VEERMATA JIJABAI TECHNOLOGICAL INSTITUTE
(VJTI) MATUNGA, MUMBAI 400 019
(Autonomous Institute affiliated to University of Mumbai)

Curriculum
(Scheme of Instruction & Evaluation and Course contents)
For
Third Year of Four Year Undergraduate Programme Leading to

Bachelor of Technology (B Tech) Degree in
in
Computer Engineering

Department of Computer Engineering and Information Technology,
2025

BTech Computer Engineering
Scheme of Instruction and Evaluation
SEMESTER V

Table 1: Course Structure with Examination Weightage

Sr.	**Course Type**	**Course Code**	**Course Name**	**L**	**T**	**P**	**Hr**	**Cr**	**TA (%)**	**MST (%)**	**ESE (%)**	**Ownership**
1	PCC	R5CO3001T	Compiler Construction	3	0	0	3	3	20	30	50	CE & IT
2	PCC	R5CO3002T	Machine Learning	3	0	0	3	3	20	30	50	CE & IT
3	PCC	R5CO3003T	Computer Network	3	0	0	3	3	20	30	50	CE & IT
4	PCC	R5CO3004T	Parallel Computing	3	0	0	3	3	20	30	50	CE & IT
5	PCC	R5CO3005T	Human Computer Interaction	2	0	0	2	2	20	30	50	CE & IT
6	MDM	R5CO3201T*	Multi-disciplinary Minor-III	3	0	0	3	3	20	30	50	Institute
7	PEC	R5CO3101T*	Program Elective –I	3	0	0	3	3	20	30	50	CE & IT
8	PEC	R5CO3101L*	Program Elective –I Laboratory	0	0	2	2	1	ISCE	60	40	CE & IT
9	VSEC	R5CO3001L	Parallel Programming Laboratory	0	0	2	2	1	ISCE	60	40	CE & IT
10	PCC	R5CO3002L	Machine Learning Lab	0	0	2	2	1	ISCE	60	40	CE & IT
11	PCC	R5CO3003L	Computer Network Laboratory	0	0	2	2	1	ISCE	60	40	CE & IT
Total				20	0	8	28	24				

Multi-disciplinary Minor-III			
S.No	Course Code	Minor Name	Course Title
1.	R5CO3202T	Minor in Software Engineering	Software Engineering Umbrella Activities
2.	R5CO3201T	Minor in Data Science	Introduction to ML with python
3.	R5CO3203T	Minor In Cyber Security	Secure Data Management and Database Security
4.	R5CO3204T	Minor In HPCA	High Performance Computing Systems

Program Elective -I		
S.No	Course Code	Course Title
1.	R5CO3101T	Optimization Techniques
2.	R5CO3102T	Image Processing
3.	R5CO3103T	NO SQL database
4.	R5CO3104T	Advanced Databases
5.	R5CO3105T	Geospatial Technologies
6.	R5CO3106T	Computer Graphics

BTech Computer Engineering
Scheme of Instruction and Evaluation
SEMESTER VI

Table 2: Course Structure with Examination Weightage

Sr.	Course Type	Course Code	Course Name	L	T	P	Hr	Cr	TA (%)	MST (%)	ESE (%)	Ownership
1	PCC	R5CO3006T	Cloud Computing	3	0	0	3	3	20	30	50	CE & IT
2	PCC	R5CO3007T	Cyber Security	3	0	0	3	3	20	30	50	CE & IT
3	PCC	R5CO3008T	Research Methodology	2	0	0	2	2	20	30	50	CE & IT
4	OE	R5CO3301T	Open elective - I	3	1	0	4	4	20	30	50	CE & IT
5	HSSM	-	Financial Management	2	0	0	2	2	20	30	50	CE & IT
6	MDM	R5CO3201T*	Multi-disciplinary Minor- IV	3	0	0	3	3	20	30	50	Institute
7	PEC	R5CO3107T*	Program Elective – II	3	0	0	3	3	20	30	50	CE & IT
8	VSEC	R5CO3004L	Devops	0	0	2	2	1	ISCE:	60	40	CE & IT
9	PCC	R5CO3005L	Cloud Computing Laboratory	0	0	2	2	1	ISCE:	60	40	CE & IT
10	PCC	R5CO3006L	Cyber Security Laboratory	0	0	2	2	1	ISCE:	60	40	CE & IT
11	PEC	R5CO3107L*	Program Elective – II Laboratory	0	0	2	2	1	ISCE:	60	40	CE & IT
Total				19	1	8	28	24				

Open elective-I		
S.No	Course Code	Course Title
1.		
2.		
3.		
4.		

Multi-disciplinary Minor-IV			
S.No	Course Code	Minor Name	Course Title
1.	R5CO3206T	Minor in Software Engineering	Software Development Activities
2.	R5CO3205T	Minor in Data Science	Data Visualization and Processing Tools
3.	R5CO3207T	Minor In Cyber Security	Operating System Security
4.	R5CO3208T	Minor In HPCA	Algorithms for High Performance Computing

Program Elective -II		
S.No	Course Code	Course Title
1.	R5CO3107T	Wireless Networks
2.	R5CO3108T	Software Defined Network
3.	R5CO3109T	Management Information System
4.	R5CO3110T	Object Oriented Analysis and Design
5.	R5CO3111T	BlockChain Technology

BTech Computer Engineering
Exit Courses Syllabus

Table 3: Exit Courses Structure with Examination Weightage

Sr.	Course Type	Course Code	Course Name	L	T	P	Hr	Cr	TA (%)	MST (%)	ESE (%)	Ownership
1	PCC	R5CO3901L	Cloud Training (Google ,Puppet, Azure)	0	0	4	4	2	ISCE	60	40	CE & IT
2	PCC	R5CO3901L	Salesforce beginners Training	0	0	4	4	2	ISCE	60	40	CE & IT
3	PCC	R5CO3901L	System Administrator	0	0	4	4	2	ISCE	60	40	CE & IT
4	PCC	R5CO3901L	Unity development tutorials	0	0	4	4	2	ISCE	60	40	CE & IT
5	PCC	R5CO3801L	Project / Mini-Project	0	0	12	12	6	20	30	50	CE & IT
6	EC	R5CO3701L	Internship (6-8 weeks)	0	0	0	0	6	20	30	50	CE & IT
Total				0	0	24	24	24				

Programme Name	B. Tech. Computer Engineering
Course Code	R5CO3001T
Course Title	Compiler Construction
Course Type	PCC
Prerequisites: C/C++ Programming, Computer Organization, Operating System.	
Course Outcomes: At the end of the course student will be able to: **CO1.** Understand Compiler basics and lexical analysis phase of compiler. **CO2.** Analyze Syntax analysis and semantic analysis phase of compiler. **CO3.** Illustrate Code optimizations, code generation and error detection. **CO4.** Apply parallelization in compiler.	

	Course Contents	Hrs.	CO
1.	**Introduction to Compilers:** Overview of compilers, difference between compilers and interpreters, structure of a compiler. **Lexical Analysis:** Role of lexical analyzer, input buffering, specification and recognition of tokens	04	CO1
2.	**Syntax Analysis:** Context-free grammars, parsing techniques (LL, LR, SLR, LALR). Operator Precedence Parser **Semantic Analysis:** Syntax-directed definitions, evaluation orders, type checking.	08	CO2
3.	**Intermediate Code Generation:** Intermediate languages, declarations, assignments, procedure calls. **Code Optimization:** Sources of optimization, optimization of basic blocks, loops, dataflow analysis.	06	CO3
4.	**Code Generation:** Design of a code generator, run-time storage management, target machine architecture. **Error Detection and Recovery:** Lexical, syntactic, and semantic errors; error recovery strategies.	06	CO3
5.	**Parallel Compiler:** Parallel compilation, parallel parsing, semantic analysis, and optimization techniques **Parallel Code Generation:** Code generation for parallel architectures, synchronization, instruction scheduling.	04	CO4
6.	**Parallel Intermediate Representations:** Dependence analysis, loop transformations for parallel execution. **Optimizations for Parallel Execution:** Compiler transformations for parallelism, loop unrolling, software pipelining. **Advanced Topics in Parallel Compilation:** Just-in-time parallel compilation, GPU-based compilation, cloud-based optimization	08	CO4

Reference Books	
1.	Aho, A. V., Sethi, R., & Ullman, J. D. "Compilers: Principles, Techniques, and Tools." Addison-Wesley, 2007.
2.	Holub, A. I. "Compiler Design in C." Prentice Hall, 1990.
3.	Wolfe, M. "High-Performance Compilers for Parallel Computing." Addison-Wesley, 1995.
4.	Banerjee, U. "Loop Transformations for Restructuring Compilers." Springer, 1993.
5.	Allen, R., & Kennedy, K. "Optimizing Compilers for Modern Architectures: A Dependence-Based Approach." Morgan Kaufmann, 2001.
6.	Manoj B Chandak and Khushboo P Khurana, "Compiler Design," ISBN: 9789386235640, Year: 2018.

Programme Name	B. Tech. Computer Engineering
Course Code	R5CO3002T
Course Title	Machine Learning
Course Type	PCC
Prerequisites: Linear Algebra, Probability, Statistics	
Course Outcomes: At the end of the course student will be able to: **CO1.** Demonstrate fundamentals of different Machine Learning Techniques. **CO2.** Apply regression, classification, and clustering methods for problem solving. **CO3.** Demonstrate the usages of supervised and unsupervised learning methods. **CO4.** Apply advanced techniques of machine learning to solve complex problems.	

	Course Contents	Hrs.	CO
1.	**Statistical Decision Theory:** Regression, Classification, Bias-Variance Tradeoff, Linear Regression, Multivariate Regression, Subset Selection, Shrinkage Methods, Principal Component Regression, Partial Least Squares	5	CO1
2.	**Classification:** Linear Classification, Logistic Regression, Linear Discriminant Analysis, Support Vector Machines	8	CO2
3.	**Neural Networks:** Introduction, Early Models, Perceptron Learning, Backpropagation, Initialization, Training & Validation, Parameter Estimation - MLE, MAP, Bayesian Estimation, CNN, RNN, LSTM, GRU	8	CO2
4.	**Tree and Ensemble Methods:** Decision Trees, Regression Trees, Stopping Criterion & Pruning, Loss Functions, Categorical Attributes, Multiway Splits, Missing Values, Decision Trees - Instability Evaluation Measures, Bootstrapping & Cross Validation, Class Evaluation Measures, ROC Curve, MDL, Ensemble Methods - Bagging, Committee Machines and Stacking, Boosting, Gradient Boosting, Random Forests, Multi-class Classification, Naive Bayes, Bayesian Networks	6	CO3
5.	**Probabilistic Models:** Undirected Graphical Models, HMM, Variable Elimination, Belief Propagation	7	CO4
6.	**Optimization of Machine Learning Algorithms:** -	6	CO4

Text Books	
1.	Tom M. Mitchell, Machine Learning, McGraw-Hill, 1st edition, 1997 Ethem Alpaydin
2.	Introduction to Machine Learning (Adaptive Computation and Machine Learning), The MIT Press 2004
3.	Foundations of Machine Learning, Mehryar Mohri, Afshin Rostamizadeh, Ameet Talwalkar
4.	Davis E.Goldberg, "Genetic Algorithms: Search, Optimization and Machine Learning", Addison Wesley, N.Y., 1989
Reference Books	
1.	Hastie. T, Tibshirani. R, Friedman. J. H, The Elements of Statistical Learning, Springer,1st edition, 2001
2.	William W.Hsieh, "Machine Learning Methods in the Environmental Sciences", Cambridge
3.	Han Kamber, "Data Mining Concepts and Techniques", Morgann Kaufmann Publishers.

Programme Name	B. Tech. Computer Engineering
Course Code	R5CO3003T
Course Title	Computer Network
Course Type	PCC
Prerequisites: NIL	
Course Outcomes: At the end of the course student will be able to: **CO1.** Demonstrate the basics of networking and layered architectures. **CO2.** Apply Physical, MAC, IP, transport, and application layer protocols to provide efficient solutions. **CO3.** Design computer network specifications to meet requirements. **CO4.** Evaluate network design specifications to meet requirements.	

	Course Contents	Hrs.	CO
1.	**Introduction:** Data Communication System and its components, Data Flow, Computer network and its goals, Types of computer networks: LAN, MAN, WAN, Wireless and wired networks, broadcast and point to point networks, Network topologies, Network software: concept of layers, protocols, interfaces and services, ISO-OSI reference model, TCP/IP reference model	6	1,2
2.	**Physical Layer:** Fundamentals of physical layer, transmission media, Signal Encoding Techniques, Multiplexing, Asynchronous and Synchronous Transmission	4	1, 2
3.	**MAC Layer:** Design issues, error detection and correction, data link protocols, Channel access protocols.	5	1, 2, 3
4.	**Network Layer:** Design issues, Bridges – Routers, Gateways, Routing algorithms, Internetworking, Address learning bridges, Spanning tree, Addressing scheme, IPv4, IPv6, Subnet, supernetting, masking. ARP/RARP, ICMP, DNS, routing algorithms, RIP/RIPV2, OSPF etc.	8	2, 3, 4
5.	**Transport Layer:** Services, Transport layer protocols, UDP, TCP: State Transition diagram, flow control, error control, TCP Timers. Congestion control and Quality of Service: Queuing disciplines, TCP Congestion control, Congestion Avoidance Mechanisms, Quality of Service	8	2, 3, 4
6.	**Applications:** Traditional Applications (WWW, HTTP, FTP, Email, Telnet, SSH, DNS), etc.	4	1, 2
7.	**Advances in the domain**	2	3, 4

Text Books	
1.	Tanenbaum, Andrew S. "Computer Networks." Pearson Education, 6th Edition, 2021.
2.	Kurose, J. F., and Ross, K. W. "Computer Networking: A Top-Down Approach." Pearson, 8th Edition, 2020.
3.	Forouzan, B. A., and Mosharraf, Firouz. "Computer Networks, A Top-Down Approach." McGraw-Hill, 1st Edition, 2012.
Reference Books	
1.	Peterson, Larry L., and Davie, B. S. "Computer Networks: A Systems Approach." Elsevier, 5th Edition, 2011.
2.	Forouzan, B. A. "Data Communications and Networking." McGraw Hill, 5th Edition, 2012.
3.	Stallings, William. "Data and Computer Communications." Pearson Education, 10th Edition, 2013.
4.	Leon-Garcia, Alberto, and Widjaja, Indra. "Communication Networks: Fundamental Concepts and Key Architectures." McGraw-Hill, 2nd Edition, 2004.

Programme Name	B. Tech. Computer Engineering
Course Code	R5CO3004T
Course Title	Parallel Computing
Course Type	PCC
Prerequisites: COA	
Course Outcomes: At the end of the course student will be able to: **CO1.** Describe different ways of achieving parallelism and different parallel computer systems. **CO2.** Design Memory and Input/output subsystems in Uni processor and Multiprocessor environment considering the performance issues influencing its design. **CO3.** Analyze the organization and operation of Pipelined processor, SIMD Array processor, Multiprocessor architectures. **CO4.** Demonstrate the parallel algorithms and operating system support for parallel computing	

This table presents the structured unit-wise course topics, including the allocated hours and associated course outcomes (COs).			
Unit No	**Topics**	**Hrs**	**CO**
1	**Introduction to Parallel Processing**	4	1,4
	A. Evolution of Computer Systems, Necessity of high performance, Constraints of conventional architecture,B. Parallelism in Uni-processor Systems, Instruction and Thread Level Parallelism, C. Evolution of Parallel processors, Parallel Computer Structures, Future Trends, D. Instruction Set Architectures-classification, instruction formats, operations. E. Processor - Architectural Classification Schemes		
2	**Memory Subsystems in Parallel Environment**	5	2,3
	A. Hierarchical Memory Structure: Interleaved memory - structure, performance. B. Virtual Memory - utilization, locality of reference, performance.C. Cache Memory - structure, performance, implementation, optimization .		
3	**I/O Subsystems in Parallel Environment**	4	2
	A. I/O techniques- polling, interrupts, direct memory access. B. I/O channels, I/O processors - structures, bandwidth issues		
4	**Pipeline and Superscalar Micro-architecture**	7	3
	A. Pipelining: An Overlapped Parallelism, Principles and implementation of Pipelining. Classification of pipelining processors. Study and comparison of processors with and without pipelining. General pipelining reservation table. B. Instruction and Arithmetic Pipelining: Design aspects. C. Issues of designing Pipelined Processors: Pipelining hazards and resolving techniques, Data buffering techniques, Job sequencing, and Collision detection. D. Data level parallelism: Vector processing. E. Superscalar Architecture.		
5	**SIMD Computer Organization**	8	3,4
	A. SIMD Array Processors: Masking and Data network mechanism, Inter PE Communication. B. Communication: SIMD Interconnection networks, Static Vs Dynamic Networks, Cube, hyper cube, Mesh Interconnection Network. C. Associative Array Processors. D. Parallel Algorithms for Array Processors: Matrix Multiplication		
6	**SIMD Computer Organization**	8	1,3
	A. Functional Structures: Loosely and tightly coupled multiprocessors, Processor characteristics of multiprocessors, centralized and distributed shared memory architectures. B. Interconnection Networks: Time shared bus, Crossbar switch, Multiport Memory Model, Memory contention and arbitration techniques, Cache coherency C. Exploiting Concurrency for Multiprocessing: Implementation issues of a program on multiprocessor system. D. Parallel Algorithms for Multiprocessors, Multiprocessor operating systems E. Multi-core systems: Structure, performance. F. GPU based Architecture, CPU-GPU integration.		

Text Books	
1.	Hennessy, John, and Patterson, David. "Computer Architecture: A Quantitative Approach." Third Edition, Morgan Kaufmann Publishers, 2003.
2.	Hwang, Kai, and Briggs, Faye A. "Computer Architecture and Parallel Processing." McGraw-Hill International Edition.
3.	Culler, D. E., Singh, J. P., and Gupta, A. "Parallel Computer Architecture." Morgan-Kaufmann Publishers.
Reference Books	
1.	Rajaraman, V., and Sivaram Murthy, L. "Parallel Computers." PHI.
2.	Hwang, Kai. "Scalable Parallel Computing."
3.	Stone, Harrold. "High Performance Computer Architecture."
4.	Kain, Richard Y. "Advanced Computer Architecture."
5.	Hwang, Kai. "Advanced Computer Architecture." Tata McGraw-Hill.

Programme Name	B. Tech. Computer Engineering
Course Code	R5CO3005T
Course Title	Human Computer Interaction
Course Type	PCC
Prerequisites: Nil	
Course Outcomes: At the end of the course student will be able to: **CO1.** Apply concepts and guidelines of HCI. **CO2.** Design and examine interfaces and the interactions among them. **CO3.** Estimate and apply models and empirical data for system development. **CO4.** Develop and evaluate interactive systems.	

	Course Contents	Hrs.	CO
1.	**Introduction:** Objective, Overview and historical evolution of HCI, Guidelines for 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.	08	CO1
2.	**Interactive System Design:** Concept of usability: definition and elaboration, HCI and software engineering, GUI design and aesthetics, Prototyping techniques.	08	CO2
3.	**Model based design and evaluation:** Fundamental concepts, basic idea, different types of models, GOMS family of models (KLM and CMN- GOMS), Fitts' law and Hick-Hyman's law, Model-based design case studies.	08	CO3
4.	**Empirical research methods in HCI:** Motivation, issues, research question formulation techniques, experiment design and data analysis.	08	CO3
5.	**Task modeling and analysis:** Hierarchical Task Analysis (HTA), Engineering task models and Concur Task Tree (CTT).	08	CO4
6.	**Dialog Design:** Introduction to formalism in dialog design, design using FSM (finite state machines), State charts and (classical) Petri Nets in dialog design.	04	CO4
7.	**Advances in the domain**	04	CO4

Text Books	
1.	Dix, A., Finlay, J., Abowd, G. D., and Beale, R. "Human Computer Interaction." Pearson Education, 3rd Edition, 2005.
2.	Preece, J., Rogers, Y., Sharp, H., Benyon, D., Holland, S., and Carey, T. "Human Computer Interaction: Concepts and Design." Addison-Wesley, 1994.
Recommended Reading	
1.	Shneiderman, B., and Catherine, P. "Designing the User Interface." Addison-Wesley, 6th Edition, 2017.

Programme Name	B. Tech. Computer Engineering
Course Code	R5CO3003L
Course Title	Computer Network Laboratory
Course Type	PCC

Prerequisites: NIL

Course Outcomes: At the end of the course student will be able to:

CO1. Demonstrate the functionality of network components and execute relevant commands.

CO2. Design and implement network scenarios utilizing various network devices.

CO3. Implement error detection and correction mechanisms using techniques such as CRC and Hamming code.

CO4. Analyze the implemented protocols used at different layers, such as MAC, IP, transport, and application layer protocols.

	Course Contents	Hrs.	CO
1.	Study Basic networking commands.	2	1,2
2.	Study different Networking Devices.	2	1,2
3.	Analysis of packets using packet sniffing tools (Wireshark), configure IPv6 addressing, and analyze traffic using Wireshark.	2	1,2
4.	Study of Physical Layer, MAC Layer, Network Layer, Transport Layer Parameter Using Wireshark.	6	2,3
5.	Design and implementation of network topology using Hub, switches, and router.	2	2,3
6.	Implementation of Internet Services by telnet, ssh, ftp, Sftp, scp utilities.	2	3,4
7.	Implementation of CRC and Hamming code using C++/Java.	2	3,4
8.	Analysis of different layer protocols.	2	3,4

Text Books

1. Tanenbaum, Andrew S. "Computer Networks." Pearson Education, 6th Edition, 2021.
2. Forouzan, B. A., and Mosharraf, Firouz. "Computer Networks, A Top-Down Approach." McGraw-Hill, 1st Edition, 2012.

Recommended Reading

1. Peterson, Larry L., and Davie, B. S. "Computer Networks: A Systems Approach." Elsevier, 5th Edition, 2011.

Programme Name	B. Tech. Computer Engineering
Course Code	R5IT3002L
Course Title	Machine Learning Lab
Course Type	PCC
Prerequisites: Nil.	
Course Outcomes: At the end of the course student will be able to: **CO1.** Demonstrate the usage of preparation of data sets for implementation of machine learning algorithms. **CO2.** Implement the machine learning concepts and algorithms in any suitable language of choice. **CO3.** Evaluate the machine learning algorithms which are more appropriate for various types of learning tasks in various domains related to data set. **CO4.** Apply and analyse deep learning algorithms to solve research problems.	

Sr. No.	Course Contents
1.	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.
2.	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.
3.	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.
4.	Build an Artificial Neural Network by implementing the Back-propagation algorithm and test the same using appropriate data sets.
5.	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 a few test data sets.
6.	Assuming a set of documents that need to be classified, use the naïve Bayesian Classifier model to perform this task. Built-in Java classes/API can be used to write the program. Calculate the accuracy, precision, and recall for your data set.
7.	Write a program to construct a Bayesian network considering medical data. Use this model to demonstrate the diagnosis of heart patients using the standard Heart Disease Data Set. You can use Java/Python ML library classes/API.
8.	Apply the EM algorithm to cluster a set of data stored in a .CSV file. Use the same data set for clustering using the 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.
9.	Write a program to implement the 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.
10.	Implement the non-parametric Locally Weighted Regression algorithm in order to fit data points. Select an appropriate data set for your experiment and draw graphs.

Text Books	
1.	Mitchell, Tom M. "Machine Learning." McGraw-Hill, 1st Edition, 2017.
2.	Alpaydin, Ethem. "Introduction to Machine Learning (Adaptive Computation & Machine Learning)." 2nd Edition, 2009.
3.	Goldberg, Davis E. "Genetic Algorithms: Search, Optimization and Machine Learning." Addison Wesley, N.Y., 1989.
Recommended Reading	
1.	Hastie, T., Tibshirani, R., and Friedman, J. H. "The Elements of Statistical Learning." Springer, 1st Edition, 2001.
2.	Hsieh, William W. "Machine Learning Methods in the Environmental Sciences." Cambridge Publication.
3.	Kamber, Han. "Data Mining Concepts and Techniques." Morgan Kaufmann Publishers.

Programme Name	B. Tech. Computer Engineering
Course Code	R5CO3001L
Course Title	Parallel Programming Laboratory
Course Type	VSEC

Prerequisites: Knowledge of Computer Organization and Architecture, Operating Systems, programming language such as C/C++ & amp; Data Structures.

Course Outcomes: At the end of the course student will be able to:
CO1. Demonstrate computer system organization and functioning of its components such as CPU, Memory I/O.
CO2. Demonstrate Computer System Architecture including Various Parallel Architectures.
CO3. Evaluate efficiency of different parallel construct programs. **CO4.** Analyse the organization and operation of different parallel computer architectures

It is expected to conduct 8-10 experiments in the field of knowledge. One hour shall be tutored about theory and relevant tools to the students, and students shall perform the experiment. This is continuous evaluation, hence all experiments shall be evaluated in the same week. A sample list of experiments is given; it may be altered as and when required.

S.N.	Topics	Hrs	CO
1.	Simulation of virtual memory systems	2	1
2.	Simulation of cache memory systems	2	1
3.	To learn basics of MPI (Message Passing Interface)	2	1
4.	To learn Communication between MPI processes	2	2
5.	To get familiarized with advance communication between MPI processes	2	2
6.	To learn basics of OpenMP API (Open Multi-Processor API)	2	2
7.	To get familiarized with OpenMP Directives	2	1, 2
8.	Implementation of Convex hull algorithm	2	3
9.	Implementation of z-buffer algorithm	2	3
10.	Implementation of a shared linked list	2	3
11.	Parallel algorithm for carrying out different matrix operations	2	4
12.	Implementation of Telephone directory using RMI	2	4
13.	Implementation of parallel search algorithm	2	4

Text Books	
1.	Hwang, Kai, Briggs, Faye A. "Computer Architecture and Parallel Processing." McGraw-Hill International Edition.
2.	Culler, D. E., Singh, J. P., and Gupta, A. "Parallel Computer Architecture." Morgan-Kaufmann Publishers.
Reference Books	
1.	Rajaraman, V., and Sivaram Murthy, L. "Parallel Computers." PHI.
2.	Stallings, William. "Computer Organization and Architecture: Designing for Performance." Prentice Hall, Sixth Edition.
3.	Hwang, Kai. "Scalable Parallel Computing."
4.	Stone, Harrold. "High Performance Computer Architecture."
5.	Kain, Richard Y. "Advanced Computer Architecture."
6.	Hennessy, J. L., and Patterson, D. A. "Computer Architecture: A Quantitative Approach." Morgan-Kaufmann Publishers.
7.	Hwang, Kai. "Advanced Computer Architecture." Tata McGraw-Hill.

Programme Name	B. Tech. Computer Engineering
Course Code	R5CO3202T
Course Title	Software Estimation, Quality Assurance & Configuration Management
Course Type	MDM
Prerequisites: Fundamentals of Software Engineering	
Course Outcomes: At the end of the course student will be able to: **CO1.** Analyze the software requirements. **CO2.** Design the software. **CO3.** Test the software.	

	Course Contents	Hrs.	CO
1.	**Software Process- Measures, Metrics, and Indicators:** Process & Project Metrics, Software Measurement, Metrics for Software Quality	6	CO1
2.	**Software Project Planning:** Project Planning Objectives-Software Scope, Software Project Estimation, Empirical Estimation Models	7	CO2
3.	**Software Quality Assurance:** Quality Concepts, Software Reviews, Formal Technical Reviews, Software Reliability	6	CO3
4.	**Software Configuration Management:** SCM Process, Identification of Objects, Version Control, Change Control, Configuration Audit, Status Reporting	7	CO3

Text Books	
1.	Roger Pressman, "Software Engineering: A Practitioner's Approach" (5th Edition), McGraw-Hill, Inc., USA, 2000.
Recommended Reading	
1.	Ian Sommerville, "Software Engineering" (9th Edition), Addison-Wesley, 2010.
2.	Pankaj Jalote, "An Integrated Approach to Software Engineering" (3rd Edition), Springer, 2005.

Programme Name	B. Tech. Computer Engineering
Course Code	R5CO3201T
Course Title	Introduction to ML with python
Course Type	MDM
Prerequisites: Nil	
Course Outcomes: At the end of the course student will be able to: **CO1.** Learn the basics of Python used for Machine Learning. **CO2.** Understand different models of Machine Learning. **CO3.** Apply the knowledge to solve Machine Learning problems.	

	Course Contents	Hrs.	CO
1.	**Introduction:** Types of Learning, Essential Libraries and Tools - scikit-learn, NumPy, SciPy, matplotlib, pandas, and editors	4	CO1,2
2.	**Data Pre-processing:** Data cleaning and formatting, Feature extraction for supervised and unsupervised learning **Supervised Learning:** Regression - Linear Regression, Logistic Regression, Classification - Nearest Neighbours, Decision Trees, Naive Bayes, SVM	6	CO3
3.	**Unsupervised Learning and Pre-processing:** Challenges in Unsupervised Learning, Pre-processing and Scaling, Different Kinds of Pre-processing, Applying Data Transformations, Scaling Training and Test Data **Clustering Algorithms:** Evaluation of algorithms	7	CO4
4.	**Evaluating Machine Learning Algorithms and Model Selection:** Cross Validation, Cross-Validation in scikit-learn, Types and Benefits of Cross Validation	7	CO5,6

Text Books	
1.	Joel Grus, "Data Science from Scratch: First Principles with Python", 2nd Edition, O'Reilly Publication.
2.	Andreas C. Müller and Sarah Guido, "Introduction to Machine Learning with Python: A Guide for Data Scientists".

Programme Name	B. Tech. Computer Engineering
Course Code	R5CO3203T
Course Title	Secure Data Management and Database Security
Course Type	MDM
Prerequisites: NIL	
Course Outcomes: At the end of the course student will be able to: **CO1.** Learn the basics of different data structures and their vulnerabilities. **CO2.** Understand different data structures and their vulnerabilities. **CO3.** Apply the knowledge to solve problems related to data structures.	

	Course Contents	Hrs.	CO
1.	**Understanding Different Data Structures and Their Vulnerabilities:** Security measures and best practices involved in managing databases securely	6	CO1
2.	**Database Security:** Access control, encryption, authentication mechanisms, auditing, and protection against common database attacks like SQL injection and data breaches	4	CO2
3.	**Database Security Tools:** Database Activity Monitoring (DAM) tools, database firewalls, and Intrusion Detection/Prevention Systems (IDPS)	4	CO3
4.	**Practical Application on IDS**	4	CO4

Text Books	
1.	Behrouz A. Forouzan, "Introduction to Cryptography and Network Security", 2008.

Programme Name	B. Tech. Computer Engineering
Course Code	R5CO3204T
Course Title	High Performance Computing Systems
Course Type	MDM
Prerequisites: Discrete Structure	
Course Outcomes: At the end of the course student will be able to: **CO1.** Understand parallel algorithm design and computation. **CO2.** Implement normal algorithms and hypercubic networks. **CO3.** Analyze and optimize message routing techniques. **CO4.** Apply HPC in real-world applications.	

	Course Contents	Hrs.	CO
1.	**Parallel Algorithm & Computation: Parallel Computer Organization:** Network Model (Fine-Grained, Coarse-Grained Models) **Parallel Algorithm Design:** Fine-Grained Model, Prefix Computation, Simulating Large Trees on Small Trees Simulation Among Different Topologies	4	CO1
2.	**Normal Algorithms and Hypercubic Networks: Normal Algorithms:** Fourier Transforms, Hypercube Implementation, Sorting, Packing **Hypercubic Networks:** Butterfly Network, Omega Network, deBruijn Network, Shuffle Exchange Network	6	CO2
3.	**Message Routing:** Routing Models and Algorithms, Path Selection, Scheduling, Buffer Management **Case Studies:** Hypercube Routing, All-to-All Routing, Permutation Routing on Hypercubes, Queue Size in Random Destination Routing on a Mesh, Existence of Schedules, Lovasz Local Lemma, Routing on Levelled Directed Networks	4	CO3
4.	**Examples and Applications of High-Performance Computing (HPC): Scientific Computing Applications:** Weather Forecasting, Climate Modeling, Biomedical and Pharmaceutical Research , Engineering and Industrial Applications Supercomputing Systems and Case Studies	6	CO4

Text Books	
1.	Ranade, Abhiram. "Foundations of Parallel Computation." 2015.
2.	Grama, Ananth. "An Introduction to Parallel Computing: Design and Analysis of Algorithms." Pearson Publication, 2009.
Recommended Reading	
1.	Hwang, Kai, and Briggs, Faye A. "Computer Architecture and Parallel Processing." McGraw-Hill International Edition.
Online Resources	
1.	https://www.cse.iitb.ac.in/ ranade/606/

Programme Name	B. Tech. Computer Engineering
Course Code	R5CO3101T
Course Title	Optimization Techniques
Course Type	Program Elective –I
Prerequisites: Basic Linear Algebra	
Course Outcomes: At the end of the course student will be able to: **CO1.** Apply linear programming techniques for problem solving. **CO2.** Analyze and implement unconstrained and constrained Non-Linear optimization techniques. **CO3.** Design and optimize Multi-Objective Problems Using Single-objective Meta-heuristic optimization algorithm. **CO4.** Integrate Optimization Techniques in Machine Learning & Parallel Applications.	

	Course Contents	Hrs.	CO
1.	**Linear Programming:** Introduction, Simplex Method, Duality, Non-simplex Method.	06	CO1
2.	**Unconstrained Optimization:** Condition for Local Minimizer, One-Dimensional Search Methods, Gradient Methods, Newton's Method.	06	CO2
3.	**Non-linear Constrained Optimization:** Problems with Equality Constraints, Optimization Problems, Algorithms for Constrained Optimization, Single-objective heuristic optimization algorithm.	06	CO2
4.	**Single-objective optimization:** Simulated Annealing, Evolutionary Algorithms, Teaching-Learning-Based Optimization (TLBO), Particle Swarm Optimization (PSO), Artificial Bee Colony (ABC), Grey Wolf Optimizer (GWO), Bat Algorithm, Hybrid Optimization Techniques.	08	CO3
5.	**Multiobjective Optimization:** Non-Elitist Multi-Objective Evolutionary Algorithms, Elitist Multi-Objective Evolutionary Algorithms, Constrained Multi-Objective Evolutionary Algorithms.	08	CO3
6.	**Optimization in Machine Learning and Parallel Programs:** Continuous Optimization, Discrete optimization, Submodular Functions, Load balancing techniques, data Locality optimization, synchronization and communication optimization, Optimization strategy selection.	08	CO4

Text Books	
1.	Nocedal, Jorge, and Wright, Stephen J. "Numerical Optimization." Springer, 2000.
2.	Chong, Edwin K. P., and Zak, Stanislaw H. "Introduction to Optimization." Wiley, 2013.
Recommended Reading	
1.	Nayak, Sukanta. "Fundamentals of Optimization Techniques with Algorithms." Academic Press, 2020.
2.	Deb, Kalyanmoy. "Multi-Objective Optimization Using Evolutionary Algorithms." Wiley, 2009.
3.	Bubeck, Sebastien. "Convex Optimization: Algorithms and Complexity." Now Publishers, 2015.

Programme Name	B. Tech. Computer Engineering
Course Code	R5CO3101L
Course Title	Optimization Techniques Lab
Course Type	Program Elective –I Lab
Prerequisites: Basic Linear Algebra	
Course Outcomes: At the end of the course student will be able to: **CO1.** The student will be able to apply optimization techniques to real-world problems using advanced modeling tools. **CO2.** Students will be able to design and implement single-objective heuristic optimization algorithms using programming languages. **CO3.** Students will be able to develop multi-objective optimization solutions for complex engineering challenges. **CO4.** The student will be able to integrate optimization algorithms into mini-projects addressing engineering problems.	

	Course Contents	Hrs.	CO
1.	**Linear, nonlinear, and discrete optimization problem:** Problem solved using Generalized Algebraic Modelling System (GAMS) software.	04	CO1
2.	**Linear, nonlinear, and discrete optimization problem:** Problem solved using IBM ILOG Optimization Studio.	04	CO1
3.	Write a MATLAB or Python program for Teaching Learning-Based Optimization.	02	CO2
4.	Write a MATLAB or Python program for Particle Swarm Optimization.	02	CO2
5.	Write a MATLAB or Python program for the Artificial Bee Colony Algorithm.	02	CO2
6.	Write a MATLAB or Python program for the Gray Wolf Optimization Algorithm.	02	CO2
7.	Write a MATLAB or Python program for the Non-Dominated Sorting Genetic Algorithm 2 (NSGA-II).	04	CO3
8.	Write a multi-objective MATLAB or Python program for the Artificial Bee Colony Algorithm.	04	CO3
1.	**Mini Project:** Integrate optimization algorithms into mini-projects addressing engineering design, scheduling, machine learning problems.	06	CO4

Text Books	
1.	Nocedal, Jorge, and Wright, Stephen J. "Numerical Optimization." Springer, 2000.
2.	Chong, Edwin K. P., and Zak, Stanislaw H. "Introduction to Optimization." Wiley, 2013.
3.	Deb, Kalyanmoy. "Multi-Objective Optimization Using Evolutionary Algorithms." Wiley, 2009.
4.	Bubeck, Sebastien. "Convex Optimization: Algorithms and Complexity." Now Publishers, 2015.
Online Resources	
1.	https://www.gams.com/
2.	https://www.ibm.com/products/ilog-cplex-optimization-studio

Programme Name	B. Tech. Computer Engineering
Course Code	R5CO3102T
Course Title	Computer Graphics
Course Type	Program Elective –I

Prerequisites: Knowledge of C/C++ Programming and Basic Mathematics.

Course Outcomes: At the end of the course student will be able to:

CO1. Describe the basic concepts of Computer Graphics & Differentiate various computer graphics hardware and display technologies.

CO2. Demonstrate various algorithms for basic graphics primitives.

CO3. Apply 2D and 3D transformation on graphical objects.

CO4. Explore 2D 3-D Viewing with projection methods, Use various Clipping algorithms on graphical objects.

CO5. Understand visible surface detection techniques, curve representation techniques.

CO6. Develop applications using Animation and images.

	Course Contents	Hrs.	CO
1.	**Introduction and Overview of Graphics System:** Overview of Computer Graphics, Computer Graphics Application and Software Display systems: Random and Raster Displays, Description of some Input and Output graphics devices for operator Interaction, Video Basics, The Video Controller, Random – Scan Display Processor, Raster – scan display Processor.	04	CO1
2.	**Scan conversion:** Points and lines, Digital Differential Analyzer (DDA) algorithm, Bresenhams' Line drawing algorithm. Bresenhams' method of Circle drawing, Midpoint Circle Algorithm, Midpoint Ellipse Algorithm, Mid-point criteria (Mathematical derivation for above algorithms is expected). Solid Area Scan-Conversion: Inside - Outside Test, Windowing Number Method and Coherence Property, Polygon Filling, Seed Fill Algorithm, Scan-Line Algorithm, Priority Algorithm, Scan Conversion of Character, Aliasing, Anti-Aliasing, Half toning, Thresholding and Dithering.	06	CO2
3.	**Two-Dimensional Transformations:** Transformations and Matrices, Transformation Conventions, 2D Transformations, Homogeneous Coordinates and Matrix Representation of 2D Transformations, Translations and Homogeneous Coordinates, Rotation, Reflection, Scaling, Combined Transformation, Transformation of Points, Transformation of The Unit Square, Rotation About an Arbitrary Point, Reflection through an Arbitrary Line, A Geometric Interpretation of Homogeneous Coordinates, The Window-to-Viewport Transformations. **Three-Dimensional Transformations:** Three-Dimensional Scaling, Three-Dimensional Shearing, Three Dimensional Rotation, Three-Dimensional Reflection, Three Dimensional Translation, Multiple Transformation, Rotation about an Arbitrary Axis in Space, Reflection through an Arbitrary Plane, Matrix Representation of 3D Transformations, Composition of 3D Transformations.	06	CO3
4.	**Viewing and Clipping in 2D:** Viewing pipeline, Viewing transformations, Point Clipping, 2-D Clipping algorithms, Line clipping algorithms such as Cohen Sutherland line clipping algorithm, Liang Barsky algorithm, Polygon clipping – Sutherland Hodgeman polygon clipping, Text clipping. **Viewing in 3D:** Stages in 3D viewing, Canonical View Volume (CVV), Specifying an Arbitrary 3D View, Examples of 3D Viewing, The Mathematics of Planar Geometric Projections, Combined transformation matrices for projections and viewing, Coordinate Systems and matrices, camera model and viewing pyramid.	06	CO4
5.	**Visible-Surface Determination:** Techniques for efficient Visible-Surface Algorithms, Categories of algorithms, Back face removal, The z-Buffer Algorithm, Scan-line method, Painter's algorithms (depth sorting), Area sub-division method, BSP trees, Visible-Surface Ray Tracing, comparison of the methods. **Plane Curves and Surfaces:** Curve Representation, Nonparametric Curves, Parametric Curves, Parametric Representation of a Circle, Parametric Representation of an Ellipse, Parametric Representation of a Parabola, Parametric Representation of a Hyperbola, Representation of Space Curves, Cubic Splines, Bezier Curves, B-spline Curves, B-spline Curve Fit, B-spline Curve Subdivision, Parametric Cubic Curves, Quadric Surfaces, Bezier Surfaces.	04	CO5

	Course Contents	Hrs.	CO
6.	**Computer Animation:** Principles of Animation, Key framing, Deformations, Character Animation, Physics-Based Animation, Procedural Techniques, Groups of Objects. **Image Manipulation and Storage:** What is an Image? Digital image file formats, Image compression standard – JPEG, Image Processing - Digital image enhancement, contrast stretching, Histogram Equalization, smoothing and median Filtering.	04	CO6
7.	**Advancement Topic in the Domain.**		

Text Books	
1.	Hearn, D., and Baker, M. P. "Computer Graphics C Version." 2nd Edition, Pearson Publication.
2.	Foley, James D., van Dam, Andries, Feiner, Steven K., Hughes, John F. "Computer Graphics Principles and Practice in C." 2nd Edition, Pearson Publication.
3.	Bhattacharya, Samit. "Computer Graphics." Oxford Publication.
References	
1.	Rogers, D. "Procedural Elements for Computer Graphics." Tata McGraw-Hill Publications.
2.	Maurya, Rajesh K. "Computer Graphics." Wiley India Publication.
3.	Hill, F. S. "Computer Graphics using OpenGL." 3rd Edition, Pearson Publications.

Programme Name	B. Tech. Computer Engineering
Course Code	R5CO3102L
Course Title	Computer Graphics Lab
Course Type	Program Elective –I
Prerequisites: Database Management System	
Course Outcomes: At the end of the course student will be able to: **CO1.** Describe the basic concepts of Computer Graphics and graphics functions in C++. **CO2.** Demonstrate various algorithms for basic graphics primitives using function. **CO3.** Apply 2D and 3D transformation on graphical objects. **CO4.** Explore 2D 3-D Viewing with projection methods, Use various Clipping algorithms on graphical objects. **CO5.** Develop a Graphical application/Animation based on learned concepts.	

	Course Contents	Hrs.	CO
1.	Study and enlist the basic functions used for graphics in C / C++ / Python language. Give an example for each of them.	04	CO1
2.	Divide your screen into four regions, draw circle, rectangle, ellipse and half ellipse in each region with appropriate message.	04	CO1
3.	Draw the following basic shapes in the centre of the screen : i. Circle ii. Rectangle iii. Square iv. Concentric Circles v. Ellipse vi. Line	04	CO1
4.	Solve the following: a. Develop the program for DDA Line drawing algorithm. b. Develop the program for Bresenham's Line drawing algorithm	06	CO2
5.	Solve the following: a. Develop the program for the mid-point circle drawing algorithm. b. Develop the program for the mid-point ellipse drawing algorithm.	06	CO2
6.	Implement 2D Transformations: Translation, Scaling, Rotation, Reflection, and Shear.	06	CO3
7.	Implement Line Clipping Algorithm: Cohen Sutherland / Liang Barsky.	06	CO4
8.	To perform 3D Transformations such as translation, rotation and scaling.	06	CO3
9.	Solve the following: a. Write a program to fill a circle using Flood Fill Algorithm. b. Write a program to fill a circle using Boundary Fill Algorithm.	06	CO4
10.	Solve the following: a. Draw a simple hut on the screen. b. Draw the moving car on the screen.	08	CO4, 5

Text Books	
1.	Hearn, D., and Baker, M. P. "Computer Graphics C Version." 2nd Edition, Pearson Publication.
2.	Foley, James D., van Dam, Andries, Feiner, Steven K., and Hughes, John F. "Computer Graphics: Principles and Practice in C." 2nd Edition, Pearson Publication.
3.	Bhattacharya, Samit. "Computer Graphics." Oxford Publication.
References	
1.	Rogers, D. "Procedural Elements for Computer Graphics." Tata McGraw-Hill Publications.
2.	Maurya, Rajesh K. "Computer Graphics." Wiley India Publication.
3.	Hill, F. S. "Computer Graphics Using OpenGL." 3rd Edition, Pearson Publications.

Programme Name	B. Tech. Computer Engineering
Course Code	R5CO3103T
Course Title	Image Processing
Course Type	Program Elective –I

Prerequisites: NIL.

Course Outcomes: At the end of the course student will be able to:

CO1. Understand fundamental concepts, transformations, and enhancement techniques used in digital image processing.

CO2. Utilize color models, transformations, and restoration methods to enhance and reconstruct images.

CO3. Analyze and apply various image compression techniques and morphological operations for image processing tasks.

CO4. Use edge, region-based segmentation, and morphological methods for extracting meaningful information from images.

CO5. Implement neural networks and decision-theoretic approaches for object detection.

CO6. Explore advanced image processing techniques.

	Course Contents	Hrs.	CO
1.	**Fundamentals of image processing & Image Enhancement:** Introduction, Applications, Fundamental steps, Components of an image processing system, Image Sensing and Acquisition, Image Sampling and Quantization, Some Basic Relationships Between pixels. **Image Transforms:** Fourier Transform and their properties, Fast Fourier Transform, Other Transforms. **Image Enhancement:** Background, some basic Intensity Transformation, Histogram processing, Fundamentals of Spatial Filtering, Smoothing Spatial Filters, Sharpening Spatial Filters. **Case Study:** Enhancement of Satellite Images.	06	CO1
2.	**Color Image Processing:** Color Fundamentals, Color Models, Pseudocolor Image processing, Basics of Full-Color Image Processing, Color Transformations, Smoothing and sharpening, Image Segmentation based on color, Noise in color images. **Case Study:** Color Segmentation application.	06	CO2
3.	**Image Restoration and Reconstruction:** Introduction to restoration and reconstruction, noise models, Restoration in the presence of Noise only – spatial Filtering, Periodic Noise Reduction by Frequency Domain Filtering, Linear Position – Invariant Degradations, Estimating the Degradation Function, Image reconstruction from Projections. **Case Study:** Restoration and reconstruction of Historical Devanagari Manuscripts.	06	CO2
4.	**Image Compression:** Fundamentals: Coding Redundancy, Spatial and Temporal Redundancy, Irrelevant Information, Fidelity Criteria, Measuring Image information, Image compression models, Image formats, Containers and Compression standards. Some Basic compression methods: Huffman Coding, Golomb Coding, Arithmetic Coding, LZW coding, Run-Length coding, Symbol based coding. **Case study:** Image compression using Bandlets and Contourlets.	08	CO3
5.	**Morphological Image Processing and Segmentation:** Morphological Image Processing: Preliminaries, Erosion and dilation, opening and closing operations, basic morphological operations such as region filling, thinning, thickening, skeletons, pruning for binary images. **Image Segmentation:** Fundamentals, Point, Line and Edge detection, Region based segmentation. **Case study:** Applications of Morphological image processing in the domain of forensic, metrology, etc. Medical Image segmentation and its applications.	05	CO3, CO4
6.	**Application of Neural Network for object detection:** Pattern and pattern classes, Recognition based on decision – Theoretic methods: Matching Optimum Statistical Classifiers, Neural Networks and Structural Methods: Matching Shape Numbers, String Matching. **Case Study:** Suspicious Object Detection.	02	CO5
7.	**Advances in Digital Image Processing.**		CO6

Text Books	
1.	Gonzalez, Rafael C., and Woods, Richard E. "Digital Image Processing." 4th Edition, Global Edition, ISBN 978-0-13-335672-4.
2.	Jayaraman, S., Esakkirajan, S., Veerakumar, T. "Digital Image Processing." Tata McGraw Hill Education, 2009.
Recommended Reading	
1.	Jain, Anil K. "Fundamentals of Digital Image Processing." Prentice-Hall of India, 1997, ISBN: 8120309294.
2.	Sonka, Milan, et al. "Image Processing, Analysis, and Machine Vision." Thomson, Austria, 2008.
3.	Dey, Sandipan. "Hands-On Image Processing with Python: Expert Techniques for Advanced Image Analysis and Effective Interpretation of Image Data." Packet Publishing, Germany, 2018.

Programme Name	B. Tech. Computer Engineering
Course Code	R5CO3103L
Course Title	Image Processing Lab
Course Type	Program Elective –I

Prerequisites: Nil

Course Outcomes: At the end of the course student will be able to:

CO1. Install and apply Python libraries for fundamental image manipulations.

CO2. Implement geometric transformations and filtering techniques for noise reduction.

CO3. Perform histogram-based enhancement, edge detection, and morphological operations.

CO4. Apply edge-based and region-based techniques for object separation.

CO5. Implement image compression methods and object detection techniques.

	Course Contents	Hrs.	CO
1.	Set up different image processing libraries in Python. Perform basic image manipulations and transformations.	02	CO1
2.	Perform linear and non-linear filtering for noise smoothing for a noisy image.	02	CO2
3.	Perform histogram equalization and matching.	02	CO2,3
4.	Perform edge detection from an image using derivatives and filters.	06	CO2,3
5.	Perform various morphological operations on an image. (Erosion, Dilation, Skeletonizing, removing small objects, extracting boundaries etc.)	02	CO2,3
6.	Perform edge-based and region-based segmentation.	02	CO4
7.	Perform image compression using any basic algorithm (e.g. Huffman coding, run length coding, symbol-based encoding).	02	CO5
8.	Perform object detection from an image.	02	CO5

Text Books

1. Gonzalez, Rafael C., and Woods, Richard E. "Digital Image Processing." Fourth Edition, Global Edition, ISBN 978-0-13-335672-4.
2. Jayaraman, S., Esakkirajan, S., and Veerakumar, T. "Digital Image Processing." Tata McGraw Hill Education, India, 2009.

Recommended Reading

1. Jain, Anil K. "Fundamentals of Digital Image Processing." Prentice-Hall of India, 1997, ISBN 8120309294.
2. Sonka, Milan, et al. "Image Processing, Analysis, and Machine Vision." Thomson, Austria, 2008.
3. Dey, Sandipan. "Hands-On Image Processing with Python: Expert Techniques for Advanced Image Analysis and Effective Interpretation of Image Data." Packet Publishing, Germany, 2018.

Programme Name	B. Tech. Computer Engineering
Course Code	R5CO3104T
Course Title	NO SQL database
Course Type	Program Elective –I

Prerequisites: Database Management System.

Course Outcomes: At the end of the course student will be able to:

CO1. Compare relational databases with No SQL databases with the knowledge of the principles of distributed databases.

CO2. Identify the type of No SQL database to be applied on an application.

CO3. Design a key-value database, document database, column family database, or graph database for an application.

CO4. Understand the significance of partitioning of data, hash functions, query processing, and indexing in No SQL databases.

	Course Contents	Hrs.	CO
1.	**Unit 1: Relational Database Management System and its limitations, Motivation for No SQL databases:** Characteristics of NoSQL databases: Scalability, Cost, Flexibility, Availability, Data Management with Distributed Databases, Managing Persistent Data, Consistency, and Availability in Distributed Databases, Consistency, Availability, and Partitioning: The CAP Theorem, ACID and BASE, Types of Eventual Consistency.	06	CO1
2.	**Unit 2: Key Value Databases:** Arrays, Essential Features of key-value databases: Simplicity, Speed and Scalability, Properties of keys, Key value data modeling, Key-value architecture, Key-value implementation, Design of key value databases: key design and Partitioning, Designing Structured values, Limitations of key-value databases, Design Patterns for key-value databases.	06	CO2
3.	**Unit 3: Document Databases:** Documents and Collections, Types of Partitions, Modeling and Query Processing, Balancing Normalization and Denormalization, Mutable Documents, Indexes, Modeling common relations.	06	CO3
4.	**Unit 4: Column Family Databases:** Google BigTable, Differences and similarities to key-value and Document Databases, Architecture: HBase Architecture, Cassandra Architecture, When to use column family databases, Components of Column family databases, Implementing Column Family Databases, Processes and Protocols: Anti Entropy, Gossip Protocol, Guidelines for designing column family database and indexing, Tools for working with Big Data.	06	CO4
5.	**Unit 5: Graph Databases:** Graphs and Network Modeling, Advantages of Graph Databases, Graph database terms: Elements, Operations, Properties of graphs and nodes, Types of graphs, Designing Graph Database, Querying: Declarative Querying, Query by Traversal, Indexing, Scalability of graph.	06	CO5
6.	**Unit 6:** Case study for each type of No SQL database, Guidelines for choosing NoSQL database.	06	CO6

Text Books	
1.	Sullivan, Dan. "No SQL for Mere Mortals." Addison-Wesley.
2.	McCreary, Dan, and Kelly, Ann. "Making Sense of NoSQL: A Guide for Managers and the Rest of Us." Manning Shelter Island.
Recommended Reading	
1.	White, Tom. "Hadoop: The Definitive Guide." O'Reilly.
2.	George, Lars. "HBase: The Definitive Guide: Random Access to Your Planet-Size Data." O'Reilly.
3.	Robinson, Ian, Webber, Jim, and Eifrem, Emil. "Graph Database." O'Reilly.

Programme Name	B. Tech. Computer Engineering
Course Code	R5CO3104L
Course Title	NO SQL database Lab
Course Type	Lab

Prerequisites: Database Management System.

Course Outcomes: At the end of the course student will be able to:

CO1. Build and maintain reliable, scalable, distributed systems with Apache Hadoop.

CO2. Develop key-value, document database, column databases for real-time database operations.

CO3. Apply partitioning and replication principles of distributed database for real-time operations on unstructured and semi-structured data.

CO4. Apply distributed database design principles to analyse query retrieval by applying partitioning and replication.

CO5. Apply Hadoop ecosystem components to solve real-world problems.

CO6. Develop critical thinking and problem-solving skills by analysing database requirements for a case study, designing appropriate solutions, and implementing efficient database structures and operations using relational and non-relational data models.

	Course Contents	Hrs.	CO
1.	Set up a pseudo-distributed, single-node Hadoop cluster backed by the Hadoop distributed file system, running on Ubuntu Linux. After successful installation on one node, configuration of a multi-node Hadoop cluster (one master and multiple slaves).	1	2
2.	To develop a No SQL database for the given case study using Mongo DB and perform database operations.	2	2
3.	Implement a Multimedia database in MongoDB.	2	4
4.	To implement partitioning algorithm using Mongo DB.	3	2
5.	To develop a No SQL database for the given case study using Cassandra and perform database operations.	3	2
6.	To implement MongoDB replication.	3	2
7.	To develop Recommendation system using Graph Analytics for Big Data on Graph Databases.	3	4
8.	To develop map reduce application using Hadoop Cluster.	4	4
9.	Mini Project.	5	6

Text Books	
1.	Sullivan, Dan. "No SQL for Mere Mortals." Addison-Wesley.
2.	McCreary, Dan, and Kelly, Ann. "Making Sense of NoSQL: A Guide for Managers and the Rest of Us." Manning Shelter Island.
Recommended Reading	
1.	Acharya, Seema, and Chellappan, Subhashini. "Big Data and Analytics." Wiley, 2016.
2.	White, Tom. "Hadoop: The Definitive Guide." O'Reilly.
3.	George, Lars. "HBase: The Definitive Guide: Random Access to Your Planet-Size Data." O'Reilly.
4.	Robinson, Ian, Webber, Jim, and Eifrem, Emil. "Graph Database." O'Reilly.

Programme Name	B. Tech. Computer Engineering
Course Code	R5CO3105T
Course Title	Advanced Databases
Course Type	Program Elective –I
Prerequisites: Database Management System.	
Course Outcomes: At the end of the course student will be able to: **CO1.** Develop knowledge and understanding of the working of parallel and distributed databases. **CO2.** Analyse the key characteristics for building a data warehouse. **CO3.** Apply design methodologies of data warehouse for multidimensional data analysis using OLAP. **CO4.** Develop XML database for effective retrieval of semi-structured data. **CO5.** Apply modern tools for retrieval of NO SQL databases in cloud environments.	

	Course Contents	Hrs.	CO
1.	**Unit 1: Parallel Databases:** Parallel Systems, Parallel Storage: Partitioning, Replication, Parallel Indexing, Parallel Query Processing, Parallel External Sort-Merge algorithm, Parallel joins, Parallel Evaluation of Query Plans: Inter-operation Parallelism, Combining Operations Using Pipelining, Independent Parallelism, Inter-query and Intra-query parallelism, Transaction Processing in Parallel systems.	06	CO1
2.	**Unit 2: Distributed Databases:** Distributed Systems, Data Partitioning, Homogeneous and Heterogeneous Databases, Storing data in distributed databases, Distributed Transactions and Query Processing, Distributed Concurrency and Recovery, Distributed catalog Management.	06	CO2
3.	**Unit 3: Data Warehouse and OLAP:** Decision support, Data Warehousing, Creating and maintaining a warehouse. **OLAP:** Multidimensional Data Model, OLAP queries, Database Design for OLAP, Implementation Techniques for OLAP bitmap indexes, Join Indexes, Views and decision support, Top N Queries, Online aggregation.	06	CO3
4.	**Unit 4: XML:** Structure of XML data, XML document schema, Querying and transformation, API to XML, Storage of XML data, XML applications.	06	CO4
5.	**Unit 5: Advanced Topics:** Hadoop, Map Reduce, No SQL databases.	06	CO5

Text Books	
1.	Elmasri, Ramez, and Navathe, Shamkant B. "Fundamentals of Database Systems." 7th Edition, Pearson.
2.	Silberschatz, Abraham, Korth, Henry F., and Sudarshan, S. "Database System Concepts." 7th Edition, McGraw Hill Education.
3.	Rob, Peter, and Coronel, Carlos. "Database Systems, Design, Implementation and Management."
Recommended Reading	
1.	White, Tom. "Hadoop: The Definitive Guide." O'Reilly.

Programme Name	B. Tech. Computer Engineering
Course Code	R5CO3105L
Course Title	Advanced Databases Lab
Course Type	Program Elective –I

Prerequisites: Database Management System

Course Outcomes: At the end of the course student will be able to:

CO1. Apply knowledge to analyse join operations for query optimization.

CO2. Apply knowledge of transaction processing in database ensuring ACID properties.

CO3. Apply distributed database design principles to analyse query retrieval by applying partitioning and replication.

CO4. Apply knowledge of NoSQL database of insert, update, delete and query operations.

CO5. Develop a data warehouse and perform OLAP and data mining operations.

CO6. Develop XML database for semi-structured data.

CO7. Develop critical thinking and problem-solving skills by analysing database requirements for a case study, designing appropriate solutions, and implementing efficient database structures and operations using relational and non-relational data models.

	Course Contents	Hrs.	CO
1a.	To perform join operations for the given case study.	1	3
1b.	Study of query optimization by analysis of execution plan.	1	3
2.	To demonstrate transactions in MySQL RDBMS and ensure the ACID properties of the Database.	2	2
3a.	To create a table containing a minimum of 15 to 20 rows and apply different types of MySQL partitioning on the table.	3	3
3b.	Installation of Power BI tool and generating reports for data analysis.	3	3
4.	Create MongoDB NoSQL database for the given case study and write queries.	4	2
5.	To implement MongoDB replication.	3	2
6.	To perform a multidimensional data model using SQL queries. E.g., snowflake, star and fact constellation schema.	4	4
7.	To perform various OLAP operations such as: slice, dice, roll up, drill up etc.	2	1
8.	To perform mining on the given data.	5	2
9.	To create and retrieve XML data for an application.	6	2
10.	Mini Project.	7	6

Text Books	
1.	Elmasri, R. and Navathe, S. B. "Fundamentals of Database Systems." 7th Edition, Addison-Wesley Publication, 2015.
2.	Silberschatz, A., Korth, H. F., and Sudarshan, S. "Database System Concepts." 6th Edition, 2010.
3.	Ramakrishnan, R., and Gehrke, J. "Database Management Systems." 3rd Edition, McGraw-Hill, 2002.
Recommended Reading	
1.	Mannino, M. "Database Design, Application Development, and Administration." 4th Edition, 2008.
2.	Rob, P., and Coronel, C. "Database Systems, Design, Implementation, and Management." 5th Edition, Thomson Learning, 2001.
3.	Date, C. J. "Introduction to Database Systems." 7th Edition, Addison Wesley Longman.

Programme Name	B. Tech. Computer Engineering
Course Code	R5CO3106T
Course Title	Geospatial Technologies
Course Type	Program Elective –I

Prerequisites: Database Management System

Course Outcomes: At the end of the course student will be able to:

CO1. Understand basic, practical understanding of GIS concepts, techniques and real-world applications.

CO2. Explore geo-referencing, projection systems, mapping, satellite data systems, and spatial data acquisition systems.

CO3. Apply the spatial data analysis and visualize using GIS tools and software.

CO4. Develop to solve societal problems using geospatial technologies, tools and programming languages like webGIS and Mobile GIS.

	Course Contents	Hrs.	CO
1.	**Geographic Information Systems, Science and Study:** Introduction: Why GIS, Science and Technology of problem solving, GISystems, GIScience, GIS applications, GIS Components, Geographic data representation, Geographic data models: Raster and Vector data models.	04	CO1
2.	**Geo referencing and projection system:** Early measurements, The Geoid, Measuring the Earth: latitude and Longitude, Map projections and coordinate System, Digitizing: Coordinate capture, coordinate transformation, GNSS basics, GNSS control points, Map Projection vs. Transformation, Geo-referencing, satellite based positioning.	05	CO2
3.	**Data acquisition and assimilation:** Data Sources: Aerial images, Satellite images, LiDAR, Digital data, remote sensing, Data acquisition methods: Field survey, Control survey, old records, Integration challenges in geospatial systems, spatial data standards, Data Quality, Data Accuracy.	05	CO2,3
4.	**Visualizing spatial data:** Introduction to maps, visualization process, cartographic toolbox, Maps types, Map scales, Map Generalization, Map boundaries, maps and cartography, Principles of map design, how to map: qualitative, quantitative, terrain elevation, time series, geo visualization, map stories.	05	CO3
5.	**Spatial Analysis:** Introduction: what is spatial analysis? Selection and Classification, Proximity Functions and Buffering, Fundamental spatial analysis techniques such as overlay, extraction, and interpolation, Raster analysis: Map Algebra, Local Functions, Global Functions, terrain analysis.	05	CO3
6.	**Web GIS:** Introduction to Web GIS, Introduction to Mobile GIS, Scripting Languages for GIS.	06	CO4
7.	**Advances in GIS and Remote sensing:** Advances and Current developments in GIS, Challenges in GIS, Understanding Satellite Image processing and other remote sensing techniques.	04	CO2,4

Text Books	
1.	Bolstad, Paul. "GIS Fundamentals: A First Text on Geographic Information Systems." XanEdu, 2016.
2.	Longley, Goodchild, Paul A., et al. "Geographic Information Systems and Science." John Wiley & Sons, 2005.
3.	Huisman, Otto. "Principles of GIS."
Recommended Reading	
1.	DeMers, Michael N. "Fundamentals of Geographic Information Systems." 4th Edition, Wiley, 2009.
2.	Lo, C. P., and Yeung, Albert. "Concepts and Techniques of Geographic Information Systems." 2nd Edition, Pearson Prentice Hall, 2007.
3.	Reddy, M. Anji, and Anji Reddy. "Textbook of Remote Sensing and Geographical Information Systems." BS Publications, Hyderabad, 2008.
4.	Sarda, N.L., Acharya, P.S., and Sen, Sumit (Eds.). "Geospatial Infrastructure, Applications and Technologies: India Case Studies." 2019.

Programme Name	B. Tech. Computer Engineering
Course Code	R5CO3106L
Course Title	Geospatial Technologies Lab
Course Type	Program Elective –I
Prerequisites: Database Management System	
Course Outcomes: At the end of the course student will be able to: **CO1.** Demonstrate fundamental concepts of PostGIS and QGIS tools. **CO2.** Implement geospatial databases using PostGIS and execute spatial queries. **CO3.** Apply and evaluate spatial indexing techniques for performance optimization. **CO4.** Implement graph queries using Cypher and develop geospatial applications.	

	Course Contents	Hrs.	CO
1.	Understanding QGIS, and other GIS mapping tools	02	CO1
2.	Working with QGIS	02	CO1
3.	Creating digital maps using geospatial objects	02	CO2
4.	Understanding digital data, data collection techniques, and various data formats	02	CO2
5.	Importing various data formats to QGIS to build map and features	02	CO2
6.	Working with basics of spatial data analysis	02	CO3
7.	Working with basics of spatial data analysis	02	CO3
8.	Working with multiple layers of digital maps and complex query analysis	02	CO3
9.	Developing web pages for webGIS	02	CO4
10.	Working with scripting languages for dynamic webGIS contents	02	CO4
11.	Working with scripting languages for dynamic MobileGIS contents	02	CO4
12.	Accessing webGIS/Mobile through private/public hosting infrastructure using GeoNode server.	02	CO4

Text Books	
1.	Bolstad, Paul. "GIS Fundamentals: A First Text on Geographic Information Systems." XanEdu, 2016.
2.	Longley, Goodchild, Paul A., et al. "Geographic Information Systems and Science." John Wiley & Sons, 2005.
3.	Huisman, Otto. "Principles of GIS."

Programme Name	B. Tech. Computer Engineering
Course Code	R5CO3006T
Course Title	Cloud Computing
Course Type	PCC

Prerequisites: Operating system

Course Outcomes: At the end of the course student will be able to:

CO1. Understand and formulate the basics of cloud computing with its benefits, architecture and measure its value.

CO2. Analyse the underlying virtualization technology for cloud and implement the same using Opensource cloud environment tool.

CO3. Explore the services offered by cloud computing like IAAS, PAAS, SAAS, storage using various application frameworks like MapReduce, HADOOP etc.

CO4. Evaluate cloud administration, management, and various cloud service providers and explore the security aspects concerning the cloud.

	Course Contents	Hrs.	CO
1.	Introduction to Cloud Computing: Roots of Cloud Computing, Benefits, SOA, Web services, Web 2.0, Mashups, Grid computing, Utility computing, Virtualization, Challenges, Cloud economics, Network role, Cloud types, service models, platforms (Openstack, Open nimbus, Eucalyptus), primary service models, cloud brokerage, deployment models, reference model, Greenfield/Brownfield deployment options.	04	CO1,2
2.	Virtualization Concepts and Architecture: Characteristics of virtualized environments, Virtualization techniques, Pros and Cons, Technology examples (Xen, KVM, VMware, Microsoft Hyper-V).	06	CO2
3.	Cloud Computing Platforms: Exploring cloud computing stack (Composability, Infrastructure, Platforms, Virtual Appliances, Communication Protocols, Applications), Defining IaaS, SaaS, PaaS, IDaaS, CaaS. SaaS overview, PaaS frameworks.	08	CO3
4.	Accessing the Cloud: Platforms, WEB applications, WEB APIs, Browsers, GCP, Cloud Storage: Overview, Storage providers, Cloud Standards, Cloud storage techniques (MAPREDUCE, HDFS, GFS).	04	CO1,3
5.	Cloud Computing at Work/Deploying Cloud: Deployment of cloud environments, Datacenter concepts, Private/Public cloud Datacenter deployment using Openstack/Open Nebula, Cloud services deployment using open-source tools (AWS, GCP). SaaS, PaaS, IaaS, Mobile Device Integration, Microsoft Online Application development, Troubleshooting, Application management.	07	CO2,3
6.	Cloud Administration: Performance prediction for HPC on Cloud, SLA management, SLA types and lifecycle, Service catalog, ordering process, management interfaces, cloud portal, lifecycle management, cloud management standards.	04	CO4
7.	Security in Cloud Computing: Data security technologies, Cloud data security risk, Identity management, Content level security, Cloud security standards, Availability management in SaaS, IaaS, PaaS, Access Control, Patch and Configuration Management.	04	CO4
8.	Advances in the Domain.	04	CO4

Recommended Reading	
1.	Denning, D. E. "Cryptography and Data Security," Addison-Wesley Publishing Company.
2.	Fleeger, C. P. "Security in Computing," 5th Edition, Prentice Hall Publication.
3.	Bishop, M. "Introduction to Computer Security," Addison-Wesley Publication.

Programme Name	B. Tech. Computer Engineering
Course Code	R5CO3006L
Course Title	Cyber Security Lab
Course Type	PCC
Prerequisites: Nil.	
Course Outcomes: At the end of the course student will be able to: **CO1.** Identify cybercrimes, and respective cyber laws. **CO2.** Build the secure network infrastructure and reduce the risk of attacks. **CO3.** Reduce the risk of data theft and web application attacks. **CO4.** Explore the security, defense mechanisms, and forensic best practices in the advanced domain.	

	Course Contents: Experiments on	Hrs.	CO
1	Cyber Crime	2	CO1
2	TCP/IP Security Model	2	CO1,2
3	Secure Network Design for Organization	2	CO1,2,3
4	Practical Experiment on Firewall	2	CO1, 3
5	Implement Intrusion Detection Systems:	2	CO2
6	Protocol Analysis Tools	2	CO1,3
7	The Attacks On Web Application and Defense Mechanism	2	CO1,3
8	Hardening Linux and Database for Cyber Security	2	CO2
9	Defense Mechanism Against Hackers Methodology	2	CO3,4
10	GROUP PROJECTS	2	CO3

Text Books	
1.	Dr. B.B. Meshram, Ms. K.A. Shirsath, "TCP/IP and Network Security: Attacks and Defense Mechanisms with Open-Source Tools," Shroff Publishers & Distributors PVT. LTD, 1st edition, 2017.
2.	John Sammons, "The Basics of Digital Forensics: The Primer for Getting Started in Digital Forensics," Elsevier, 1st Edition, 2012.
Recommended Reading	
1.	Charles Pfleeger, "Security in Computing," 4th Edition, Prentice Hall of India, 2006.
2.	Roberta Bragg, M.R. Ousley, Keith Strassberg, "Network Security - The Complete Reference," Tata McGraw-Hill.

Programme Name	B. Tech. Computer Engineering
Course Code	R5CO3008T
Course Title	Research Methodology and IPR
Course Type	PCC
Prerequisites: Nil.	
Course Outcomes: At the end of the course student will be able to: **CO1.** Design and formulation of research problem. **CO2.** Analyze research related information and statistical methods in research. **CO3.** Carry out research problem individually in a perfect scientific method. **CO4.** Understand the filing patent applications processes, Patent search, and various tools of IPR, Copyright, and Trademarks.	

	Course Contents	Hrs.	CO
1.	Introduction to research: Definitions and characteristics of research, Types of Research, Research Process, Problem definition, Objectives of Research, Research Questions, Research design, Quantitative vs. Qualitative Approach, Building and Validating Theoretical Models, Exploratory vs. Confirmatory Research, Experimental vs. Theoretical Research, Importance of reasoning in research.	2	CO1
2.	Problem Formulation, Understanding Modeling & Simulation, Literature Review, Referencing, Information Sources, Information Retrieval, Indexing and abstracting services, Citation indexes, Development of Hypothesis, Measurement Systems Analysis, Error Propagation, Validity of experiments, Statistical Design of Experiments, Data/Variable Types & Classification, Data collection, Numerical and Graphical Data Analysis: Sampling, Observation, Interpretation of Results.	3	CO1
3.	Statistics: Probability & Sampling distribution, Estimation, Measures of central Tendency, Arithmetic mean, Median, Mode, Standard deviation, Coefficient of variation (Discrete series and continuous series), Hypothesis testing & application, Correlation & regression analysis, Orthogonal array, ANOVA, Standard error, Concept of point and interval estimation, Level of significance, Degree of freedom, Analysis of variance, One-way and two-way classified data, 'F' test.	4	CO2
4.	Preparation of Dissertation and Research Papers, Tables and illustrations, Guidelines for writing the abstract, introduction, methodology, results and discussion, conclusion sections of a manuscript. References, Citation and listing system of documents.	2	CO3
5.	Intellectual property rights (IPR): patents, copyrights, trademarks, industrial design, geographical indication. Ethics of Research, Scientific Misconduct, Forms of Scientific Misconduct, Plagiarism, Unscientific practices in thesis work, Ethics in science.	3	CO4

Text Books	
1.	Bordens, K. S., and Abbott, B. B. "Research Design and Methods – A Process Approach," 8th Edition, McGraw Hill, 2011.
2.	Montgomery, D. C., and Runger, G. C. "Applied Statistics & Probability for Engineers," Wiley, 2007.
Reference Books	
1.	Marder, M. P. "Research Methods for Science," Cambridge University Press, 2011.

Programme Name	B. Tech. Computer Engineering
Course Code	
Course Title	Financial Management
Course Type	HSSM
Prerequisites: Nil.	
Course Outcomes: At the end of the course student will be able to: **CO1.** Identify and understand issues in financial technologies. **CO2.** Design and apply models using R programming of financial technologies. **CO3.** Demonstrate and summarize stock market trends. **CO4.** Apply the knowledge of cryptocurrency market.	

	Course Contents	Hrs.	CO
1.	Introduction to FinTech: Introduction to finance and technologies, current trends in financial technologies, Fintech ecosystems, emerging markets and social impact.	4	CO1
2.	Financial Solutions: Predictive Algorithms – Building Innovative Online Banking Solutions, Big Data is the Cornerstone of Regulatory Compliance Systems, FinTech Solutions in Complex Contracts Optimization, FinTech Solutions for Small Businesses.	4	CO1
3.	Capital, Investment and Innovations: Investment and Capital – Back to Basics, Angel Investing, Access to "Smart Money" to Fund the Best FinTech Companies. Crowd funding and Marketplace (P2P) Lending – Online Capital Marketplaces as New Asset Classes to Access Funding. The Digital Investment Space, Spanning from Social Trading to Digital Private Banking – A FinTech Sector Made for Disruption?, Leading the Way with an Investor-led Approach to Crowd funding.	4	CO1
4.	Financial Technology in R: Computation, Programming, plotting, statistics and Inference, utility functions, assets management, option valuation, and portfolio design.	4	CO2
5.	Stock Market analysis: Introduction to stock market, equity, derivatives, put options and call options, trading algorithms implementation using R.	2	CO3
6.	Crypto-currencies & Blockchain: Digital currencies, convergence and collisions, Blockchain technology.	4	CO4
7.	Advances in the domain.	2	CO4

Text Books	
1.	Chishti, S., and Barberis, J. "The FINTECH Book: The Financial Technology Handbook for Investors, Entrepreneurs and Visionaries," 2016.
2.	Würtz, D., Setz, T., Chalabi, Y., Lam, L., and Ellis, A. "Basic R for Finance," 2015.
3.	Jeet, P., and Vats, P. "Learning Quantitative Finance with R," 2017.
Recommended Reading	
1.	Archarya, S. "Data Analytics Using R," 2018.
2.	Clifford, A. "Analyzing Financial Data and Implementing Financial Models Using R."
3.	Magee, J. "Technical Analysis of Stock Trends," 2009.

Programme Name	B. Tech. Computer Engineering
Course Code	R5CO3004L
Course Title	Devops
Course Type	VSEC

Prerequisites: Software Engineering, Web Development, Cloud, Networking.

Course Outcomes: At the end of the course student will be able to:
CO1. Track the changes in the software application development and maintenance.
CO2. Demonstrate continuous integration and development of the software application.
CO3. Design continuous deployment strategy for the software application.
CO4. Apply test automation to the software application.
CO5. Perform configuration management and monitoring of the software application.
CO6. Develop and deploy a software application in the cloud environment.

It is expected to conduct 8-10 experiments in the field of knowledge. One hour shall be tutored about theory and relevant tools to the students, and students shall perform the experiment. This is continuous evaluation, hence all experiments shall be evaluated in the same week. A sample list of experiments is given it may be altered as and when required.

Sr. No.	Course Contents
1.	Practice source code management using Git and GitHub.
2.	Jenkins installation and setup, explore the environment. Demonstrate continuous integration and development using Jenkins.
3.	Explore Docker commands for content management. Develop a simple containerized application using Docker.
4.	Integrate Kubernetes and Docker. Automate the process of running containerized applications developed in exercise 3 using Kubernetes.
5.	Install and Explore Selenium for automated testing. Write a simple program in JavaScript and perform testing using Selenium.
6.	Install Ansible in the VM. Setup the inventory, run Ansible AdHoc commands. Also run a playbook in Ansible.
7.	Monitor systems, networks and infrastructure using Nagios application.
8.	Design an application using Cloud Services to apply DevOps concepts.

Programme Name	B. Tech. Computer Engineering
Course Code	R5CO3005L
Course Title	Cloud Computing Lab
Course Type	PCC
Prerequisites: NIL	
Course Outcomes: At the end of the course student will be able to: **CO1.** Demonstrate use of virtual machine on virtual machine manager. **CO2.** Simulate resource allocation in the virtual environment in cloud computing. **CO3.** Simulate data center allocation, load balancing in cloud computing. **CO4.** Demonstrate PaaS programs in cloud computing.	

	Course Contents	Hrs.	CO
1.	To create virtual machines using VirtualBox or VMware on Windows or Linux platform and know its various features (Virtualization Concept).	2	CO1
2.	To study and implement logical volumes in physical disk via LVM utility (allocation of resource).	2	CO1, CO2
3.	To create x datacenters with x hosts, x VMs, x cloudlets in Cloud Sim.	2	CO2
4.	To create x datacenter with x hosts (x per data center). Set storage capacity, RAM, and cost using Cloud Reports.	2	CO2
5.	To study and perform Equally Spread Current Execution Load Balancing Policy in Cloud Analyst.	2	CO3
6.	To study and perform Throttled Load Balancing Policy in Cloud Analyst.	2	CO3
7.	Implement the service model of "Infrastructure as a Service" or private cloud datacenter. Use devstack (OpenStack) or Open Nebula or any other open-source framework for IaaS.	2	CO3
8.	Implement "Software as a Service" (SaaS) model using Google Cloud Platform (GCP) or any other.	2	CO4
9.	Implement the service model of "Platform as a Service". Deploy an application on Google App Engine or any other platform providers like AWS.	2	CO4
10.	Study and Analysis of Hadoop Distributed File System framework by implementing Similarity Search program or word count program using MapReduce on HADOOP framework.	2	CO4

Text Books	
1.	Buyya, R., Broberg, J., and Goscinki, A. "Mastering Cloud Computing," 1st Edition, 2017.
2.	Shroff, G. "Enterprise Cloud Computing: Technology, Architecture, Applications," Cambridge University Press, 2010.
Recommended Reading	
1.	Sosinsky, B. "Cloud Computing Bible," Wiley & Sons, Illustrated Edition, 2010.
2.	Velte, A. T. "Cloud Computing: A Practical Approach," Tata McGraw Hill, 2009.

Programme Name	B. Tech. Computer Engineering
Course Code	R5CO3006L
Course Title	Cyber Security Lab
Course Type	PCC
Prerequisites: Nil.	
Course Outcomes: At the end of the course student will be able to: **CO1.** Identify cybercrimes, and respective cyber laws. **CO2.** Build the secure network infrastructure and reduce the risk of attacks. **CO3.** Reduce the risk of data theft and web application attacks. **CO4.** Explore the security, defense mechanisms, and forensic best practices in the advanced domain.	

	Course Contents: Experiments on	Hrs.	CO
1	Cyber Crime	2	CO1
2	TCP/IP Security Model	2	CO1,2
3	Secure Network Design for Organization	2	CO1,2,3
4	Practical Experiment on Firewall	2	CO1, 3
5	Implement Intrusion Detection Systems:	2	CO2
6	Protocol Analysis Tools	2	CO1,3
7	The Attacks On Web Application and Defense Mechanism	2	CO1,3
8	Hardening Linux and Database for Cyber Security	2	CO2
9	Defense Mechanism Against Hackers Methodology	2	CO3,4
10	GROUP PROJECTS	2	CO3

Text Books	
1.	Dr. B.B. Meshram, Ms. K.A. Shirsath, "TCP/IP and Network Security: Attacks and Defense Mechanisms with Open-Source Tools," Shroff Publishers & Distributors PVT. LTD, 1st edition, 2017.
2.	John Sammons, "The Basics of Digital Forensics: The Primer for Getting Started in Digital Forensics," Elsevier, 1st Edition, 2012.
Recommended Reading	
1.	Charles Pfleeger, "Security in Computing," 4th Edition, Prentice Hall of India, 2006.
2.	Roberta Bragg, M.R. Ousley, Keith Strassberg, "Network Security - The Complete Reference," Tata McGraw-Hill.

Programme Name	B. Tech. Computer Engineering
Course Code	R5CO3206T
Course Title	Software Development Activities
Course Type	MDM
Prerequisites: Software Estimation, Quality Assurance & Configuration Management	
Course Outcomes: At the end of the course student will be able to: **CO1.** Analyze software requirements. **CO2.** Design software. **CO3.** Test software.	

	Course Contents	Hrs.	CO
1.	**Software Requirements Analysis Principles & Modeling:** Requirements Elicitation for Software, Software Requirements Analysis, Software Prototyping, SRS, Data Modeling, Functional Modeling, Behavioral Modeling	6	CO1
2.	**Software Design Principles & Modeling:** Software Design Process- Design Principles & Concepts, Data Design, Software Architectural Design, Mapping Requirements into a Software Architecture, Transform Mapping, Transaction Mapping	6	CO2
3.	**User Interface Design, Component-Level Design:** Graphical Design Notation, Tabular Design Notation, Program Design Language	7	CO2
4.	**Software Testing Techniques & Strategies:** White-Box Testing, Black-Box Testing, Software Testing Strategies- Unit Testing, Integration Testing, Validation Testing	7	CO3

Text Books	
1.	Roger Pressman, "Software Engineering: A Practitioner's Approach" (5th Edition), McGraw-Hill, Inc., USA, 2000.
Recommended Reading	
1.	Ian Sommerville, "Software Engineering" (9th Edition), Addison-Wesley, 2010.
2.	Pankaj Jalote, "An Integrated Approach to Software Engineering" (3rd Edition), Springer, 2005.

Programme Name	B. Tech. Computer Engineering
Course Code	R5CO3205T
Course Title	Data visualization
Course Type	MDM
Prerequisites: Nil	
Course Outcomes: At the end of the course student will be able to: **CO1.** Learn the basics of Python for data visualization. **CO2.** Understand different models and techniques used for visualization. **CO3.** Apply the knowledge to solve various data visualization problems.	

	Course Contents	Hrs.	CO
1.	**Data Import and Visualization:** Introduction to various plots, Implementing data visualization techniques using Python libraries such as Matplotlib and Seaborn	4	CO1,2
2.	**Chart and Plot Creation:** Line, area, histograms, bar, pie, box, scatter, and bubble charts	6	CO3
3.	**Correlation Visualization and Analysis:** Dimensionality Reduction Algorithms, PCA Analysis	7	CO4
4.	**APIs for Advanced Processing:** APIs for various learning models	7	CO5,6

Text Books	
1.	Joel Grus, "Data Science from Scratch: First Principles with Python", 2nd Edition, O'Reilly Publication.
2.	Andreas C. Müller and Sarah Guido, "Introduction to Machine Learning with Python: A Guide for Data Scientists".

Programme Name	B. Tech. Computer Engineering
Course Code	R5CO3207T
Course Title	Operating System Security
Course Type	MDM
Prerequisites: Nil	
Course Outcomes: At the end of the course student will be able to: **CO1.** Learn the basics of different OS security mechanisms. **CO2.** Understand different OS security features and their vulnerabilities. **CO3.** Apply the knowledge to analyze OS security threats and mitigation strategies.	

	Course Contents	Hrs.	CO
1.	**Overview of Operating System Security:** Security goals and challenges, Role-based Access Control (RBAC), and Discretionary Access Control (DAC)	6	CO1
2.	**File System Security:** Network stack security features (e.g., firewalls, IPSec)	4	CO2
3.	**Secure Remote Access:** Secure remote access protocols (e.g., SSH, VPN)	4	CO3
4.	**Security Information and Event Management (SIEM) Systems**	4	CO4

Text Books	
1.	**Introduction to Cryptography and Network Security:** Behrouz A. Forouzan, 2008.

Programme Name	B. Tech. Computer Engineering
Course Code	R5CO3208T
Course Title	Algorithms High Performance Computing
Course Type	MDM

Prerequisites: Discrete Structure

Course Outcomes: At the end of the course student will be able to:

CO1. Analyze the complexity of parallel algorithms.

CO2. Implement parallel graph and numerical algorithms.

CO3. Apply linear algebra concepts and load balancing techniques in HPC.

CO4. Optimize and tune parallel algorithms for performance improvement.

	Course Contents	Hrs.	CO
1.	**Complexity Analysis of Parallel Algorithms:** Understanding time and space complexity in parallel computing, Performance metrics (Speedup, efficiency, scalability), Complexity analysis of Parallel Sorting Algorithms (Parallel Merge Sort, Bitonic Sort), Parallel Searching Algorithms (Parallel Binary Search, Hash-based Search), Examples and case studies of parallel sorting and searching	6	CO1
2.	**Parallel Graph Algorithms & Numerical Methods: Graph Algorithms in Parallel:** Parallel BFS and DFS, Minimum Spanning Tree (Prim's & Kruskal's in parallel), Shortest Path Algorithms (Dijkstra's, Floyd-Warshall in parallel) **Numerical Methods in HPC:** Parallel Computation of Matrix Operations, Iterative Methods (Jacobi, Gauss-Seidel), Finite Difference Methods in Parallel Computing	6	CO2
3.	**Linear Algebra for HPC, Load Balancing & Scalability: Linear Algebra for HPC:** Vector and Matrix Operations in Parallel, Parallel LU, QR, and Cholesky Decomposition **Load Balancing in Parallel Computing:** Static vs. Dynamic Load Balancing, Load balancing techniques (Work Stealing, Graph Partitioning) **Scalability Analysis:** Strong vs. Weak Scaling, Amdahl's and Gustafson's Law	6	CO3
4.	**Optimization Techniques for Parallel Algorithms:** Code and memory optimization for HPC, Parallelization Techniques (Task Parallelism vs. Data Parallelism, Optimizing Synchronization & Communication Overhead), Cache Optimization & Data Locality, Case studies on performance tuning in HPC	6	CO4

Text Books

1. Ananth Grama, "An Introduction to Parallel Computing: Design and Analysis of Algorithms," Pearson Publication, 2009.

Recommended Reading

1. Michael J. Quinn, "Parallel Programming in C with MPI and OpenMP," Tata McGraw-Hill, 2011.

Programme Name	B. Tech. Computer Engineering
Course Code	R5CO3107T
Course Title	Wireless Networks
Course Type	PEC

Prerequisites: Computer Network

Course Outcomes: At the end of the course student will be able to:

CO1. Demonstrate the fundamentals of wireless technology.

CO2. Apply the layered protocols and fundamentals for the design of wireless Scenario.

CO3. Apply resource optimization techniques for better performance.

CO4. Design and evaluate the working of different wireless networks.

	Course Contents	Hrs.	CO
1.	Introduction: History of wireless communication, Frequency spectrum, Applications.	2	CO1
2.	Wireless Transmission: Frequency for radio transmission, Signals, Antennas, Signal propagation, Multiplexing, modulation, Spread spectrum, Cellular systems.	4	CO1,2
3.	Medium Access Control: Motivation for a specialized MAC: Hidden and Exposed terminals. Near and Far terminals, multiplexing techniques.	4	CO1,2
4.	Wireless LAN: Infrared vs. Radio transmission, Infrastructure and Ad hoc Networks, IEEE 802.11: System architecture, Protocol architecture, Physical layer, Medium access control layer, MAC management, Overview of 3G, 4G, 5G, HIPERLAN, Bluetooth.	7	CO2,3
5.	Mobile Network Layer: Mobile IP: Goals, assumptions and requirements, Entities and Terminology, IP packet delivery, Agent advertisement and discovery, Registration, Tunnelling and Encapsulation, Optimizations, Reverse tunnelling, Ipv6; Dynamic host configuration protocol, Ad hoc networks: Routing, Destination sequenced distance vector, Dynamic source routing, Hierarchical algorithms, Alternative metrics.	7	CO2,3
6.	Mobile Transport Layer: Traditional TCP, indirect TCP, Snooping TCP, Fast retransmit/fast recovery, transmission/time out freezing, selective retransmission, transaction oriented TCP.	7	CO2,3
7.	Support for Mobility: File system, World Wide Web, Wireless application protocol.	5	CO2,3,4
9.	Wireless network case study: WSN, WiMax, Cellular network.	4	CO3
10.	Advances in the domain.	2	CO3,4

Text Books	
1.	Schiller, J. "Mobile Communications," Addison Wesley, Pearson Education, 2nd Edition, 2002.
Recommended Reading	
1.	Stallings, W. "Wireless Communication Networks and Systems," Cory Beard, 1st Edition, 2015.
2.	Rappaport, T. S. "Wireless Communications Principles and Practices," 2nd Edition, Pearson Education Pvt. Ltd, 2003.

Programme Name	B. Tech. Computer Engineering
Course Code	R5CO3107L
Course Title	Wireless Networks Lab
Course Type	PEC

Prerequisites: Operating system

Course Outcomes: At the end of the course student will be able to:

CO1. Demonstrate wireless fundamentals and build the topologies for wireless networks.

CO2. Implement to demonstrate the working of protocols of wireless networks.

CO3. Analysis of protocols in wireless networks.

CO4. Evaluate the performance of wireless networks.

	Course Contents	Hrs.	CO
1	Study of Simulators for wireless networks.	2	CO1
2	Build and configure Ad-hoc networks for various topologies.	2	CO1, CO2
3	Study of working Physical MAC, Network, Transport Layer parameters.	4	CO1, CO2
4	Analysis of protocols at different layers.	2	CO2, CO3
5	Implement and Study star topology for wireless sensor networks.	2	CO2, CO3
6	Implement and Study Multi-hop topology for wireless sensor networks.	2	CO2, CO3
7	Study and analyse protocols for wireless sensor networks.	2	CO2, CO3
8	Comparative analysis of IEEE 802.11a/b/g etc using network simulation software.	2	CO3
9	Set up a Wi-Fi network and analyze IEEE 802.11 protocol parameters using Wireshark.	2	CO2
10	Analysis of power consumption and energy optimization.	2	CO4

Text Books

1. Schiller, Jochen. "Mobile Communications," Addison Wesley, Pearson Education, 2nd Edition, 2002.

Recommended Reading

1. Stallings, William. "Wireless Communication Networks and Systems," Cory Beard, 1st Edition, 2015.
2. Rappaport, Theodore S. "Wireless Communications Principles and Practices," 2nd Edition, Pearson Education Pvt. Ltd, 2003.

Programme Name	B. Tech. Computer Engineering
Course Code	R5CO3108T
Course Title	Software Defined Network
Course Type	PEC
Prerequisites: Computer Network.	
Course Outcomes: At the end of the course student will be able to: **CO1.** Demonstrate the working of SDN. **CO2.** Emulate SDN using openflow. **CO3.** Programme the SDN. **CO4.** Apply SDN in data center. **CO5.** Study SDN security and its applications.	

	Course Contents	Hrs.	CO
1.	**Computer Network Design Foundation:** Introduction to SDN: History of Software Defined Networking (SDN), Modern Data Center, Traditional Switch Architecture, Why SDN, Evolution of SDN, How SDN Works – Centralized and Distributed Control and Date Planes, The Genesis of SDN	06	CO1
2.	**Open Flow and SDN Controllers:** Open Flow Specification, SDN via APIs, SDN via Hypervisor- Based Overlays – SDN via Opening up the Device, General Concepts, OpenFlow Protocol, SDN Controllers: Introduction, VMware - Nicira - VMware/Nicira - OpenFlow-Related - Mininet - NOX/POX - Trema - Ryu - Big Switch Networks/Floodlight Layer 3 Centric - Plexxi - Cisco OnePK	06	CO2
3.	**SDN Programming:** Northbound Application Programming Interface, Current Languages and Tools, Composition of SDNs – Network Functions Virtualization (NFV) and Software Defined Networks: Concepts, Implementation and Applications, NetApp Development, Network Slicing	06	CO3
4.	**SDN in Data Center:** SDN in the Data Center - SDN in Other Environments - SDN Applications - SDN Use Cases - The Open Network Operating System 3, Multitenant and Virtualized Multitenant Data Center – SDN Solutions for the Data Center Network – VLANs – EVPN – VxLAN – NVGRE	08	CO4
5.	**SDN Security:** Security Characteristics of SDN, Security Analysis and Potential attacks in SDN,Security Principles of SDN, Solutions to the security issues in SDN, Network Security enhancement using the SDN Framework – Issues and Challenges, Threats to SDN -Networks, Controllers, Applications	06	CO5

6.	**SDN Applications and SDN Future:** SDN applications-Reactive versus Proactive Applications, Analysing Simple SDN Applications, A Simple Reactive Java Application, Using the Floodlight Controller, Using the Open Daylight Controller, Access Control for the Campus, Traffic Engineering for Service Providers, Applications of SDN to Real Networks. SDN Future -Potential Novel Applications of Open SDN-Managing Non-traditional Physical Layer Links, Applying Programming Techniques to Networks, Security Applications, Roaming in Mobile Networks, Traffic Engineering in Mobile Networks, SDN Open Source - SDN Futures - Final Thoughts and Conclusions	08	CO5

Text Books	
1.	Paul Goransson and Chuck Black, "Software Defined Networks: A Comprehensive Approach", Morgan Kaufmann, 2014, ISBN: 9780124166752, 9780124166844.
2.	SiamakAzodolmolky, "Software Defined Networking with Open Flow, Packt Publishing, 2013, ISBN: 9781849698726.
3.	Thomas D. Nadeau, Ken Gray, "SDN: Software Defined Networks, An Authoritative Review"
Reference Books	
1.	1. Vivek Tiwari, "SDN and OpenFlow for Beginners", Digital Services, 2013, ISBN: 10: 1-940686-00-8, 13: 978-1-940686-00-4.
2.	Fei Hu, "Network Innovation through OpenFlow and SDN: Principles and Design", CRC Press, 2014, ISBN: 10: 1466572094.
3.	Open Networking Foundation (ONF) Documents, https://www.opennetworking.org, 2015

Programme Name	B. Tech. Computer Engineering
Course Code	R5CO3108L
Course Title	Software Defined Network Lab
Course Type	PEC

Prerequisites: Computer Network.

Course Outcomes: At the end of the course student will be able to:

CO1: Demonstrate an understanding of the architecture and principles of Software Defined Networking (SDN).

CO2: Implement and configure OpenFlow protocol and SDN controllers for network management.

CO3: Develop SDN applications using Northbound APIs for network automation and management.

CO4: Apply SDN principles in data center networks and implement security measures to address SDN-related vulnerabilities.

	Course Contents	Hrs.	CO
1	Introduction to SDN Architecture	06	CO1
2	OpenFlow Protocol Implementation	06	CO2
3	SDN Controller Setup and Configuration	06	CO3
4	SDN Programming with Northbound API	06	CO4
5	Network Functions Virtualization (NFV) with SDN	06	CO5
6	SDN in Data Centers	08	CO6
7	SDN Security - Basic Security Implementation	06	CO7
8	SDN-based Traffic Engineering	08	CO8
9	Implementing SDN Applications	06	CO9
10	Future of SDN - OpenFlow and Mobile Networks	08	CO10

Text Books

1. Paul Goransson and Chuck Black, "Software Defined Networks: A Comprehensive Approach", Morgan Kaufmann, 2014, ISBN: 9780124166752, 9780124166844.
2. SiamakAzodolmolky, "Software Defined Networking with Open Flow, Packt Publishing, 2013, ISBN: 9781849698726.
3. Thomas D. Nadeau, Ken Gray, "SDN: Software Defined Networks, An Authoritative Review"

Reference Books

1. 1. Vivek Tiwari, "SDN and OpenFlow for Beginners", Digital Services, 2013, ISBN: 10: 1-940686-00-8, 13: 978-1-940686-00-4.
2. Fei Hu, "Network Innovation through OpenFlow and SDN: Principles and Design", CRC Press, 2014, ISBN: 10: 1466572094.
3. Open Networking Foundation (ONF) Documents, https://www.opennetworking.org, 2015

Programme Name	B. Tech. Computer Engineering
Course Code	R5CO3109T
Course Title	Management Information Systems
Course Type	PEC
Prerequisites: Nil.	
Course Outcomes: At the end of the course student will be able to: **CO1:** Identify Information Systems in an organization. **CO2:** Manage IT infrastructure for Electronic Business and Electronic Commerce in an organization. **CO3:** Use Enterprise systems in an organization. **CO4:** Develop Information Systems and Manage change in an organization.	

	Course Contents	Hrs.	CO
1	Introduction to Information Systems: Perspectives on Information Systems, Contemporary Approaches to Information Systems, Learning to Use Information Systems	3	CO1
2	Information Systems in the Enterprise: Major Types of Systems in Organizations, Systems from a Functional Perspective, Integrating Functions and Business Processes: Introduction to Enterprise Applications	4	CO1
3	Information Systems, Organizations, Management, and Strategy: Organizations and Information Systems, How Information Systems Impact, Organizations and Business Firms, The Impact of IT on Management Decision Making, Information Systems and Business Strategy	3	CO1
4	The Digital Firm: Electronic Business and Electronic Commerce: Electronic Business, Electronic Commerce, and the Emerging Digital Firm Electronic Commerce, Electronic Business and the Digital Firm	4	CO2
5	IT Infrastructure and Platforms: IT Infrastructure, Infrastructure Components, Contemporary Hardware & Software Platform Trends, Database Trends	3	CO2
6	Telecommunications, Networks, the Internet & the Wireless Revolution: Technologies and Tools for Communication and E-Business Wireless Computer Networks and Internet Access, M-Commerce, Wireless Technology in the Enterprise	4	CO2
7	Enterprise Applications and Business Process Integration: Enterprise Systems, Supply Chain Management Systems, Customer Relationship Management Systems, Enterprise Integration Trends	4	CO3
8	Managing Knowledge in the Digital Firm: The Knowledge Management Landscape, Enterprise-Wide Knowledge Management Systems, Knowledge Work Systems, Intelligent Techniques	4	CO3
9	Enhancing Decision Making for the Digital Firm: Decision Making and Decision-Support Systems, Systems for Decision Support	3	CO3
10	Redesigning the Organization with Information Systems: Systems as Planned Organizational Change, Overview of Systems Development Alternative Systems-Building Approaches	3	CO4
11	Understanding the Business Value of Systems and Managing Change: Information Technology Investments and Productivity, Importance of Change Management in Information Systems Success and Failure, Managing Implementation	3	CO4
12	Advances in the domain	1	CO4

Text Books	
1.	Laudon K. C., Laudon J. P, "Management Information Systems: Managing the Digital Firm," Pearson Education Global Edition, 2019.
2.	James O'Brien, George Marakas, "Management Information Systems," McGraw-Hill Education.
Recommended Reading	
1.	J. Sousa, Effy Oz, "Management Information Systems," Cengage Learning.

Programme Name	B. Tech. Computer Engineering
Course Code	R5CO3109L
Course Title	Management Information Systems Lab
Course Type	PEC

Prerequisites: Nil.

Course Outcomes: At the end of the course student will be able to:

CO1. Carry out cost & effort estimation, risk management, project scheduling, software quality assurance and software configuration management for an Information Systems development project.

CO2. Carry out requirements analysis, software design, coding & testing for an Information Systems development project.

	Course Contents	Hrs.	CO
1	Give detailed Problem Statement for the Information System (I S) being designed.	1	CO1
2	Perform Software Scoping activity for the I S.	1	CO1
3	Estimate required Resources for the I S.	1	CO1
4	Perform Cost and effort Estimation for the I S.	2	CO1
5	Perform Risk Analysis for the I S.	2	CO1
6	Prepare the Project Schedule.	2	CO1
7	Prepare the Project Plan.	2	CO1
8	Prepare Software Quality Assurance Plan.	2	CO2
9	Carry out Requirement Analysis Modelling using structured or object-oriented analysis.	3	CO2
10	Carry out Software Design using structured or object-oriented design.	3	CO2
11	Develop the MIS & Test it.	4	CO2

Text Books

1. Laudon, K. C., and Laudon, J. P. "Management Information Systems: Managing the Digital Firm," Pearson Education, Global Edition, 2019.
2. O'Brien, James, and Marakas, George. "Management Information Systems," McGraw-Hill Education.

Recommended Reading

1. Sousa, Ken J., and Oz, Effy. "Management Information Systems," Cengage Learning.

Programme Name	B. Tech. Computer Engineering
Course Code	R5CO3110T
Course Title	Object Oriented Analysis and Design
Course Type	PEC
Prerequisites: Nil.	
Course Outcomes: At the end of the course student will be able to: **CO1.** Identify and model the requirement of the software requirement. **CO2.** Apply Object-oriented design and development techniques to problems. **CO3.** Apply architectural design to the problems. **CO4.** Analyze and apply the deployment techniques for the complex problems.	

Text Books	
1.	Bahrami, Ali. "Object Oriented System Development," McGraw Hill.
2.	Booch, Grady, Rambaugh, J., Jacobson, Ivar. "The UML Users Guide," Pearson.
3.	Haigh, Andrew. "Object Oriented Analysis and Design," Tata McGraw Hill.
Recommended Reading	
1.	Bennett, Simon, McRobb, Steve, Farmer, Ray. "Object Oriented System Analysis and Design Using UML," McGraw Hill.
2.	Lethbridge, Timothy C., Laganiere, Robert. "Object Oriented Software Engineering," McGraw Hill.

	Course Contents	Hrs.	CO
1	Introduction: Overview Of OOL; Object Classes; Meta Types. Object Oriented Methodologies; The Unified Approach Modeling; Why Modeling? Static And Dynamic Models; Functional Models.	3	CO1
2	Object Modeling: Object. Links. Association. Inheritance. Grouping Constructs; Problems On Object Modeling; Advantages Of Object Modeling.	3	CO1
3	Analysis: Problem Analysis. Problem Domain Classes. Identify Classes And Objects Of Real World Problems. Using Use Case Analysis; Recording Analysis.	3	CO2
4	Basic Object Modeling: Multiplicity. Constraints. Aggregation. Component.	2	CO1,2
5	Sequence Diagram: Modeling Scenarios. Mapping Events To Object. Interfaces. Discovering Attributes. Modeling Simple Collaboration Modeling. Logical Database Schema. Activity Diagram. Modeling Workflow.	2	CO1,2
6	Class Diagram: Test Scenarios. Interfaces. Classes. Methods. Stress Testing. System Testing. Scalability Testing. Regression Testing.	2	CO2,3
7	Behavioral Modeling. State Chart Diagram.	3	CO2,3
8	Design: Architectural Design. Refining The Model. Refactoring. Coupling And Cohesion. Who Should Own The Attribute? Who Should Own The Operations? Process And Threads.	3	CO2,3
9	Design Classes: Classes Visibility; User Interface. Subsystem Interface.	3	CO2,3
10	Deployment Diagram: Modeling deployment diagrams.	3	CO3,4
11	Advances in the domain.	2	CO4

Programme Name	B. Tech. Computer Engineering
Course Code	R5CO3110L
Course Title	Object Oriented Analysis and Design Lab
Course Type	PEC

Prerequisites: Nil.

Course Outcomes: At the end of the course student will be able to: **CO1.** Demonstrate fundamental knowledge of software development life cycle.
CO2. Design software requirement specification document for a project.
CO3. Analyze and apply object modeling techniques for solving complex problems.
CO4. Evaluate different design artifacts developed to provide solutions to the problem.

	Course Contents	Hrs.	CO
1	Draw software life cycle with phases.	02	CO1
2	SRS Documentation for project.	02	CO1
3	Class Modeling.	02	CO2
4	State Modeling.	02	CO2
5	Interaction Modeling.	02	CO3
6	Analysis and Design.	02	CO3
7	System Design.	02	CO3
8	Class design.	02	CO4
9	Component Diagram.	02	CO4

Text Books	
1.	Bahrami, Ali. "Object Oriented System Development," McGraw Hill.
2.	Booch, Grady, Rambaugh, J., Jacobson, Ivar. "The UML Users Guide," Pearson.
3.	Haigh, Andrew. "Object Oriented Analysis and Design," Tata McGraw Hill. (Page No: 53)
Recommended Reading	
1.	Bennett, Simon, McRobb, Steve, Farmer, Ray. "Object Oriented System Analysis and Design Using UML," McGraw Hill.
2.	Lethbridge, Timothy C., Laganiere, Robert. "Object Oriented Software Engineering," McGraw Hill.

Programme Name	B. Tech. Computer Engineering
Course Code	R5CO3111T
Course Title	BlockChain Technology
Course Type	PEC
Prerequisites: Nil.	
Course Outcomes: At the end of the course student will be able to: **CO1.** Understand blockchain architecture and requisite crypto foundations and resolve security concerns in blockchain. **CO2.** Demonstrate various consensus protocols and their usage for specific applications. **CO3.** Explore blockchain advances and upcoming platforms. **CO4.** Analyze smart contracts and distributed applications and design use-cases.	

	Course Contents	Hrs.	CO
1	Introduction and Crypto foundations: Elliptic curve cryptography, ECDSA, Cryptographic hash functions, SHA-256, Merkle Trees, Cryptocurrencies	4	CO1
2	Bitcoin: Bitcoin addresses, Bitcoin's blockchain, block header, mining, proof of work (PoW) algorithms, difficulty adjustment algorithm, mining pools, transactions, double spending attacks, the 51% attacker, block format, pre-SegWit transaction formats, Bitcoin script, transaction malleability, SegWit transaction formats, smart contracts (escrow, micropayments, decentralized lotteries), payment channels, Lightning network	8	CO1, 3
3	Ethereum: Overview of differences between Ethereum and Bitcoin, block format, mining algorithm, proof-of-stake (PoS) algorithm, account management, contracts and transactions, Solidity language, decentralized applications using Ethereum	4	CO1,2
4	Smart Contracts	4	CO4
5	Different Blockchains and Consensus mechanisms	4	CO2
6	Blockchain and Security: Attacks and countermeasures	4	CO1
7	R3, CORDA and Hyperledger: System architecture, ledger format, chain code execution, transaction flow and ordering, private channels, membership service providers, case studies	8	CO3
8	Advances in the domain	3	CO4

Text Books	
1.	Antonopoulos, Andreas. "Mastering Bitcoin: Unlocking Digital Cryptocurrencies," O'Reilly Media, Inc., 2014.
2.	Narayanan, Arvind. "Bitcoin and Cryptocurrency Technologies: A Comprehensive Introduction," Princeton University Press, 2016. ISBN-10: 0691171696.
Recommended Reading	
1.	Hyperledger Fabric Documentation: http://hyperledger-fabric.readthedocs.io/en/latest/http://hyperledger-fabric.readthedocs.io/en/latest/
2.	Ethereum Documentation: http://www.ethdocs.org/en/latest/http://www.ethdocs.org/en/latest/
3.	Narayanan, Arvind. "Bitcoin and Cryptocurrency Technologies," Princeton University Press, 2016. ISBN-10: 0691171696.

Programme Name	B. Tech. Computer Engineering
Course Code	R5CO3111L
Course Title	BlockChain Technology Lab
Course Type	PEC

Prerequisites: Nil.

Course Outcomes: At the end of the course student will be able to:

CO1. Demonstrate the basic concepts of cryptography in Blockchain technology.
CO2. Implement Ethereum contracts.
CO3. Analyze distributed applications.
CO4. Implement consensus algorithms.

	Course Contents	Hrs.	CO
1	Understanding ECDSA	2	CO1
2	Implement a program to chain the message using hash functions	2	CO1
3	Analyze the bitcoin blockchain and ethereum blockchain	2	CO1,2
4	Write a program to implement proof-of-work consensus algorithm	2	CO4
5	Implement a smart contract to creation of Token	3	CO2,3
6	Implement a smart contract to election	3	CO2,3
7	Design a Distributed Application	4	CO3
8	Configure hyperledger Blockchain	3	CO4

Text Books

1. Saravanan, V. "An Introduction to Bitcoin," Lecture Notes.
2. Antonopoulos, Andreas. "Mastering Bitcoin: Unlocking Digital Cryptocurrencies," O'Reilly Media, Inc., 2014.

Recommended Reading

1. Narayanan, Arvind. "Bitcoin and Cryptocurrency Technologies: A Comprehensive Introduction," Princeton University Press, 2016. ISBN-10: 0691171696.
2. Antonopoulos, Andreas M., and Wood. "Mastering Ethereum," O'Reilly Media, Inc., 2018.

Programme Name	B. Tech. Computer Engineering
Course Code	R5CO3901L
Course Title	Cloud Practitioner Essentials Training (AWS)
Course Type	PCC

Prerequisites: General IT business knowledge, General IT technical knowledge
General IT technical knowledge

Course Outcomes: At the end of the course student will be able to:
CO1. Understand AWS fundamentals and demonstrate knowledge of AWS cloud computing concepts, global infrastructure, and core services.
CO2. Utilize AWS compute, storage, and database services by identifying appropriate solutions for various use cases.
CO3. Implement networking and security best practices by explaining AWS networking concepts and security models to ensure cloud security compliance.
CO4. Monitor and manage AWS costs using AWS monitoring, analytics, and cost management tools to optimize cloud resources.
CO5. Prepare for AWS certification by developing the knowledge and skills required to pass the AWS Certified Cloud Practitioner exam.

	Course Contents	Hrs.	CO
1.	**Introduction to AWS and Cloud Computing:** Summarize the benefits of AWS, explain cloud computing concepts (on-demand delivery, cloud deployments, and pay-as-you-go pricing), Understand the AWS Global Infrastructure (Regions, Availability Zones, Edge locations), Compare different methods for provisioning AWS services. **Experiments:** 1. Exploring AWS Global Infrastructure & Deploying a Virtual Machine 2. Understanding AWS Pricing with Pay-as-You-Go Model	3	CO1
2.	**Compute, Storage, and Databases:** Describe the benefits and use cases of Amazon EC2, EC2 Auto Scaling, and Elastic Load Balancing, Explain different EC2 instance types and billing options, Summarize additional AWS compute services (such as AWS Lambda and containers). Summarize the concepts of cloud storage and database services, Explain the benefits of Amazon S3, EBS, EFS, RDS, and DynamoDB, Compare various storage and database solutions. **Experiments:** 1. Deploying and Scaling an EC2 Instance with Load Balancing 2. Comparing AWS Storage and Database Solutions	3	CO2
3.	**Networking and Security:** Explain basic networking concepts and AWS networking services (VPC, DirectConnect, VPN), Differentiate between public and private networking resources, Describe hybrid deployments and AWS global network interactions, Explain the AWS shared responsibility model and security best practices, Summarize key security services like IAM, MFA, AWS Organizations, and compliance. **Experiments:** 1. Creating a Secure VPC with Public and Private Subnets 2. Implementing AWS Security Best Practices with IAM and MFA	4	CO3
4.	**Monitoring, Analytics, and Cost Management:** Describe approaches to monitoring AWS environments using CloudWatch, CloudTrail, and Trusted Advisor, Explain AWS pricing models, Free Tier, and cost management tools (Budgets, Cost Explorer, Pricing Calculator), Differentiate AWS Support Plans and their benefits, Summarize AWS Marketplace and its advantages. **Experiments:** 1. Monitoring AWS Resources with CloudWatch, CloudTrail, and Trusted Advisor 2. Managing AWS Costs with Cost Explorer, Budgets & Pricing Calculator	4	CO4
5.	**Migration, Innovation, and Cloud Best Practices:** Explain cloud migration strategies and AWS data migration solutions (Snowcone, Snowball, Snowmobile), Understand the AWS Cloud Adoption Framework (AWS CAF), Describe AWS innovation solutions (AI, ML, IoT, serverless computing), Summarize the six pillars of the AWS Well-Architected Framework. **Experiments:** 1. Simulating a Cloud Migration with AWS S3 and AWS DataSync 2. Implementing the AWS Well-Architected Framework for Serverless Applications	4	CO5
6.	**AWS Certification and Final Assessment:** Describe the benefits of AWS Certification, Identify resources for preparing for the AWS Certified Cloud Practitioner exam, Solve practice questions similar to the AWS Cloud Practitioner Certification exam.	2	CO5

Text Books	
1.	Amazon Cloud Services AWS, https://aws.amazon.com/training/learn-about/cloud-practitioner/.
2.	Ben Piper, David Clinton, "AWS Certified Cloud Practitioner Study Guide: CLF-C01 Exam".
3.	Andreas Wittig, Michael Wittig, "Amazon Web Services in Action".
4.	Thomas Erl, Zaigham Mahmood, "Cloud Computing: Concepts, Technology & Architecture".

Programme Name	B. Tech. Computer Engineering
Course Code	R5CO3902L
Course Title	Salesforce beginners Training
Course Type	PCC

Prerequisites: Salesforce Navigation, Cloud Computing

Course Outcomes: At the end of the course student will be able to:
CO1. Demonstrate an understanding of Salesforce fundamentals, including CRM concepts, cloud computing, and Salesforce platform navigation.
CO2. Apply data management techniques by handling standard/custom objects, implementing security measures, and managing user roles and permissions in Salesforce.
CO3. Utilize Salesforce automation tools like Workflow Rules, Process Builder, and Approval Processes to streamline business operations and enhance productivity.
CO4. Analyze and generate data-driven insights using Salesforce reports, dashboards, and analytics tools to support business decision-making.

	Course Contents	Hrs.	CO
1.	**Introduction & Navigation:** Overview of Salesforce, CRM and Cloud Computing, Salesforce editions and products, navigating the Salesforce interface, understanding standard and custom objects, records, fields, relationships, and tabs, working with apps and search functionality. **Experiments:** 1. Navigating Salesforce and Understanding Objects 2. Utilizing Salesforce's Search Functionality	3	CO1
2.	**Data Management & Security:** Managing standard and custom objects, data import and export techniques, data validation rules, duplicate management, user roles, profiles, permission sets, organization-wide defaults, record-level security, field-level security, and sharing settings. **Experiments:** 1. Managing Data with Import, Export, and Validation Rules 2. Configuring Security Settings with Roles, Profiles, and Sharing Rules	5	CO2
3.	**Automation & Customization:** Workflow rules and actions, Process Builder for automating business processes, approval processes, customizing page layouts and record types, introduction to Lightning App Builder, creating custom fields, formulas, and validation rules, automation best practices. **Experiments:** 1. Automating an Approval Process Using Flow Builder 2. Customizing a Record Page Using Lightning App Builder	4	CO3
4.	**Reports, Dashboards & Analytics:** Creating custom reports (Tabular, Summary, Matrix), filtering and grouping data, using report charts, building dashboards for data visualization, scheduling and exporting reports, key performance indicators (KPIs) in Salesforce, leveraging analytics for business insights. **Experiments:** 1. Creating and Customizing Reports 2. Building Dashboards and Scheduling Reports	4	CO4

Learning Resources	
1.	https://trailhead.salesforce.com
2.	https://focusonforce.com/

Programme Name	B. Tech. Computer Engineering
Course Code	R5CO3903L
Course Title	System Administrator
Course Type	PCC
Prerequisites: Basic Knowledge of Operating Systems and Networking	
Course Outcomes: At the end of the course student will be able to: **CO1.** Manage users, files, and processes in Windows and Linux systems. **CO2.** Monitor system performance and perform software updates. **CO3.** Configure basic network settings and apply security measures. **CO4.** Set up virtual machines, explore cloud services, and automate tasks.	

	Course Contents	Hrs.	CO
1.	**Introduction to System Administration:** Role of a System Administrator, Overview of Operating Systems (Windows & Linux), File System Management and Permissions, User and Group Management. **Experiments:** 1. Manage files, directories, and permissions on Windows & Linux. 2. Create, modify, and manage users and groups.	4	CO1
2.	**System Maintenance and Monitoring:** Process and Task Management, Software Installation and Updates, System Performance Monitoring (Task Manager, top, htop), Backup and Recovery Basics. **Experiments:** 1. Monitor and manage system processes using system tools. 2. Install, update, and configure software on Windows & Linux.	6	CO2
3.	**Networking and Security:** Basics of Network Configuration, Firewall and Access Control Management, Secure Remote Access (SSH, RDP), System Security Best Practices. **Experiments:** 1. Configure network settings and troubleshoot connectivity. 2. Secure systems with firewalls, SSH, RDP, and security patches.	6	CO3
4.	**Virtualization and Cloud Basics:** Introduction to Virtual Machines (VMware, VirtualBox), Basics of Cloud Platforms (AWS, Azure), Containerization with Docker, Automating Tasks with Scripts. **Experiments:** 1. Set up and manage virtual machines using VMware/VirtualBox. 2. Deploy cloud instances and automate tasks using scripts.	8	CO4

Text Books	
1.	Evi Nemeth et al., "UNIX and Linux System Administration Handbook", Pearson, 2017.
2.	Tom Limoncelli, "The Practice of System and Network Administration", Addison-Wesley, 2016.
Online Resources	
1.	Linux Documentation Project.
2.	Microsoft Learn - Windows Administration.

Programme Name	B. Tech. Computer Engineering
Course Code	R5CO3904L
Course Title	Unity Development Tutorials
Course Type	PCC

Prerequisites: Basic programming knowledge, understanding of game development concepts, Basic Math and Physics.

Course Outcomes: At the end of the course student will be able to:
CO1. Students will be able to Master Unity & C Programming
CO2. Students will be able to Develop 2D & 3D Games.
CO3. Students will be able to Implement UI, Audio, & Effects.
CO4. Students will be able to Optimize & Publish Games.

	Course Contents	Hrs.	CO
1.	**Foundations of Unity & C Scripting:** Introduction to Game Development & Unity, Installing and setting up Unity & Visual Studio, Understanding the Unity Editor (Hierarchy, Scene, Inspector, Game, Project, Console), Game Objects & Components, C for Unity: Variables, Methods, Classes, and Objects, Unity Lifecycle Methods (Start, Update, FixedUpdate), Handling User Input (Keyboard, Mouse, Touch), Simple Object Interactions (Transform, Movement, Rotations). **Experiments:** Experiment 1: Creating a Simple Interactive Scene in Unity Experiment 2: Handling User Input for Object Rotation & Interaction	4	CO1
2.	**2D & 3D Game Development:** 2D Development: Sprites, Tilemaps, Sprite Animations, Physics (Rigidbody2D, Colliders, Triggers), Player Movement & Camera Follow System, Simple Enemy AI and Pathfinding. 3D Development: 3D Coordinate System & Models, Rigidbody, Colliders, Gravity, and Forces, Character Controller & Movement, Basic Animations using Animator. **Experiments:** Experiment 1: 2D Player Movement and Enemy AI (Pathfinding) Experiment 2: 3D Character Movement with Physics and Animations	6	CO2
3.	**UI, Audio, and Game Mechanics:** User Interface (UI) Development: Canvas, Panels, Buttons, Text, Health Bars, Scene Management & Transitions. Game Mechanics: Object Pooling for Performance Optimization, Level Progression & Saving Game Data. Audio & Special Effects: Adding Background Music & Sound Effects, Particle Systems (Fire, Smoke, Explosions), Post-Processing Effects. **Experiments:** Experiment 1: UI Development with Health Bar & Scene Transitions Experiment 2: Game Mechanics with Object Pooling & Audio Effects	6	CO3
4.	**Game Deployment:** Game Deployment & Optimization: Performance Optimization Techniques, Publishing to PC, Android, and Web, Introduction to Unity Ads & Monetization. **Experiments:** Experiment 1: Performance Optimization Techniques in Unity Experiment 2: Deploying and Monetizing a Unity Game	4	CO4

Text Books	
1.	Joseph Hocking, “Unity in Action” (3rd Edition).
2.	Harrison Ferrone, “Learning C# by Developing Games with Unity”.
3.	Paris Buttfield-Addison, Jon Manning, Tim Nugent, “Unity Game Development Cookbook”.
Online Resources	
1.	https://learn.unity.com
2.	https://docs.unity.com
3.	https://opengameart.org