information Processing.

Unit-V 07 Hrs.

Data Analytics for IoT : Visualizing the power of Data from IoT:Data analysis, Machine Learning, Model building process,Modeling algorithms, Model Performance, Big data platform, Big data Pipeline.

IoT System Management with NETCONF-YANG: Need for IoT system Management, SNMP, Network operator requirements, NETCONF,YANG

Artificial Intelligence of Things (AIoT): Combining AI with IoT for smarter applications.

Unit-VI 06 Hrs.

Mining: Mining today and its challenges, Challenges for IoT in modern mining, An IoT strategy for mining ,An architecture for IoT in Mining.

Advanced Applications of IoT:

Home automation, Smart Cities, Healthcare, Practical Applications of Edge/Fog Computing, Agriculture, Logistics,Retail,Smart Medication Management System, Smart Factory System.

Advanced Internet of Things Laboratory (22PECS7043L)

List of Laboratory Experiments

Suggested Experiments:(Any 08)

1. Creating first Raspberry Pi project.
2. Publishing Information Using MQTT.
3. Creating HTTP Server.
4. Creating XMPP sensor server.
5. Configuring the IOT Gateway.
6. Adding CoAP to our devices.
7. Running the IoT Gateway project.
8. Set up an IoT device (e.g., ESP8266/ESP32) to publish and subscribe to MQTT messages.
9. Send IoT sensor data to AWS IoT Core and visualize it.
10. Perform real-time processing of sensor data on an edge device.
11. Implement SSL/TLS encryption in an MQTT-based IoT setup.

12. Control access to IoT devices using authentication mechanisms.
13. Process real-time traffic data at the fog layer instead of the cloud.
14. Collect and analyse heart rate data from a wearable IoT device.
15. Demonstrate the vulnerability of insecure OT protocols.
16. Store IoT data on a blockchain to ensure immutability.
17. Detect unusual patterns in IoT sensor data using AI.

Any other experiment based on syllabus may be included which would help the learner to understand topic/concept.

Text Books:

1. David Hanes,Gonzalo Salgueiro,Patrick Grossetete,,Rob Barton,Jerome Henry, "IoT Fundamentals", Cisco Press ,June 2017.
2. Shriram Vasudevan, Abhishek Nagarajan, "Internet of Things", 2^{nd} Edition, Wiley.
3. Arshdeep Bagha, Vijay Madisetti, "Internet of Things", Universities Press.
4. Peter Waher, "Mastering Internet of Things",Published by Packt.
5. "Advanced IoT Technologies and Applications in the Industry 4.0 Digital Economy", CRC Press ,2024.
6. "Internet of Things: Technological Advances and New Applications", Apple Academic Press,2024.

Reference Books:

1. "Smart Home and Industrial IoT Devices: Critical Perspectives on Cyber Threats, Frameworks, and Protocols", Bentham Science Publishers,2024.
2. "IoT Security: Advances in Authentication", Springer,2023.

Web Links:

1. Introduction to internet of things By Prof. Sudip Misra , IIT Kharagpur
   https://onlinecourses.nptel.ac.in/noc21_cs17/preview
2. Introduction To Industry 4.0 And Industrial Internet Of Things By Prof. Sudip Misra , IIT Kharagpur
   https://onlinecourses.nptel.ac.in/noc25_cs43/preview
3. https://thingspeak.mathworks.com/
4. https://app.arduino.cc/iot/

Program: Computer Science & Engineering (Data Science)	Final Year B.Tech	Semester: VII
Adversarial Machine Learning (22PECS7044T)		
Adversarial Machine Learning Laboratory (22PECS7044L)		

Prerequisite: Mathematics for Intelligent System, Machine Learning – I, Information Security.

Course Objective(s):

The Course provide an in-depth understanding of adversarial machine learning (AML), focusing on the security vulnerabilities of machine learning models and defenses against adversarial attacks. Students will explore foundational concepts in supervised, unsupervised, and reinforcement learning, along with adversarial settings in each. The course will cover various categories of attacks, including causative and evasion attacks, and introduce frameworks for secure learning. Through case studies and hands-on implementations, students will analyze real-world AML applications in cybersecurity, computer vision, and NLP. The course will also explore open challenges, defensive strategies, and applications beyond security, such as model programming and data augmentation.

Course Outcomes:

On completion of the course, the learner will be able to:

CO	Course Outcomes	Blooms Level	Blooms Description
CO1	Analyze and apply fundamental machine learning and deep learning techniques to adversarial settings, understanding their vulnerabilities and potential threats.	L4	Analyze
CO2	Identify and categorize different adversarial attacks on machine learning models, evaluating their impact on security-critical applications.	L4	Analyze
CO3	Assess and compare various defense strategies against adversarial attacks, demonstrating an understanding of security frameworks for robust learning models.	L5	Evaluate
CO4	Investigate real-world applications of adversarial machine learning in cybersecurity, autonomous systems, and NLP, proposing innovative defensive mechanisms based on research findings.	L6	Create

Adversarial Machine Learning (22PECS7044T)
Course Contents

Unit-I 05 Hrs.

Machine Learning Preliminaries:

Supervised Learning, Supervised Learning in Adversarial Settings, Unsupervised Learning, Unsupervised Learning in Adversarial Settings, Reinforcement Learning in Adversarial Settings, Categories of Attacks on Machine Learning .

Deep Learning Overview:

Machine learning basics, Introduction to deep learning, Elements of neural networks (NNs), Training NNs, NN architectures.

Introduction to Adversarial Machine Learning:

Adversarial Machine Learning Taxonomy and History, Statistical Machine Learning, A Framework for Secure Learning: Analyzing the Phases of Learning, Framework, Security Analysis, Exploratory Attacks, Causative Attacks.

Unit-II 08 Hrs.

Causative Attacks on Machine Learning:

Availability Attack Case Study: SpamBayes, The SpamBayes Spam Filter, Threat Model for Spam Bayes, The Reject on Negative Impact (RONI) Defense Causative Attacks on Machine Learning: Integrity Attack.

Case Study:

PCA Detector, PCA Method for Detecting Traffic Anomalies, Corrupting the PCA Subspace, Corruption-Resilient Detectors.

Unit-III 08 Hrs.

Evasion Attacks:

Evasion Attacks against White box: Fast gradient sign method (FGSM) attack. Projected gradient descent (PGD) attack, DeepFool attack Black box adversarial attacks: Query based attacks, Transfer based attacks or transferability attacks, Attacks on Real Models.

Defences Against Evasion Attacks:

Adversarial examples detection, Gradient masking/obfuscation, Robust optimization.

Unit-IV 09 Hrs.

Adversarial Machine Learning in Cyber Security:

Malware Detection and Classification: Machine Learning in cybersecurity, Taxonomy of AML attacks in cybersecurity, Malware detection and classification, Adversarial attacks on ML-based malware clas-

sifiers, Malware Detection and Classification.

Network Intrusion Detection:

Network intrusion detection, Datasets for network intrusion detection, Anomaly detection with Machine Learning, Adversarial attacks on ML-based NIDS.

Unit-V 06 Hrs.

Adversarial Machine Learning Challenges:

Discussion and Open Problems, Unexplored Components of the Adversarial Game, Development of Defensive Technologies.

Unit-VI 06 Hrs.

Practical Applications:

Adversarial Machine Learning in Computer Vision, Adversarial Machine Learning in Natural Language Processing (NLP), Adversarial Machine Learning in Autonomous Systems.

Applications beyond attack and defence:

Model Programming, Contrastive explanations, model watermarking and fingerprinting, Data augmentation for unsupervised Learning.

Adversarial Machine Learning Laboratory (22PECS7044L)

List of Laboratory Experiments

Suggested Experiments:(Any 08)

1. Implement non-targeted white-box evasion attacks against the deep learning models: Fast Gradient Sign Method (FGSM), and Projected Gradient Descent (PGD)
2. Implement targeted white-box evasion attacks against the deep learning models.
3. Implement a PGD attack on the DL model ResNet50, and investigate if the adversarial examples transfer to the other conventional ML models.
4. Implement a non-targeted PGD attack on the logistic regression model for the set of 120 images.
5. Implement adversarial defenses for white-box evasions attacks against deep learning-based classification models.
6. Get familiar with ML classification models used in cybersecurity applications and implement adversarial attacks against such models.
7. Attacks on ML systems for Network Intrusion Detection
8. Attacks on ML systems for Malware Detection
9. ML systems for Spam Filtering

10. Mini Project

Text Books:

1. Anthony D. Joseph, Blaine Nelson, "Adversarial Machine Learning", © Cambridge University Press 2019, ISBN: 978-1-107-04346-6.

2. A. Zhang, Z. Lipton, and A. Smola, "Dive into Deep Learning".

3. Soma Halder, "Hands-On Machine Learning for Cybersecurity: Safeguard your system by making your machines intelligent using the Python ecosystem", Packt Publishing ltd.

Reference Books:

1. Yevgeniy Vorobeychik and Murat Kantarcioglu, "Adversarial Machine Learning", Copyright © 2018 by Morgan & Claypool.

2. Pin-Yu Chen and Cho-Jui Hsieh, "Adversarial Robusteness for MAchine Learning", Academic Press an imprint of Elsevier.

3. Shuhe Wang, Kuan-Chieh Wang, "Adversarial Machine Learning" Springer Series in Advanced Machine Learning.

Web Links:

1. Goodfellow (2014) Explaining and Harnessing Adversarial Examples

2. Carlini (2017) Towards Evaluating the Robustness of Neural Networks

3. Brendel (2017) Decision-Based Adversarial Attacks: Reliable Attacks Against Black-Box Machine Learning Models

4. Bhagoji (2017) Exploring the Space of Black-box Attacks on Deep Neural Networks

5. Xu (2019) Adversarial Attacks and Defenses in Images, Graphs and Text: A Review

6. Tramer (2018) Ensemble Adversarial Training: Attacks and Defenses

7. Rosenberg (2021) Adversarial Machine Learning Attacks and Defense Methods in the Cyber Security Domain

8. Severi (2021) Explanation-Guided Backdoor Poisoning Attacks Against Malware Classifiers

9. Kuleshov (2018) Adversarial Examples for Natural Language Classification Problems

10. Erba (2019) Constrained Concealment Attacks against Reconstruction-based Anomaly Detectors in Industrial Control Systems

Program: Computer Science & Engineering (Data Science)	Final Year B.Tech	Semester: VII
Product Life Cycle Management (22OECS7051T)		

Prerequisite: Knowledge of basic concepts of Management

Course Objective(s):

1. To familiarize the students with the need, benefits and components of PLM.
2. To acquaint students with Product Data Management & PLM strategies.
3. To give insights into new product development program and guidelines for designing and developing a product.
4. To familiarize the students with Virtual Product Development.

Course Outcomes:

On completion of the course, the learner will be able to:

CO	Course Outcomes	Blooms Level	Blooms Description
CO1	Describe the phases of PLM, PLM strategies and methodology for PLM feasibility study and PDM implementation.	L2	Understand
CO2	Illustrate various approaches and techniques for designing and developing products.	L3	Apply
CO3	Apply product engineering guidelines / thumb rules in designing products for moulding, machining, sheet metal working etc.	L3	Apply
CO4	Acquire knowledge in applying virtual product development tools for components, machining and manufacturing plant.	L3	Apply

Product Life Cycle Management (22OECS7051T) Course Contents

Unit-I 10 Hrs.

Introduction to Product Lifecycle Management (PLM):

Product Lifecycle Management (PLM), Need for PLM, Product Lifecycle Phases, Opportunities of Globalization, Pre-PLM Environment, PLM Paradigm, Importance & Benefits of PLM, Widespread Impact of PLM, Focus and Application, A PLM Project, Starting the PLM Initiative, PLM Applications

PLM Strategies: Industrial strategies, Strategy elements, its identification, selection and implementation, Developing PLM Vision and PLM Strategy, Change management for PLM

Unit-II 08 Hrs.

Product Design:

Product Design and Development Process, Engineering Design, Organization and Decomposition in Product Design, Typologies of Design Process Models, Reference Model, Product Design in the Context of the Product Development Process, Relation with the Development Process Planning Phase, Relation with the Post design Planning Phase, Methodological Evolution in Product Design, Concurrent Engineering, Characteristic Features of Concurrent Engineering, Concurrent Engineering and Life Cycle Approach, New Product Development (NPD) and Strategies, Product Configuration and Variant Management, The Design for X System, Objective Properties and Design for X Tools, Choice of Design for X Tools and Their Use in the Design Process.

Unit-III 08 Hrs.

Product Data Management (PDM):

Product and Product Data, PDM systems and importance, Components of PDM, Reason for implementing a PDM system, financial justification of PDM, barriers to PDM implementation

Virtual Product Development Tools:

For components, machines, and manufacturing plants, 3D CAD systems and realistic rendering techniques, Digital mock-up, Model building, Model analysis, Modelling and simulations in Product Design, Examples/Case studies

Unit-IV 08 Hrs.

Integration of Environmental Aspects in Product Design:

Sustainable Development Design for Environment, Need for Life Cycle Environmental Strategies, Useful Life Extension Strategies, End-of-Life Strategies, Introduction of Environmental Strategies into

the Design Process, Life Cycle Environmental Strategies and Considerations for Product Design.

Unit-V 08 Hrs.

Life Cycle Assessment and Life Cycle Cost Analysis:

Properties, and Framework of Life Cycle Assessment, Phases of LCA in ISO Standards, Fields of Application and Limitations of Life Cycle Assessment, Cost Analysis and the Life Cycle Approach, General Framework for LCCA, Evolution of Models for Product Life Cycle Cost Analysis.

Text Books:

1. John Stark, "Product Lifecycle Management: Paradigm for 21st Century Product Realization", Springer-Verlag, 2004.
2. Guido La Rosa, Antonino Risitano, Taylor & Francis, "Product Design for the environment-A life cycle approach", Fabio Giudice, 2006.

Reference Books:

1. Saaksvuori Antti, Immonen Anselmie,"Product Life Cycle Management", Springer, Dreamtech, 2009.
2. Michael Grieve, "Product Lifecycle Management: Driving the next generation of lean thinking", Tata McGraw Hill, 2006.
3. François Villeneuve, Luc Mathieu, Max Giordano, "Product Life-Cycle Management: Geometric Variations", Wiley, 2010.

Program: Computer Science and Engineering (Data Science)	Final Year B.Tech	Semester: VII
Management Information System (22OECS7052T)		

Course Objective(s):

1. The course is blend of Management and Technical field.
2. Discuss the roles played by information technology in today‘s business and define various technology architectures on which information systems are built.
3. Define and analyze typical functional information systems and identify how they meet the needs of the firm to deliver efficiency and competitive advantage.
4. Identify the basic steps in systems development.

Course Outcomes:

On completion of the course, the learner will be able to:

CO	Course Outcomes	Blooms Level	Blooms Description
CO1	Explain how information systems transform business.	L2	Understand
CO2	Use information systems concepts to assess their effects on organizational operations.	L3	Apply
CO3	Describe IT infrastructure and its components and its current trends.	L2	Understand
CO4	Explain principal tools and technologies for accessing information from databases to improve business performance and decision making.	L2	Understand
CO5	Use enterprise-wide knowledge management systems to show their benefits for business operations.	L3	Apply

Management Information System (22OECS7052T) Course Contents

Unit-I 05 Hrs.

Foundation Concepts:

Information Systems in Business, Functional Area Information System, The Components of Information Systems, Impact of IT on organizations and society, Organizational Strategy, Information systems for strategic advantage.

Unit-II 08 Hrs.

Information Technologies: Hardware and Software

Computer Systems: End User and Enterprise Computing

Computer Peripherals: Input, Output, and Storage Technologies

Application Software: End User Applications

System Software: Computer System Management

Data Resource Management: Technical Foundations of Database Management, Managing Data Resources, Big data, Data warehouse and Data Marts, Knowledge Management.

Networks: The Networked Enterprise (Wired and wireless), Pervasive computing, Cloud Computing models.

Unit-III 08 Hrs.

MIS Tools and applications for Decision making: ERP and ERP support of Business Process Reengineering.

Business intelligence (BI): Managers and Decision Making, BI for Data analysis and Visualization.

Artificial Intelligence Technologies in Business

Unit-IV 06 Hrs.

Security and Ethical Challenges: Security, Ethical, and Societal Challenges of IT Security Management of Information Technology

Unit-V 07 Hrs.

Social Computing (SC): Web 2.0 and 3.0, SC in business-shopping, Marketing, Operational and Analytic CRM, E-business and E-commerce – B2B B2C, Mobile commerce.

Unit-VI 08 Hrs.

Information System within Organization: Acquiring Information Systems and Applications:

Various System development life cycle models.

Enterprise and Global Management of Information Technology: Managing Information Technology, Managing Global IT.

Reference Books:

1. James A O'Brien, George M., RameshBehl, "Management Information Systems", 11^{th} edition.
2. Kelly Rainer, Brad Prince, "Management Information Systems", Wiley.
3. K.C. Laudon and J.P. Laudon, "Management Information Systems: Managing the Digital Firm", 10^{th} Ed., Prentice Hall, 2007.
4. D. Boddy, A. Boonstra, "Managing Information Systems: Strategy and Organization", Prentice Hall, 2008.

Program: Computer Science & Engineering (Data Science)	Final Year B.Tech	Semester: VII
Operations Research (22OECS7053T)		

Prerequisite: Basic Knowledge of Algebra, Probability and Statistics.

Course Objective(s):

1. To formulate a real-world decision problem as a mathematical programming model.
2. To learn the mathematical tools that are employed to solve mathematical programming models.

Course Outcomes:

On completion of the course, the learner will be able to:

CO	Course Outcomes	Blooms Level	Blooms Description
CO1	Analyze real-world problems by converting them into Linear Programming Problems and analyzing the solutions obtained using the Simplex method or other algorithms	L4	Analyze
CO2	Apply appropriate algorithms to identify real-world problems as Transportation Problems and Assignment Problems and address decision problems	L3	Apply
CO3	Analyze time-varying decision situations and analyze them using the principles of dynamic programming in real-life situations	L4	Analyze
CO4	Apply queuing theory concepts to identify the reasons for formation of queues, classify various queuing systems, and use defined system parameters for decision making in real-life situations.	L3	Apply
CO5	Apply decision-making concepts to competitive situations and determine appropriate strategies for two-person zero-sum games.	L3	Apply
CO6	Apply the concept of simulation and Monte Carlo simulation techniques to systems such as inventory and queuing, and determine solutions for them.	L3	Apply
CO7	Apply the concept of replacement policy to determine the optimal replacement age.	L3	Apply

Operations Research (22OECS7053T)
Course Contents

Unit-I 10 Hrs.

Introduction to Operations Research:

Concept of decision making. Definition of OR. Formulation of decision problem as OR model, Concept of Optimization

Linear Programming Problem:

Mathematical Formulation. Finding optimal solution - Graphical method, Simplex Method, Big M-method, Two Phase Method. Duality, Primal – Dual construction, Symmetric and Asymmetric Dual. Dual Simplex Method.

Unit-II 08 Hrs.

Assignment Problems:

Mathematical Formulation, Finding optimal solution - Hungarian Method

Transportation problem:

Mathematical Formulation, Finding initial basic feasible solution – Northwest corner rule, row minima, column minima, least cost method and Vogel's approximation method.

Optimality test:

The stepping stone method and MODI method. Improving the solution.

Unit-III 06 Hrs.

Dynamic Programming:

Bellman's Principle of optimality - Applications of dynamic programming- Employment smoothening problem, capital budgeting problem, shortest path problem, cargo loading problem

Unit-IV 10 Hrs.

Queuing Models:

Characteristics of queuing models. Single Channel – Single and multi-phase servers, Poisson arrivals, exponential service time - with infinite population and finite population models – with infinite and finite capacity. Multichannel – Single phase server - Poisson arrivals, exponential service time with infinite population.

Game Theory:

Introduction. Minimax & Maximin Criterion and optimal strategy. Solution of games with saddle points, rectangular games without saddle points - 2 x 2 games, dominance principle.

Approximate methods - Iterative method, m x 2 & 2 x n games -Graphical method and method of sub-games. Expressing game as LPP.

Unit-V 08 Hrs.

Simulation:

Definition. Types of simulation models. Monte Carlo simulation technique. Applications of simulation - Inventory and Queuing problems. Simulation Languages.

Replacement Models:

Replacement of items that deteriorate with time - when money value is not counted and counted, Replacement of items that fail suddenly – individual and group replacement policy

Text Books:

1. Sharma J. K.,"Operations Research", Trinity Press.
2. Gupta P. K., Hira D. S.,"Operations Research", S. Chand Limited.

Reference Books:

1. Taha, H.A."Operations Research - An Introduction", Prentice Hall
2. Ravindran, A, Phillips, D. T and Solberg, J. J.,"Operations Research: Principles and Practice", John Willey and Sons
3. Hiller, F. S. and Liebermann, G. J.,"Introduction to Operations Research", Tata McGraw Hill
4. Pradeep Prabhakar Pai,"Operations Research Principles and Practice", Oxford University Press
5. R. Panneerselvam, "Operations Research", PHI Publications.
6. A. M. Natarajan, P. Balasubramani, A. Tamilarasi,"Operations Research", Pearson Education.
7. Kanti Swarup, P. K. Gupta and Man Mohan,"Operations Research", Sultan Chand & Sons.

Program: Computer Science and Engineering (Data Science)	Final Year B.Tech	Semester: VII
Cyber Security and Laws (22OECS7054T)		

Course Objective(s):

1. To understand and identify different types cybercrime and cyber offences.
2. To recognized Indian IT Act 2008 and its latest amendments.
3. To learn various types of security standards compliances.

Course Outcomes:

On completion of the course, the learner will be able to:

CO	Course Outcomes	Blooms Level	Blooms Description
CO1	Explain the different types of cybercrime and security issues in E-Business.	L2	Understand
CO2	Analyze different types of cyber threats and techniques for security management.	L4	Analyze
CO3	Analyze the legal requirements and standards for cyber security in various countries to regulate cyberspace.	L4	Analyze
CO4	Explain the Information Technology Act and the legal framework of right to privacy, data security, and data protection.	L2	Understand

Cyber Security and Laws (22OECS7054T)
Course Contents

Unit-I 12 Hrs.

Introduction to Cybercrime:

Cyber Crime, Cyber Law, Cyber Security, History of Cyber Crime, Hacking, Data Theft, Cyber Terrorism, Virus & Worm's, Email Bombing, Pornography, online gambling, Forgery, Web Defacements, Web Jacking, Illegal online Selling, Cyber Defamation, Software Piracy, Electronics/ Digital Signature, Phishing, Password Cracking, Key loggers and Spywares, Steganography, DoS and DDoS attacks, SQL Injection, Buffer Over Flow,, Phishing Identity Theft (ID Theft) ,How criminal plan the attacks, Social Engineering, Cyber stalking .

Unit-II 08 Hrs.

Cyber Threats Analysis

Knowledge of Dynamic and Deliberate Targeting

Knowledge of Indications and Warning

Knowledge of Internal Tactics to Anticipate and/or, Emulate Threat Capabilities and Actions

Knowledge of Key Cyber Threat Actors and their Equities

Knowledge of Specific Target Identifiers and Their Usage

Unit-III 06 Hrs.

Electronic Business and legal issues

Evolution and development in Ecommerce, Policy Frameworks for Secure Electronic Business, paper vs paper less contracts, E-Commerce models- B2B, B2C, E security. E- Payment Mechanism; Payment through card system, E- Cheque, E-Cash, E-Payment, Threats & Protections, Security for E-Commerce.

Unit-IV 08 Hrs.

Indian IT Act

Cyber Crime and Criminal Justice, Penalties, Adjudication and Appeals Under the IT Act, 2000, IT Act. 2008 and its Amendments

Security aspect in cyber Law

The Contract Aspects in Cyber Law , The Security Aspect of Cyber Law, The Intellectual Property Aspect in Cyber Law ,The Evidence Aspect in Cyber Law ,The Criminal Aspect in Cyber Law.

Unit-V 08 Hrs.

Security Industries Standard Compliances

IT Security v/s IT Compliance, Cyber Security Standards, critical security controls for cyber security, GRC (Governance, Risk Management, and Compliance), SOX, GLBA, HIPAA, ISO/IEC 27001, NIST Cyber Security Framework (CSF), PCI- DSS. OWASP Top Ten Project, GDPR (General Data Protection Regulation), NIST (National Institute of Standards and Technology), CIS Controls (Center for Internet Security Controls).

Reference Books:

1. Nina Godbole, Sunit Belapure, "Cyber Security", Wiley India, New Delhi.
2. Suresh T. Vishwanathan, "The Indian Cyber Law",Bharat Law House New Delhi.
3. "The Information Technology Act", Bare Act- Professional Book Publishers, New Delhi, 2000.
4. Anup K. Ghosh, "E-Commerce Security and Privacy", Springer Science and Business Media, 2012.
5. Izzat Alsmadi, "The NICE Cyber Security Framework Cyber Security Intelligence and Analytics", Springer.
6. Advocate Prashant Mali,"Cyber Law & Cyber Crimes", Snow White Publications, Mumbai
7. Nina Godbole, "Information Systems Security", Wiley India, New Delhi.
8. Kennetch J. Knapp, "Cyber Security & Global Information Assurance" Information Science Publishing.
9. William Stallings, "Cryptography and Network Security", Pearson Publication

Web Links:

1. The Information Technology ACT, 2008- TIFR : https://www.tifrh.res.in
2. A Compliance Primer for IT professional: https://www.sans.org/reading-room/whitepapers/compliance/compliance-primer- professionals-33538

Program: Computer Science and Engineering (Data Science)	Final Year B.Tech	Semester: VII
Personal Finance Management (22OECS7055T)		

Prerequisite: Basic Knowledge of Algebra, Probability, and Statistics.

Course objective(s):

1. To create awareness and educate consumers about access to financial services.
2. To make the students understand the basic concepts, definitions, and terms related to direct taxation.
3. To Help students compute the Goods and Service Tax (GST) payable by a supplier after considering the eligible input tax credit.
4. To familiarize students with microfinance to accelerate the expansion of local micro-businesses.

Course outcomes:

On completion of the course, the learner will be able to:

CO	Course Outcomes	Blooms Level	Blooms Description
CO1	Use a framework for financial planning to understand the overall role finances play in his/her personal life.	L3	Apply
CO2	Calculate income from salaries, house property, business/profession, capital gains and income from other sources.	L3	Apply
CO3	Calculate the amount of CGST, SGST and IGST payable after considering the eligible input tax credit.	L3	Apply
CO4	Describe how Microfinance can help in financial inclusion.	L2	Understand

Personal Finance Management
(22OECS7055T)
Course Contents

Unit-I 07 Hrs.

Overview of Indian Financial System:

Characteristics, Components, and Functions of Financial System. Financial Instruments and Financial Markets, Financial Inclusion.

Introduction to Personal Finance:

Personal Financial Planning in Action, Money Management Skills, Taxes in Your Financial Plan, Savings and Payment Services. Consumer Credit: Advantages, Disadvantages, Sources and Costs.

Unit-II 07 Hrs.

Personal Financial Management:

Loans:

Home, Car, Education, Personal, Loan against property, and Jewel loan.

Insurance:

Types of Insurance – ULIP and Term; Health and Disability Income Insurance, Life Insurance.

Investment:

Investing Basics and Evaluating Bonds, Investing in Stocks and Investing in Mutual Funds, Planning.

Unit-III 08 Hrs.

Income Tax:

Income Tax Act Basics- Introduction to Income Tax Act, 1961 Heads of Income and Computation of Total Income and Tax Liability- Heads of Income and Computation of Total Income under various heads, Clubbing Provisions, set off and carry forward of Losses, Deductions, Assessment of Income and tax liability of different persons. Tax Management, Administrative Procedures and ICDS - TDS, TCS and Advance Tax Administrative Procedures, ICDS.

Unit-IV 10 Hrs.

Goods and Services Tax:

GST Constitutional framework of Indirect Taxes before GST (Taxation Powers of Union & State Government); Concept of VAT: Meaning, Variants and Methods; Major Defects in the structure of Indirect Taxes prior to GST; Rationale for GST; Structure of GST (SGST, CGST, UTGST & IGST); GST Council, GST Network, State Compensation Mechanism, Registration.

Levy and Collection of GST:

Taxable event- "Supply" of Goods and Services; Place of Supply: Within state, Interstate, Import and

Export; Time of supply: Valuation for GST- Valuation rules, taxability of reimbursement of expenses; Exemption from GST: Small supplies and Composition Scheme: Classification of Goods and Services

Unit-V 10 Hrs.

Introduction to Micro – finance:

Micro-Finance: Definitions, Scope & Assumptions, Types of Microfinances, Customers of Microfinance, Credit Delivery Methodologies, SHG concept, origin, Formation & Operation of Self-Help Groups (SHGs).

Models in Microfinance:

Joint Liability Groups (JLG), SHG Bank Linkage Model and GRAMEEN Model: Achievements & Challenges.

Institutional Mechanism:

Current Challenges for Microfinance, Microfinance Institutions (MFIs): Constraints & Governance Issues, Institutional Structure of Microfinance in India: NGO-MFIs, NBFC- MFIs, Co-operatives, Banks, Microfinance Networks and Associations; Demand & Supply of Microfinance Services in India, Impact assessment and social assessments of MFIs

Reference Books:

1. Asha Singh, M.S. Gupta, "Banking and Financial Sector Reforms in India" , Serials Publication.
2. M.S. Gupta & J.B. Singh,"Indian Banking Sector: Essays and Issues",1st Edition, Serials Publication.
3. K.M. Bhattacharya O.P. Agarwal,"Basics Of Banking & Finance", Himalaya Publishing House.
4. S. Subba Reddy , P. Raghu Ram, "Agricultural Finance And Management".
5. Dr.Vasant Desai, "The Indian Financial System And Development", 4th Edition, Himalaya Publishing House.
6. Sanjay Kumar Satapathy, "Income Tax Management Simple Way of Tax Management, Tax Planning and Tax Saving".
7. Dr. R. K. Jain, "Direct Tax System Income Tax", SBPD Publications.
8. S K Mishra,"Simplified Approach to GST Goods and Services Tax", Educreation Publishing.
9. Todd A Watkins, "Introduction To Microfinance", World Scientific Publishing Company.

Program: Computer Science and Engineering (Data Science)	Final Year B.Tech	Semester: VII
Energy Audit and Management (22OECS7056T)		

Prerequisite: Nil

Course objective(s):

1. To understand the importance of energy security for sustainable development and the fundamentals of energy conservation.
2. To identify and describe the basic principles and methodologies adopted in energy audit of a utility
3. To introduce performance evaluation criteria of various electrical and thermal installations to facilitate the energy management.
4. To relate the data collected during performance evaluation of systems for identification of energy saving opportunities.

Course outcomes:

On completion of the course, the learner will be able to:

CO	Course Outcomes	Blooms Level	Blooms Description
CO1	Identify and describe the present state of energy security and its importance.	L2	Understand
CO2	Identify and describe the basic principles and methodologies adopted in the energy audit of a utility.	L2	Understand
CO3	Describe the energy performance evaluation of some common electrical installations and identify energy-saving opportunities.	L2	Understand
CO4	Describe the energy performance evaluation of some common thermal installations and identify energy-saving opportunities.	L2	Understand
CO5	Analyze the data collected during performance evaluation and recommend energy-saving measures.	L4	Analyze

Energy Audit and Management (22OECS7056T) Course Contents

Unit-I 05 Hrs.

Energy Scenario:

Present Energy Scenario, Energy Pricing, Energy Sector Reforms, Energy Security, Energy Conservation and its Importance, Energy Conservation Act- 2001 and its Features. Basics of Energy and its various forms, Material and Energy balance.

Unit-II 10 Hrs.

Energy Audit:

Definition, Energy audit- need, Types of energy audit, Energy management (audit) approach-understanding energy costs, Bench marking, Energy performance, matching energy use to requirement, Maximizing system efficiencies, Optimizing the input energy requirements, Fuel and energy substitution. Elements of monitoring & targeting, Energy audit instruments. Technical and economic feasibility, Classification of energy conservation measures. Safety considerations during energy audit.

Financial analysis techniques:

Simple payback period, NPV, Return on investment (ROI) Internal rate of return (IRR).

Unit-III 10 Hrs.

Energy Management and Energy Conservation in Electrical System:

Electricity billing, Electrical load management and maximum demand Control; Power factor improvement, Energy efficient equipments and appliances, star ratings. Energy efficiency measures in lighting system, lighting control: Occupancy sensors, daylight integration, and use of intelligent controllers. Energy conservation opportunities in water pumps, compressor, fan and blower. industrial drives, induction motors, motor retrofitting, soft starters, variable speed drives.

Unit-IV 10 Hrs.

Energy Management and Energy Conservation in Thermal Systems:

Review of different thermal loads; Energy conservation opportunities in: Steam distribution system, Steam leakages, Steam trapping, Condensate and flash steam recovery system. Waste heat recovery, use of insulation- types and application. Energy conservation opportunities in: Boiler system. Refrigeration system and HVAC system.

Unit-V 07 Hrs.

Energy conservation in Buildings:

Energy Conservation Building Codes(ECBC):Green Building, LEED rating
Application of Non-Conventional and Renewable Energy Sources, Energy sources and energy management in electric vehicles.

Reference Books:

1. Geofry Stokes,"Handbook of Electrical Installation Practice", Blackwell Science.
2. Anil Valia, "Designing with light: Lighting Handbook", Lighting System.
3. W.C. Turner, "Energy Management Handbook", John Wiley and Sons.
4. A. K. Tyagi,"Handbook on Energy Audits and Management", Tata Energy Research Institute (TERI).
5. C.B. Smith,"Energy Management Principles", Pergamon Press.
6. Dale R. Patrick, S. Fardo, Ray E. Richardson, "Energy Conservation Guidebook", Fairmont Press.
7. Albert Thumann, W. J. Younger, T. Niehus, "Handbook of Energy Audits", , CRC Press.

Web Links:

1. www.energymanagertraining.com
2. www.bee-india.nic.in

Program: Computer Science and Engineering (Data Science)	Final Year B.Tech	Semester: VII
Public Systems and Policies (22OECS7057T)		

Prerequisite: Basic Knowledge of Social Science and Current Affairs

Course Objective(s):

1. To analyze the transformations in public systems with emphasis on current initiatives and emerging challenges in the field.
2. To understand public systems in a fast-changing environment in the global context.
3. To provide an in-depth understanding of the ills prevailing in the society and aids to identify the solutions for them.
4. To explain public policy and its operations with special focus on policy relating to Government finance.
5. To analyze and evaluate the impact of the public policy on firms and economy at large.

Course Outcomes:

CO	Course Outcomes	Bloom's Level	Bloom's Description
CO1	Explain the importance of public systems in a fast-changing environment in the global context.	L2	Understand
CO2	Analyze the transformations in public systems with emphasis on current initiatives and emerging challenges in the field.	L4	Analyze
CO3	Explain public policy and its operations with special focus on policy relating to Government finance.	L2	Understand
CO4	Analyze the impact of public policy on firms and the economy at large and work under various fields as policymakers.	L4	Analyze
CO5	Apply analytical skills through expenditure policy in public services case studies.	L3	Apply

Public Systems and Policies (22OECS7057T)
Course Contents

Unit I — 10 Hrs.

Introduction and Overview of Public Systems: Ideology of Public Systems Problem Solving: Mechanistic and Organic view of society and individuals, the legal framework; federal government; state and local governments; government growth; The size of government.

Unit II — 06 Hrs.

Public Sector in the Economic Accounts:

Public sector in the circular flow; public sector in national income accounts.

Unit III — 08 Hrs.

Public Choice and Fiscal Politics:

Direct Democracy, Representative Democracy, The Allocation Function; The Distribution Function; The Stabilization Function; Coordination of Budget Functions; The Leviathan Hypothesis.

Unit IV — 12 Hrs.

Introduction and Overview of Public Policy:

Markets and Government; Social goods and Market failure, Public expenditure and its evaluation; Cost Benefit Analysis, Public policy and Externalities, Taxation Policy and its impact, Income distribution, redistribution and social security issues Fiscal & Budgetary Policy, Fiscal Federalism in India.

Unit V — 06 Hrs.

Case Studies in Expenditure Policy – Public Services:

A) National Defense B) Highways C) Outdoor Recreation D) Education

Reference Books:

1. Charles Wheelan, "Introduction to Public Policy", W.W. Norton & Company.
2. Thomas R. Dye, "Understanding Public Policy", Prentice Hall.
3. Anderson J.E.,"Public Policy-Making: An Introduction", Boston, Houghton.
4. Avasthi & Maheshwari, "Public Administration", Lakshminarayan Agarwal, Agra.
5. Bhattacharya, Mohit, "New Horizons of Public Administration", Jawahar Publishers, New Delhi.

6. Henry, Nicholas,"Public Administration and Public Affairs", Prentice Hall of India, New Delhi.

7. Harvey S Rosen and Ted Gayer, "Public Finance", 10^{th} Edition, McGraw-Hill Education, 2013.

8. Musgrave and Musgrave, "Public Finance in Theory and Practice".

Program: Computer Science & Engineering (Data Science)	Final Year B.Tech	Semester: VII
Science of Well-being (22OECS7058T)		

Prerequisite: Nil

Course Objective(s):

1. To create consciousness about importance of holistic health and physical as well as mental well-being.
2. To make learners aware of the concepts of Happiness, Gratitude, Self-Compassion, Empathy etc.
3. To introduce the learners to the means of mental and physical well-being, ill effects of malpractices like alcoholism, smoking etc.
4. To equip the learners to manage and cope up with stress in their daily living.

Course Outcomes:

On completion of the course, the learner will be able to:

CO	Course Outcomes	Blooms Level	Blooms Description
CO1	Describe concepts of holistic health and well-being, differentiate between its true meaning and misconceptions, and explain the benefits of well-being.	L2	Understand
CO2	Describe the meaning of happiness, practice gratitude and self-compassion, and analyze incidents from one's own life.	L2	Understand
CO3	Explain the causes and effects of stress, identify reasons for stress in one's own surroundings and self.	L2	Understand
CO4	Describe the importance of physical health and fitness, assess one's lifestyle, and justify its limitations or effectiveness.	L2	Understand
CO5	Analyze one's own coping mechanisms, assess their effectiveness, develop and strategize for betterment, and execute them.	L4	Analyze

Science of Well-being (22OECS7058T)
Course Contents

Unit I — 06 Hrs.

Health and well-being: The concept of health, dimensions of health, the notion of well- being, various facets of well-being, relation between health and well-being.

Concept of holistic health, its principles and importance, concept and benefits of holistic care, misconceptions about holistic health approach, the application of a true holistic approach to our well-being.

Unit II — 08 Hrs.

Concepts of happiness: Happiness: what is it and how do we measure it? Philosophical perspectives on happiness, Happiness: Nature or Nurture? Happiness in the modern world: impediments and accelerators, Narrow vs. Broad Band Approaches to Happiness, Benefits of Happiness, Self-Compassion and Gratitude. Misconceptions of happiness.

Unit III — 10 Hrs.

Stress and mental health/well-being: Nature and concept of stress, meaning and definitions of stress, types of stress, meaning of stressors, types of stressors, symptoms of stress, effects of stress, different models of stress.

Sources of stress and how does stress cause illness, various sources of stress, delineate between external and internal sources of stress, differentiate between continuous and discrete stressors, the effects of these stressors on health and well-being, diversity of stressors and their health consequences, relation between stress and illness from different perspectives association between stress related physiological mechanisms and different illnesses.

Unit IV — 10 Hrs.

Physical Well-being / Health management: concept of health behaviours, dimensions of health behaviours. Health enhancing behaviors: Exercise and Weight control, application and importance of these health enhancing behaviours. Health protective behaviors and illness management: concept of illness management, effectiveness of illness management. Concept of Nutrition, Role of Nutrition, Components of Nutrition, Concept of Malnutrition, Health compromising behaviours: Alcoholism, Smoking and its effects on health.

Unit V — 08 Hrs.

Dealing with Difficult Times / Coping mechanisms: The concept of chronic stress, Health and safety risks of chronic stress, Forms and Treatment of chronic stress, Coping with Acute and Chronic stress, theories of the stress-illness link, role of stress in mental disorders.

Concept of coping, Ways of coping and stress management, basic knowledge about stress management, various techniques of stress management, stress management programs.

Mental strengths and virtues, Hope, Optimism, Resilience – concept, pathways and models, Meditation and Self-introspection.

Text Books:

1. Felicia Huppert, Nick Baylis, Barry Keverne, "The Science of well-being", Oxford University Press.
2. S. Ojha, U. Rani Srivastava, Shobhna Joshi, "Health and Well-Being: Emerging Trends", Global Vision Publishing House.
3. Shane J. Lopez, Jennifer Teramoto Pedrotti, Charles Richard Snyder, "Positive psychology: The scientific and practical explorations of human strengths", Sage Publications.

Reference Books:

1. Kitayama S. & Markus H. R, "The pursuit of happiness and the realization of sympathy: Cultural patterns of self, social relations, and well-being.", Culture and subjective well-being, The MIT Press.
2. Dubos R., "Man Adapting", New Haven: Yale University Press.
3. McMahon D. M., "Happiness a history", Atlantic Monthly Press.
4. D. Kahneman, E. Diener & N. Schwarz, "Well-being: The foundations of hedonic psychology", New York: Russell Sage.
5. Selye H., "The Stress of Life." New York; McGraw-Hill; 1984.

Program: Computer Science and Engineering (Data Science)	Final Year B.Tech	Semester: VII
Research Methodology (22OECS7059T)		

Prerequisite: Basic knowledge of Probability and Statistics

Course Objective(s):

1. To understand Research and research Process.
2. To acquaint learners with identifying problems for research and develop research strategies
3. To familiarize learners with the techniques of data collection, analysis of data and interpretation

Course Outcomes:

On completion of the course, the learner will be able to:

CO	Course Outcomes	Blooms Level	Blooms Description
CO1	Apply preliminary research design concepts for projects in their subject matter areas.	L3	Apply
CO2	Analyze and report research data using appropriate statistical and analytical techniques.	L4	Analyze
CO3	Explain complex data or situations clearly.	L2	Understand
CO4	Analyze the research findings.	L4	Analyze
CO5	Summarize a structured research report based on research findings.	L2	Understand

Research Methodology (22OECS7059T)
Course Contents

Unit-I 07 Hrs.

Basic Research Concepts:

Meaning of research, Objectives of research, Types of research, Significance of research Research process.

Unit-II 10 Hrs.

Research Methodology:

Identification of research problem, Literature review, Formulation of hypothesis, Formulation of Research design.

Unit-III 10 Hrs.

Research and Sample Design::

Meaning of research and sample design, Need of research design, Features of good research design, Important concepts, Different research designs, Types of sampling designs

Unit-IV 10 Hrs.

Data Collection and Data Analysis:

Types of data, Methods for collecting data: Experiments and surveys, Collection of primary and secondary data, Hypothesis testing and interpretation of Data

Unit-V 05 Hrs.

Interpretation and Report Writing:

Interpretation and drawing conclusions on the research, Preparation of the report, Ethical Issues

Reference Books:

1. Dawson, Catherine, 2002, "Practical Research Methods", UBS Publishers Distributors, New Delhi, 2002.
2. Kothari, C.R., "Research Methodology-Methods and Techniques",Wiley Eastern Limited, New Delhi, 1985.
3. Kumar, Ranjit, "Research Methodology-A Step-by-Step Guide for Beginners", Pearson Education, 2^{nd} Edition, Singapore, 2005.

Program: Computer Science & Engineering (Data Science)	Final Year B.Tech	Semester: VII
Project Stage-II (22PJCS7060L)		

Course Objectives:

- To implement the solution as per the problem statement.
- To develop the team building, writing, logical reasoning and management skills.
- To provide the connections between the designs and concepts across different disciplinary boundaries.
- To encourage students to become independent personnel, critical thinkers and lifelong learners

Course Outcomes:

CO	Course Outcomes	Blooms Level	Blooms Description
CO1	Analyze the problem statement and produce solution of the problem considering cultural, social, environmental and economic factors using appropriate tool and method.	L4	Analyze
CO2	Interpret project based learning that allows students to transfer existing ideas into new applications.	L2	Understand
CO3	Apply the ability to work in teams and manage to conduct the project development activity.	L3	Apply
CO4	Use different perspectives from relevant disciplines which help them to get internships, jobs, and admission for higher studies.	L3	Apply
CO5	Explain the project development in the form of technical writing, and interpret what constitutes plagiarism and the use of proper referencing styles.	L2	Understand

Syllabus:

Project-I work done in VI semester shall be continued as Project-II in semester VII.

Students should complete remaining implementation of ideas given in synopsis/Abstract of semester VI.

Students / group must plan their execution of project, so that project work should be completed before end of semester.

Project-II involves fabrication, design, experimentation, data analysis within realistic constraints such as economic, environmental, social, ethical, health and safety, manufacturability, and sustainability. The stage also includes testing, possible results and report writing.

Each project group is required to maintain log book for documenting various activities of Project-II and submit group project report at the end of Semester-VII in the form of Hard bound.

Domain knowledge (any beyond) needed from the various areas in the field of Computer Science & Engineering (Data Science) for the effective implementation of the project.

The above areas can be updated based on the technological innovations and development needed for specific project.

Guidelines:

The main purpose of this activity is to improve the students' technical skills, communication skills by integrating writing, presentation and teamwork opportunities.

Each group will be reviewed twice in a semester and marks will be allotted based on the various points mentioned in the evaluation scheme.

In the first review of this semester, each group is expected to complete 70% of project.

In the second review of this semester, each group is expected to complete 100% of project.

The students may use this opportunity to learn different computational techniques towards development of a product.

Interaction with alumni mentor will also be appreciated for the improvement of project.

Student is expected to:

- Maintain Log Book of weekly work done(Log Book Format will be as per Table 1).
- Report weekly to the project guide along with log book.

Table 1: Log Book Format

Sr	Week (Start Date:End Date)	Work Done	Sign of Guide	Sign of Coordinator
1				
2				

Assessment Criteria:

- At the end of the semester, after confirmation by the project guide, each project group will submit project completion report in prescribed format for assessment to the departmental committee (including project guide).
- Assessment of the project (at the end of the semester) will be done by the departmental committee (including project guide).
- The candidate must bring the Project Stage-I report and the final report completed in all respect while appearing for End Semester Examination.
- Oral examination should be conducted by Internal and External examiners. Students have to give presentation and demonstration based on their project.

Prescribed project report guidelines:
Every group should prepare hard bound report (preferrable LaTeX) of about minimum 40 pages on the work carried out by a batch of students in respect of the project work done during semester-VII. Project Report should include appropriate content for:

- Title
- Abstract
- Introduction
- Problem identification and project objectives
- Literature Survey
- Related Theory
- Project design and Implementation details
- Case study/Analysis/Design Methodology
- Project Outcomes
- Result and Conclusion
- Future scope
- References

Assessment criteria for the departmental committee for Continuous Assessment:
Guide will monitor weekly progress and marks allocation will be as per Table 2.
Assessment criteria for the departmental committee for End Semester Exam:
Departmental committee will evaluate project as per Table 3.

Table 2: Continuous Assessment Table

Sr	Exam Seat No	Name of Student	Student Attendance	Log Book Logbook Maintenance	Literature Review	Depth of Understanding	Report	Total
			5	5	5	5	5	25

Assessment criteria for the departmental committee (including project guide) for End Semester Exam:

Each group will be reviewed twice in a semester by faculty guide and faculty coordinator based on the following criteria:

- Project progress
- Documentation/Technical paper writing
- Key findings
- Validation of results
- Product Development

Each review consists of 25 marks. Average of the marks scored in both the two reviews will be considered for final grading. The final certification and acceptance of TW ensures the satisfactory performance on the above aspects.

Table 3: Evaluation Table

Sr	Exam Seat No	Name of Student	Project Selection	Design/ Methodology	Implementation/ Modelling/ Simulation	Result Verification	Presentation	Total
			5	5	5	5	5	25

Program: Computer Science and Engineering (Data Science)	Final Year B.Tech	Semester: VII
Employability Skill Development Program-III (22HMCS7070L)		

Course Objective(s):

- To build a solid foundation in programming fundamentals.
- To enhance problem-solving abilities through mathematical reasoning.
- To develop algorithmic thinking.
- To provide hands-on experience with essential data structures.

Course Outcomes:

CO	Course Outcomes	Blooms Level	Blooms Description
CO1	Apply basic programming skills to write and debug simple programs using conditions, loops, and functions.	L3	Apply
CO2	Analyze mathematical problems and use techniques like number theory and modular arithmetic in problem-solving.	L4	Analyze
CO3	Design and implement algorithms to solve real-world problems using methods like recursion, greedy, and sorting.	L6	Create
CO4	Use common data structures such as arrays, strings, sets, and maps effectively in programming tasks.	L3	Apply

Employability Skill Development Program-III (22HMCS7070L) Course Contents

Unit-I 07 Hrs.

Programming Fundamentals:

- Basic Programming Concepts
- Conditional Statements
- Loops
- Inbuilt functions
- Data Types
- Python

Unit-II 07 Hrs.

Mathematics:

- Mathematics
- Basic Math
- Arithmetic
- Modular Arithmetic
- Divisibility
- Integer Division
- GCD
- Geometry
- Number System
- Binary

Unit-III 07 Hrs.

Algorithms:

- Algorithms
- Brute Force
- Greedy

- Constructive
- Sorting
- Simple Algos
- Recursion
- Recurrence Relation
- Observation
- Implementation

Unit-IV 07 Hrs.

Data Structures:

- Data Structures
- Arrays
- 1D Arrays
- String
- Subsequence
- Frequency Arrays
- Maps
- Sets

Reference Books:

1. Narasimha Karumanchi, "Data Structures and Algorithms Made Easy", 5^{th} Edition, Career-Monk Publications, 2016.
2. Dr. R. S. Aggarwal, "Quantitative Aptitude for Competitive Examinations", Revised Edition, S. Chand Publishing, 2021.
3. Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, and Clifford Stein, "Introduction to Algorithms", 4^{th} Edition, The MIT Press, 2022.

Semester - VIII

Program: Computer Science & Engineering (Data Science)	Final Year B.Tech	Semester: VIII
High Performance Computing (22PECS8011T)		

Prerequisite: Parallel Computing, Distributed Computing

Course Objective(s):

1. This course in High-Performance Computing (HPC) for Data Science with an emphasis on GPU parallel computing introduces students to the fundamental concepts and practical skills necessary for harnessing the power of Graphics Processing Units (GPUs) in data-intensive computations.
2. Throughout the course, students will explore GPU architecture, CUDA programming, memory optimization techniques, parallel programming patterns, and performance optimization strategies.
3. They will also delve into advanced topics like GPU-accelerated libraries and the integration of GPUs with popular data science frameworks. By the end of this course, students will be equipped to leverage GPU parallel computing to significantly enhance the efficiency and performance of data science applications.

Course Outcomes:

CO	Course Outcomes	Blooms Level	Blooms Description
CO1	Explain the architecture of modern GPUs, CUDA programming model, and parallel programming challenges.	L2	Understand
CO2	Solve data parallelism problems and use CUDA memory models effectively.	L3	Apply
CO3	Analyze GPU performance metrics, including memory coalescing, thread scheduling, and control divergence impacts.	L4	Analyze
CO4	Analyze different GPU computing frameworks and libraries (cuBLAS, cuDNN) based on application requirements and efficiency.	L4	Analyze

High Performance Computing (22PECS8011T) Course Contents

Unit-I 08 Hrs.

Introduction to Heterogeneous Parallel Computing:

Introduction: Architecture Of A Modern GPU, Challenges in Parallel Programming, Parallel Programming Languages and Models.

Data Parallelism: Data Parallelism, CUDA C Program Structure, A Vector Addition Kernel, Device Global Memory and Data Transfer, Kernel Functions and Threading, Kernel Launch

Unit-II 08 Hrs.

CUDA Parallelism Model:

Scalable Parallel Execution: CUDA Thread Organization, Mapping Threads to Multidimensional Data, Synchronization and Transparent Scalability, Resource Assignment, Thread Scheduling and Latency Tolerance

Memory And Data Locality: CUDA Memories, Tiled Parallel Algorithms, Tiled Matrix Multiplication, Tiled Matrix Multiplication Kernel, Boundary Checks, Memory as A Limiting Factor to Parallelism

Unit-III 08 Hrs.

Performance Considerations On GPUs:

Memory Access Performance: Global Memory Bandwidth, Memory Coalescing in CUDA, Channels and Banks in Dram Systems, Techniques for Reducing Memory Transfers Between CPU And GPU.

Thread Execution Efficiency: Warps and SIMD Hardware, Dynamic Partitioning of Resources, Performance impact of Control Divergence.

Unit-IV 08 Hrs.

Parallel Computation Patterns:

Parallel Patterns: Convolution: 1d Parallel Convolution- A Basic Algorithm, Constant Memory and Caching, Tiled 1d Convolution with Halo Cells, A Simpler Tiled 1d Convolution- General Caching.

Parallel Computation Patterns (Histogram): Atomic Operations in Cuda, Atomic Operation Performance-Block versus Interleaved Partitioning, Latency versus Throughput of Atomic Operations, Atomic Operation in Cache Memory, Privatization Technique for Improved Throughput.

Unit-V 04 Hrs.

Efficient Host-Device Data Transfer:

Pinned Host Memory, Task Parallelism in CUDA, Overlapping Data Transfer with Computation, CUDA Unified Memory.

Unit-VI 06 Hrs.

Advanced Topics in GPU Computing:

Introduction to GPU-accelerated libraries (cuBLAS, cuDNN, cuGraph), GPU computing frameworks (TensorFlow, PyTorch) and their integration with GPUs, Introduction to GPU clusters and distributed GPU computing.

Application Case Study- Machine Learning: Convolutional Neural Networks, Convolutional Layer: A Basic CUDA Implementation of Forward Propagation, Reduction of Convolutional Layer to Matrix Multiplication, cuDNN Library.

Text Books:

1. Georg Hager, Gerhard Wellein, "Introduction to High Performance computing for Scientist and Engineers", CRC press, 2019.
2. Duane Storti and Mete Yurtoglu, "CUDA for Engineers", Addison-Wesley,1st Edition, 2016.

Reference Books:

1. David B. Kirk and Wen-mei W. Hwu, "Programming Massively Parallel Processors: A Hands-on Approach", Morgan Kaufmann, 2nd Edition, 2012.
2. Charles Severance and Kevin Dowd, "High Performance Computing" , O'Reilly Media, 2nd Edition, 1998.
3. Sowmya Vajjala, Bodhisattwa Majumder, Anuj Gupta, Harshit Surana, "Practical Natural Language Processing: A Comprehensive Guide to Building Real-World NLP Systems", O'Reilly, 1st Edition, 2020.
4. Jason Sanders and Edward Kandrot , "CUDA by Example: An Introduction to General-Purpose GPU Programming" , Addison-Wesley, 2010.
5. NVIDIA Corporation , "GPU Gems", Addison-Wesley
6. Gerhard Hager and Markus Hadwiger , "Programming the GPU with CUDA", Springer
7. Brian Tuomanen and Daniel Kim, "Deep Learning with CUDA", O'Reilly Media

Weblinks:

1. HPC: https://archive.nptel.ac.in/courses/106/105/106105033/.
2. HPC Springer Journal: https://link.springer.com/book/10.1007/978-3-030-13325-2.
3. Programming Model: https://homepage.physics.uiowa.edu/ ghowes/teach/phys5905/lect/NumLec11_IntroH

Program: Computer Science & Engineering (Data Science)	Final Year B.Tech	Semester: VIII
Data Ethics (22PECS8012T)		

Prerequisite: Fundamentals of Data Analysis, Machine Learning

Course Objective(s):

1. To enable students to understand and apply ethical principles in data-driven technologies through the concepts of fairness, privacy-preserving learning, explainable AI, and responsible governance.

Course Outcomes:

CO	Course Outcomes	Blooms Level	Blooms Description
CO1	Explain data privacy, security, bias and accountability issues in real world problem.	L2	Understand
CO2	Apply different concepts of Data Ethics to solve real world problem.	L3	Apply
CO3	Analyze model transparency in the field of data science.	L4	Analyze
CO4	Design ethical governance strategies and assess the broader social impact of AI and data systems.	L6	Create

Data Ethics (22PECS8012T)
Course Contents

Unit-I 08 Hrs.

Introduction to Data Ethics: Overview and Importance of Data Ethics. The significance of data ethics in modern technology, its impact on individuals and society.

Historical Examples of Data Ethics Violations: A historical perspective on data ethics violations, such as data breaches and misuse of data. Consequences of ethical lapses and their implications for technology and society.

Overview of Ethical Theories: Exploration of ethical theories, including utilitarianism, deontology, virtue ethics, and their application in data ethics. Applying Ethical Frameworks to Data-Related Dilemmas Practical application of ethical frameworks to analyze and address data-related ethical dilemmas.

Case Study: Facial recognition technology by the New York Police Department (NYPD) in the wake of protests of police brutality and racial injustice in 2020.

Unit-II 07 Hrs.

Data-driven Business Model: Data as payment, good data, Data at risk, Data brokers in a grey area, a need for new business models, Needs of customers: general concern for digital surveillance, targeted ads and prices, demand for data control, act, consumers cookies and using VPM, false data on the rise, obfuscation, from lack of knowledge to resignation, pay for privacy, Best practices for data ethics, Emerging Technologies and Ethical Challenges, Examination of ethical challenges posed by emerging technologies like AI, IoT, and blockchain.

Case Study: COVID-19 Vaccine Distribution and Equity, ethical dilemmas in cutting-edge projects.

Unit-III 07 Hrs.

Bias & Analysis: Introduction and Importance of Algorithm Fairness, the reasons for unfairness, Analyzing and measuring unfairness, Sources of Bias, Dealing with Bias, Mitigating Bias , Further Considerations, addressing different types of bias, Examples, causes and detection strategies of algorithmic biases, Detecting and Addressing Bias in Data and Algorithms, Understanding the types of bias in data and algorithms (selection bias and algorithmic bias),techniques and tools for identifying and mitigating bias in data-driven projects.

Case Studies: Aequitas - A Toolkit for Auditing Bias and Fairness in Machine Learning Models.

Unit-IV 08 Hrs.

Data Privacy: Data Privacy and Legal Frameworks, Data Privacy Laws and Regulations, GDPR, CCPA, and HIPAA, Understanding the key principles and requirements of privacy laws, Data com-

modification's, examples of companies complying with or violating data privacy regulations, Data Collection and Storage Ethics Considerations for ethical data collection methods, including informed consent, data minimization, and transparency, Exploring fairness in machine learning models and algorithmic transparency.

Data Storage and Secure Handling: Encryption, and data handling protocols, Strategies for ensuring data security and integrity, Cybersecurity and Data Breaches, Handling Data Breaches Responsibly, Ethical and legal obligations following a data breach, including incident response and notification procedures.

Case studies: Facebook's Data Privacy Controversies, Ethical data collection in various contexts.

Unit-V 07 Hrs.

Data Ethics and Trust: Introduction to digital trust, the snowden effect, the sharing economy, ethical data use, sharing and access, ethical considerations when sharing data with partners, stakeholders, and the public, Strategies for ensuring responsible data sharing and access Best Practices for Responsible Data Use, Strategies for integrating data ethics into professional practices, software development, system design, and decision-making processes.

Case studies: Real-world examples of organizations implementing responsible data use practices.

Unit-VI 05 Hrs.

Data Governance and Regulation: Introduction to Data Governance, Importance of Governance, Examples of Data Governance in action, The Business value of Data Governance, why data Governance is easier in the public cloud, Ingredients of Data Governance: Tools

Case studies: The Volkswagen (VW) emissions scandal.

Text Books:

1. Christoph Stückelberger, Pavan Duggal, "Data Ethics: Building Trust: How Digital Technologies Can Serve Humanity", Globethics Publications, 1st Edition, 2023.
2. Gry Hasselbalch & Pernille Tranberg, "Data Ethics", PubliShare, 1st Edition, 2016.

Reference Books:

1. Ian Foster, Rayid Ghani, Ron S. Jarmin, Frauke Kreuter, Julia Lane, "Big Data and Social Science: Data Science Methods and Tools for Research and Practice", Chapman and Hall/CRC, 2nd Edition, 2020.
2. Evren Eryurek, Uri Gilad, Valliappa Lakshmanan, "Data Governance: The Definitive Guide - People, Processes, and Tools to Operationalize Data Trustworthiness", Shroff/O'Reilly, 1st Edition, 2021.

3. Loukides, Mike, Hilary Mason, and DJ Patil, "Ethics and Data Science- Doing Good Data Science", Sebastopol, CA: O'Reilly Media., 2018.

4. Sandvig, Christian, Kevin Hamilton, Karrie Karahalios, and Cedric Langbort, "Auditing Algorithms: Research Methods for Detecting Discrimination on Internet Platforms", Computational Culture, 2014.

5. Ananny, Mike, "Toward an Ethics of Algorithms : Convening Observation , Probability and Timeliness", Science, Technology, & Human Values vol. 41 no. 1, pp. 93–117, 2016.

Web Links:

1. Ethics in Data Science: https://www.analyticsvidhya.com/blog/2022/02/ethics-in-data-science-and-proper-privacy-and-usage-of-data/

2. Business Insights Harvard: https://online.hbs.edu/blog/post/data-ethics

3. Data Science Professionals: https://emeritus.org/blog/data-science-and-analytics-data-science-course-curriculum/

Program: Computer Science & Engineering (Data Science)	Final Year B.Tech	Semester: VIII
Introduction to Quantum Computing (22PECS8013T)		

Prerequisite: Computer System Fundamentals, Machine Learning, Information Security

Course Objective(s):

1. To introduce the basics of Quantum Computing and Quantum state transformation and classical computation versions.
2. To understand advanced Quantum Computation Algorithms and basics of Quantum Machine Leaming.

Course Outcomes:

CO	Course Outcomes	Blooms Level	Blooms Description
CO1	Analyze fundamental quantum computing concepts such as qubits, quantum states, superposition, entanglement, and basic quantum gates.	L4	Analyze
CO2	Apply quantum computation techniques and advanced quantum algorithms to address simple real-world computational problems.	L3	Apply
CO3	Apply quantum machine learning and quantum deep learning techniques using parameterized quantum circuits and implement basic quantum cryptography protocols.	L3	Apply

Introduction to Quantum Computing (22PECS8013T) Course Contents

Unit-I 07 Hrs.

Complex Numbers, Vector Space, and Dirac Notation:

Complex Numbers, Complex Conjugation, Vector Space, Basic set, Dirac Notation, Ket and Bra, Inner Product, Linearly Dependent and Independent Vectors, Dual Vector Space, Computational Basis, Outer Product, Spin and Qubit.

Unit-II 07 Hrs.

Quantum Computing vs. Classical Computing:

History of quantum computation and quantum information, Quantum State, Bloch sphere, Dense coding, Physical quantum phenomena: Spin, Quantum superposition, Interference and Entanglement.

Logic Gates and Circuits: Boolean Algebra, Functional Completeness, Gates, Circuits, Universal Gates, Gates and Computation,

Quantum Gates and Circuits: Qubits, The CNOT, Pauli, Hadamard, Toffoli Gates, Quantum Gate, Quantum Gates Acting on one Qubit, No Cloning Theorem, Quantum Computation, Multiple qubit gates, Qubit copying circuit, Example: Bell states, quantum teleportation.

Unit-III 06 Hrs.

Quantum Computing algorithms:

Classical computations on a quantum computer, Quantum parallelism, Quantum key distribution, Superdense coding, quantum teleportation, applications of teleportation, probabilistic versus quantum algorithms, phase kick-back, Quantum phase estimation and quantum Fourier Transform, eigenvalue estimation, Shor's Factorization Algorithm, Grover's Search Algorithm, Quantum algorithms summarized.

Unit-IV 05 Hrs.

Quantum Cryptography algorithm:

Cryptography using principles of quantum computing, No-cloning theorem, Quantum key distribution Algorithm, Quantum secret sharing Algorithm.

Unit-V 09 Hrs.

Quantum Machine Learning Basic (QML):

Variational Quantum Circuits, Parameterized quantum circuits, Parameterized quantum circuit properties, Entangling capability, Parameterized quantum circuits for machine learning Data encoding

Methods, Basis encoding, Amplitude encoding, Angle encoding, Arbitrary encoding, Supervised learning, Quantum variational classification, Quantum kernel estimation, Variational training, Quantum Support Vector Machine (QSVM).

Unit-VI 08 Hrs.

Quantum Deep Learning (QDL):

Basics of Quantum Neural Networks, Finite difference gradients, Analytic gradients, Natural gradients, Simultaneous Perturbation Stochastic Approximation, Training in practice, exponentially vanishing gradients (barren plateaus), Quantum Convolutional Neural Network.

Text Books:

1. Parag K. Lala, 'Quantum Computing', McGraw Hill, 1st Edition, 2020.
2. Chris Bernhardt, 'Quantum Computing for Everyone', MIT Press, 1st Edition, 2020.

Reference Books:

1. Jack D. Hidary, 'Quantum Computing: An Applied Approach', Springer, 2nd Edition, 2021.
2. Johan Vos, 'Quantum Computing in Action', Manning Publications, 1st Edition, 2022.

Weblinks:

1. https://qiskit.org/learn

Program: Computer Science & Engineering (Data Science)	Final Year B.Tech	Semester: VIII
Advanced Computer Networks NPTEL (22PECS8014T)		

Prerequisite: Computer Networks and Computer Architecture

Course Objective(s):

1. To provide an understanding of contemporary computer networking concepts, including the design and implementation of high-performance networks, data center networking architectures, information-centric networking, and network softwarization technologies such as Software-Defined Networking (SDN), network virtualization, and programmable networks.

Course Outcomes:

CO	Course Outcomes	Blooms Level	Blooms Description
CO1	Explain the design principles, performance considerations, and algorithms used in high-performance switching and routing, including IP address lookup and packet classification techniques.	L2	Understand
CO2	Analyze and evaluate Quality of Service (QoS) mechanisms, differentiated services, traffic policing, and traffic shaping techniques for high-speed networks.	L4	Analyze
CO3	Apply concepts of network softwarization including Software-Defined Networking (SDN), Network Function Virtualization (NFV), and programmable networks using tools such as Mininet and P4.	L3	Apply
CO4	Examine data center networking architectures, topologies, and container networking interfaces, and assess their impact on scalability and performance.	L3	Apply
CO5	Explain information-centric networking architectures including content naming, routing, caching, and security mechanisms in Named Data Networking.	L2	Understand

Advanced Computer Networks NPTEL (22PECS8014T) NPTEL Course Contents

Week-I

High Performance Switching and Routing: An Introduction to High Performance Switching and Routing, IP address lookup.

Week-II

Algorithms for IP address lookup and optimization,IP Table Lookup: Trie Based Data Structures, Optimized Trie based Data Structures, hardware implementation of address lookup.

Week-III

Packet Classification: Need for packet classification and methods for packet classification.

Week-IV

Differentiated Service, Quality of Service, Traffic Polishing, Traffic Shaping

Week -V

Network Softwarization - Introduction,Network Ossification,Network Virtualization

Week-VI

Software Defined Networking (SDN) - Road to SDN,Active Networks,Deep Dive (Northbound and Southbound interface) ,Data and Control Plane Separation,Control Plane Abstractions, OpenFlow, SND Prospects and Challenges

Week-VII

Network Function Virtualization (NFV) - Architecture and Concepts,Network Function Virtualization - Road ahead and Key challenges,High Performance Network Packet Processing, Summary and Comparision of NFV and SDN.

Week-VIII

Programmable Networks - Data Plane Programmability,Reconfigurable Match Action Tables, Introduction to P4

Week-IX

Data Center Networking (DCN) - Introduction

Week-X

DCN - Deep Dive (Network topologies, Container Network Interfaces),Serverless Computing,Network Telemetry,SmartNICs and In-band Network Telemetry, Future of Network Softwarization, SDN 3.0

Week-XI

Green and Sustainable Data Centers ,Content Distribution on the Internet,Architectures for Information Centric Networking

Week-XII

Content Naming, Routing and Caching, Security in Named Data Networking

Text Books:

1. H. Jonathan Chao, Bin Liu, 2007, John Wiley & Sons "High Performance Switches and Routers", Inc. ISBN-10: 0-470-05367-4

2. Gabriel M. de Brito, Pedro B. Velloso, Igor M. Moraes, "Information-Centric Networks: A New Paradigm for the Internet (Focus Series in Networks and Telecommunications)", Wiley-ISTE; 1st edition, 2013, ISBN: 9781848214491

Reference Books:

1. B. Wissingh, C. Wood, A. Afanasyev, L. Zhang, D. Oran and C. Tschudin "Information-Centric Networking (ICN): Content Centric Networking (CCNx) and Named Data Networking (NDN) Terminology" B. Wissingh, RFC 8793, June 2020

2. Peterson, Cascone, O'Connor, Vachuska, and Davie, "Software-Defined Networks: A Systems Approach".

3. Cloud Networking: Understanding Cloud-based Data Centre Networks, Gary Lee (Author), Morgan Kaufmann (Publisher), 2014,ISBN-139780128007280

Weblinks:

1. NPTEL course Advanced Computer Networks, IIT Indore, IIT Gandhi nagar https://onlinecourses.nptel.ac.in/noc26_cs60/preview

2. https://sdn.systemsapproach.org/index.html

Program: Computer Science & Engineering (Data Science)	Final Year B.Tech	Semester: VIII
Social Network Analysis (22PECS8021T)		

Prerequisite: Probability and Statistics, Machine Learning

Course Objective(s):

1. To equip students with the knowledge and analytical skills necessary for the study of massive networks, addressing the associated computational, algorithmic, and modeling challenges, and to cultivate a research-oriented perspective on the structure, dynamics, and analysis of large-scale networks.

Course Outcomes:

CO	Course Outcomes	Blooms Level	Blooms Description
CO1	Analyze social networks using visualization techniques and structural measures.	L4	Analyze
CO2	Illustrate network growth patterns and ranking methodologies in complex networks.	L4	Analyze
CO3	Examine methods for detecting communities, predicting links, and modelling information flow.	L3	Apply
CO4	Apply anomaly detection and representation learning approaches for network analysis.	L3	Apply

Social Network Analysis (22PECS8021T)
Course Contents

Unit-I 08 Hrs.

Society & Network: Introduction, Use of social networks, defining a network, types of network (link-centric, node and link centric, local view, temporal view, generalization, real-world network), levels of social network analysis, graph visualization tools.

Network Measures: Network basics, node centrality, assortativity, transitivity and reciprocity, similarity, degeneracy.

Network Growth Models: Overview of real-world networks and their properties, brief introduction to Erdős-Rényi Random Network Model, Watts Strogatz Model, and Preferential Attachment Model with their key characteristics and limitations.

Unit-II 07 Hrs.

Link Analysis:

Application of link analysis, Signed networks: Balance Theory of Undirected Signed Networks, Status Theory of Signed Networks, Triad Balance vs Status, Strong and Weak Ties: Strength of a Tie, Triadic Closure, Dunbar Number, Local Bridges and Importance of Weak Ties, PageRank, DivRank, SimRank, PathSim.

Unit-III 07 Hrs.

Community Detection: Application of community detection, types of communities, community detection methods, Disjoint Community Detection: Node-centric community detection, modularity and community detection, Overlapping Community Detection: Clique Dynamics, Local Community Detection.

Link Prediction: Applications of link prediction, Evaluating Link Prediction methods.

Unit-IV 06 Hrs.

Cascade Behaviors & Network Effects: Preliminaries and Important Terminologies, Cascade Models, Probabilistic Cascades, Epidemic Models, Independent Cascade Models, Cascade Prediction.

Unit-V 06 Hrs.

Anomaly Detection in Networks:

Outliers verses network based anomalies. Anomaly in Static Networks: Plain and attributed networks, relational learning, Anomaly in Dynamic Networks: Preliminaries, feature and decomposition based approaches, Challenges in anomaly detection.

Unit-VI 08 Hrs.

Graphical Representation Learning:

Intuition behind representation learning, representation learning methods.

Graph Convolutional Network (GCN) and its variations and applications in social network analysis.

Dynamic Graph Convolutional Networks (DGCN) & Continuous-Time Dynamic Graph Neural Networks (CTDGNN): Advanced models for analyzing evolving social networks

Text Books:

1. Tanmoy Chakraborty, "Social Network Analysis", 1st, Wiley, 2021.
2. Stephen P Borgatti, Martin G. Everett, Jeffrey C. Johnson, "Analyzing Social Networks", Sage Publications Ltd, 2nd Edition, 2018.
3. William L. Hamilton, "Graph Representation Learning", Morgan & Claypool Publishers,2020.

Reference Books:

1. Xiaoming Fu, Jar-Der Luo, Margarete Boos, 'Social Network Analysis Interdisciplinary Approaches and Case Studies', 1st Edition, CRC Press, 2020.
2. Dr. Krishna Raj P.M., Mr. Ankith Mohan, Dr. Srinivasa K.G, "Practical Social Network Analysis with Python (Computer Communications and Networks)", 1stt Edition, Springer, 2019.
3. John Scott, "Social Network Analysis", 4th Edition, SAGE Publications Ltd,2017. Yang, Franziska Barbara Keller, LuZheng, "Social Network Analysis: Methods and Examples", 1st Edition, SAGE Publications, 2016.

Weblinks:

1. A course on Social Network Analysis
   https://onlinecourses.nptel.ac.in/noc22_cs117/preview
2. Social Network Analysis 101: Ultimate Guide Comprehensive Introduction for Beginners:
   https://visiblenetworklabs.com/guides/social-network-analysis-101/
3. Real-world use cases of Social Network Analysis
   https://www.latentview.com/social-media-analytics/a-guide-to-social-network-analysis-and-its-use-cases/

Program: Computer Science & Engineering (Data Science)	Final Year B.Tech	Semester: VIII
Applied Game Theory (22PECS8022T)		

Prerequisite: Linear Algebra, Calculus, Probability, Statistics and Basic algorithm design and analysis.

Course Objective(s):

1. To understand how individuals and groups make strategic decisions in competitive and cooperative situations, using mathematical models and algorithms to analyze, predict, and optimize outcomes in real-world scenarios such as economics, AI, and multi-agent systems.

Course Outcomes:

CO	Course Outcomes	Blooms Level	Blooms Description
CO1	Analyze strategic, zero-sum, and non-zero-sum games to identify Nash equilibria and optimal strategies.	L4	Analyze
CO2	Apply algorithmic techniques and reinforcement learning to compute equilibria and model multiagent interactions.	L3	Apply
CO3	Evaluate evolutionary, cooperative, and Bayesian game scenarios for fairness, stability, and decision-making efficiency.	L5	Evaluate

Applied Game Theory ((22PECS8022T) Course Contents

Unit-I 04 Hrs.

Introduction to Game Theory:

Strategic games, players, strategies, payoffs; dominance, minimax, saddle points; pure & mixed strategy Nash equilibria; real-world examples: auctions, pricing, simple multi-agent interactions

Unit-II 05 Hrs.

Zero-Sum and Non-Zero-Sum Games:

Zero-sum games, saddle points, matrix games; mixed strategies; non-zero-sum games, iterated elimination of dominated strategies; Lemke–Howson algorithm.

Unit-III 08 Hrs.

Evolutionary and Cooperative Game Theory:

Evolutionarily Stable Strategies (ESS), replicator dynamics, fictitious play; cooperative games: transferable utility, core, Shapley value, nucleolus; correlated equilibria; Multi-Agent Reinforcement Learning (MARL) and reward shaping with human feedback.

Unit-IV 08Hrs.

Bayesian and Algorithmic Game Theory:

Bayesian games, Bayes–Nash equilibrium, auctions, bilateral trading; complexity of equilibrium computation; mechanism design basics; Vickrey auction, incentive compatible resource allocation.

Unit-V 07 Hrs.

Repeated and Extensive Form Games:

Repeated games: Nash Folk Theorem, subgame perfect equilibrium, one-shot deviation principle; extensive form games: game trees, backward induction, sequential equilibria

Unit-VI 10 Hrs.

Game Design, Simulation, and Real-World Applications:

Game design principles: payoff engineering, fairness, multiplayer dynamics; applications: oligopoly models, voting games, matching markets, resource allocation, utility theory; RL-based strategy optimization and human-in-the-loop feedback.

Text Books:

1. Game Theory: An Introduction, 3rd Edition by E.N. Barron, Wiley, 2024.

2. Richard S. Sutton and Andrew G. Barto, “Reinforcement Learning: An Introduction”, MIT Press, 2nd Edition, 2022.

3. Binmore, K., Game Theory: A Very Short Introduction, OUP, 2010.

Reference Books:

1. Shoham Y., Leyton-Brown K., ”Multiagent Systems: Algorithmic, Game-Theoretic, and Logical Foundations” , Cambridge University Press, 2024.

2. Thomas Ferguson, ”Game Theory” , World Scientific, 2018

Web Links:

1. NPTEL Course: https://nptel.ac.in/courses/106105237

2. IIT Bombay: Useful Lecture Notes on Game Theory — IEOR @ IIT Bombay

Program: Computer Science & Engineering (Data Science)	Final Year B.Tech	Semester: VIII
Robotics and AI (22PECS8023T)		

Prerequisite: Linear algebra and Probability theory.

Course Objective(s):

1. To introduce fundamental concepts, kinematics, perception, planning, and control in robotics with an emphasis on data acquisition, machine learning, and autonomous navigation.

Course Outcomes:

CO	Course Outcomes	Blooms Level	Blooms Description
CO1	Illustrate the fundamental principles, components, and kinematics of robotic systems.	L3	Apply
CO2	Apply sensor data acquisition, preprocessing, and fusion techniques using Python and ROS.	L3	Apply
CO3	Analyze computer vision, path planning, and SLAM algorithms for perception and navigation.	L4	Analyze
CO4	Develop control and decision-making strategies for autonomous robot operation.	L6	Create

Robotics and AI (22PECS8023T)
Course Contents

Unit-I 06 Hrs.

Introduction to Robotics:

Evolution of Robotics, Types of robots – industrial, mobile, humanoid, and autonomous, Components of robotic system (sensing, actuation, control, AI), Types of Sensors – IMU, LiDAR, Camera, GPS, Ultrasonic, Proximity Sensors (Infrared), Vision Sensors, Accelerometers, Gyroscopes, and Encoders (Linear or Rotary), Types of Actuators – Electric (DC, Stepper, Servo Motors), Hydraulic, Pneumatic, and Emerging Smart Actuators (Piezoelectric, Shape Memory Alloy, Electroactive Polymer).

Unit-II 10 Hrs.

Robot Kinematics and Motion planning:

Coordinate frames and transformations – homogeneous transformation matrices,Forward and inverse kinematics; Denavit–Hartenberg (D–H) parameters,Differential kinematics and Jacobians – conceptual and numerical examples,Configuration space and robot motion representation, Motion planning introduction, path and trajectory concepts,Types of trajectory planning – Point-to-Point (PTP) and Continuous Path (CP).

Unit-III 08 Hrs.

Data Acquisition and Preprocessing:

Data collection and preprocessing from multiple sensors through frameworks and middleware (e.g., ROS) for acquisition, synchronization, and refinement of sensor data., Understanding sensor data formats and structures (CSV, JSON, image/video files and ROS bag files). Noise handling using Gaussian, Median, and Kalman filtering methods. Aligning multi-sensor data streams (camera, LiDAR, IMU) using temporal synchronization, spatial calibration, and sensor fusion methods. Handlingmissing or corrupted data using interpolation, statistical imputation, and smoothing methods, Sensor calibration using intrinsic and extrinsic methods for camera– LiDAR and IMU sensors.

Unit-IV 08 Hrs.

Robot Perception:

Introduction to robot perception and environment understanding, Computer vision in robotics – image acquisition, feature extraction, and object recognition,Application of machine learning and deep learning for perception: Classification using CNN and SVM, Object detection using YOLO and SSD, Image segmentation using U-Net and SegNet, building 3D representations from LiDAR using Voxel Grid Mapping or from stereo vision using SGBM (Semi-Global Block Matching).

Unit-V 04 Hrs.

Path Planning:

Path planning algorithms Rapidly-exploring Random Tree(RRT), and PRM, Simultaneous Localization and Mapping (SLAM),Components – Localization, mapping, sensor data processing.

Unit-VI 06 Hrs.

Autonomous Navigation:

Types of SLAM Visual SLAM, LiDAR-based SLAM, RGB-D SLAM, Data association and map building, Learning-based SLAM and navigation using neural implicit mapping and policy learning, Integration of SLAM with path planning and control for autonomous navigation, Evaluation metrics accuracy, drift, real-time performance, and scalability, Reinforcement Learning for Navigation using Q-Learning, Sim-to-Real Transfer Domain Randomization, Imitation Learning, Challenges, and Evaluation.

Text Books:

1. Roland Siegwart, Illah R. Nourbakhsh, and Davide Scaramuzza, "Introduction to Autonomous Mobile Robots", 3rd Edition, MIT Press, 2022.
2. Peter Corke, "Robotics, Vision and Control: Fundamental Algorithms in Python", 3rd Edition,Springer, 2023.
3. Jonathan Cacace, "Ultimate Robotics Programming with ROS 2 and Python", 1st Edition, 2024.

Reference Books:

1. Mohamed M. Atia, "Sensor Fusion Approaches for Positioning, Navigation, and Mapping: How Autonomous Vehicles and Robots Navigate in the Real World with MATLAB Examples", 1st Edition, Springer, 2025.
2. Christoph Bartneck, Tony Belpaeme, Friederike Eyssel, Takayuki Kanda, Merel Keijsers & Selma Šabanović, "Human-Robot Interaction – An Introduction", 2nd Edition, Cambridge University Press, 2024.
3. Larry T. Ross, Stephen W. Fardo & Michael F. Walach, "Industrial Robotics Fundamentals", 4th Edition, Jones & Bartlett Learning, 2023.

Web Links:

1. Introduction to Robotics by IIT Madras and Robotics by IIT Kharagpur
   https://swayam.gov.in/nc_details/NPTEL
2. https://www.udemy.com/course/robotics-course/
3. https://www.coursera.org/courses?query=robotics

Program: Computer Science & Engineering (Data Science)	Final Year B.Tech	Semester: VIII
Social Networks NPTEL (22PECS8024T)		

Prerequisite: Probability and Statistics, Machine Learning

Course Objective:

1. To understand, model, analyze, and simulate real-world social and complex networks using graph theory and computational tools to study connectivity, diffusion, link analysis, community structure, and viral phenomena.

Course Outcomes:

CO	Course Outcomes	Blooms Level	Blooms Description
CO1	Explain fundamental concepts of social and complex networks including graph theory, connectedness, homophily, weak ties, and small-world phenomenon.	L2	Understand
CO2	Apply Python-based tools such as NetworkX and Gephi to construct, visualize, and analyze real-world network datasets.	L3	Apply
CO3	Apply structural properties of networks such as clustering coefficient, centrality measures, PageRank, community detection, and structural balance.	L3	Apply
CO4	Analyze diffusion models, cascading behaviors, and epidemic spreading models (SIR/SIS) in social and web networks.	L4	Analyze
CO5	Analyze network models such as Barabási–Albert model, Erdős–Rényi model, Schelling model, and cascading models for understanding real-world phenomena.	L4	Analyze

Social Networks NPTEL (2PECS8024T)
NPTEL Course Contents

Week 1: Introduction

Introduction, Introduction to Python, Introduction to Networkx, Social Networks: The Challenge, Google Page Rank, Searching in a Network, Link Prediction, The Contagions, Importance of Acquaintances, Marketing on Social Networks.

Week 2: Handling Real-world Network Datasets

Introduction to Datasets, Ingredients Network, Synonymy Network, Web Graph, Social Network Datasets, Datasets: Different Formats, Datasets : How to Download?, Datasets: Analysing Using Networkx, Datasets: Analysing Using Gephi, Introduction : Emergence of Connectedness, Advanced Material : Emergence of Connectedness, Programming Illustration : Emergence of Connectedness, Summary to Datasets.

Week 3: Strength of Weak Ties

Introduction, Granovetter's Strength of weak ties; Triads, clustering coefficient and neighborhood overlap; Structure of weak ties, bridges, and local bridges; Validation of Granovetter's experiment using cell phone data; Embededness; Structural Holes; Social Capital; Finding Communities in a graph (Brute Force Method); Community Detection Using Girvan Newman Algorithm; Visualising Communities using Gephi; Tie Strength, Social Media and Passive Engagement; Betweenness Measures and Graph Partitioning; Strong and Weak Relationship – Summary.

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

Introduction to Homophily - Should you watch your company ?, Selection and Social Influence, Interplay between Selection and Social Influence, Homophily - Definition and measurement, Foci Closure and Membership Closure, Introduction to Fatman Evolutionary model, Fatman Evolutionary Model- The Base Code (Adding people), Fatman Evolutionary Model- The Base Code (Adding Social Foci), Fatman Evolutionary Model- Implementing Homophily, Quantifying the Effect of Triadic Closure, Fatman Evolutionary Model- Implementing Closures, Fatman Evolutionary Model- Implementing Social Influence, Fatman Evolutionary Model- Storing and analyzing longitudnal data.

Week 5: Homophily Continued and Ve / -Ve Relationships

Spatial Segregation: An Introduction, Spatial Segregation: An Introduction, Spatial Segregation: Simulation of the Schelling Model, Spatial Segregation: Conclusion, Schelling Model Implementation-1(Introduction), Schelling Model Implementation-2 (Base Code), Schelling Model Implementation-3 (Visualization and Getting a list of boundary and internal nodes), Schelling Model Implementation-4 (Getting a list of unsatisfied nodes), Schelling Model Implementation-5 (Shifting the unsatisfied nodes

and visualizing the final graph).

Positive and Negative Relationships (Introduction): Structural Balance, Enemy's Enemy is a friend, characterizing the structure of balanced networks, Balance Theorem, proof of balance theorem, Introduction to positive and negative edges, Outline of implementation, Creating graph, displaying it and counting unstable triangles, Moving a network from an unstable to stable state, Forming two coalitions, visualizing coalitions and the evolution.

Week 6: Link Analysis

The Web Graph, Collecting the Web Graph, Equal Coin Distribution, Random Coin Dropping, Google Page Ranking Using Web Graph, Implementing PageRank Using Points Distribution Method-1, Implementing PageRank Using Points Distribution Method-2, Implementing PageRank Using Points Distribution Method-3, Implementing PageRank Using Points Distribution Method-4, Implementing PageRank Using Random Walk Method -1, Implementing PageRank Using Random Walk Method -2, DegreeRank versus PageRank.

Week 7: Cascading Behavior in Networks

We Follow, Why do we Follow?, Diffusion in Networks, Modeling Diffusion, Impact of Communities on Diffusion, Cascade and Clusters, Knowledge, Thresholds and the Collective Action, An Introduction to the Programming Screencast (Coding 4 major ideas), The Base Code, Coding the First Big Idea - Increasing the Payoff, Coding the Second Big Idea - Key People, Coding the Third Big Idea- Impact of Communities on Cascades, Coding the Fourth Big Idea - Cascades and Clusters.

Week 8: Link Analysis (Continued)

Introduction to Hubs and Authorities (A Story), Principle of Repeated Improvement (A story), Principle of Repeated Improvement (An example), Hubs and Authorities, PageRank Revisited - An example, PageRank Revisited - Convergence in the Example, PageRank Revisited - Conservation and Convergence, PageRank, conservation and convergence - Another example, Matrix Multiplication (Pre-requisite 1), Convergence in Repeated Matrix Multiplication (Pre-requisite 1), Addition of Two Vectors (Pre-requisite 2), Convergence in Repeated Matrix Multiplication- The Details, PageRank as a Matrix Operation, PageRank Explained.

Week 09 - Rich Get Richer Phenomenon

Introduction to Powerlaw, Why do Normal Distributions Appear?, Power Law emerges in WWW graphs, Detecting the Presence of Powerlaw, Rich Get Richer Phenomenon, Summary So Far, Implementing Rich-getting-richer Phenomenon (Barabasi-Albert Model)-1, Implementing Rich-getting-richer Phenomenon (Barabasi-Albert Model)-2, Implementing a Random Graph (Erdos- Renyi Model)-1, Implementing a Random Graph (Erdos- Renyi Model)-2, Forced Versus Random Removal of Nodes (Attack Survivability).

Week 10 - Rich Get Richer Phenomenon - 2

Rich Get Richer - A Possible Reason, Rich Get Richer - The Long Tail, Epidemics- An Introduction, Introduction to epidemics (contd..), Simple Branching Process for Modeling Epidemics, Simple Branching Process for Modeling Epidemics (contd..), Basic Reproductive Number, Modeling epidemics on complex networks, SIR and SIS spreading models, Comparison between SIR and SIS spreading models, Basic Reproductive Number Revisited for Complex Networks, Percolation model, Analysis of basic reproductive number in branching model (The problem statement), Analyzing basic reproductive number 2, Analyzing basic reproductive number 3, Analyzing basic reproductive number 4, Analyzing basic reproductive number 5.

Week 11 - The Small World Effect

Small World Effect - An Introduction, Milgram's Experiment, The Reason, The Generative Model, Decentralized Search – I, Decentralized Search – II, Decentralized Search – III.

Week 12 - How to go Viral on Web

Programming illustration- Small world networks : Introduction, Base code, Making homophily based edges, Adding weak ties, Plotting change in diameter, Programming illustration- Myopic Search : Introduction, Myopic Search, Myopic Search comparision to optimal search, Time Taken by Myopic Search, PseudoCores : Introduction, How to be Viral, Who are the right key nodes?, finding the right key nodes (the core), Coding K-Shell Decomposition, Coding cascading Model, Coding the importance of core nodes in cascading, Pseudo core.

Text Books:

1. Barabási, Albert-László, "Network Science", 1st Edition, Cambridge University Press, 2016 (online updated edition continues).
2. Jure Leskovec, Anand Rajaraman, Jeffrey D. Ullman, "Mining of Massive Datasets (3rd Edition)", Cambridge University Press, 2020.
3. Guillaume, Jean-Laurent; Latapy, Matthieu, "Graph Theory and Complex Networks: An Introduction to Statistical Physics", 1st Edition, ISTE Press – Elsevier, 2021.
4. Peter G. Doyle, Fan Chung-Yau; Linyuan Lü, "Handbook of Graph Theory and Network Applications", 1st Edition, CRC Press, 2022.
5. Anna Nagurney, "Networks Against Time: Supply Chain Analytics for Perishable Products" (focus on network modeling and diffusion), 2nd Edition, Springer, 2023.

Reference Books:

1. David Easley, Jon Kleinberg, "Networks, Crowds, and Markets: Reasoning About a Highly Connected World", 1^{st} Edition, Cambridge University Press, 2010 (latest continuing reference in network theory).

2. Reinhard Diestel, "Graph Theory (Graduate Texts in Mathematics)", 6^{th} Edition, Springer, 2020.

3. Ted G. Lewis, "Network Science: Theory and Practice", 2^{nd} Edition, Wiley, 2021.

4. Ulrik Brandes, Thomas Erlebach (Eds.), "Network Analysis: Methodological Foundations", 2^{nd} Edition, Springer, 2021.

5. Michele Coscia, Vito Latora, Kevin B. Wood, "Analyzing Networks and Health Systems: A Guide for Practitioners", 1^{st} Edition, Oxford University Press, 2024.

Weblinks:

1. https://networksciencebook.com/ – Network Science (Barabási) — foundational and actively updated.

2. https://networkx.org/documentation/stable/ – NetworkX Python Library (latest docs & examples).

3. https://gephi.org/users/ – Gephi Visualization Tutorials & Latest Updates.

4. https://snap.stanford.edu/data/ – Stanford Network Datasets for research and practice.

5. https://www.coursera.org/learn/social-network-analysis – Social Network Analysis course with recent methodologies.

Program: Computer Science & Engineering (Data Science)	Final Year B.Tech	Semester: VIII
Disaster Management and Preparedness (22MCCS8040T)		

Course Objective(s):

1. To provide basic understanding of hazards, disasters and various types and categories of disaster occurring around the world.
2. To identify extent and damaging capacity of a disaster.
3. To study and understand the means of losses and methods to overcome /minimize it.
4. To understand roles and responsibilities of individual and various organizations during and after disaster.
5. To appreciate the significance of GIS, GPS in the field of disaster management.
6. To understand the emergency government response structures before, during and after disaster.

Course Outcomes:

CO	Course Outcomes	Blooms Level	Blooms Description
CO1	Apply disaster management principles & guidelines.	L3	Apply
CO2	Analyse risk assessments.	L4	Analyze
CO3	Demonstrate community awareness & participation.	L3	Apply
CO4	Use Science & Technology tools (GIS, GPS).	L3	Apply
CO5	Prepare disaster management plans.	L3	Apply

Disaster Management and Preparedness (22MCCS8040T) Course Contents

Unit-I 06 Hrs.

Understanding Disasters & Hazards:

• Definition and types of disasters: Natural, Man-made and hybrid disasters, Study of Natural disasters: Flood, drought, cloud burst, Earthquake, Landslides, Avalanches, Volcanic eruptions, Mudflow, Cyclone, Storm, Storm Surge, climate change, global warming, sea level rise, ozone depletion etc.

• Study of Human/Technology Induced Disasters: Chemical, Industrial and Nuclear disasters, internally displaced persons, road and train accidents Fire Hazards, terrorism, militancy, • Hazard & Vulnerability profiles of India (seismic zones, flood-prone areas).

• Role of growing population and subsequent industrialization, urbanization and changing lifestyle of human beings in frequent occurrences of manmade disasters.

• India's vulnerability to disasters, and the impact of disasters on National development.

Unit-II 06 Hrs.

Disaster Risk Reduction (DRR) & Mitigation:

• Disaster Management Cycle: Prevention, Mitigation, Preparedness, Response, Recovery. Need for disaster prevention and mitigation, mitigation guiding principles, challenging areas, structural and non-structural measures for disaster risk reduction.

• Risk Assessment & Vulnerability Analysis.

• Science & Technology: Use of information management, Geo informatics like RS, GIS, GPS and remote sensing mitigation measure.

Unit-III 04 Hrs.

Disaster Preparedness & Response:

• Preparedness Planning, Early Warning Systems (EWS), & Communication.

• Emergency Response: Search & Rescue, Logistics, Medical Aid.

• Psychological Response & Management (Trauma, Stress).

• Role of IT, Media, Govt., NGOs, & Community

Unit-IV 04 Hrs.

Recovery, Rehabilitation & Reconstruction:

• Post-disaster damage assessment.

• Rehabilitation, Reconstruction, & Livelihood Restoration.

• Sanitation, Hygiene, & Waste Management.

Unit-V 04 Hrs.

Policy, Governance & Capacity Building:

• National Disaster Management Authority (NDMA) & Legislation.

• Institutional Mechanisms & Community Mobilization. Non-Structural Mitigation: Community based disaster preparedness, risk transfer and risk financing, capacity development and training, awareness and education, contingency plans

Unit-VI 04 Hrs.

Case studies on disaster (National /International):

• Case study discussion of National Disasters: Tsunami (2004), Bhopal gas tragedy, Kerala and Uttarakhand flood disaster, 26th July 2005 Mumbai flood

• Case study discussion of International Disasters: Hiroshima – Nagasaki (Japan), Cyclone Phailin(2013), Fukushima, Daiichi nuclear disaster (2011), Chernobyl meltdown

Reference Books:

1. Harsh K. Gupta, "Disaster Management", Universities Press Publications, 2003.
2. O. S. Dagur, "Disaster Management: An Appraisal of Institutional Mechanisms in India",published by Centre for land warfare studies, New Delhi, 2011.
3. Damon Copolla, Butterworth Heinemann, "Introduction to International Disaster Management", Elsevier Publications, 2015.
4. Jack Pinkowski, CRC Press, "Disaster Management Handbook", Taylor and Francis group, 2008.
5. Rajdeep Dasgupta, "Disaster management & rehabilitation", Mittal Publications, New Delhi,2007.
6. R B Singh, "Natural Hazards and Disaster Management, Vulnerability and Mitigation", Rawat Publications, 2006.
7. C. P. Lo Albert, K.W. Yonng, "Concepts and Techniques of GIS", Prentice Hall (India) Publications, 2006.
8. Claudia G. Flores Gonzales, "Risk management of natural disasters", KIT Scientific Publishing, 2010.
9. W. Nick Carter, "Disaster Management – a disaster manger's handbook", Asian Development Bank, 2008.

10. R. K. Srivastava, “Disaster Management in India”, Ministry of Home Affairs, GoI, New Delhi, 2011.

11. Wil Mara, “The Chernobyl Disaster: Legacy and Impact on the Future of Nuclear Energy”, Marshall Cavendish Corporation, New York, 2011.

12. Ronald Eisler, “The Fukushima 2011 Disaster”, Taylor & Francis, Florida, 2013. (Learners are expected to refer reports published at national and international level and updated information available on authentic web sites.)

Program: Computer Science & Engineering (Data Science)	Final Year B.Tech.	Semester: VIII
Internship (22INTCS8030L)		

Course Objective(s):

1. To expose technically students for the industrial environment, allowing them to gain real-world experience and develop into competent professionals.
2. To provide opportunities to learn and enhance the practical technical skills required for professional roles.
3. To familiarize students with current technological developments relevant to their field of study.
4. To develop technical writing skills for reports and projects.
5. To introduce students to the responsibilities and ethics of the engineering profession.
6. To develop an understanding of employee psychology, habits, attitudes, and problem-solving approaches.

Course Outcomes:

On completion of the course, the learner will be able to:

CO	Course Outcomes	Blooms Level	Blooms Description
CO1	Apply theoretical knowledge to real-world engineering problems through hands-on experience in industry or field settings.	L3	Apply
CO2	Apply technical knowledge and problem-solving approaches to address complex engineering problems in an industrial environment.	L2	Apply
CO3	Analyze organizational structures, workflows, and technologies to understand industry practices and operational challenges.	L4	Analyze
CO4	Develop technical documentation, reports, and presentations reflecting experiential learning and problem-solving approaches.	L6	Create
CO5	Discuss career goals and identify areas for personal and professional development based on internship exposure.	L2	Understand

Internships offer valuable educational and career development opportunities by providing students with practical experience in their field of study. In Semester–VIII, students have two options for their internship: Industry Internship and In-house Internship.

1. Industry Internship

Industry Internship Guidelines:

- The Training and Placement (T&P) cell of the institute will arrange internships for students in industries/organizations after the seventh semester.
- Students are expected to accept internship offers regardless of the company, job profile, location, or stipend offered.
- Alternatively, students can individually apply by submitting "Student Internship Program Application" (available on Institute Website) for industry internships, adhering to the prescribed guidelines as follows:
    1. Only T&P department granted internship will be considered.
    2. The internship duration should be of minimum 12 Weeks.
    3. Each student needs to take prior permission from T&P department before proceeding for any internship opportunity on his/her own.
    4. Each student will be monitored twice (virtually/through online meetings) during the internship period in the presence of an industry mentor and the departmental faculty mentor and the concerned TPC.
    5. If any student wants to withdraw from the Internship, he/she can only be allowed within two weeks of joining the same. Such students will have to continue the semester VIII academic activities regularly along with In-house internship.

Expected Activity in Industry Internship:

- Students may choose to work on innovation or entrepreneurial activities resulting in start-ups or undergo internships with Industry/NGO/ Government organizations/Micro/ Small/ Medium enterprises to prepare for the industry.
- Every student is required to prepare a file containing documentary proofs of the activities done by him/her. The evaluation of these activities will be done twice (virtually/through online meetings) during the internship period by the committee constituted by the Head of the Department which shall include Industry mentor, faculty mentor and Department T&P Co-ordinator (TPC). The assessment criteria for continuous assessment is as per Table 4.
- The ESE will be jointly evaluated by an industry mentor, faculty member and department T&P coordinator (TPC). The evaluation criteria is as per Table 5.

Table 4: Continuous Assessment for Industry Internship

Internship Objectives and Goals (30 Marks)	**Internship Experience Skills Gained/Enhanced (30 Marks)**	**Professional Development and Growth (30 Marks)**	**Internship Report (30 Marks)**	**Presentation (30 Marks)**

Table 5: Evaluation Criteria of Industry Internship

Internship Objectives and Goals (30 Marks)	**Internship Experience Skills Gained/Enhanced (30 Marks)**	**Professional Development and Growth (30 Marks)**	**Internship Report (30 Marks)**	**Presentation (30 Marks)**

Industry Internship Report:

- Upon completion of the internship, students should prepare a comprehensive report that reflects their observations and learnings during the internship period. Students can consult their Industrial Supervisor, Faculty Mentor, or T&P Co-ordinator/Officer for guidance on selecting special topics and problems for the report.

- The internship report will be evaluated based on the following criteria:
  i. Adequacy and purposeful write-up.
  ii. Variety and relevance of learning experience.
  iii. Practical applications and connections with the fundamental theories and concepts covered in the course (Semester I to VII).

2. In-house Internship

The in-house internship provides students with research-oriented opportunities to cultivate a research mindset. It serves as an extension of the project completed in VI and VII semesters (Project Stage-I & II) or offers new objectives provided by the department or research guide.

1. The in-house internship can be pursued individually or as a group activity.
2. If extending a project from Stage II, at least one student in the group must have participated in Stage I & II.
3. If working on the topic offered by the department or in-house mentor, a group of fresh students can form a team.
4. The maximum group size is limited to four students.
5. In case of extension of project stage II, the outcomes should be in the form of product development/technology transfer along with patent and copyright / one research publication (UGC care listed journal/conference). Students can work jointly with any government

funding agency or industry. In such cases, a detailed project report shall be submitted after verification by the in-house mentor and industry/funding agency mentor/authority. In case of standalone/non-sponsored activity, i.e. without any funding agency/industry collaboration, the detailed project report shall be submitted after verification by the in-house mentor.

6. If pursuing a Topic offered by the department or in-house mentor, the outcome of the in-house internship should include the publication of a research paper, preferably in an SCI/Scopus/UGC care listed/indexed Journal/Conference. The detailed project report must be submitted and verified by the in-house mentor.
7. All the designated work shall be submitted to the department in the form of a report in hardbound as well as soft copy.
8. **Evaluation Scheme:**

   I. Continuous Assessment:

   (a) A logbook (as per Table 6) of the work done must be maintained by each group.

   (b) Each in-house internship activity will be reviewed twice in the semester. In the first review (as per Table 7), at least 40% work shall be completed including the topic identification /introduction/scope of the work, literature survey, problem definition and objectives. The remaining 60% of work shall be completed in the second review (as per Table 8) including implementations, key findings, publications/ patenting/copyright/product development etc.

   II. End Semester Examination:

   End semester examination (as per Table 9) will be jointly evaluated by the faculty mentor and an external examiner appointed by the HOD in consultation with the COE.

9. **Assessment Formats:**

Table 6: Log Book Format

Sr	Week (Start Date: End Date)	Work Done	Sign of In-house mentor	Sign of Coordinator
1				

Table 7: First Review

Topic Identification & Validation (20 Marks)	Literature Survey (20 Marks)	Problem Definition (20 Marks)	Objectives (15 Marks)

Table 8: Second Review

Implementation (20 Marks)	**Publications (20 Marks)**	**Report (20 Marks)**	**Presentation (15 Marks)**

Table 9: End Semester Examination

Topic Identification & Validation (30 Marks)	**Literature Survey & Problem Definition (30 Marks)**	**Objectives & Implementation or Product Development (30 Marks)**	**Presentation (30 Marks)**	**Report, Publications/Patent/IPR Documents (30 Marks)**