SCHEME & SYLLABUS OF UNDERGRADUATE DEGREE COURSE

B. TECH.

COMPUTER SCIENCE & ENGINEERING

(DATA SCIENCE)

III YEAR

(V & VI Semester)

Effective for the students admitted in year 2021-22 and onwards
Approved by ……. academic council meeting held on …….

Teaching & Examination Scheme
B. Tech.(Computer Science & Engineering (Data Science))
3rd Year – V Semester
(Effective for the students admitted in year 2021-22 and onwards)

S. No.	Category	Course Code	Course Title	Hours			Exam Hours	Marks			Credit
				L	T	P		IA	ETE	Total	
	THEORY										
1	DC	5CD4-01	Operating Systems	3	-	-	3	30	70	100	**3**
2		5CD4-02	Computer Organization and Architecture	3	-	-	3	30	70	100	**3**
3		5CD4-03	Computer Networks	3	-	-	3	30	70	100	**3**
4		5CD4-04	Fuzzy Logic and Soft Computing Algorithms	3	-	-	3	30	70	100	**3**
5		5CD4-05	Mathematical Foundation Course	3	-	-	3	30	70	100	**3**
6	DE	5CD5-11	Information Security Systems	2	-	-	3	30	70	100	**2**
		5CD5-12	Smart Systems								
		5CD5-13	Distributed Systems								
7		5CD5-14	Cloud Computing	2	-	-	3	30	70	100	**2**
		5CD5-15	Introduction to Blockchain								
		5CD5-16	Natural Language Processing								
Sub Total				**19**	**00**	**00**	**-**	**210**	**490**	**700**	**19**
PRACTICAL & SESSIONAL											
8	DC	5CD4-21	Soft Computing Lab	-	-	2	-	60	40	100	**1**
9		5CD4-22	R Programming Lab	-	-	2	-	60	40	100	**1**
10		5CD4-23	Data Visualization Lab	-	-	2	-	60	40	100	**1**
11	UI	5CD7-30	Industrial Training	-	-	1	-	60	40	100	**3**
12	CCA	5CD8-00	SODECA / Co-Curricular Activity	-	-	-	-	-	100	100	**1**
Sub Total				**00**	**00**	**07**	**-**	**240**	**260**	**500**	**7**
Total				**19**	**00**	**07**	**-**	**450**	**750**	**1200**	**26**

L = Lecture, **T** = Tutorial, **P** = Practical, **IA** = Internal Assessment, **ETE** = End Term Exam, **Cr** = Credits

Teaching & Examination Scheme
B. Tech.(Computer Science & Engineering (Data Science))
3rd Year – VI Semester
(Effective for the students admitted in year 2021-22 and onwards)

S. No.	Category	Course Code	Course Title	Hours			Exam Hours	Marks			Credit
				L	T	P		IA	ETE	Total	
	THEORY										
1	DC	6CD4-01	Compiler Design	3	-	-	3	30	70	100	**3**
2		6CD4-02	Design and Analysis of Algorithms	3	-	-	3	30	70	100	**3**
3		6CD4-03	Machine Learning and its Applications	3	-	-	3	30	70	100	**3**
4		6CD4-04	Data Mining and Predicting Modeling	3	-	-	3	30	70	100	**3**
5		6CD4-05	Deep Learning	3	-	-	3	30	70	100	**3**
6	DE	6CD5-11	Internet of Things	2	-	-	3	30	70	100	**2**
		6CD5-12	Pattern Recognition								
		6CD5-13	GPU Computing								
Sub Total				**17**	**00**	**00**		**180**	**420**	**600**	**17**
	PRACTICAL & SESSIONAL										
7	DC	6CD4-21	Design and Analysis of Algorithms Lab	-	-	2	-	60	40	100	**1**
8		6CD4-22	Machine Learning and Neural Network Lab	-	-	2	-	60	40	100	**1**
9		6CD4-23	Data Mining and Predicting Modeling Lab	-	-	2	-	60	40	100	**1**
10	UI	6CD7-50	Innovation and Design Thinking Hands-on Project	-	-	3	-	60	40	100	**2**
11	CCA	6CD8-00	SODECA / Co-Curricular Activity	-	-	-	-	-	100	100	**2**
Sub Total				**00**	**00**	**09**	**-**	**240**	**260**	**500**	**7**
Total				**17**	**00**	**09**	**-**	**420**	**680**	**1100**	**24**

L = Lecture, **T** = Tutorial, **P** = Practical, **IA**=Internal Assessment**, ETE**=End Term Exam, **Cr**=Credits

V Semester B. Tech.(Computer Science & Engineering (Data Science))	
5CD4-01: Operating Systems	
Credit: 3	**Max. Marks: 100 (IA:30, ETE:70)**
3L+0T+ 0P	**End Term Exams: 3 Hours**

Course Objectives: As a result of successfully completing this course, students will:

- Learn about how Operating System is Important for Computer System.
- Learn about different types of Operating Systems and their services.
- Learn different process scheduling algorithms and synchronization techniques to achieve better performance of a computer system.
- Learn about device and device management.
- Learn about the concept of memory management and virtual memory.
- Learn about the concept of file system.

Course Outcomes: Upon successful completion of the course the students will be able to

CO-1: Analyze basic concepts of operating systems and their structures.

CO-2: Analyze various issues related to inter-process communication like process synchronization and critical section.

CO-3: Synthesize the concepts of I/O management, file system implementation, scheduling, resource management and deadlocks.

CO-4: Interpret the issues and challenges of memory management.

CO-5: Understand protection and security issues related to the operating system.

S. No.	Contents	Hours
1	**Introduction to OS and Process Management:** Introduction to operating systems, operating system structure, system calls, Process concept, Operations on processes, cooperating processes, inter process communication, mutual exclusion, critical section problem, Synchronization hardware, wait and signal procedures, Semaphores, Classic problems of synchronization, critical regions, Monitors, process scheduling and algorithms, threads, multithreading. **CPU Scheduling**: Scheduling criteria, Scheduling algorithms, Multiple processor scheduling, Real time scheduling	**9**
2	**Memory Management:** Background, Swapping, Contiguous memory allocation, Paging, Segmentation, Segmentation with paging. Virtual Memory, Demand paging, Page replacement policies, Allocation of frames, Thrashing, case study.	**8**
3	**Deadlock and Device Management:** ***Deadlock:*** System model, Deadlock characterization, Methods for handling deadlocks, Deadlock prevention, Deadlock avoidance, Deadlock detection, Recovery from deadlock. ***Device management***: devices and their characteristics, device drivers, device handling, disk scheduling algorithms, Swap space management.	**9**
4	**File Systems and Its Implementation**: File System Interface, File concepts, Access methods, Directory structure, File system mounting, Directory implementation, Allocation methods, Free space management – efficiency and performance, recovery, log structured file systems	**7**
5	**Protection and Case Studies:** ***Protection***: Goals of protection, Principles of protection, Domain of protection, Access matrix, Implementation of access matrix, Access control, Revocation of access rights, file security, user authentication	**7**

	Case Study: Linux Operating System Linux history; Design principles; Kernel modules; Process management; Scheduling; Memory management; File systems, Input and output; Inter-process communication, Case studies of Real Time and Mobile OS.	
Total		**40**

Suggested Books:

1. Silberschatz, Galvin, and Gagne, "Operating System Concepts", Wiley India Pvt Ltd.
2. Modern Operating Systems, Andrew S. Tanenbaum, Herbert Bos, Pearson Education India; Fourth edition 2016. ISBN-13:978- 9332575776
3. Operating Systems: Internals and Design Principles William Stallings, Pearson Education India; 7 edition (2013). ISBN-13: 978-9332518803
4. Gary Nutt, "Operating Systems", Third Edition, Pearson Education
5. Operating Systems: A Design-Oriented Approach, Charles Crowley, International edition, McGraw-Hill Education (ISE Editions). ISBN-13 978 0071144629

V Semester
B. Tech.(Computer Science & Engineering (Data Science))

5CD4-02: Computer Organization and Architecture

Credit: 3	**Max. Marks: 100 (IA:30, ETE:70)**
3L+0T+ 0P	**End Term Exams: 3 Hours**

Course Objectives:
As a result of successfully completing this course, students will:

- Learn the principles of computer organization and basic architectural concepts.
- Understand the basics of instructions sets and their impact on processor design.
- Demonstrate an understanding of the design of the functional units of a digital computer system.
- Evaluate cost performance and design trade-offs in designing and constructing a computer processor including memory.
- Design a pipeline for consistent execution of instructions with minimum hazards.
- Recognize and manipulate representations of numbers stored in digital computers.

Course Outcomes:
Upon successful completion of the course, students will be able to

CO-1: Study of the basic structure and operation of a digital computer system.

CO-2: Analysis of the design of arithmetic & logic unit and understanding of the fixed point and floating point arithmetic operations.

CO-3: Implementation of control unit techniques and the concept of Pipelining.

CO-4: Understanding the hierarchical memory system, cache memories and virtual memory.

CO-5: Understanding the different ways of communicating with I/O devices and standard I/O interfaces.

S. No.	Contents	Hours
1	**Introduction:** Objective, scope and outcome of the course.	**1**
2	**Register Transfer and Micro-operations**: Register Transfer Language (RTL), Bus and Memory Transfers, Arithmetic Micro-Operations, Logic Micro-Operations, Shift Micro-Operations, Arithmetic Logic Shift Unit (ALU).	**9**
3	**Basic Computer Organization and Design**: Instruction Codes, Computer Registers, Computer Instructions, Timing and Control, Instruction Cycle, Register-Reference and Memory- Reference Instructions, Input-Output and Interrupt, Design of Basic Computer.	**8**
4	**Central Processing Unit:** General Register Organization, Stack Organization, Instruction Format, Addressing Modes, Data Transfer and Manipulation, Program Control, Reduced Instruction Set Computer (RISC) and Complex Instruction Set Computer (CISC).	**8**
5	**Pipeline and Vector Processing**: Flynn's Taxonomy, Parallel Processing, Pipelining, Arithmetic Pipeline, Instruction Pipeline. **Computer Arithmetic**: Signed Magnitude Binary Numbers - Addition and Subtraction, Multiplication- Booth Multiplication Algorithm, Array Multiplier, Division Algorithm.	**8**
6	**Input-Output Organization**: Input-output Interface Modes of Transfer, Daisy Chaining Priority, Direct Memory Access (DMA), Input-Output Processor (IOP)- CPU-IOP Communication. **Memory Organization**: Memory Hierarchy, Main Memory, Auxiliary Memory, Associative Memory, Cache Memory, Virtual Memory.	**8**
	Total	**42**

Suggested Books:

1. M. Morris Mano, Computer System Architecture, Pearson
2. Carl Hamacher, Zvonko Vranesic, Safwat Zaky Computer Organization, McGraw-Hill, Fifth Edition, Reprint 2012
3. John P. Hayes, Computer Architecture and Organization, Tata McGraw Hill, Third Edition, 1998.

Reference books

4. William Stallings, Computer Organization and Architecture-Designing for Performance, Pearson Education, Seventh edition, 2006.
5. Behrooz Parahami, "Computer Architecture", Oxford University Press, Eighth Impression, 2011.
6. David A. Patterson and John L. Hennessy, "Computer Architecture-A Quantitative Approach", Elsevier, a division of reed India Private Limited, Fifth edition, 2012
7. Structured Computer Organization, Tannenbaum(PHI)

V Semester
B. Tech.(Computer Science & Engineering (Data Science))

5CD4-03: Computer Networks

Credit: 3	**Max. Marks: 100 (IA:30, ETE:70)**
3L+0T+ 0P	**End Term Exams: 3 Hours**

Course Objectives:
As a result of successfully completing this course, students will:

- Become familiar with layered communication architectures (OSI and TCP/IP models).
- Understand different services offered by various OSI and TCP/IP model layers.
- Understand the client/server model and key application layer protocols.
- Understand the concept of unreliable data transfer and its role in communication.
- Understand the concepts of reliable data transfer and how TCP implements these concepts.
- Know the principles of congestion control and trade-offs in fairness and efficiency.
- Understand the role and concept of routing in communication.
- Understand the basics of error detection, including parity, checksums, and CRC.
- Familiarize the student with current topics such as security, network management, sensor networks, and/or other topics.

Course Outcomes:
Upon successful completion of the course, students will be able to

CO-1: Understand basic computer network technology.

CO-2: Understand OSI and TCP/IP reference model and working of each layer of these reference models.

CO-3: Obtain the skills of subnetting and routing mechanisms.

CO-4: Address design and implementation aspects of various essential network protocols and its integration into network-based applications.

S. No.	Contents	Hours
1	**Introduction:** history and development of computer networks, networks topologies. Layering and protocols. OSI and TCP/IP Protocol Stacks, Basics of packet, circuit and virtual circuit switching. **Physical Layer:** Guided Transmission media: twisted pairs, coaxial cable, fiber optics, Wireless transmission.	**6**
2	**Data link layer:** Design issues, framing, Error detection and correction. Elementary data link protocols: simplex protocol, A simplex stop and wait protocol for an error-free channel, A simplex stop and wait protocol for noisy channel. Sliding Window protocols: A one-bit sliding window protocol, A protocol using Go-Back-N, A protocol using Selective Repeat, Example data link protocols. Medium Access sub layer: The channel allocation problem, Multiple access protocols: ALOHA, Carrier sense multiple access protocols, collision free protocols. Wireless LANs, Data link layer switching, Ethernet bridging.	**8**
3	**Network Layer:** Design issues, Routing algorithms, shortest path routing, Flooding, Hierarchical routing, Broadcast, Multicast, distance vector routing, link state routing, Congestion Control Algorithms, Quality of Service, Internetworking, Fragmentation, The Network layer in the internet, IP addressing, IPv4, IPv6. CIDR, NAT, Basics of IP support protocols (ARP, DHCP, ICMP)	**8**
4	**Transport Layer:** Transport Services, Elements of Transport protocols, Connection management, Error and Flow Control, Congestion Control, TCP and UDP protocols, Sockets.	**7**
5	**Application Layer**: Domain name system, Electronic Mail; the World Wide Web, HTTP,	**7**

	FTP, Streaming audio and video.	
6.	**Current Topics Related to Computer Network**: Basic overview of the role and working of topic such as Software-defined Networks, Wireless Sensor Networks and Internet of Things, Cyber-physical systems	**6**
Total		**42**

Suggested Books:

1. Computer Networks, Andrew S. Tanenbaum and David J Wetherall, 5th Edition. Pearson publication.
2. Computer Networking: A Top-Down Approach Featuring the Internet, James F Kurose and Keith W Ross. Pearson publication.
3. Computer Networking: A Top-Down Approach, Behrouz A. Forouzan, Firouz Mosharraf, TMH.
4. Data Communications and Networking – Behrouz A. Forouzan. 4th Edition TMH.
5. Computer Networks: A Systems Approach, 5th Ed., LL Peterson, BS Davie, Morgan-Kauffman, 2011.
6. Cryptography and Network Security, Principles and Practice, 5th Ed., W Stallings, Prentice-Hall, 2010
7. Internet of Things: A Hands-on Approach , by Arshdeep Bagha and Vijay Madisetti, Universities Press, 2015, ISBN: 9788173719547
8. Fundamentals of Cyber-Physical Systems - https://eprints.whiterose.ac.uk/173235/1/Chapter%201 .%20 Fundamentals%20of%20 Cyber-Physical %20Systems.pdf
9. Cyber-Physical Systems and Internet of Things - https://nvlpubs.nist.gov/nistpubs/SpecialPublications /NIST.SP.1900-202.pdf

V Semester
B. Tech.(Computer Science & Engineering (Data Science))

5CD4-04: Fuzzy Logic and Soft Computing Algorithms

Credit:3	**Max. Marks: 100 (IA:30, ETE:70)**
3L+0T+ 0P	**End Term Exams: 3 Hours**

Course Objectives:
As a result of successfully completing this course, students will:

- Able to understand basics of Fuzzy Set
- Able to understand the concepts of the genetic algorithms.
- Able to understand the ide of the evolutionary algorithms.
- Able to understand working of latest state of art Evolutionary Algorithms.
- Able to understand basic python/MATLAB libraries.

Course Outcomes:
Upon successful completion of the course, students will be able to

CO-1: Comprehend the fuzzy logic and the concept of fuzziness involved in various systems and fuzzy set theory.
CO-2: Understand the concepts of fuzzy sets, knowledge representation using fuzzy rules, approximate reasoning, fuzzy inference systems, and fuzzy logic
CO-3: Describe with genetic algorithms and other random search procedures useful while seeking global optimum in self learning situations.
CO-4: Develop some familiarity with current research problems and research methods in Soft Computing Techniques
CO-5: Develop some familiarity with Latest state of art Evolutionary Algorithms.

S. No.	Contents	Hours
1	**Introduction to Soft Computing**: Aims of Soft Computing-Foundations of Fuzzy Sets Theory-Basic Concepts and Properties of Fuzzy Sets- Elements of Fuzzy Mathematics-Fuzzy Relations-Fuzzy Logic	**6**
2	**Application of Fuzzy Sets**: Applications of Fuzzy Sets-Fuzzy Modeling – Fuzzy Decision Making-Pattern Analysis and Classification-Fuzzy Control Systems-Fuzzy Information Processing- Fuzzy Robotics.	**6**
3	**Neuro-Fuzzy Technology**: Fuzzy Neural Networks and their learning-Architecture of Neuro- Fuzzy Systems- Generation of Fuzzy Rules and membership functions - Fuzzification and Defuzzyfication in Neuro-Fuzzy Systems- Neuro-Fuzzy Identification - Neuro Fuzzy Control- Combination of Genetic Algorithm with Neural Networks- Combination of Genetic Algorithms and Fuzzy Logic-Neuro-Fuzzy and Genetic Approach in engineering applications.	**6**
4	**Basic Evolutionary Processes, EV**: A Simple Evolutionary System, Evolutionary Systems as Problem Solvers, A Historical Perspective, Canonical Evolutionary Algorithms - Evolutionary Programming, Evolution Strategies, A Unified View of Simple EAs- A Common Framework, Population Size	**6**
5	**Genetic Algorithms**: Main Operators- Genetic Algorithm Based Optimization-Principle of Genetic Algorithm- Genetic Algorithm with Directed Mutation- Comparison of Conventional and Genetic Search Algorithms Issues of GA in practical implementation. Introduction to Particle swarm optimization-PSO operators-GA and PSO in engineering applications	**8**
6	**New trends in Evolutionary Algorithms:** Ant Colony Optimization: Ant system, MM-AS, Ant Miner, Snake-Ant Algorithm. Artificial Bee Colony, Cuckoo Search Algorithm. Co-	**10**

	evolution, Plasticity and lifetime learning, Lamarckian learning, the "No free lunch" theorem.	
Total		**42**

Suggested Books:

1.An Introduction to Genetic Algorithm Melanic Mitchell (MIT Press)
2.Evolutionary Algorithm for Solving Multi-objective, Optimization Problems (2nd Edition), Collelo, Lament, Veldhnizer (Springer)
3.Fuzzy Logic with Engineering Applications Timothy J. Ross (Wiley)
4.Sivanandam, Deepa, " Principles of Soft Computing", Wiley
5.Jang J.S.R, Sun C.T. and Mizutani E, "Neuro-Fuzzy and Soft computing", Prentice Hall
6.Timothy J. Ross, "Fuzzy Logic with Engineering Applications", McGraw Hill

V Semester B. Tech.(Computer Science & Engineering (Data Science))	
5CD4-05: Mathematical Foundation Course	
Credit: 3	**Max. Marks: 100 (IA:30, ETE:70)**
3L+0T+ 0P	**End Term Exams: 3 Hours**

Course Objectives:
As a result of successfully completing this course, students will:

- Able to learn and understand the fundamental concepts in probability & statistics, Liner methods, Basic of vector space and Linear Transformations.
- Able to perform test of hypothesis
- Learn about Mathematics foundation of various ML, AI and DS methods.

Course Outcomes:
Upon successful completion of the course, students will be able to

CO-1:.Able to Understand sampling theory and sampling distributions

CO-2: Able to Understand multivariate statistics

CO-3: To make aware of the Sampling and Test of Hypothesis.

CO-4: Able to Understand about basic linear algebra

CO-5: Able to Understand the Linear Transformations and its use in AI.

S. No.	Contents	Hours
1	**Sampling Theory:** Population and Sample, Statistical inference, Sampling with and without replacement, Random samples, Population parameters, Sample statics, Sampling distributions, Sample mean, Sampling distribution of means, Sample variances, Sampling distribution of variances, Case where population variances is unknown, Unbiased estimates and efficient estimates, the point estimate and Interval Estimates, & Confidence Interval, sampling distributions, Confidence Interval estimates of population parameters, Confidence intervals for the variance of a Normal distribution, Maximum likelihood estimates**.**	**10**
2	**Introduction to Multivariate Statistics-**Degree of Relationship among Variables-Review of Univariate and Bivariate Statistics-Screening Data Prior to Analysis-Missing Data, Outliers, Normality, Linearity, and Homoscedasticity	**6**
3	**Test of Hypothesis and Significance** Statistical hypothesis, Null and Alternate hypothesis, the test of hypothesis and significance, Type I and Type II errors, Level of Significance, Tests involving the Normal distribution, Goodness of fit, Test of Independence, Permutations and Randomization Test, t-test/z-test (one sample, independent, paired), One-Tailed and Two-Tailed tests, P-value. Special tests of significance for large samples and small samples (F, chi-square, z,), Analysis of Variance and Covariance (ANOVA & ANCOVA) - Multivariate Analysis of Variance and Covariance (MANOVA & MANCOVA)	**10**
4	**Basics of Linear Algebra:** System of Linear Equations, Vector space and subspaces (definition, examples, and concepts of basis), Linear mappings, Matrices, Eigenvalues and Eigenvectors Norms, Inner Product, Orthogonally, Spectral Decomposition, Singular value Decomposition, Low-rank Approximation, Projection, Principal Component Analysis and Generative Model	**8**
5	**Linear Transformations:** Linear Transformations and Matrices for Linear Transformation, Kernel and Range of a Linear Transformations, Change of Basis **Information Theory:** Entropy, cross-entropy, KL divergence, mutual information	**6**
	Total	**40**

Suggested Books:

1. M. P. Deisenroth, A. A. Faisal, C. S. Ong, Mathematics for Machine Learning, Cambridge

University Press (1st edition) 2020
2. S. Axler, Linear Algebra Done Right. Springer International Publishing (3rd edition) 2015
3. E. Kreyszig, Advanced Engineering Mathematics, John Wiley and Sons, Inc., U.K. (10th Edition) 2015
4. R. A. Johnson, I. Miller, and J. E. Freund, "Miller & Freund's Probability and Statistics for Engineers", Prentice Hall PTR, (8th edition) 2011
5. E. Walpole, R. H. Mayers, S. L. Mayers, and K. Ye, (2007), Probability and Statistics for Engineers and Scientists,8th Edition, Pearson Education
6. Douglas C. Montgomery, (2012), Applied Statistics and Probability for Engineers, 5th Edition, Wiley India,
7. Spiegel, M. R., Schiller, J., and Srinivasan, R. A., (2010), Probability & Statistics, 3rdEdition, Tata McGraw Hill,
8. S.C. Gupta & V.K. Kapoor, "Fundamentals of Mathematical Statistics", Sultan Chand & Sons
9. Sheldon M. Ross, "Introduction to Probability and Statistics for Engineers and Scientists", Academic Press.

V Semester B. Tech.(Computer Science & Engineering (Data Science))	
5CD5-11: Information Security Systems	
Credit: 2	**Max. Marks: 100 (IA:30, ETE:70)**
2L+0T+ 0P	**End Term Exams: 3 Hours**

Course Objectives:
As a result of successfully completing this course, students will:

- Understand vulnerability in a computer system.
- Understand basic concept of how to protect and design private network.
- Understand how to protect security of information.
- Use theoretical and practical knowledge in securing data transfer and authentication.

Course Outcomes:
Upon successful completion of the course, students will be able to

CO-1: Identify the security issues in the network and resolve it

CO-2: Analyze the vulnerabilities in any computing system and hence be able to design a security solution.

CO-3: Evaluate security mechanisms using rigorous approaches by key ciphers and Hash functions.

CO-4: To understand various network security applications, IPSec, Firewall, IDS, Web Security, Email Security and Malicious software

S. No.	Contents	Hours
1	**Introduction:** Objective, scope and outcome of the course.	**1**
2	Security Attacks, Security Services, Security Mechanisms and Principles, Security goals, Malicious software, Worms, Viruses, Trojans, Spyware, Botnets	**5**
3	**Basic of Cryptography:** Symmetric and asymmetric cryptography, cryptographic hash functions, authentication and key establishment, Message Authentication Codes (MACs), digital signatures.	**5**
4	**Security Vulnerabilities:** DoS attacks, Buffer Overflow, Race Conditions, Access Control Problems, Spoofing and Sniffing attacks.	**5**
5	**Internet Security:** TCP/IP Security, Secure Sockets Layer (SSL), Transport Layer Security (TLS), HTTPS, Secure Shell (SSH), IPsec, Email Security, DNS Security, Authentication Protocols	**5**
6	**Web Security:** Phishing attack, SQL Injection, Securing databases and database access, Cross Site Scripting Attacks, Cookies, Session Hijacking, E-commerce security **System Security:** Firewalls, Types: Packet filter (stateless, stateful), Application layer proxies, Firewall Location and Configurations, Intruders, Intrusion Detection System.	**7**
	Total	**28**

Suggested Books:

1. Stallings, W., Network Security Essentials, Prentice Hall (2017) 6th Edition.
2. Cheswick, R., W., Bellovin, M., S., and Rubin, D., A., Firewalls and Internet Security, Addison-Wesley Professional (2003) 2nd Edition.
3. Graves, K., Certified Ethical Hacking Study Guide,Sybex (2010) 1st Edition.
4. Stallings, W., Cryptography and Network Security, Prentice Hall (2013), 6th Edition.

V Semester B. Tech.(Computer Science & Engineering (Data Science))	
5CD5-12: Smart Systems	
Credit: 2	**Max. Marks: 100 (IA:30, ETE:70)**
2L+0T+ 0P	**End Term Exams: 3 Hours**

Course Objectives:

As a result of successfully completing this course, students will:

- To introduce the fundamental concepts of MEMS based sensors and actuators.
- To acquaint the students with various materials and material properties for Microsystem designing.
- To provide comprehensive understanding of various micromachining techniques and expose the students to design, simulation and analysis software.

Course Outcomes:

Upon successful completion of the course, students will be able to

CO-1: Identify and understand the fundamental concepts and background of MEMS and Microsystems.

CO-2: Familiar with the basics of various sensors and actuators.

CO-3: Recognize and interpret various micromachining techniques and design, analysis and applications of various MEMS devices micromachining tools and techniques

CO-4: Incorporate simulation and micro-fabrication knowledge for developing various MEMS devices.

S. No.	Contents	Hours
1	Introduction to Sensor Devices, Piezoresistive pressure sensor, Piezoresistive Accelerometer, Capacitive Sensing, Accelerometer and Microphone, Resonant Sensor and Vibratory Gyroscope, Low-Power, Low Voltage Sensors Micro Electro Mechanical Systems Analysis and Design of MEMS Devices- Nano Sensors.	**5**
2	Interfacing Sensor Information and MCU Amplification and Signal Conditioning, Integrated Signal Conditioning, Digital conversion, MCU Control MCUs for Sensor Interface, Techniques and System Consideration, Sensor Integration.	**6**
3	Control Techniques and Standards Control of Sensors using - State Machines, Fuzzy Logic, Neural Networks, Adaptive Control. Control Application using - CISC, RISC, DSP Control and IEEE 1451 Standards.	**6**
4	Communication For Smart Sensors Wireless Data Communications- RF Sensing, Telemetry, Automotive Protocols, Industrial Networks Home Automation, MCU Protocols.	**6**
5	Packaging, Testing and Reliability Implications of Smart Sensors Semiconductor Packaging- Hybrid Packaging- Packaging for Monolithic Sensors- Reliability Implications Testing Smart Sensors- HVAC Sensor Chip	**5**
	Total	**28**

Suggested Books:

1. G. K. Ananthasuresh, K J Vinoy, S Gopalakrishnan, KN Bhatt, V K Aatre," Micro and Smart Systems: Technology and Modeling ", 2012, 1st ed., Wiley, New York.
2. Tai-Ran Hsu, “MEMS & Microsystem, Design and Manufacture”, 2017, 1st ed., McGraw Hill India, New Delhi.
3. Wolfgang Menz, Jürgen Mohr, Oliver Paul, "Microsystem Technology", 2011, 2nd ed., Wiley, New York.
4. Banks H.T. Smith R.C. and Wang Y. Smart, ‘Material Structures – Modeling, Estimation and Control’, 2011, 1st ed., John Wiley & Sons, NewYork.
5. Artificial Intelligence: A Modern Approach by S. Russell and P. Norvig, Prentice Hall.

V Semester
B. Tech.(Computer Science & Engineering (Data Science))

5CD5-13: Distributed Systems

Credit: 2	**Max. Marks: 100 (IA:30, ETE:70)**
2L+0T+ 0P	**End Term Exams: 3 Hours**

Course Objectives: As a result of successfully completing this course, students will:

- To Understand hardware and software issues in modern distributed systems.
- To get knowledge in distributed architecture, naming, synchronization, consistency and replication, fault tolerance, security, and distributed file systems.
- To analyze the current popular distributed systems such as peer-to-peer (P2P) systems will also be analyzed.

Course Outcomes: Upon successful completion of the course, students will be able to

CO-1: To understand the foundations of distributed systems.

CO-2: To learn issues related to clock Synchronization and the need for global state in distributed systems.

CO-3: To learn distributed mutual exclusion and deadlock detection algorithms.

CO-4: To understand the significance of agreement, fault tolerance and recovery protocols in Distributed Systems.

CO-5: To learn the characteristics of peer-to-peer and distributed shared memory systems

S. No.	Contents	Hours
1	**Introduction:** Objective, scope and outcome of the course.	**1**
2	**Distributed Systems:** Features of distributed systems, nodes of a distributed system, Distributed computation paradigms, Model of distributed systems, Types of Operating systems: Centralized Operating System, Network Operating Systems, Distributed Operating Systems and Cooperative Autonomous Systems, design issues in distributed operating systems. Systems Concepts and Architectures: Goals, Transparency, Services, Architecture Models, Distributed Computing Environment (DCE).	**5**
3	**Theoretical issues in distributed systems:** Notions of time and state, states and events in a distributed system, time, clocks and event precedence, recording the state of distributed systems. **Concurrent Processes and Programming:** Processes and Threads, Graph Models for Process Representation, Client/Server Model, Time Services, Language Mechanisms for Synchronization.	**5**
4	**Distributed Process Scheduling:** A System Performance Model, Static Process Scheduling with Communication, Dynamic Load Sharing and Balancing, Distributed Process Implementation. Distributed File Systems: Transparencies and Characteristics of DFS, DFS Design and implementation, Transaction Service and Concurrency Control	**5**
5	**Distributed Shared Memory**: Non-Uniform Memory Access Architectures, Memory Consistency Models, Multiprocessor Cache Systems, Distributed Shared Memory, Implementation of DSM systems.	**6**
6	**Distributed Agreement:** Concept of Faults, failure and recovery, Replicated Data Management: concepts and issues, Database Techniques, Atomic Multicast, and Update Propagation. CORBA case study: Introduction, Architecture, CORBA RMI, CORBA Services.	**6**
	Total	**28**

Suggested Books:

1. Distributed Systems, Principles and Paradigms, 2nd edition by Andrew S. Tanenbaum and Maarteen Van Steen, Pearson Education, (ISBN-13: 978- 0132392273), 2013 IT-89
2. Distributed System: Concepts and Design, 5th edition by Coulouris, Dollimore, Kindberg,Pearson Ed, (ISBN-13: 978-0132143011), 2013
3. Distributed Algorithms: Principles, Algorithms, and Systems by A. D. Kshemkalyani and M. Singhal, (ISBN-13: 978-0521189842) , 2013

V Semester B. Tech.(Computer Science & Engineering (Data Science))	
5CD5-14: Cloud Computing	
Credit: 2	**Max. Marks: 100 (IA:30, ETE:70)**
2L+0T+ 0P	**End Term Exams: 3 Hours**

Course Objectives: As a result of successfully completing this course, students will:

- The fundamental ideas behind Cloud Computing, the evolution of the paradigm, its applicability; benefits
- The basic ideas and principles in data center design; cloud management techniques and cloud software deployment considerations;
- Different CPU, memory and I/O virtualization techniques in cloud

Course Outcomes: Upon successful completion of the course, students will be able to

CO-1: Explain the core concepts of the cloud computing paradigm

CO-2: Discuss system, network and storage virtualization and outline their role in enabling the cloud computing system model.

CO-3: Understanding security architecture of cloud infrastructure

S. No.	Contents	Hours
1	**Introduction:** Objective, scope and outcome of the course.	**1**
2	**Cloud Computing:** Nutshell of cloud computing, Enabling Technology, Historical development, Vision, feature Characteristics and components of Cloud Computing. Challenges, Risks and Approaches of Migration into Cloud. Ethical Issue in Cloud Computing, Evaluating the Cloud's Business Impact and economics, Future of the cloud. Networking Support for Cloud Computing.	**5**
3	**Cloud Computing Architecture:** Cloud Reference Model, Layer and Types of Clouds, Services models, Data centre Design and interconnection Network, Architectural design of Compute and Storage Clouds. Cloud Programming and Software: Fractures of cloud programming, Parallel and distributed programming paradigms-Map Reduce, Hadoop, High level Language for Cloud. Programming of Google App engine	**6**
4	**Virtualization Technology:** Definition, Understanding and Benefits of Virtualization. Implementation Level of Virtualization, Virtualization Structure/Tools and Mechanisms, Hypervisor VMware, KVM, Xen. Virtualization of CPU, Memory, I/O Devices, Virtual Cluster and Resources Management, Virtualization of Server, Desktop, Network, and Virtualization of data-centre	**5**
5	**Securing the Cloud:** Cloud Information security fundamentals, Cloud security services, Design principles, Policy Implementation, Cloud Computing Security Challenges, Cloud Computing Security Architecture . Legal issues in cloud Computing.	**5**
6	**Data Security in Cloud:** Business Continuity and Disaster Recovery , Risk Mitigation , Understanding and Identification of Threats in Cloud, SLA-Service Level Agreements, Trust Management	**6**
	Total	**28**

Suggested Books:

1. Rajkumar Buyya, James Broberg, Andrzej M. Goscinski: "Cloud Computing: Principles and Paradigms", Wiley, 2011
2. Rajkumar Buyya, Christian Vecchiola, S Thamarai Selvi, Mastering Cloud Computing, Tata McGraw Hill, 2013
3. Barrie Sosinsky: "Cloud Computing Bible", Wiley-India, 2010

4. Ronald L. Krutz, Russell Dean Vines: "Cloud Security: A Comprehensive Guide to Secure Cloud Computing", Wiley-India, 2010
5. Tim Mather, Subra Kumara swamy, Shahed Latif, Cloud Security and Privacy: An Enterprise Perspective on Risks and Compliance, O'Reilly Media, 2009.

V Semester B. Tech.(Computer Science & Engineering (Data Science))	
5CD5-15: Introduction to Blockchain	
Credit: 2	**Max. Marks: 100 (IA:30, ETE:70)**
2L+0T+ 0P	**End Term Exams: 3 Hours**

Course Objectives: As a result of successfully completing this course, students will:

- The students should be able to understand a broad overview of the essential concepts of blockchain technology.
- To familiarize students with Bitcoin protocol followed by the Ethereum protocol – to lay the foundation necessary for developing applications and programming.
- Students should be able to learn about different types of blockchain and consensus algorithms.

Course Outcomes: Upon successful completion of the course, students will be able to

CO-1: To explain the basic notion of distributed systems.

CO-2: To use the working of an immutable distributed ledger and trust model that defines blockchain.

CO-3: To illustrate the essential components of a blockchain platform.

S. No.	Contents	Hours
1	**Introduction:** Objective, scope and outcome of the course.	**1**
2	Basics: The Double-Spend Problem, Byzantine Generals' Computing Problems, Public-Key Cryptography, Hashing, Distributed Systems, Distributed Consensus.	**5**
3	Technology Stack: Blockchain, Protocol, Currency. Bitcoin Blockchain: Structure, Operations, Features, Consensus Model, Incentive Model	**5**
4	Ethereum Blockchain: Smart Contracts, Ethereum Structure, Operations, Consensus Model, Incentive Model.	**5**
5	Tiers of Blockchain Technology: Blockchain 1.0, Blockchain 2.0, Blockchain 3.0, Types of Blockchain: Public Blockchain, Private Blockchain, Semi-Private Blockchain, Sidechains.	**6**
6	Types of Consensus Algorithms: Proof of Stake, Proof of Work, Delegated Proof of Stake, Proof Elapsed Time, Deposite-Based Consensus, Proof of Importance, Federated Consensus or Federated Byzantine Consensus, Practical Byzantine Fault Tolerance. Blockchain Use Case: Supply Chain Management.	**6**
Total		**28**

Suggested Books:

1. Kirankalyan Kulkarni, Essentials of Bitcoin and Blockchain, Packt Publishing.
2. Anshul Kaushik, Block Chain & Crypto Currencies, Khanna Publishing House.
3. Tiana Laurence, Blockchain for Dummies, 2nd Edition 2019, John Wiley & Sons.
4. Mastering Blockchain: Deeper insights into decentralization, cryptography, Bitcoin, and popular Blockchain frameworks by Imran Bashir, Packt Publishing (2017).
5. Blockchain: Blueprint for a New Economy by Melanie Swan, Shroff Publisher O'Reilly Publisher Media; 1st edition (2015).

V Semester B. Tech.(Computer Science & Engineering (Data Science))	
5CD5-16: Natural Language Processing	
Credit:2	**Max. Marks: 100 (IA:30, ETE:70)**
2L+0T+ 0P	**End Term Exams: 3 Hours**

Course Objectives:

As a result of successfully completing this course, students will:

- Able Able to Understand language and the tools that are available to efficiently study
- Analyze large collections of text and should learn about the effects of electronic communication on our language.

Course Outcomes:

Upon successful completion of the course, students will be able to

CO-1: Learn about major NLP issues and solutions

CO-2: Become agile with NLP programming.

CO-3: Be able to asses NLP problems

CO-4: Understand Natural language understanding, processing, generation

S. No.	Contents	Hours
1	**Introduction:** Objective, scope and outcome of the course.	**1**
2	**Introduction:** A computational framework for natural language, description of English or an Indian language in the frame work, lexicon, algorithms and data structures for implementation of the framework, Finite state automata. Applications like machine translations.	**5**
3	**Word Level and Syntactic Analysis:** Word Level Analysis: Regular Expressions, Finite-State Automata, Morphological Parsing, Spelling Error Detection and correction, Words and Word classes, Part-of Speech Tagging. Syntactic Analysis: Context-free Grammar, Constituency, Parsing-Probabilistic Parsing. Machine-readable dictionaries and lexical databases , RTN, ATN.	**5**
4	**Semantic Analysis:** Semantic Analysis: Meaning Representation, Lexical Semantics, Ambiguity, Word Sense Disambiguation. Discourse Processing: cohesion, Reference Resolution, Discourse Coherence and Structure. Knowledge Representation, reasoning.	**5**
5	**Natural Language Generation:** Natural Language Generation (NLG): Architecture of NLG Systems, Generation Tasks and Representations, Application of NLG. Machine Translation: Problems in Machine Translation, Characteristics of Indian Languages, Machine Translation Approaches, Translation involving Indian Languages.	**6**
6	**Information Retrieval and Lexical Resources:** Information Retrieval: Design features of Information Retrieval Systems, Classical, Non-classical, Alternative Models of Information Retrieval, valuation Lexical Resources: World Net,Frame Net, Stemmers, POS Tagger.	**6**
	Total	**28**

Suggested Books:

1. Natural Language understanding by James Allen, Pearson Education 2008
2. NLP: A Paninian Perspective by Akshar Bharati, Vineet Chaitanya, and Rajeev Sangal, Prentice Hall
3. Meaning and Grammar by G. Chirchia and S. McConnell Ginet, MIT Press
4. An Introduction to Natural Language Processing, Computational Linguistics, and Speech Recognition by Daniel Jurafsky and James H. Martin, Pearson Education
5. Natural language processing in Prolog by Gazdar, & Mellish, Addison-Wesley

V Semester B. Tech.(Computer Science & Engineering (Data Science))	
5CD4-21: Soft Computing Lab	
Credit: 1	**Max. Marks: 100 (IA:60, ETE:40)**
0L+0T+ 2P	**End Term Exams: 2 Hours**

Course Objectives: As a result of successfully completing this course, students will:

- Gain hands-on experience in implementing and applying machine learning algorithms and techniques.
- Develop skills in preprocessing and analyzing data for machine learning tasks.
- Acquire proficiency in using popular machine learning frameworks and libraries.
- Learn to evaluate and optimize machine learning models through practical experimentation.

Course Outcomes: Upon successful completion of the course, students will be able to

CO-1: Develop practical skills in implementing and training machine learning models using various algorithms and techniques.

CO-2: Gain hands-on experience in preprocessing and analyzing real-world datasets for machine learning tasks.

CO-3: Acquire proficiency in using industry-standard tools and libraries for machine learning and AI development.

CO-4: Learn to evaluate model performance, interpret results, and make data-driven decisions.

CO-5: Apply ethical considerations and address potential biases in the design and implementation of machine learning systems.

S. No.	**List of Experiments**
1	**MATLAB/Python Lib:** Introduction to MATLAB/Python, Arrays and array operations, Functions and Files, Study of neural network toolbox and fuzzy logic toolbox, Simple implementation of Artificial Neural Network and Fuzzy Logic.
2	Implement and demonstrate the FIND-S algorithm for finding the most specific hypothesis based on a given set of training data samples. Read the training data from a .CSV file.
3	For a given set of training data examples stored in a .CSV file, implement and demonstrate the Candidate-Elimination algorithm to output a description of the set of all hypotheses consistent with the training examples.
4	Write a program to demonstrate the working of the decision tree based ID3 algorithm. Use an appropriate data set for building the decision tree and apply this knowledge to classify a new sample
6	Build an Artificial Neural Network by implementing the Backpropagation algorithm and test the same using appropriate data sets
7	Write a program to implement the naïve Bayesian classifier for a sample training data set stored as a .CSV file. Compute the accuracy of the classifier, considering few test data sets.
8	Write a program to construct a Bayesian network considering medical data. Use this model to demonstrate the diagnosis of heart patients using standard Heart Disease Data Set. You can use Java/Python ML library classes/API.
9	Apply EM algorithm to cluster a set of data stored in a .CSV file. Use the same data set for clustering using k-Means algorithm. Compare the results of these two algorithms and comment on the quality of clustering. You can add Java/Python ML library classes/API in the program.
10	Write a program to implement k-Nearest Neighbour algorithm to classify the iris data set. Print both correct and wrong predictions. Java/Python ML library classes can be used for this problem.

Suggested Books:

1. Mitchell M., T., Machine Learning, McGraw Hill (1997) 1stEdition.
2. Kevin Murphy, Machine Learning: A Probabilistic Perspective, MIT Press, 2012
3. Ethem Alpaydin, Introduction to Machine Learning, MIT Press, 2004
4. Tom Mitchell, Machine Learning, McGraw Hill, 1997.
5. Pat Langley , Elements of Machine Learning, Morgan Kaufmann Publishers, Inc. 1995. ISBN 1-55860-301-8
6. Bishop M., C., Pattern Recognition and Machine Learning, Springer-Verlag (2011) 2ndEdition.
7. Michie D., Spiegelhalter J. D., Taylor C. C., Campbell, J., Machine Learning, Neural and Statistical Classification. Overseas Press (1994).

V Semester B. Tech.(Computer Science & Engineering (Data Science))	
5CD4-22: R Programming Lab	
Credit: 1	**Max. Marks: 100 (IA:60, ETE:40)**
0L+0T+ 2P	**End Term Exams: 2 Hours**

Course Objectives:
As a result of successfully completing this course, students will:

- Explain critical R programming concepts
- Demonstrate how to install and configure RStudio and Apply OOP concepts in R programming
- Explain the use of data structure and loop functions
- Analyze data and generate reports based on the datasets

Course Outcomes:
Upon successful completion of the course, students will be able to

CO-1: Show the installation of R Programming Environment.
CO-2: Utilize and R Data types for developing programs.
CO-3: Make use of different R Data Structures.
CO-4: Develop programming logic using R Packages.
CO-5: Analyze the datasets using R programming capabilities.

S. No.	List of Experiments
1	Point-to-point transformation. This laboratory experiment provides for thresholding an image and the evaluation of its histogram. Histogram equalization. This experiment illustrates the relationship among the intensities (gray levels) of an image and its histogram.
2	Geometric transformations. This experiment shows image rotation, scaling, and translation. Two-dimensional Fourier transform
3	Linear filtering using convolution. Highly selective filters.
4	Ideal filters in the frequency domain. Non Linear filtering using convolutional masks. Edge detection. This experiment enables students to understand the concept of edge detectors and their operation in noisy images.

Suggested Books:

1. R Programming for Data Science, Roger D Peng, Lean Publication, 2016
2. R for Data Science: Import, Tidy, Transform, Visualize, and Model Data by Hadley Wickham, O'RELLY, 2017
3. Hands-On Programming with R: Write Your Own Functions and Simulations, Garrett Goleman, O'RELLY, 2014 http://cran.r-project.org(link is external)

V Semester B. Tech.(Computer Science & Engineering (Data Science))	
5CD4-23: Data Visualization Lab	
Credit: 1	**Max. Marks: 100 (IA:60, ETE:40)**
0L+0T+ 2P	**End Term Exams: 2 Hours**

Course Objectives:

As a result of successfully completing this course, students will:

- Handle data and data visualisations to demonstrate an understanding of ethical considerations surrounding data (including data storage, citation, and protection).

Course Outcomes:

Upon successful completion of the course, students will be able to

CO-1: To introduce students to the fundamental problems, concepts, and approaches in the design and analysis of data visualization systems.

CO-2: Analyze data using exploratory visualization

CO-3: Build commonly requested types of visualizations as well as more advanced visualizations using ground-up customization.

CO-4: Create useful, performing visualizations from real-world data sources, including large and complex datasets

S. No.	List of Experiments
1	Learn how to import data from various sources such as SQL database, CSV, XML, XLSX into plot variables in python.
2	Study various data visualization library of python such as Matplotlib, Seaborn, plotly etc.
3	Use standard datasets and draw Scatter plot, line chart, bar chart, histogram, heatmap, using different python libraries
4	Use different data visualization techniques to filter the data.
5	Use different data visualization techniques to transform the data.
6	Use multiple data source to draw various visualization patterns.
7	Create a Time Series visualization For a sales dataset.
8	Create a trend line with a confidence band in any suitable dataset.
9	Show an example of Skewed data and removal of skewedness using data visualization Techniques.

Suggested Books:

1. Visualization Analysis & Design by Tamara Munzner (2014) (ISBN 9781466508910)
2. Interactive Data Visualization for the Web by Scott Murray 2nd Edition (2017)

VI Semester B. Tech.(Computer Science & Engineering (Data Science))	
6CD4-01: Compiler Design	
Credit: 3	**Max. Marks: 100 (IA:30, ETE:70)**
3L+0T+ 0P	**End Term Exams: 3 Hours**

Course Objectives:
As a result of successfully completing this course, students will:

- Familiar with basic ideas and the working of the compiler.
- Learn about syntax analysis.
- Learn about representation in the form of DAG.
- Learn about theory knowledge of Parsing, Code generation, and optimization.

Course Outcomes:
Upon successful completion of the course, students will be able to

CO-1: Acquire knowledge of different phases and passes of the compiler and use compiler tools like LEX and YACC.

CO-2: Understand the Top-Down and Bottom-up parsers and construction of LL, SLR, CLR, and LALR parsing tables.

CO-3: Acquire knowledge about runtime data structure, like symbol table organization and different techniques.

CO-4: Understand the target machine's run time environment, its instruction set for code generation, and techniques for code optimization.

S. No.	Contents	Hours
1	**Introduction:** Objective, scope, and outcome of the course. Compiler, Translator, Interpreter definition, Phase of compiler, Bootstrapping, Review of Finite automata lexical analyzer, Input, Recognition of tokens, Idea about LEX: A lexical analyzer generator, Error handling.	**6**
2	**Review of CFG Ambiguity of grammars:** Introduction to parsing. Top-down parsing, LL grammars & passers error handling of LL parser, Recursive descent parsing predictive parsers, Bottom-up parsing, Shift reduce parsing, LR parsers, Construction of SLR, Conical LR & LALR parsing tables, parsing with ambiguous grammar. Operator precedence parsing, Introduction of automatic parser generator: YACC error handling in LR parsers.	**10**
3	**Syntax-directed translation:** Construction of syntax trees, S-Attributed Definition, L-attributed definitions, Top-down translation. Intermediate code forms using postfix notation, DAG, Three address code, TAC for various control structures, Representing TAC using triples and quadruples, Boolean expression, and control structures.	**10**
4	**Runtime environments:** Storage allocation, Strategies, heap management, Activation records, Accessing local and non-local names in a block structured language, Parameters passing, Symbol table organization, Data structures used in symbol tables.	**8**
5	**Definition of basic block control flow graphs:** DAG representation of basic block, Advantages of DAG, Sources of optimization, Loop optimization, Loop invariant computation, Peephole optimization, Issues in the design of code generator, A simple code generator, Code generation from DAG. Machine Independent Optimization: Idea about global data flow analysis, constant propagation, liveness analysis, and common subexpression elimination.	**6**
Total		**40**

Suggested Books:

1. Compilers: Principles, Techniques, and Tools, Second Edition, Alfred Aho, Monica Lam, Ravi Sethi, Jeffrey D. Ullman, January 2013. ISBN-978-9332518667.
2. Modern Compiler Implementation in Java. Andrew W Appel, Jens Paisberg. Cambridge University Press, January 2002. ISBN-978-0521820608
3. Modern Compiler Implementation in ML, Andrew W Appel, Cambridge University Press, December 1997. ISBN-0 521 58274 1
4. Modern Compiler Implementation in C, Andrew W Appel, Cambridge University Press, December 1997. ISBN 0-521-60765-5
5. Compiler Construction: Principles and Practice, 1st Edition, Kenneth C. Louden, Cengage Learning; 1 edition (January 24, 1997), ISBN-13: 978-0534939724
6. V Raghvan, " Principles of Compiler Design," McGraw-Hill, ISBN:9780070144712

VI Semester B. Tech.(Computer Science & Engineering (Data Science))	
6CD4-02: Design and Analysis of Algorithms	
Credit: 3	**Max. Marks: 100 (IA:30, ETE:70)**
3L+0T+ 0P	**End Term Exams: 3 Hours**

Course Objectives:
As a result of successfully completing this course, students will:

- Able to analyze asymptotic runtime complexity of algorithms including formulating recurrence relations.
- Able to understand and design algorithms using greedy strategy, divide and conquer approach, dynamic programming.
- Demonstrate a familiarity with major algorithms and data structures and Synthesize efficient algorithms in common engineering design situations

Course Outcomes:
Upon successful completion of the course the students will be able to
CO-1: The ability of how to design an algorithm which solves the current problem in hand.
CO-2: To Write efficient algorithms for given problems.
CO-3: To focus on Deriving the complexities of any given algorithm.
CO-4: Learning the programming of various algorithms through assignments

S. No.	Contents	Hours
1	**Introduction**: Concept of algorithmic efficiency, run time analysis of algorithms, Asymptotic Notations. Growth of Functions, Master's Theorem,	**5**
2	**Searching and Sorting:** Structure of divide-and-conquer algorithms; examples: binary search, quick sort, Strassen Matrix Multiplication; merge sort, heap sort and Analysis of divide and conquer run time, recurrence relations.	**7**
3	**Greedy Method:** Overview of the greedy paradigm examples of exact optimization solution: minimum cost spanning tree, approximate solutions: Knapsack problem, Kruskal's algorithm and Prim's algorithm for finding Minimum cost Spanning Trees, Dijkstra's and Bellman Ford Algorithm for finding Single source shortest paths, Huffman coding, Activity Selection Problem.	**8**
4	**Dynamic programming:** Principles of dynamic programming. Applications: Rod cutting problem, Floyd-Warshall algorithm for all pair shortest paths. Matrix multiplication, travelling salesman Problem, Longest Common sequence, Back tracking: Overview, 8-queen problem, and Knapsack problem, Traveling Salesman problem.	**7**
5	**Branch and bound:** LC searching Bounding, FIFO branch and bound, LC branch and bound application: 0/1 Knapsack problem	**6**
6	**Computational Complexity:** Polynomial Vs non-polynomial time complexity; NP-hard and NP-complete classes, examples: Circuit Satisfiablity, Vertex cover, Subset Sum problem, Randomized Algorithms, String Matching, NP-Hard and NP Completeness, Introduction to Approximation Algorithms,	**7**
Total		**40**

Suggested Books:

1. T .H .Cormen, C .E .Leiserson, R .L . Rivest "Introduction to Algorithms", 3rd Ed.,PHI, 2011 (reprint)
2. E. Horowitz, S. Sahni, and S. Rajsekaran, "Fundamentals of Computer Algorithms,"Galgotia Publication
3. Sara Basse, A. V. Gelder, " Computer Algorithms," Addison Wesley
4. Aho ,Ullman "Principles of Algorithms "
5. S.K Basu- Design Methods and Analysis of Algorithms, 2nd Ed., PHI

VI Semester B. Tech.(Computer Science & Engineering (Data Science))	
6CD4-03: Machine Learning and its Applications	
Credit: 3	**Max. Marks: 100 (IA:30, ETE:70)**
3L+0T+ 0P	**End Term Exams: 3 Hours**

Course Objectives:

As a result of successfully completing this course, students will:

- Develop a comprehensive understanding of machine learning and AI concepts and principles.
- Acquire skills to apply machine learning techniques to real-world problems.
- Ability to design and develop AI models for complex problem-solving.
- Cultivate critical thinking and problem-solving abilities in the context of machine learning and AI.

Course Outcomes:

Upon successful completion of the course, students will be able to

CO-1: Analyze methods and theories in the field of machine learning and provide an introduction to the basic principles, techniques, and applications of machine learning, classification tasks, decision tree learning.

CO-2: Apply decision tree learning, Bayesian learning and artificial neural network in real world problems.

CO-3: Understand the use of genetic algorithms and genetic programming.

CO-4: Apply inductive and analytical learning with related domain theories.

CO-5: Compare different learning models and algorithms and utilize existing machine learning algorithms to design new algorithms.

S. No.	Contents	Hours
1	**Introduction:** Objective, scope and outcome of the course.	**1**
2	**Artificial Neural Network:** Neural network representation, Neural Networks as a paradigm for parallel processing, Linear discrimination, Pairwise separation, Gradient Descent, Logistic discrimination, Perceptron, Training a perceptron, Multilayer perceptron, Back propagation Algorithm. Recurrent Networks, Dynamically modifying network structure.	**9**
3	**Decision Tree Learning:** Decision tree representation, appropriate problems for decision tree learning, Univariate Trees (Classification and Regression), Multivariate Trees, Basic Decision Tree Learning algorithms, Hypothesis space search in decision tree learning, Inductive bias in decision tree learning, Issues in decision tree learning.	**8**
4	**Genetic Algorithms:** Basic concepts, Hypothesis space search, Genetic programming, Models of evolution and learning, Parallelizing Genetic Algorithms.	**6**
5	**Bayesian Learning:** Bayes theorem and concept learning, Bayes optimal classifier, Gibbs algorithms, Naive Bayes Classifier, Bayesian belief networks, The EM algorithm. **Design of Machine Learning:** Guidelines for machine learning experiments, Factors, Response, and Strategy of experimentation	**8**
6	**Analysis of Machine Learning:** Cross-Validation and Resampling methods, measuring classifier performance, Hypothesis testing, Assessing a classification algorithm's performance, Comparing two classification algorithms, Comparing multiple algorithms: Analysis of variance, Comparison over multiple datasets.	**8**
Total		**40**

Suggested Books:

1. Mitchell M., T., Machine Learning, McGraw Hill (1997) 1stEdition.
2. Kevin Murphy, Machine Learning: A Probabilistic Perspective, MIT Press, 2012
3. Ethem Alpaydin, Introduction to Machine Learning, MIT Press, 2004
4. Tom Mitchell, Machine Learning, McGraw Hill, 1997.
5. Pat Langley , Elements of Machine Learning, Morgan Kaufmann Publishers, Inc. 1995. ISBN 1-55860-301-8
6. Bishop M., C., Pattern Recognition and Machine Learning, Springer-Verlag (2011) 2ndEdition.
7. Michie D., Spiegelhalter J. D., Taylor C. C., Campbell, J., Machine Learning, Neural and Statistical Classification. Overseas Press (1994).

VI Semester B. Tech.(Computer Science & Engineering (Data Science))	
6CD4-04: Data Mining and Predicting Modeling	
Credit: 3	**Max. Marks: 100 (IA:30, ETE:70)**
3L+0T+ 0P	**End Term Exams: 3 Hours**

Course Objectives:
As a result of successfully completing this course, students will:

- To introduce the fundamental processes data warehousing and major issues in data mining
- To impart the knowledge on various data mining concepts and techniques that can be applied to text mining, web mining etc.
- To develop the knowledge for application of data mining and social impacts of data mining.

Course Outcomes:
Upon successful completion of the course, students will be able to

CO-1: Interpret the contribution of data warehousing and data mining to the decision-support systems.
CO-2: Prepare the data needed for data mining using preprocessing techniques.
CO-3: Extract useful information from the labeled data using various classifiers.
CO-4: Compile unlabeled data into clusters applying various clustering algorithms.
CO-5: Discover interesting patterns from large amounts of data using Association Rule Mining

S. No.	Contents	Hours
1	**Data Warehousing And Online Analytical Processing** Basic of Data Warehouse - Data Warehouse Modeling: Data Cube and OLAP - Data Warehouse Implementation - Data Generalization by Attribute-Oriented Induction - Data Cube Computation - Data Cube Computation Methods - Processing Advanced Kinds of Queries by Exploring Cube Technology - Multidimensional Data Analysis in Cube Space.	**9**
2	**Introduction, Data Preprocessing And Mining Frequent Patterns And Association** Introduction to data mining – kinds of data – Kinds of patterns to be mined – Technologies – applications – issues in mining – Data objects and attribute types – statistical distribution of data – data visualization – Measuring Data similarity and dissimilarity – Need for preprocessing – Data cleaning – Data Integration – Data reduction - Data Transformation and Data Discretization - Frequent Itemset, Closed Itemset, and Association Rules - Frequent Itemset Mining Methods.	**8**
3	**Classification** Basics – Decision tree Induction – Baye's Classification - Rule-Based Classification - Model Evaluation and Selection - Techniques to Improve Classification Accuracy - Bayesian Belief Networks - Classification by Backpropagation - Support Vector Machines - Classification Using Frequent Patterns- Lazy Learners (or Learning from Your Neighbors) - Other Classification Methods.	**8**
4	**Clustering** Basics - Partitioning Methods - Hierarchical Method - Density-Based Methods - Grid-Based Methods- Evaluation of Clustering - Clustering with Constraints - Outliers and Outlier Analysis - Outlier Detection Methods - Statistical Approaches - Proximity-Based Approaches - Clustering-Based Approaches.	**9**
5	**Data Mining Trends And Research Frontiers** Mining Complex Data Types - Other Methodologies - Data Mining Applications - Data Mining and Society – Data Mining Trends – Real world applications – Data Mining Tool study.	**8**

Total	42

Suggested Books:

1. Han, M.Kamber, "Data Mining: Concept and Techniques", Academic Press, Morgan Kaufmann.
2. Alex Berson and Stephen J. Smith. "Data Warehousing, Data Mining & OLAP", Tata McGraw Hill,2016.
3. Pieter Adrians, Dolf Zantinge. "Data Mining", Addison Wesley, 2000.

VI Semester B. Tech.(Computer Science & Engineering (Data Science))	
6CD4-05: Deep Learning	
Credit: 3	**Max. Marks: 100 (IA:30, ETE:70)**
3L+0T+ 0P	**End Term Exams: 3 Hours**

Course Objectives: As a result of successfully completing this course, students will:

- To describe the major differences between deep learning and other types of machine learning algorithms.
- To explain the fundamental methods involved in deep learning.
- To understand various aspects of deep learning and its building block.
- To understand and differentiate between the major types of neural network architectures.
- To Select or design neural network architectures for new data problems based on their requirements and problem characteristics and analyze their performance.
- To understand basic working principles and how Deep Learning is used to solve real-world problems

Course Outcomes: Upon successful completion of the course, students will be able to

CO-1: Able to learn the fundamental concepts of neural networks and deep neural networks.

CO-2: Able to understand the working principle of convolution neural networks.

CO-3: Able to perform hyperparameter tuning.

CO-4: Able to analyze and design neural network for real work problem.

CO-5: Able to understand working principle of various types of neural networks.

S. No.	Contents	Hours
1	**Introduction to Neural Networks** Introduction of artificial neural network and deep learning, characteristics of neural networks terminology, neurons, perceptron, backpropagation, Basic learning laws, Activation and Loss function - Function approximation, applications	**7**
2	**Introduction to Convolution Neural Networks** CNN Architecture and Operations, convolutional layer, Pooling layer, Variants of the Convolution Model, Forward and Backward propagation, Building a Deep Neural Network **Improving Deep Neural Networks** Training a deep neural network, hyper-parameter tuning, Hidden layers, Generalization Gap – Under-fitting Vs Over-fitting – Optimization, Normalization	**9**
3	**Practical aspects of Deep Learning:** Train/Dev / Test sets, Bias/variance, Overfitting and regularization, Linear models and optimization, Vanishing/exploding gradients, Gradient checking – Logistic Regression, Convolution Neural Networks, RNN and Backpropagation – Convolutions and Pooling.	**9**
4	**Optimization algorithms:** Mini-batch gradient descent, exponentially weighted averages, RMS prop, Learning rate decay, the problem of local optima, Batch norm – Parameter tuning process.	**8**
5	**Neural Network Architectures**: Recurrent Neural Networks, Adversarial NN, Spectral CNN, Self-Organizing Maps, Restricted Boltzmann Machines, Long Short-Term Memory Networks (LSTM) and Deep Reinforcement Learning – Tensor Flow, Keras or MatConvNet for implementation.	**9**
Total		**42**

Suggested Books:

1. Deep Learning, Ian Goodfellow Yoshua Bengio Aaron Courville, MIT Press, 2017 (link:

https://www.deeplearningbook.org/)
2. Deep Learning Step by Step with Python, N D Lewis, 2016
3. Deep Learning: A Practitioner's Approach, Josh Patterson, Adam Gibson, O'Reilly Media, 2017
4. Deep Learning, Ian Goodfellow Yoshua Bengio Aaron Courville, MIT Press, 2017
5. James Allen "Natural Language Understanding", Pearson Publication 8th Edition. 2012.
6. François Chollet "Deep Learning with Python," First Edition, Manning Publication,2018
7. Neural Networks and Deep Learning, Michael Nielsen, Determination Press (2015) (link: http://neuralnetworksanddeeplearning.com/)

VI Semester B. Tech.(Computer Science & Engineering (Data Science))	
6CD5-11: Internet of Things	
Credit:2	**Max. Marks: 100 (IA:30, ETE:70)**
2L+0T+ 0P	**End Term Exams: 3 Hours**

Course Objectives:

As a result of successfully completing this course, students will:

- Able to Understand the fundamentals about IoT
- Able to Understand about IoT Access technologies
- Able to Understand the design methodology and different IoT hardware platforms.
- Able to Understand the basics of IoT Data Analytics and supporting services.
- Able to Understand about various IoT case studies and industrial applications.

Course Outcomes:

Upon successful completion of the course, students will be able to

CO-1: Understand the basics and Architecture of IoT

CO-2: Understand design methodology and hardware platforms involved in IoT

CO-3: Analyze the challenges in IoT based design and development

CO-4: Understand IOT Applications in Industrial & real world.

S. No.	Contents	Hours
1	Introduction: Objective, scope and outcome of the course.	**1**
2	Introduction to IoT: Definition and characteristics of IoT, Design of IOT: Physical design of IOT, Logical Design of IOT- Functional Blocks, communication models, communication APIs, IOT enabling Technologies- Wireless Sensor Networks, Cloud computing, big data analytics, embedded systems. IOT Levels and deployment templates.	**6**
3	IoT Hardware and Software: Sensor and actuator, Humidity sensors, Ultrasonic sensor, Temperature Sensor, Arduino, Raspberry Pi, LiteOS, RIoTOS, Contiki OS, Tiny OS.	**7**
4	Architecture and Reference Model: Introduction, Reference Model and architecture, Representational State Transfer (REST) architectural style, Uniform Resource Identifiers (URIs). Challenges in IoT- Design challenges, Development challenges, Security challenges, Other challenges.	**7**
5	IOT and M2M: M2M, Difference and similarities between IOT and M2M, Software defined networks, network function virtualization, difference between SDN and NFV for IoT. Case study of IoT Applications	**7**
Total		**28**

Suggested Books:

1. IoT Fundamentals: Networking Technologies, Protocols and Use Cases for Internet of Things, David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Rob Barton and Jerome Henry, Cisco Press, 2017
2. Internet of Things – A hands-on approach, Arshdeep Bahga, Vijay Madisetti, Universities Press, 2015
3. Internet of Things: Architecture, Design Principles And Applications, Rajkamal, McGraw Hill HigherEducation
4. "From Machine-to-Machine to the Internet of Things Introduction to a New Age of Intelligence" Jan Höller, Vlasios Tsiatsis, Catherine Mulligan, Stamatis Karnouskos, Stefan Avesand, David Boyle, Elsevier, 2014.

VI Semester B. Tech.(Computer Science & Engineering (Data Science))	
6CD5-12: Pattern Recognition	
Credit:2	**Max. Marks: 100 (IA:30, ETE:70)**
2L+0T+ 0P	**End Term Exams: 3 Hours**

Course Objectives:
As a result of successfully completing this course, students will:

- Students should be able to understand soft computing concepts and techniques and foster their abilities in designing and implementing soft computing based solutions for real-world problems.

Course Outcomes:

Upon successful completion of the course, students will be able to

CO-1: Describe and compare a variety of pattern classification, structural pattern recognition, and pattern classifier combination techniques

CO-2: Apply pattern recognition techniques to real-world problems such as document analysis and recognition

CO-3: Summarize, analyze and relate research in the pattern recognition area

S. No.	Contents	Hours
1	**Introduction:** Objective, scope and outcome of the course.	**1**
2	**Basics Of Probability, Random Processes And Linear Algebra, Bayes Decision Theory** : Bayes' theorem , Minimum-error-rate classification, Classifiers, Discriminant functions, Decision surfaces, Normal density and discriminant functions, Discrete Features	**7**
3	**Parameter Estimation Methods** : Maximum-Likelihood estimation, Gaussian case, Maximum a Posteriori estimation, Bayesian estimation, Gaussian case	**6**
4	**Unsupervised Learning and Clustering**: Criterion functions for clustering, Algorithms for clustering, K-Means, Hierarchical and other methods, Cluster validation, Gaussian mixture models, Expectation-Maximization method for parameter estimation, Maximum entropy estimation	**7**
5	**Sequential Pattern Recognition**: Hidden Markov Models (HMMs), Discrete Hmms, Continuous HMMs Nonparametric Techniques For Density Estimation Parzen-Window Method, K-Nearest Neighbor Method	**7**
	Total	**28**

Suggested Books:

1. Pattern Classification, Richard O. Duda, Peter E. Hart, David G. Stork John Wiley 2001
2. Pattern Recognition, Konstantinos Koutroumbas and Sergios Theodoridis 4th Edition., Academic Press 2009
3. Pattern Recognition and Machine Learning, Bishop, Christopher,Springer 2006

VI Semester B. Tech.(Computer Science & Engineering (Data Science))	
6CD5-13: GPU Computing	
Credit:2	**Max. Marks: 100 (IA:30, ETE:70)**
2L+0T+ 0P	**End Term Exams: 3 Hours**

Course Objectives:
As a result of successfully completing this course, students will:

- Understand parallel programming with graphics processing units (GPUs).
- Understand Memory management and mechanism for parallel computing

Course Outcomes:
Upon successful completion of the course, students will be able to

CO-1: Define and understand terminology commonly used in parallel computing.
CO-2: Describe common GPU architectures and programming models.
CO-3: Understand a Given problem and develop an efficient parallel algorithm to solve it.
CO-4: Understand CUDA memory access mechanism.

S. No.	Contents	Hours
1	**Introduction:** Objective, scope and outcome of the course.	**1**
2	**GPU Introduction**: To study architecture and capabilities of modern GPUs and learn programming techniques for the GPU such as CUDA programming model. Heterogeneous Parallel Computing, Architecture of a Modern GPU, Speeding Up Real Applications, Parallel Programming Languages and Models.	**6**
3	**History of GPU Computing**: Evolution of Graphics Pipelines, The Era of Fixed-Function Graphics Pipelines, Evolution of Programmable Real-Time Graphics, Unified Graphics and Computing Processors, GPGPU, Scalable GPUs, Recent Developments, Future Trends.	**5**
4	**Introduction to Data Parallelism and CUDA C:** Data Parallelism, CUDA Program Structure, A Vector Addition Kernel, Device Global Memory and Data Transfer, Kernel Functions and Threading.	**5**
5	**Data-Parallel Execution Model:** CUDA Thread Organization, Mapping Threads to Multidimensional Data, Matrix-Matrix Multiplication—A More Complex Kernel, Synchronization and Transparent Scalability, Assigning Resources to Blocks, Thread Scheduling and Latency Tolerance.	**6**
6	**CUDA Memories:** Importance of Memory Access Efficiency, CUDA Device Memory Types, A Tiled Matrix – À Matrix Multiplication Kernel, Memory as a Limiting Factor to Parallelism.	**5**
	Total	**28**

Suggested Books:

1. Sanders, J. and Kandrot, E., CUDA by Example: An Introduction to General-Purpose GPU Programming, Addison-Wesley Professional (2012) 4th Edition.

2. Kirk, D. and Hwu, M., W., Programming Massively Parallel Processors: A Hands-on Approach. Morgan Kaufmann (2016) 3rd Edition.

3. Hwu, M., W., A GPU Computing Gems Emerald Edition (Applications of GPU Computing Series), Morgan Kaufmann (2011) 1st Edition.

VI Semester B. Tech.(Computer Science & Engineering (Data Science))	
6CD4-21: Design and Analysis of Algorithms Lab	
Credit: 1	**Max. Marks: 100 (IA:60, ETE:40)**
0L+0T+ 2P	**End Term Exams: 2 Hours**

Course Objectives: As a result of successfully completing this course, students will:

- Able to understand a solid background in the design and analysis of the major classes of algorithms
- Able to develop their own versions for a given computational task and to compare and contrast their performance

Course Outcomes: Upon successful completion of the course, students will be able to

CO-1: Design algorithms using divide and conquer, greedy and dynamic programming.

CO-2: Execute sorting algorithms such as sorting, graph related and combinatorial algorithm in a high level language.

CO-3: Analyze the performance of merge sort and quick sort algorithms using divide and conquer technique.

CO-4: Apply the dynamic programming technique to solve real world problems such as knapsack and TSP

S. No.	List of Experiments
1	Sort a given set of elements using the Quicksort method and determine the time required to sort the elements. Repeat the experiment for different values of n, the number of elements in the list to be sorted and plot a graph of the time taken versus n. The elements can be read from a file or can be generated using the random number generator.
2	Implement a parallelized Merge Sort algorithm to sort a given set of elements and determine the time required to sort the elements. Repeat the experiment for different values of n, the number of elements in the list to be sorted and plot a graph of the time taken versus n. The elements can be read from a file or can be generated using the random number generator.
3	a. Obtain the Topological ordering of vertices in a given digraph. b. Compute the transitive closure of a given directed graph using Warshall's algorithm.
4	Implement 0/1 Knapsack problem using Dynamic Programming.
5	From a given vertex in a weighted connected graph, find shortest paths to other vertices using Dijkstra's algorithm.
6	Find Minimum Cost Spanning Tree of a given undirected graph using Kruskal's algorithm.
7	a. Print all the nodes reachable from a given starting node in a digraph using BFS method. b. Check whether a given graph is connected or not using DFS method.
8	Find Minimum Cost Spanning Tree of a given undirected graph using Prim's algorithm.

Suggested Books:

1. T .H .Cormen, C .E .Leiserson, R .L . Rivest "Introduction to Algorithms", 3rd Ed.,PHI, 2011 (reprint)
2. E. Horowitz, S. Sahni, and S. Rajsekaran, "Fundamentals of Computer Algorithms,"Galgotia Publication
3. Sara Basse, A. V. Gelder, " Computer Algorithms," Addison Wesley
4. Aho ,Ullman "Principles of Algorithms "
5. S.K Basu- Design Methods and Analysis of Algorithms, 2nd Ed., PHI

VI Semester B. Tech.(Computer Science & Engineering (Data Science))	
6CD4-22: Machine Learning and Neural Network Lab	
Credit: 2	**Max. Marks: 100 (IA:60, ETE:40)**
0L+0T+3P	**Mode of evaluation: Report and presentation**

Course Objectives:

As a result of successfully completing this course, students will:

- Learn about the National Innovation and Startup Policy (NISP)of Govt. of India.
- Learn how to ideate, prototype and Iterate solutions.
- Learn about applying Design Thinking Tools and Approaches for Right Problem Identification and Solution Development.
- Learn about Business Plan Development.
- Learn about Legal Structures and Ethical Steps in Establishing Startups.
- Able to design and develop a Prototype.
- Students will be able to pitch their idea.
- Will be able to demonstrate their innovative and design thinking capabilities using mock-up models.

Course Outcomes:

Upon successful completion of the course, students will be able to

CO-1: learn about opportunities and challenges for startup and incubation.

CO-2: Students will be able to identify an Opportunity from a Problem using design thinking.

CO-3: Students will be able to frame Product and service ideas.

CO-4: Learn and implement Design Thinking Process.

CO-5: Students will be able to design and develop a Prototype.

CO-6: Students will be able to prepare documentation and pitch their idea.

exp. No.	Contents
1	National Innovation and Startup Policy (NISP) and Legal Structures and Ethical Steps in Establishing Startups, Generation and Management of IP at the Early Stage of Innovation and Startup Development, IPR and IPR policies.
2	Design Thinking, Process of Design Thinking, Empathy, Define, Ideate, Prototype, Testing.
3	Understanding Technology Readiness Level (TRL), Manufacturing Readiness Level (MRL) and Investment Readiness Level (IRL) Stages & Implications in Innovation Development
4	Capstone Project: Students in the group of 3 to 5 students must prepare a project idea using the design thinking process under the mentorship of the Institute innovation ambassador (For the Institute having IIC cells) or faculty member(For the Institute not having IIC cells). Students must submit capstone project report containing various ideas learned in experiment no 1-3 and their implementation or usage in capstone project to IIC cell along with presentation.

Assessment or Evaluation:

Students need to submit capstone project report to the Institute innovation council (For the Institute having IIC cells) or the head of department (For the Institute not having IIC cells) containing step by step approach to the project based on design thinking methodology along with the final presentation to IIC Cell(For the Institute having IIC cells) or Head of department (For the Institute not having IIC cells).

Suggested Books:

1. Idris Mootee, "Design Thinking for Strategic Innovation: What They Can't Teach You at Business or Design School", John Wiley & Sons (2013).
2. Tim Brown, "Change by design", Harper Collins, 2009
3. "Design Thinking- The Guide Book" – Facilitated by the Royal Civil service Commission, Bhutan
4. The Lean Startup: How Constant Innovation Creates Radically Successful Businesses
5. Start With Why: How Great Leaders Inspire Every
6. National Innovation and Startup Policy 2019 for students and faculty of Higher Education Institutions (HEIs) https://mic.gov.in/assets/doc/startup_policy_2019.pdf
7. Tom Kelley, The Art of Innovation: Lessons in Creativity from IDEO, America's Leading Design Firm
8. Roger L. Martin , Design of Business: Why Design Thinking is the Next Competitive Advantage, Harvard Business Review Press
9. Online resource

VI Semester B. Tech.(Computer Science & Engineering (Data Science))	
6CD4-23: Data Mining and Predicting Modeling Lab	
Credit: 1	**Max. Marks: 100 (IA:60, ETE:40)**
0L+0T+ 2P	**End Term Exams: 2 Hours**

Course Objectives:
As a result of successfully completing this course, students will:

- To introduce the fundamental processes data warehousing and major issues in data mining
- To impart the knowledge on various data mining concepts and techniques that can be applied to text mining, web mining etc.
- To develop the knowledge for application of data mining and social impacts of data mining.

Course Outcomes:
Upon successful completion of the course, students will be able to

CO-1: Interpret the contribution of data warehousing and data mining to the decision-support systems.
CO-2: Prepare the data needed for data mining using preprocessing techniques.
CO-3: Extract useful information from the labeled data using various classifiers.
CO-4: Compile unlabeled data into clusters applying various clustering algorithms.
CO-5: Discover interesting patterns from large amounts of data using Association Rule Mining

S. No.	List of Experiments (Students May Download required dataset from Kaggle.com)
1	Demonstration of pre-processing on dataset choose any data from Kaggle.com
2	Demonstration of classification rules process on dataset using ID3 and J48 algorithm.
3	Implement the classification rules process on car dataset using Naïve Baye's algorithm in Weka explorer.
4	Demonstration of classification rule process on dataset using simple K-means algorithm in weka explorer.
5	Build a Neural Network model to process Diabetic diagnosis dataset (https://www.kaggle.com/datasets/mathchi/diabetes-data-set)
7	Demonstration of classification on dataset diabetic and car (both taken from Kaggle.com) using decision table algorithm in weka explorer.
8	Demonstration of association rule using dataset diabetic diagnosis (taken from Kaggle.com) using apriori algorithm in weka explorer.
9	Demonstration of classification on dataset choose any data from Kaggle.com
10	Demonstration of clustering on dataset choose any data from Kaggle.com

Suggested Books:

1. Ian H. Witten & Eibe Frank, "Data Mining: Practical Machine Learning Tools and Techniques", 2005 Elsevier Inc.

VI Semester B. Tech.(Computer Science & Engineering (Data Science))	
6CD7-50: Innovation and Design Thinking Hands-on Project	
Credit: 2	**Max. Marks: 100 (IA:60, ETE:40)**
0L+0T+3P	**Mode of evaluation: Report and presentation**

Course Objectives:

As a result of successfully completing this course, students will:

- Learn about the National Innovation and Startup Policy (NISP)of Govt. of India.
- Learn how to ideate, prototype and Iterate solutions.
- Learn about applying Design Thinking Tools and Approaches for Right Problem Identification and Solution Development.
- Learn about Business Plan Development.
- Learn about Legal Structures and Ethical Steps in Establishing Startups.
- Able to design and develop a Prototype.
- Students will be able to pitch their idea.
- Will be able to demonstrate their innovative and design thinking capabilities using mock-up models.

Course Outcomes:

Upon successful completion of the course, students will be able to

CO-1: learn about opportunities and challenges for startup and incubation.

CO-2: Students will be able to identify an Opportunity from a Problem using design thinking.

CO-3: Students will be able to frame Product and service ideas.

CO-4: Learn and implement Design Thinking Process.

CO-5: Students will be able to design and develop a Prototype.

CO-6: Students will be able to prepare documentation and pitch their idea.

S. No.	Contents
1	National Innovation and Startup Policy (NISP) and Legal Structures and Ethical Steps in Establishing Startups, Generation and Management of IP at the Early Stage of Innovation and Startup Development, IPR and IPR policies.
2	Design Thinking, Process of Design Thinking, Empathy, Define, Ideate, Prototype, Testing.
3	Understanding Technology Readiness Level (TRL), Manufacturing Readiness Level (MRL) and Investment Readiness Level (IRL) Stages & Implications in Innovation Development
4	Capstone Project: Students in groups of 3 to 5 students must prepare a project idea using the design thinking process under the mentorship of the faculty members. Students must submit a capstone project report containing various ideas learned in experiments numbers 1-3 and their implementation or usage in the capstone project to the Institute Innovation Council (IIC) cell or Head of Department along with a presentation.

Assessment or Evaluation:

Students need to submit a capstone project report to the Institute Innovation Council (For the Institute having IIC cells) or the head of the department (For the Institute not having IIC cells) containing step by step approach to the project based on design thinking methodology along with the final presentation to IIC Cell (For the Institute having IIC cells) or Head of department (For the Institute not having IIC cells).

Suggested Books:

1. Idris Mootee, “Design Thinking for Strategic Innovation: What They Can't Teach You at Business or

Design School", John Wiley & Sons (2013).
2. Tim Brown, "Change by design", Harper Collins, 2009
3. "Design Thinking- The Guide Book" – Facilitated by the Royal Civil service Commission, Bhutan
4. The Lean Startup: How Constant Innovation Creates Radically Successful Businesses
5. Start With Why: How Great Leaders Inspire Every
6. National Innovation and Startup Policy 2019 for students and faculty of Higher Education Institutions (HEIs) https://mic.gov.in/assets/doc/startup_policy_2019.pdf
7. Tom Kelley, The Art of Innovation: Lessons in Creativity from IDEO, America's Leading Design Firm
8. Roger L. Martin , Design of Business: Why Design Thinking is the Next Competitive Advantage, Harvard Business Review Press
9. Online resource