SCHEME & SYLLABUS OF UNDERGRADUATE DEGREE COURSE

B. TECH.
MACHINE LEARNING & COMPUTING

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. (Machine Learning & Computing)
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	5MC4-01	Operating Systems	3	-	-	3	30	70	100	**3**
2		5MC4-02	Computer Organization and Architecture	3	-	-	3	30	70	100	**3**
3		5MC4-03	Computer Networks	3	-	-	3	30	70	100	**3**
4		5MC4-04	Digital Image Processing	3	-	-	3	30	70	100	**3**
5		5MC4-05	Mathematical Foundation Course	3	-	-	3	30	70	100	**3**
6	DE	5MC5-11	Human Computer Interaction	2	-	-	3	30	70	100	**2**
		5MC5-12	Computer Vision								
		5MC5-13	Distributed Systems								
7		5MC5-14	Cloud Computing	2	-	-	3	30	70	100	**2**
		5MC5-15	Introduction to Blockchain								
		5MC5-16	Data Mining and Warehousing								
Sub Total				**19**	**00**	**00**	**-**	**210**	**490**	**700**	**19**
PRACTICAL & SESSIONAL											
8	DC	5MC4-21	Digital Image Processing Lab	-	-	2	-	60	40	100	**1**
9		5MC4-22	R Programming Lab	-	-	2	-	60	40	100	**1**
10		5MC4-23	Data Science Lab using R	-	-	2	-	60	40	100	**1**
11	UI	5MC7-30	Industrial Training	-	-	1	-	60	40	100	**3**
12	CCA	5MC8-00	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. (Machine Learning & Computing)
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	6MC4-01	Compiler Design	3	-	-	3	30	70	100	**3**
2		6MC4-02	Design and Analysis of Algorithms	3	-	-	3	30	70	100	**3**
3		6MC4-03	Artificial Intelligence	3	-	-	3	30	70	100	**3**
4		6MC4-04	Data Analytics and Applications	3	-	-	3	30	70	100	**3**
5		6MC4-05	Introduction to Internet of Things	3	-	-	3	30	70	100	**3**
6	DE	6MC5-11	Soft Computing and Evolutionary Algorithms	2	-	-	3	30	70	100	**2**
		6MC5-12	Big Data Analytics								
		6MC5-13	GPU Computing								
Sub Total				**17**	**00**	**00**		**180**	**420**	**600**	**17**
PRACTICAL & SESSIONAL											
7	DC	6MC4-21	Design and Analysis of Algorithms Lab	-	-	2	-	60	40	100	**1**
8		6MC4-22	Mobile Application Development Lab	-	-	2	-	60	40	100	**1**
9		6MC4-23	Data Analytics and Applications Lab	-	-	2	-	60	40	100	**1**
10	UI	6MC7-50	Innovation and Design Thinking Hands-on Project	-	-	3	-	60	40	100	**2**
11	CCA	6MC8-00	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. (Machine Learning & Computing)	
5MC4-01: 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	**7**

	security, user authentication ***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. (Machine Learning & Computing)	
5MC4-02: 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. (Machine Learning & Computing)	
5MC4-03: 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, FTP, Streaming audio and video.	**7**
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. (Machine Learning & Computing)	
5MC4-04: Digital Image Processing	
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 learn the fundamental concepts of Digital Image Processing.
- Able to Understand basic image processing operations.
- To understand image analysis algorithms.
- Exposure to current applications in the field of digital image processing.

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

CO-1: Review the fundamental concepts of digital image processing systems.

CO-2: Analyze images in the frequency domain using various transforms.

CO-3: Evaluate the techniques for image enhancement, image restoration, and Morphological Operation.

CO-4: Categorize various compression techniques.

CO-5: Interpret image segmentation and representation techniques.

S. No.	Contents	Hours
1	**Introduction:** Objective, scope and outcome of the course.	**1**
2	**Introduction to Image Processing:** Digital Image representation, Sampling & Quantization, Steps in image Processing, Image acquisition, color image representation.	**7**
3	**Image Transformation & Filtering:** Intensity transform functions, histogram processing, Spatial filtering, Fourier transforms and its properties, frequency domain filters, colour models, Pseudo colouring, colour transforms, Basics of Wavelet Transforms.	**8**
4	**Image Restoration:** Image degradation and restoration process, Noise Models, Noise Filters, degradation function, Inverse Filtering, Homomorphism Filtering.	**8**
5	**Image Compression:** Coding redundancy, Interpixel redundancy, Psychovisual redundancy, Huffman Coding, Arithmetic coding, Lossy compression techniques, JPEG Compression.	**8**
6	**Image Segmentation & Representation:** Point, Line and Edge Detection, Thresholding, Edge and Boundary linking, Hough transforms, Region Based Segmentation, Boundary representation, Boundary Descriptors.	**8**
	Total	**40**

Suggested Books:

1. Gonzalez C. R., Woods E. R., Digital Image Processing, Pearson Education (2008) 3rd ed.
2. A.K.Jain, " Fundamentals of Digital Image Processing", PHI,1995
3. Sonka M., Hlavac V. and Boyle R., Image Processing, Analysis and Machine Vision, Thomson Learning, (1993)1st ed.
4. McAndrew A., Introduction to Digital Image Processing with Matlab, Thomson Course Technology (2004)
5. Low A., Introductory Computer Vision and Image Processing, McGraw-Hill (1991), 1st ed.
6. Boyle and Thomas: Computer Vision - A First Gurse 2nd Edition, ISBN 0-632-028-67X, Blackwell Science 1995.
7. Pakhera Malay K: Digital Image Processing and Pattern Recogination, PHI.

V Semester B. Tech Machine Learning & Computing	
5MC-04:05 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. (Machine Learning & Computing)	
5MC5-11: Human Computer Interaction	
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:

- Historical Evaluation of Field, Interactive System Design
- Understand model based design case studies
- Empirical design and data analysis in HCI

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

CO-1: Understand Interactive system design, concept of usability, HCI and GUI

CO-2: Understand model based design and evaluation

CO-3: Understand various guidelines in HCI

CO-4: Analyze empirical research methods in HCI

CO-5: Understand task modeling and its analysis

S. No.	Contents	Hours
1	Introduction: Objective, scope and outcome of the course.	**1**
2	Historical evolution of the field, Interactive system design, Concept of usability -definition and elaboration, HCI and software Engineering, GUI design and Aesthetics, Prototyping techniques.	**2**
3	Model-based Design and evaluation: Basic idea, introduction to different types of models, GOMS family of models (KLM and CMNGOMS), Fitts' law and Hick-Hyman's law, Model-based design case studies	**3**
4	Guidelines in HCI:Shneiderman's eight, golden rules, Norman's seven principles, Norman's model of interaction, Nielsen's ten heuristics with example of its use Heuristic evaluation, Contextual inquiry, Cognitive walkthrough	**5**
5	Empirical research methods in HCI: Introduction (motivation, issues, research question formulation techniques), Experiment design and data analysis (with explanation of one-way ANOVA)	**6**
6	Task modelling and analysis: Hierarchical task analysis (HTA), Engineering task models and Concur Task Tree (CTT), Introduction to formalism in dialog design, design using FSM (finite state machines) State charts and (classical) Petri Nets in dialog design	**6**
7	Introduction to CA, CA types, relevance of CA in IS design Model Human Processor (MHP), OOP- Introduction OOM- Object Oriented Modeling of User Interface Design	**5**
Total		**28**

Suggested Books:

1. Human–Computer Interaction, Third Edition Alan Dix, Janet Finlay, Gregory D. Abowd, Pearson Education Limited

V Semester B. Tech. (Machine Learning & Computing)	
5MC5-12: Computer Vision	
Credit: 2	**Max. Marks: 100 (IA:30, ETE:70)**
2L+0T+ 0P	**End Term Exams: 3 Hours**

Course Objectives: To introduce the fundamentals of image formation
To provide understanding of segmentation techniques in vision-based applications
To impart knowledge on advanced concepts in image representation techniques
To provide insights on implementation of computer vision algorithms for biomedical applications

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

CO1: Ability to understand the fundamental concepts in computer vision
CO2: Ability to understand different image formation model
CO3: Ability to apply segmentation techniques and descriptors
CO4: Ability to analyze medical problems using computer vision techniques
CO5: Ability to evaluate performance of computer vision algorithms in biomedical applications

S. No.	Contents	Hours
1	**What is Computer Vision** - Low-level, Mid-level, High-level, Overview of Diverse Computer Vision Applications: Document Image, Analysis, Bio-metrics, Object Recognition, Tracking, Medical Image Analysis, Content-Based Image Retrieval, Video Data Processing, Multimedia, Virtual Reality and Augmented Reality.	**6**
2	**Image Formation Models**: Monocular imaging system, Orthographic & Perspective Projection, Camera model and Camera calibration, Binocular imaging systems, Multiple views geometry, Structure determination, shape from shading, Photometric Stereo, Depth from Defocus, Construction of the 3D model from images.	**6**
3	**Image Processing, Feature Extraction, and Motion Estimation**: Image pre-processing, Image representations (continuous and discrete), Edge detection, Regularization theory, Optical computation, Stereo Vision, Motion estimation, Structure from motion.	**4**
4	**Shape Representation and Segmentation**: Contour-based representation, Region-based representation, De-formable curves and surfaces, Snakes and active contours, Level set representations, Fourier, and wavelet descriptors, Medial representations, Multi-resolution analysis, Object recognition.	**6**
5	**Image Understanding and Computer Vision Applications**: Pattern recognition methods, Face detection, Face detection, Face recognition, 3D shape models of faces Application: Surveillance-foreground-background separation–human gait analysis Application: In-vehicle **vision system**: locating roadway–road markings–identifying road signs-locating pedestrians.	**6**
Total		**28**

Suggested Books:

1. D. Forsyth and J. Ponce, Computer Vision - A modern approach, Prentice Hall
2. Richard Szeliski, Computer Vision: Algorithms and Applications (CVAA), Springer, 2010
3. E. R. Davies, Computer & Machine Vision, Academic Press, 2012
4. Dana H. Ballard, Christopher M. Brown, Computer Vision, Prentice Hall 1st Edition (May 1, 1982),

V Semester
B. Tech. (Machine Learning & Computing)

5MC5-13: 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. (Machine Learning & Computing)	
5MC5-14: 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. (Machine Learning & Computing)	
5MC5-15: 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. (Machine Learning & Computing)	
5MC5-16: Data Mining and Warehousing	
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 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	**Introduction:** Objective, scope and outcome of the course.	**1**
2	**Introduction to Data Mining:** Introduction to data mining-Data mining functionalities-Steps in data mining process- Classification of data mining systems, Major issues in data mining. Data Wrangling and Preprocessing: Data Preprocessing: An overview-Data cleaning-Data transformation and Data discretization	**5**
3	**Predictive Modeling:** General approach to classification-Decision tree induction- Bayes classification methods- advanced classification methods: Bayesian belief networks Classification by Backpropagation- Support Vector Machines-Lazy learners	**6**
4	**Descriptive Modeling:** Types of data in cluster analysis-Partitioning methods- Hierarchical methods-Advanced cluster analysis: Probabilistic model-based clustering- Clustering high dimensional data-Outlier analysis	**5**
5	**Discovering Patterns and Rules:** Frequent Pattern Mining: Basic Concepts and a Road Map - Efficient and scalable frequent item set mining methods: Apriori algorithm, FP-Growth algorithm- Mining frequent item sets using vertical data format- Mining closed and max patterns Advanced Pattern Mining: Pattern Mining in Multilevel, Multidimensional Space	**5**
6	**Data Mining Trends and Research Frontiers:** Other methodologies of data mining: Web mining Temporal mining-Spatial mining-Statistical data mining- Visual and audio data mining- Data mining applications- Data mining and society: Ubiquitous and invisible data mining- Privacy, Security, and Social Impacts of data mining	**6**
Total		**28**

Suggested Books:

1. Jiawei Han and Micheline Kamber, Data Mining: Concepts and Techniques, Morgan Kaufmann Publishers, third edition ,2013
2. Pang-Ning Tan, Michael Steinbach, Anuj Karpatne, Vipin Kumar, Introduction to Data Mining, second edition, Pearson, 2019
3. Ian. H. Witten, Eibe Frank and Mark. A. Hall, Data Mining: Practical Machine Learning Tools and

Techniques, third edition , 2017
4. Alex Berson and Stephen J. Smith, Data Warehousing, Data Mining & OLAP, Tata McGraw Hill Edition, Tenth Reprint, 2008.
5. Hand, D., Mannila, H. and Smyth, P. Principles of Data Mining, MIT Press: Massachusetts third edition, Pearson, 2013

V Semester B. Tech. (Machine Learning & Computing)	
5Mc4-21: Digital Image Processing 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 concepts of image processing and basic analytical methods to be used in image processing.
- To familiarize students with image enhancement and restoration techniques
- To explain different image compression techniques. To introduce segmentation and morphological processing techniques.

Course Outcomes:

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

CO-1: Review the fundamental concepts of a digital image processing system.

CO-2: Analyze images in geometric transforms with image rotation, scaling, and translation.

CO-3: Evaluate the techniques for image enhancement and image restoration.

CO-4: Categorize various compression techniques and Interpret Image compression standards

CO-5: Interpret image segmentation and representation techniques.

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.
5	Morphological operations: This experiment is intended so students can appreciate the effect of morphological operations using a small structuring element on simple binary images. The operations that can be performed are erosion, dilation, opening, closing, open-close, close-open.

Suggested Books:

1. Digital Image Processing, Rafeal C. Gonzalez, Richard E. Woods, Second Edition, Pearson Education/PHI
2. Image Processing, Analysis, and Machine Vision, Milan Sonka, Vaclav Hlavac and Roger Boyle, Second Edition, Thomson Learning.
3. Digital Image Processing using Matlab, Rafeal C. Gonzalez, Richard E. Woods, Steven L. Eddins, Pearson Education.

V Semester B. Tech. Machine Learning & Computing)	
5MC4-22: 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. (Machine Learning & Computing)	
5MC4-23: 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 visualizations 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. (Machine Learning & Computing)

6MC4-01: 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. (Machine Learning & Computing)	
6MC4-02: 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. (Machine Learning & Computing)	
6MC4-03: Artificial Intelligence	
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 impart knowledge about Artificial Intelligence
- To give understanding of the main abstractions and reasoning for AI systems.
- To enable the students to understand the basic principles of Artificial Intelligence in various applications

Course Outcomes:

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

CO-1: Know the Essential concepts of Artificial Intelligence and its real time use.

CO-2: : Solve basic AI based problems

CO-3: Select appropriately from a range of techniques when implementing AI systems.

CO-4: Understand the basics of Game Theory

S. No.	Contents	Hours
1	**Introduction and Overview of Artificial intelligence:** Problems of AI, AI technique, Tic - Tac - Toe problem. Intelligent Agents, Agents & environment, nature of environment, structure of agents, goal-based agents, utility-based agents, learning agents.	**8**
2	**Meaning and definition of artificial intelligence:** Physical Symbol System Hypothesis, production systems, Characteristics of production systems; Breadth-first search and Depth-first search techniques. **Heuristic search Techniques**: Hill Climbing, Iterative deepening DFS, bidirectional search. Analysis of search methods. A* algorithm, and their analysis. Introduction to Genetic Algorithms.	**8**
3	**LOGIC:** Propositional logic, predicate logic, Resolution, Resolution in proportional logic and predicate logic, Clause form, unification algorithm. Knowledge Representation Schemes: Mapping between facts and representations, Approaches to knowledge representation	**8**
4	**Knowledge Representation and Reasoning:** Procedural vs declarative knowledge, Forward vs. Backward reasoning, Matching, conflict resolution, Non-monotonic reasoning, Default reasoning, statistical reasoning, fuzzy logic Weak and Strong filler structures, semantic nets, frame, conceptual dependency, scripts. Reasoning in uncertain environments, Fuzzy logic, fuzzy composition relation, operations on fuzzy sets. Probabilistic reasoning, Bayes theorem, construction of Bayesian networks	**8**
5	Adversarial Search and Game theory, classification of games, game playing strategies, prisoner's Dilemma. Game playing techniques, minimax procedure, alpha-beta cut-offs. The complexity of the alpha-beta search. Automated planning, classical planning problem, forward planning, partial order planning, planning with proposal logic, hierarchical task planning, multi-agent planning.	**8**
Total		**40**

Suggested Books:

1. Artificial Intelligence: A modern approach by Stuart Russel, Pearson Education
2. Artificial neural network by B. Yegnanarayana PHI Publication

3. Artificial Intelligence by Rich and Knight, TMH.
4. Artificial Intelligence: A new synthesis by Nils and Nilson, Elsevier
5. Artificial Intelligence by Luger, Pearson Education
6. Artificial Intelligence by Padhy, Oxford Press
7. Introduction to Artificial Intelligence by Charniak and Mcdermott, Addison-Wesley

VI Semester B. Tech. (Machine Learning & Computing)	
6MC4-04: Data Analytics and 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:

- To understand EDA, inference and regression techniques.
- Apply Matrix decomposition techniques to perform data analysis.
- Understand concepts and importance of data pre-processing techniques.
- Importance and application of Machine Learning Algorithms.
- Knowledge of acquiring data through web-scraping and data APIs

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

CO-1: Utilize EDA, inference and regression techniques.
CO-2: Utilize Matrix decomposition techniques to perform data analysis.
CO-3: Apply data pre-processing techniques.
CO-4: Apply Basic Machine Learning Algorithms.
CO-5: Acquire data through web-scraping and data APIs.

S. No.	Contents	Hours
1	**Introduction:** Objective, scope and outcome of the course.	**1**
2	**Introduction to data analysis**: Introduction and importance of data science. Big Data Analytics, Business intelligence vs Big data, Current landscape of analytics, Exploratory Data Analysis (EDA), statistical measures, Basic tools (plots, graphs and summary statistics) of EDA, Data Analytics Lifecycle, Discovery, Data Visualization Principles of Data Visualization	**8**
3	**Introductory hypothesis testing and statistical inference**: Introduction to Hypothesis Testing, Central Limit Theorem, A/B testing. Identifying Potential Data Sources Linear regression - Introduction to simple linear regression, multiple linear regression, least squares principle, exploratory vs. inferential viewpoints, Model generalizability, cross validation, and using categorical variables in regression, logistic regression, Multiple correlation, Partial correlation	**9**
4	**Linear Algebra Basics:** Matrices to represent relations between data, Linear algebraic operations on matrices – Matrix decomposition: Singular Value Decomposition (SVD) and Principal Component Analysis (PCA).	**8**
5	**Data Pre-processing and Feature Selection:** Data cleaning - Data integration - Data Reduction - Data Transformation and Data Discretization, Feature Generation and Feature Selection, Feature Selection algorithms: Filters- Wrappers - Decision Trees - Random Forests	**8**
6	**Basic Machine Learning Algorithms**: Classifiers - Decision tree - Naive Bayes - k-Nearest Neighbors (k-NN), k-means – SVM Association Rule mining – Ensemble methods	**8**
	Total	**42**

Suggested Books:

1. Mining of Massive Datasets. v2.1, Jure Leskovek, Anand Rajaraman and Jefrey Ullman., Cambridge University Press. (2019)
2. Doing Data Science, Straight Talk From The Frontline, Cathy O'Neil and Rachel Schutt, O'Reilly
3. Python for Data Analysis: Data Wrangling with Pandas, NumPy, and IPython Wes McKinney, O'Reilly Media
4. Hands-On Machine Learning with Scikit-Learn and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems, Aurélien Géron, O'Reilly Media

VI Semester
B. Tech. (Machine Learning & Computing)

6MC4-05: Introduction to Internet of Things

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 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	**7**
3	**IoT Hardware and Software:** Sensor and actuator, Humidity sensors, Ultrasonic sensor, Temperature Sensor, Arduino, Raspberry Pi, LiteOS, RIoTOS, Contiki OS, Tiny OS.	**8**
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.	**8**
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.	**8**
6	**Case study of IoT Applications:** Domain specific IOTs- Home automation, Cities, environment, Energy, Retail, Logistics, Agriculture, Industry, Health and Lifestyles.	**8**
	Total	**40**

Suggested Books:
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. (Machine Learning & Computing)	
6MC5-11 Soft Computing and Evolutionary Algorithms	
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 basics of Fuzzy Set
- Able to understand the concepts of the genetic algorithms.
- Able to understand the ide of the evolutionary algorithms.

Course Outcomes:

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

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

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	**5**
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	**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	**6**
4	**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**
5	**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	**5**
Total		**28**

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

VI Semester B. Tech. (Machine Learning & Computing)	
6MC5-12: Big Data Analytics	
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 the need of Big Data, challenges and different analytical architectures
- Installation and understanding of Hadoop Architecture and its ecosystems
- Processing of Big Data with Advanced architectures like Pig, Hive.

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

CO-1: Discuss the challenges and their solutions in Big Data

CO-2: Understand and work on Hadoop Framework and eco systems.

CO-3: Analyze the Big Data using Map-reduce programming in Hadoop

S. No.	Contents	Hours
1	**Introduction:** Objective, scope and outcome of the course.	**1**
2	**Introduction to Big Data:** Big data features and challenges, Problems with Traditional Large-Scale System , Sources of Big Data, 3 V's of Big Data, Types of Data. **Working with Big Data**: Google File System. Hadoop Distributed File System (HDFS) - Building blocks of Hadoop (Namenode. Data node. Secondary Namenode. Job Tracker. Task Tracker), Introducing and Configuring Hadoop cluster (Local. Pseudo- distributed mode, Fully Distributed mode). Configuring XML files.	**6**
3	**Writing MapReduce Programs:** A Weather Dataset. Understanding Hadoop API for MapReduce Framework (Old and New). Basic programs of Hadoop MapReduce: Driver code. Mapper code, Reducer code. Record Reader, Combiner, Partitioner.	**7**
4	**Hadoop I/O:** The Writable Interface. Writable Comparable and comparators. Writable Classes: Writable wrappers for Java primitives. Text. Bytes Writable. Null Writable, Object Writable and Generic Writable. Writable collections. Implementing a Custom Writable: Implementing a Raw Comparator for speed, Custom comparators.	**7**
5	**Pig:** Hadoop Programming Made Easier Admiring the Pig Architecture, Going with the Pig Latin Application Flow. Working through the ABCs of Pig Latin. Evaluating Local and Distributed Modes of Running Pig Scripts, Checking out the Pig Script Interfaces, Scripting with Pig Latin.	**7**
	Total	**28**

Suggested Books:

1. Mike Frampton, "Mastering Apache Spark", Packt Publishing, 2015.
2. Tom White, "Hadoop: The Definitive Guide",O'Reilly,4thEdition,2015.
3. Nick Pentreath, "Machine Learning with Spark", Packt Publishing,2015
4. Mohammed Guller, Big Data Analytics with Spark, Apress,2015
   Donald Miner, Adam Shook, "Map Reduce Design Pattern", O'Reilly, 2012

VI Semester B. Tech. (Machine Learning & Computing)	
6MC5-13: 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. (Machine Learning & Computing)	
6MC4-21: 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. (Machine Learning & Computing)	
6MC4-22: Mobile Application Development 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 concepts of app development and basic concepts like activity, intents, broadcasts, to be used in app development.
- To familiarize students with GUI widgets and their usage
- To develop ability to design Android applications

Course Outcomes:

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

CO-1: To be able to install IDE, SDK, NDK required for development of Apps

CO-2: To be able to design basic GUI based applications

CO-3: To be able to design applications interacting with database

CO-4: To be able to learn communication between applications

S. No.	List of Experiments
1	Able to Understand Android Studio and android studio installation. Create “Hello World” application.
2	Design an application to display IMEI, IMSI, Location, Version, and other basic information of device
3	To understand Activity, Intent, Create sample application with login module.(Check username and password).
4	Design simple GUI application with activity and intents e.g. calculator.
5	Write an application that draws basic graphical primitives on the screen
6	Create an android app for database creation using SQLite Database
7	Develop a application that takes phone number and message as input from user and send the message to given number
8	Design simple GUI application to display all sensors available in device
9	Implement an menu driven application that writes data to the SD card file and read data from sdcard file.
10	Design a location tracking application using GPS

Suggested Books:

1. "Android Programming: The Big Nerd Ranch Guide" by Bill Phillips, Chris Stewart, and Kristin Marsicano
2. "Head First Android Development: A Brain-Friendly Guide" by Dawn Griffiths and David Griffiths, O′Reilly
3. "Android App Development for Dummies" by Michael Burton, For Dummies
4. Android Cookbook , Ian Darwin, O′Reilly

VI Semester B. Tech. (Machine Learning & Computing)	
6MC4-23: Data Analytics and Applications Lab using R	
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:

- Expand R by installing R packages.
- Explore and understand how to use the R documentation.
- Read Structured Data into R from various sources.
- Understand the different data types in R.
- Understand the different data structures in R.

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

CO-1: To understand basic data types and syntax of R languages.
CO-2: Able to read and load data from files.
CO-3: Able to implement various algorithms using R
CO-4: Able to implement logistics model using R

S. No.	List of Experiments
1	Write a R program to create a list containing strings, numbers, vectors and logical values
2	Write a R program to experiment with loops and other conditional statements
3	Write a R program to merge two given lists into one list.
4	Write a R program to create a list containing a vector, a matrix and a list and give names to the elements in the list. Access the first and second element of the list.
5	Write a R program to Read the data from same and different directory.
6	Write a R Program to read and load data from larger datasets.
7	Install the necessary R packages and apply data manipulation packages- dplyr, data.table, reshape2, tidyr, Lubridate.
8	Write R Programs to implement decision tree and KNearest Neighbor algorithms
9	Build a linear regression model and logistic regression model, check the model on a test data and predict the numerical quantities.
10.	Work with R to implement logistic regression and PCA.

Suggested Books:

1. R for Data Science , Hadley Wickham and Garrett Gorlemund, O'Reilly
2. The Art of R Programming – A Tour of Statistical Software Design, Norman Matloff

VI Semester B. Tech. (Machine Learning & Computing)	
6MC7-50: 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.

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 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