VIT®

Vellore Institute of Technology

(Deemed to be University under section 3 of UGC Act, 1956)

School of Computer Science and Engineering

CURRICULUM AND SYLLABI

(2019-2020)

B. Tech. Computer Science and Engineering with Specialization in Data Science

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VISION STATEMENT OF VELLORE INSTITUTE OF TECHNOLOGY

Transforming life through excellence in education and research.

MISSION STATEMENT OF VELLORE INSTITUTE OF TECHNOLOGY

World class Education: Excellence in education, grounded in ethics and critical thinking, for improvement of life.

Cutting edge Research: An innovation ecosystem to extend knowledge and solve critical problems.

Impactful People: Happy, accountable, caring and effective workforce and students.

Rewarding Co-creations: Active collaboration with national & international industries & universities for productivity and economic development.

Service to Society: Service to the region and world through knowledge and compassion.

VISION STATEMENT OF THE SCHOOL OF COMPUTER SCIENCE AND ENGINEERING

To be a world-renowned centre of education, research and service in computing and allied domains.

MISSION STATEMENT OF THE SCHOOL OF COMPUTER SCIENCE AND ENGINEERING

- To offer computing education programs with the goal that the students become technically competent and develop lifelong learning skill.
- To undertake path-breaking research that creates new computing technologies and solutions for industry and society at large.
- To foster vibrant outreach programs for industry, research organizations, academia and society.

VIT
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B.Tech-CSE (Spl. in Data Science)

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

1. Graduates will be engineering practitioners and leaders, who would help solve industry's technological problems.
2. Graduates will be engineering professionals, innovators or entrepreneurs engaged in technology development, technology deployment, or engineering system implementation in industry.
3. Graduates will function in their profession with social awareness and responsibility.
4. Graduates will interact with their peers in other disciplines in industry and society and contribute to the economic growth of the country.
5. Graduates will be successful in pursuing higher studies in engineering or management.
6. Graduates will pursue career paths in teaching or research.

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B.Tech-CSE (Spl. in Data Science)

PROGRAMME OUTCOMES (POs)

PO_1 Having an ability to apply mathematics and science in engineering applications

PO_2 Having a clear understanding of the subject related concepts and of contemporary issues

PO_3 Having an ability to design a component or a product applying all the relevant standards and with realistic constraints

PO_4 Having an ability to design and conduct experiments, as well as to analyze and interpret data

PO_5 Having an ability to use techniques, skills and modern engineering tools necessary for engineering practice

PO_6 Having problem solving ability-solving social issues and engineering problems

PO_7 Having adaptive thinking and adaptability

PO_8 Having a clear understanding of professional and ethical responsibility

PO_9 Having cross cultural competency exhibited by working in teams

PO_10 Having a good working knowledge of communicating in English

PO_11 Having a good cognitive load management [discriminate and filter the available data] skills

PO_12 Having interest in lifelong learning

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B.Tech-CSE (Spl. in Data Science)

PROGRAMME SPECIFIC OUTCOMES (PSOs)

1. Apply computing theory, languages and algorithms, as well as mathematical and statistical models, and the principles of optimization to appropriately formulate and use data analysis.

2. Apply the principles and techniques of database design, administration, and implementation to enhance data collection capabilities and decision-support systems. Ability to critique the role of information and analytics in supporting business processes and functions.

3. Invent and use appropriate models of data analysis, assess the quality of input, derive insight from results, and investigate potential issues. Also to organize big data sets into meaningful structures, incorporating data profiling and quality standards.

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SCHOOL OF COMPUTER SCIENCE AND ENGINEERING

B.Tech – CSE with specialization in Data Science

Curriculum for 2019-2020 Batch

Sl.NO	Category	Total No. of Credits
1	University Core	53
2	Programme Core	66
3	University Elective	12
4	Programme Elective	29
	Total	160

University Core (Total 53 Credits)

Sl.No	Course Code	Course Title	L	T	P	J	C	Pre Requisite	Category
1.	ENG1002	Effective English (Bridge Course)	0	0	4	0	Pass	-	H
2.	ENG1011	English for Engineers	0	0	2	4	2	A Pass in VIT EPT or ENG1002	H
3.	CHY1701	Engineering Chemistry	3	0	2	0	4	-	S
4.	PHY1701	Engineering Physics	3	0	2	0	4	-	S
5.	MAT1011	Calculus for Engineers	3	0	2	0	4	-	S
6.	MAT2001	Statistics for Engineers	3	0	2	0	4	MAT1011	S
7.	FLC4097	Foreign Language	2	0	0	0	2	-	H
8.	HUM1021	Ethics and Values	2	0	0	0	2	-	H
9.	CSE1001	Problem Solving and Programming	0	0	6	0	3	-	E
10.	CSE1002	Problem Solving and Object Oriented Programming	0	0	6	0	3	-	E
11.	MGT1022	Lean Startup Management	1	0	0	4	2	-	M
12.	CSE1901	Technical Answers to Real World Problems	1	0	0	4	2	-	E
13.	CSE1902	Industrial Internship	0	0	0	0	1	-	E
14.	CSE1904	Capstone Project	0	0	0	0	12	-	E

15.	CSE1903	Comprehensive Examination	0	0	0	0	1	-	E
16.	STS4097	Soft Skills (6 courses)	18	0	0	0	6	-	H
17.	CHY1002	Environmental Science	3	0	0	0	3	-	S
18.	PHY1901	Introduction to Innovative Projects	1	0	0	0	1	-	S
19.	EXC4097	Co/Extracurricular Activity	0	0	0	0	0	-	M
		Total	***53 Credits***						

Programme Core (Total 66 Credits)

Sl.No	Course Code	Course Title	L	T	P	J	C	Pre Requsite	Category
1.	MAT1014	Discrete Mathematics and Graph Theory	3	2	0	0	4	-	S
2.	MAT2002	Applications of Differential and Difference Equations	3	0	2	0	4	MAT1011	S
3.	MAT3004	Applied Linear Algebra	3	2	0	0	4	MAT2002	S
4.	EEE1001	Basic Electrical and Electronics Engineering	2	0	2	0	3	-	E
5.	CSE1003	Digital Logic and Design	3	0	2	0	4	-	E
6.	CSE2001	Computer Architecture and Organization	3	0	0	0	3	-	E
7.	CSE2002	Theory of Computation and Compiler Design	4	0	0	0	4	-	E
8.	CSE2010	Advanced C Programming	2	0	2	0	3	CSE1001	E
9.	CSE2003	Data Structures and Algorithms	2	0	2	4	4	-	E
10.	CSE1004	Network and Communication	3	0	2	0	4	-	E
11.	CSE2004	Database ManagementSystems	3	0	2	0	4	-	E
12.	CSE2005	Operating Systems	3	0	2	0	4	-	E
13.	CSE2015	Internet Programming and WebTechnologies	3	0	2	0	4	-	E
14.	CSE1007	Java Programming	3	0	2	0	4	-	E
		Total	***53 Credits***						

Data Science Core **Total Credits: 13**

Sl.No	Course Code	Course Title	L	T	P	J	C	Pre Requsite	Category
1.	CSE3045	Mathematical Modeling for Data Science	2	0	2	0	3	-	E
2.	CSE3046	Programming for Data Science	3	0	2	0	4	-	E

3.	CSE3047	Predictive Analytics	2	0	0	4	3	-	E
4.	CSE3044	Cryptography and Network Security	3	0	0	0	3	-	E
		Total	***13 Credits***						

Programme Elective (Total 29 Credits)

CSE Elective (Min 10 credits)

Sl.No	Course Code	Course Title	L	T	P	J	C	Pre Requsite	Category
1.	CSE3050	Data Visualization and Presentation	3	0	2	0	4	-	E
2.	CSE3035	Principles of Cloud Computing	3	0	2	0	4	-	E
3.	CSE3092	Advanced Java Programming	3	0	2	0	4	-	E
4.	CSE1006	Blockchain and Cryptocurrency Technologies	3	0	0	0	3	-	E
5.	CSE4003	Cyber Security	3	0	0	4	4	-	E
6.	CSE3048	Computer Graphics	3	0	0	0	3	-	E
7.	CSE3049	Distributed Computing Systems	3	0	0	0	3	-	E
8.	CSE3009	Internet of Things	3	0	0	4	4	-	E
9.	CSE4022	Natural Language Processing	3	0	0	4	4	-	E
10.	CSE3034	Nature Inspired Computing	3	0	0	0	3	-	E
11.	CSE2016	Microprocessor and Microcontrollers	3	0	2	0	4	-	E
12.	CSE4007	Mobile Computing	3	0	0	4	4	-	E
13.	CSE3022	Soft Computing	3	0	0	4	4	-	E
14.	CSE3052	Software Quality and Testing	3	0	0	0	3	-	E
15.	CSE3001	Software Engineering	2	0	2	4	4	-	E
16.	CSE4019	Image Processing	3	0	0	4	4	-	E
17.	CSE3051	Open Source Programming	3	0	2	0	4	-	E
18.	CSE3011	Robotics and its Applications	3	0	0	4	4	-	E
19.	CSE3501	Information Security Analysis and Audit	2	0	2	4	4	-	E
20.	CSE3502	Information Security Management	2	0	2	4	4	-	E

Data Science Elective - Min 10 credits

Sl.No	Course Code	Course Title	L	T	P	J	C	Pre Requsite	Category
1.	CSE3013	Artificial Intelligence	3	0	0	4	4	-	E
2.	BCD3001	Bayesian Data Analysis	3	0	0	4	4	-	E
3.	CSE3053	Big Data Analytics	3	0	0	4	4	-	E
4.	BCD3002	Business Intelligence and Analytics	3	0	0	0	3	-	E
5.	BCD3003	Cognitive Systems	3	0	0	4	4	-	E
6.	CSE3054	Data Mining: Concepts and Techniques	3	0	0	4	4	-	E
7.	BCD3004	Data Modeling and Simulation	3	0	0	0	3	-	E
8.	CSE3055	Deep Learning	3	0	0	4	4	-	E
9.	BCD4001	Decision Support systems and Intelligent systems	3	0	0	0	3	-	E
10.	BCD4003	Intelligent Database System	3	0	0	4	4	-	E
11.	BCD4002	Information Extraction and Retrieval	3	0	0	0	3	-	E
12.	BCD4004	Knowledge Representation and Reasoning	3	0	0	4	4	-	E
13.	CSE4020	Machine Learning	2	0	2	4	4	MAT2001	E
14.	CSE3014	Nature Inspired computing for Data Science	3	0	0	4	4	-	E
15.	BCD4006	Time series analysis and Forecasting	3	0	0	0	3	-	E

CSE1003	DIGITAL LOGIC AND DESIGN	L	T	P	J	C
		3	0	2	0	4
Pre-requisite	**NIL**	**Syllabus version**				
		v1.0				

Course Objectives:

1. Introduce the concept of digital and binary systems.
2. Analyze and Design combinational and sequential logic circuits.
3. Reinforce theory and techniques taught in the classroom through experiments in thelaboratory.

Expected Course Outcome:

1. Comprehend the different types of number system.
2. Evaluate and simplify logic functions using Boolean Algebra and K-map.
3. Design minimal combinational logic circuits.
4. Analyze the operation of medium complexity standard combinational circuits like theencoder, decoder, multiplexer, demultiplexer.
5. Analyze and Design the Basic Sequential Logic Circuits
6. Outline the construction of Basic Arithmetic and Logic Circuits
7. Acquire design thinking capability, ability to design a component with realistic constraints, to solve real world engineering problems and analyze the results.

Module:1	**INTRODUCTION**	**3 hours**
Number System - Base Conversion - Binary Codes - Complements(Binary and Decimal)		
Module:2	**BOOLEAN ALGEBRA**	**8 hours**
Boolean algebra - Properties of Boolean algebra - Boolean functions - Canonical and Standard forms - Logic gates - Universal gates – Karnaugh map - Don‟t care conditions - Tabulation Method		
Module:3	**COMBINATIONAL CIRCUIT - I**	**4 hours**
Adder - Subtractor - Code Converter - Analyzing a Combinational Circuit		
Module:4	**COMBINATIONAL CIRCUIT –II**	**6 hours**
Binary Parallel Adder- Look ahead carry - Magnitude Comparator - Decoders – Encoders - Multiplexers –Demultiplexers.		
Module:5	**SEQUENTIAL CIRCUITS – I**	**6 hours**
Flip Flops - Sequential Circuit: Design and Analysis - Finite State Machine: Moore and Mealy model - Sequence Detector.		
Module:6	**SEQUENTIAL CIRCUITS – II**	**7 hours**
Registers - Shift Registers - Counters - Ripple and Synchronous Counters - Modulo counters - Ring and Johnson counters		
Module:7	**ARITHMETIC LOGIC UNIT**	**9 hours**
Bus Organization - ALU - Design of ALU - Status Register - Design of Shifter - Processor Unit - Design of specific Arithmetic Circuits Accumulator - Design of Accumulator.		
Module:8	**Contemporary Issues: RECENT TRENDS**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)		
1.	M. Morris Mano and Michael D.Ciletti– Digital Design: With an introduction to Verilog HDL, Pearson Education – 5th Edition- 2014. ISBN:9789332535763.	
Reference Books		
1.	Peterson, L.L. and Davie, B.S., 2007. Computer networks: a systems approach. Elsevier.	
2.	Thomas L Floyd. 2015. Digital Fundamentals. Pearson Education. ISBN: 9780132737968	
3.	Malvino, A.P. and Leach, D.P. and Goutam Saha. 2014. Digital Principles and Applications (SIE). Tata McGraw Hill. ISBN: 9789339203405.	
4.	Morris Mano, M. and Michael D.Ciletti. 2014. Digital Design: With an introduction to Verilog HDL. Pearson Education. ISBN:9789332535763	
Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar		
List of Challenging Experiments (Indicative)		
1.	Realization of Logic gates using discrete components, verication of truth table for logic gates, realization of basic gates using NAND and NOR gates	4.5 hours
	Implementation of Logic Circuits by verification of Boolean laws and verification of De Morgans law	3 hours
	Adder and Subtractor circuit realization by implementation of Half-Adder and Full-Adder, and by implementation of Half-Subtractor and Full-Subtractor	4.5 hours
	Combinational circuit design i. Design of Decoder and Encoder ii. Design of Multiplexer and De multiplexer iii. Design of Magnitude Comparator iv. Design of Code Converter	4.5 hours
	Sequential circuit design i. Design of Mealy and Moore circuit ii. Implementation of Shift registers iii. Design of 4-bit Counter iv. Design of Ring Counter	4.5 hours
	Implementation of different circuits to solve real world problems: A digitally controlled locker works based on a control switch and two keys which are entered by the user. Each key has a 2-bit binary representation. If the control switch is pressed, the locking system will pass the difference of two keys into the controller unit. Otherwise, the locking system will pass the sum of the two numbers to the controller unit. Design a circuit to determine the input to the controller unit.	4.5 hours
	Implementation of different circuits to solve real world problems: A bank queuing system has a capacity of 5 customers which serves on first come first served basis. A display unit is used to display the number of customers waiting in the queue. Whenever a customer leaves the queue, the count is reduced by one and the count is increased by one if a customer joins a queue. Two sensors (control signals) are used to sense customers leaving and joining the queue respectively. Design a circuit that displays the number of customers waiting in the queue in binary format using LEDs. Binary 1 is represented by LED glow and 0 otherwise.	4.5 hours
	Total Laboratory Hours	**30 hours**
Mode of assessment: Project/Activity		
Recommended by Board of Studies	28-02-2017	
Approved by Academic Council	No. 46	Date 24-08-2017

CSE1007	JAVA PROGRAMMING	L	T	P	J	C
		3	0	2	0	4
Pre-requisite	**NIL**	**Syllabus version**				
		v1.0				

Course Objectives:

1. To impart the core language features of Java and its Application Programming Interfaces (API).
2. To demonstrate the use of threads, exceptions, files and collection frameworks in Java.
3. To familiarize students with GUI based application development anddatabase connectivity.

Expected Course Outcome:

1. Comprehend Java Virtual Machine architecture and Java Programming Fundamentals.
2. Design applications involving Object Oriented Programming concepts such asinheritance, association, aggregation, composition, polymorphism, abstract classes and interfaces.
3. Design and build multi-threaded Java Applications.
4. Build software using concepts such as files, collection frameworks and containers.
5. Design and implement Java Applications for real world problems involving Database Connectivity.
6. Design Graphical User Interface using JavaFX.
7. Design, Develop and Deploy dynamic web applications using Servlets and JavaServer Pages.

Module:1	**Java Fundamentals**	**4 hours**

Java Basics: Java Design goal - Features of Java Language - JVM - Bytecode - Java source file structure basic programming constructs Arrays one dimensional and multi-dimensional enhanced for loop String package

Module:2	**Object Oriented Programming**	**5 hours**

Class Fundamentals - Object Object reference array of objects constructors methods over- loading this reference static block - nested class inner class garbage collection finalize() Wrapper classes Inheritance types - use of super - Polymorphism abstract class interfaces packages and sub packages.

Module:3	**Robustness and Concurrency**	**6 hours**

Exception Handling - Exceptions Errors - Types of Exception - Control Flow in Exceptions - Use of try, catch, finally, throw, throws in Exception Handling - user defined exceptions - Multithreading Thread creation sharing the workload among threads synchronization inter thread communication deadlock.

Module:4	**Files, Streams and Object serialization**	**7 hours**

Data structures: Java I/O streams Working with files Serialization and deserialization of objects Lambda expressions, Collection framework List, Map, Set Generics Annotations

Module:5	**GUI Programming and Database Connectivity**	**7 hours**

GUI programming using JavaFX, exploring events, controls and JavaFX menus Accessing databases using JDBC connectivity.

Module:6	**Servlet**	**7 hours**

Introduction to servlet - Servlet life cycle - Developing and Deploying Servlets - Exploring Deployment Descriptor (web.xml) - Handling Request and Response - Session Tracking Man- agement.		
Module:7	**Java Server Pages**	**7 hours**
JSP Tags and Expressions - JSP Expression Language (EL) - Using Custom Tag - JSP with Java Bean.		
Module:8	**Latest Trends**	**2 hours**
Industry Expert talk		
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	Herbert Schildt, The Complete Reference -Java, Tata McGraw-Hill Education, Tenth Edition, 2017.
2.	Paul J. Deitel, Harvey Deitel ,Java SE8 for Programmers (Deitel Developer Series) 3rd Edition, 2014
3.	Y. Daniel Liang, Introduction to Java programming-comprehensive version-Tenth Edition, Pearson ltd 2015
Reference Books	
1.	Paul Deitel Harvey Deitel ,Java, How to Program, Prentice Hall; 9th edition , 2011.
2.	Cay Horstmann BIG JAVA, 4th edition, John Wiley Sons,2009
3.	Nicholas S. Williams, Professional Java for Web Applications, Wrox Press, 2014.
Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar	

List of Challenging Experiments (Indicative)		
1.	Write a program to demonstrate the use of multidimensional arrays and looping constructs.	2 hours
2.	Write a program to demonstrate the application of String handling functions.	2 hours
3.	Write a program to demonstrate the use of Inheritance.	2 hours
4.	Write a program to demonstrate the application of user-defined packages and sub-packages.	2 hours
5.	Write a program to demonstrate the use of Java Exception handling methods.	2 hours
6.	Write a program to demonstrate the use of threads in Java.	2 hours
7.	Demonstrate with a program the use of File handling methods in Java.	2 hours
8.	Demonstrate the use of Java collection frameworks in reducing application development time.	2 hours
9.	Build a GUI application using JavaFX	2 hours
10.	Write a program to register students data using JDBC with MySQL Database.	2 hours
11.	Write a program that uses Servlets to perform basic banking tasks.	2 hours
12.	Write a web application using JSP and demonstrate the use of http request and response methods.	2 hours
13.	Write a JSP program for an order management system.	2 hours
14.	Write a JSP program that using JDBC and MySQL database to store the user data.	2 hours
15.	JSP with Java Bean	2 hours
	Total Laboratory Hours	30 hours

Mode of assessment: Project/Activity			
Recommended by Board of Studies	10-08-2018		
Approved by Academic Council	No. 52	Date	14-09-2018

CSE2001	COMPUTER ARCHITECTURE AND ORGANIZATION	L	T	P	J	C
		3	0	0	0	3
Pre-requisite		**Syllabus version**				
		v1.0				

Course Objectives:

1. To acquaint students with the basic concepts of fundamental component, architecture, register organization and performance metrics of a computer.
2. To impart the knowledge of data representation in binary and understand implementation of arithmetic algorithms in a typical computer.
3. To teach students how to describe machine capabilities and design an effective data path design for instruction execution. To introduce students to syntax and semantics ofmachine level programming.
4. To make students understand the importance of memory systems, IO interfacing techniques and external storage and their performance metrics for a typical computer. And explore various alternate techniques for improving the performance of a processor.

Expected Course Outcome:

1. Differentiate Von Neumann, Harvard, and CISC and RISC architectures. Analyze the performance of machines with different capabilities.
2. Illustrate binary format for numerical and characters. Validate efficient algorithmfor arithmetic operations.
3. Construct machine level program for given expression on n-address machine. Analyzeand calculate memory traffic for a program execution. Design an efficient data path for an instruction format for a given architecture.
4. Explain the importance of hierarchical memory organization. Able to construct larger memories. Analyze and suggest efficient cache mapping technique and replacement algorithms for given design requirements. Demonstrate hamming code for errordetection and correction.
5. Understand the need for an interface. Compare and contrast memory mapping and IO mapping techniques. Describe and Differentiate different modes of data transfer. Appraise the synchronous and asynchronous bus for performance and arbitration.
6. Understand the structure and read write mechanisms for different storage systems. Illustrate and suggest appropriate use of RAID levels. Assess the performance of IO and external storage systems.
7. Classify parallel machine models. Illustrate typical 6-stage pipeline foroverlapped execution. Analyze the hazards and solutions.

Module:1	Introduction and overview of computer architecture	3 hours

Introduction to computer systems - Overview of Organization and Architecture -Functional components of a computer -Registers and register files-Interconnection of components-Organization of the von Neumann machine and Harvard architecture-Performance of processor

Module:2	Data Representation And Computer Arithmetic	6 hours

Fixed point representation of numbers-algorithms for arithmetic operations: multiplication (Booths, Modified Booths) - division (restoring and non-restoring) - Floating point representation with IEEE standards and algorithms for common arithmetic operations- Representation of non-numeric data (character codes).

Module:3	Fundamentals of Computer Architecture	11 hours

Introduction to ISA (Instruction Set Architecture)-Instruction formats- Instruction types and addressing modes- Instruction execution (Phases of instruction cycle)- Assembly language programming-Subroutine call and return mechanisms-Single cycle Data path design-Introduction to multi cycle data path-Multi cycle Instruction execution.			
Module:4	**Memory System Organization and Architecture**		**9 hours**
Memory systems hierarchy-Main memory organization-Types of Main memory-memory inter-leaving and its characteristics and performance- Cache memories: address mapping-line size-replacement and policies- coherence- Virtual memory systems- TLB- Reliability of memory systems- error detecting and error correcting systems.			
Module:5	**Interfacing and Communication**		**7 hours**
I/O fundamentals: handshaking, buffering-I/O techniques: programmed I/O, interrupt-driven I/O, DMA- Interrupt structures: vectored and prioritized-interrupt overhead- Buses: Syn- chronous and asynchronous- Arbitration.			
Module:6	**Device Subsystems**		**4 hours**
External storage systems-organization and structure of disk drives: Electronic- magnetic and optical technologies- RAID Levels- I/O Performance			
Module:7	**Performance Enhancements**		**4 hours**
Classification of models - Flynns taxonomy of parallel machine models (SISD, SIMD, MISD, MIMD)- Introduction to Pipelining- Pipelined data path-Introduction to hazards			
Module:8	**Contemporary issues: Recent Trends**		**1 hour**
Multiprocessor architecture: Overview of Shared Memory architecture, Distributed architecture.			
	Total Lecture hours:	**45 hours**	

Text Book(s)	
1.	David A. Patterson and John L. Hennessy Computer Organization and Design-The Hardware/Software Interface 5th edition, Morgan Kaufmann, 2013.
2.	Carl Hamacher, Zvonko Vranesic, Safwat Zaky, Computer organization, Mc Graw Hill, Fifth edition, Reprint 2011.
Reference Books	
1.	W. Stallings, Computer organization and architecture, Prentice-Hall, 8th edition, 2013

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar			
Recommended by Board of Studies	04-04-2014		
Approved by Academic Council	No. 37	Date	16-06-2015

CSE2002	THEORY OF COMPUTATION AND COMPILER DESIGN	L	T	P	J	C
		4	0	0	4	4
Pre-requisite	**NIL**	**Syllabus version**				
		v1.0				

Course Objectives:

1. Provides required theoretical foundation for a computational model and compiler design
2. Discuss Turing machines as a abstract computational model
3. Compiler algorithms focus more on low level system aspects.

Expected Course Outcome:

On successful completion of the course, the student should be able to:

1. Design computational models for formal languages
2. Design scanners and parsers using top-down as well as bottom-up paradigms
3. Design symbol tables and use them for type checking and other semantic checks
4. Implement a language translator
5. Use tools such as lex, YACC to automate parts of implementation process

Module:1	**Introduction To Languages and Grammers**	**3 hours**

Overview of a computational model - Languages and grammars – alphabets – Strings - Operations on languages, Introduction to Compilers - Analysis of the Source Program - Phases of a Compiler

Module:2	**Regular Expressions and Finite Automata**	**9 hours**

Finite automata – DFA – NFA – Equivalence of NFA and DFA (With Proof) - Regular expressions – Conversion between RE and FA (With Proof) Lexical Analysis - Recognition of Tokens - Designing a Lexical Analyzer using finite automata

Module:3	**Myhill-Nerode Theorem**	**4 hours**

Myhill-Nerode Theorem - Minimization of FA – Decision properties of regular languages – Pumping lemma for Regular languages (With Proof)

Module:4	**CFG, PDAs and Turing Machines**	**15 hours**

CFG – Chomsky Normal Forms - NPDA – DPDA - Membership algorithm for CFG. Syntax Analysis - Top-Down Parsing - Bottom-Up Parsing - Operator-Precedence Parsing - LR Parsers

Module:5	**Turing Machines**	**5 hours**

Turing Machines – Recursive and recursively enumerable languages – Linear bounded automata - Chomsky's hierarchy – Halting problem

Module:6	**Intermediate Code Generation**	**10 hours**

Intermediate Code Generation - Intermediate Languages – Declarations - Assignment Statements - Boolean Expressions - Case Statements – Backpatching - Procedure Calls.

Module:7	**Code Optimization**	**7 hours**

Code Optimization - Basic Blocks and Flow Graphs – The DAG Representation of Basic Blocks - The Principal Sources of Optimization - Optimization of Basic Blocks - Loops in Flow Graphs - Peephole Optimization - Introduction to Global Data-Flow Analysis

Module:8	**Code Generation**	**7 hour**

Code Generation – Issues in the Design of a Code Generator - The Target Machine - Run-Time Storage Management - Next-Use Information - Register Allocation and Assignment - A Simple Code Generator - Generating Code from DAG Recent Trends – Just-in-time compilation with adaptive optimization for dynamic languages - Parallelizing Compilers			
	Total Lecture hours:	**60 hours**	
Text Book(s)			
1.	Introduction to Automata Theory, Languages, and Computation (3rd Edition), John E Hopcroft, Rajeev Motwani, Jeffery D. Ullman, Pearson education, 2013.		
2.	Principles of Compiler Design, Alferd V. Aho and Jeffery D. Ullman, Addison Wesley, 2006		
Reference Books			
1.	Introduction to Languages and the Theory of Computation, John Martin, McGraw-Hill Higher Education,2010		
2.	Modern Compiler Implementation in Java, 2nd ed., Andrew W. Appel Cambrdige University Press, 2012.		
Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar			
Recommended by Board of Studies	19-11-2018		
Approved by Academic Council	No. 53	Date	13-12-2018

CSE2003	DATA STRUCTURES AND ALGORITHMS	L	T	P	J	C
		2	0	2	4	4
Pre-requisite	**NIL**	**Syllabus version**				
		v1.0				

Course Objectives:

1. To impart the basic concepts of data structures and algorithms.
2. To assess how the choice of data structures and algorithm design methods impactsthe performance of programs.
3. To provide an insight into the intrinsic nature of the problem and to develop softwaresystems of varying complexity.

Expected Course Outcome:

1. Evaluating and providing suitable techniques for solving a problem using basicproperties of Data Structures.
2. Analyse the performance of algorithms using asymptotic notations.
3. Demonstrate knowledge of basic data structures and legal operations on them.
4. Illustrate different types of algorithmic approaches to problem solving and assess thetrade-offs involved.
5. Analyse basic graph algorithms, operations and applications through a structured(well-defined) algorithmic approach.
6. Categorize the feasibility and limitations of solutions to real-world problems.
7. Provide efficient algorithmic solution to real-world problems.

Module:1	Introduction to Data structures and Algorithms	1 hour

Overview and importance of algorithms and data structures, Stages of algorithm development for solving a problem: Describing the problem, Identifying a suitable technique, Design of an Algorithm, Proof of Correctness of the Algorithm, Computing the time complexity of the Algorithm.

Module:2	Analysis of Algorithms	3 hours

Asymptotic notations and their significance, Running time of an algorithm, Time-complexity of an algorithm, Performance analysis of an algorithm, Analysis of iterative and recursive algorithms, Master theorem (without proof).

Module:3	Data Structures	7 hours

Importance of data structures, Arrays, Stacks, Queues, Linked list, Trees, Hashing table, Binary Search Tree, Heaps.

Module:4	Algorithm Design Paradigms	8 hours

Divide and Conquer, Brute force, Greedy, Recursive Backtracking and Dynamic programming.

Module:5	Graph Algorithms	4 hours

Breadth First Search (BFS), Depth First Search (DFS), Minimum Spanning Tree (MST), Single Source Shortest Paths.

Module:6	Computational Complexity classes	5 hours

Tractable and Intractable Problems, Decidable and Undecidable problems, Computational complexity Classes: P, NP and NP complete - Cooks Theorem (without proof),3-CNF-SAT Problem, Reduction of 3-CNF-SAT to Clique Problem, Reduction of 3-CNF-SAT to Subset sum problem.

Module:7	Recent Trends	2 hours

Algorithms related to Search Engines			
	Total Lecture hours:		**30 hours**
Text Book(s)			
1.	Thomas H. Cormen, C.E. Leiserson, R L.Rivest and C. Stein, Introduction to Algorithms, Third edition, MIT Press, 2009.		
Reference Books			
1.	Sanjoy Dasgupta, C.Papadimitriou and U.Vazirani , Algorithms , Tata McGraw-Hill, 2008.		
2.	A. V. Aho, J.E. Hopcroft and J. D. Ullman, Data Strucures and Algorithms ,Pearson India, Ist Edition, 2002		
3.	A. V. Aho, J.E. Hopcroft and J. D. Ullman, The Design and Analysis of Computer Algorithms ,Pearson,1st edition, 2006.		
4.	Sara Baase , Allen Van Gelder, Computer Algorithms, Introduction to Design and Analysis, 3rd edition, Wesley Longman Publishing, 1999.		
Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar			
List of Challenging Experiments (Indicative)			
1.	Extract the features based on various color models and apply on image and video retrieval		2 hours
2.	Arrays, loops and Lists		2 hours
3.	Stacks and Queues		2 hours
4.	Searching and Sorting		3 hours
5.	Linked List and operations		4 hours
6.	Brute force technique		2 hours
7.	Greedy Technique		2 hours
8.	Backtracking		2 hours
9.	Dynamic Programming		2 hours
10.	Trees and Tree Operations		3 hours
11.	BFS and DFS		3 hours
12.	Minimum Spanning Tree		3 hours
		Total Laboratory Hours	**30 hours**
Mode of assessment: Project/Activity			
Recommended by Board of Studies	04-04-2014		
Approved by Academic Council	No. 37	Date	16-06-2015

Course code	Course Title	L	T	P	J	C
CSE2004	DATABASE MANAGEMENT SYSTEM	3	0	2	0	4

Pre-requisite	**NIL**	**Syllabus version**
Anti-requisite	**CSI1001 – Principles of Database Systems**	**v1.0**

Course Objectives:

1. To understand the concept of DBMS and ER Modeling.
2. To explain the normalization, Query optimization and relational algebra.
3. To apply the concurrency control, recovery, security and indexing for the real time data

Expected Course Outcome:

1. Explain the basic concept and role of DBMS in an organization.
2. Illustrate the design principles for database design, ER model and normalization.
3. Demonstrate the basics of query evaluation and heuristic query optimization techniques.
4. Apply Concurrency control and recovery mechanisms for the desirable database problem.
5. Compare the basic database storage structure and access techniques including B Tree, B+ Tress and hashing
6. Review the fundamental view on unstructured data and its management.
7. Design and implement the database system with the fundamental concepts of DBMS

Module:1	DATABASE SYSTEMS CONCEPTS AND ARCHITECTURE	4 hours

History and motivation for database systems -characteristics of database approach - Actors on the scene - Workers behind the scene - Advantages of using DBMS approach – Data Models, Schemas, and Instances – Three-Schema Architecture and Data Independence – The Database System Environment – Centralized and Client/Server Architectures for DBMSs – Classification of database management systems.

Module:2	DATA MODELING	6 hours

Entity Relationship Model: Types of Attributes, Relationship, Structural Constraints - Relational Model, Relational model Constraints - Mapping ER model to a relational schema - Integrity constraints

Module:3	SCHEMA REFINEMENT	7 hours

Guidelines for Relational Schema – Functional dependency; Normalization, Boyce Codd Normal Form, Multi-valued dependency and Fourth Normal form; Join dependency and Fifth Normal form.

Module:4	PHYSICAL DATABASE DESIGN	7 hours

Indexing and Hashing: Single level indexing, multi-level indexing, dynamic multilevel Indexing, Ordered Indices – B+ tree Index Files – Static Hashing – Dynamic Hashing.

Module:5	QUERY PROCESSING	4 hours

Translating SQL Queries into Relational Algebra - heuristic query optimization – cost based query optimization.

Module:6	TRANSACTION PROCESSING	5 hours

Introduction to Transaction Processing - Transaction and System concepts – Desirable properties of Transactions-Characterizing schedules based on recoverability - Characterizing schedules based on serializability.

Module:7	CONCURRENCY CONTROL AND	10 hours

	RECOVERY TECHNIQUES, NoSQL MANAGEMENT	
Two-Phase Locking Techniques for Concurrency Control – Concurrency Control based on timestamp – Recovery Concepts – Recovery based on deferred update – Recovery techniques based on immediate update - Shadow Paging. Introduction to NoSQL, CAP Theorem, NoSQL data models: Key-value stores, Column families, Document databases.		
Module:8	**RECENT TRENDS**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)

1.	Abraham Silberschatz, Henry F. Korth, S. Sudharshan, "Database System Concepts", Seventh Edition, Tata McGraw Hill, 2019.
2.	RamezElmasri, Shamkant B. Navathe, "Fundamentals of Database Systems", Seventh Edition, Pearson Education, 2016.

Reference Books

1.	Raghu Ramakrishnan, Johannes Gehrke, "Database Management Systems", Fourth Edition, Tata McGraw Hill, 2014.
2.	Thomas Connolly, Carolyn Begg, Database Systems: A Practical Approach to Design, Implementation and Management,6thEdition, Pearson,2015
3.	Meier, Andreas, Kaufmann, Michael, "SQL & NoSQL Databases - Models, Languages, Consistency Options and Architectures for Big Data Management", Springer, 2019
4.	C. J. Date, A. Kannan, S. Swamynathan, "An Introduction to Database Systems", Eighth Edition, Pearson Education, 2006
5.	Pramod J. Sadalage and Marin Fowler, NoSQL Distilled: A brief guide to merging world of Polyglot persistence, Addison Wesley, 2012.

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar

List of Experiments

1.	SQL tool, Data types in SQL, Creating Tables (along with Primary and Foreign keys), Altering Tables and Dropping Tables	3 hours
2.	Practice Queries using Aggregate Functions (COUNT, SUM, AVG, MAX, MIN) and GROUP BY, HAVING, VIEWS Creation and Dropping.	3 hours
3.	Practicing Sub queries Joins (Inner, Outer and Equi) and (Nested, Correlated)	3 hours
4.	Practicing Queries using Constraints	3 hours
5.	Practicing Queries using ANY, ALL, IN, EXISTS, NOT EXISTS, UNION, INTERSECT, CONSTRAINTS etc.	3 hours
6.	While looping in sql server	3 hours
7.	Creation of Stored Procedures, Execution of Procedure, and Modification of Procedure	3 hours
8.	Declaring Cursor, Opening Cursor, Fetching the data, closing the cursor	2 hours
9.	Practicing Trigger Creation, Insertion, Deletion and Updation.	2 hours
10	Practicing User Defined Exception and System Defined Exception.	2 hours
11.	Database Application development	3 hours
	Total Laboratory Hours	**30 hours**

Mode of Evaluation: Project/Activity

Recommended by Board of Studies	09-09-2020		
Approved by Academic Council	No. 59	Date	24-09-2020

Course code	Course Title	L	T	P	J	C
CSE2005	OPERATING SYSTEMS	3	0	2	0	4
Pre-requisite	Nil	Syllabus version				
Anti-requisite	CSI1002 – Operating System Principles	v.x.x				

Course Objectives:

1. To introduce the operating system concepts, designs and provide skills required to implement the services.
2. To describe the trade-offs between conflicting objectives in large scale system design.
3. To develop the knowledge for application of the various design issues and services.

Expected Course Outcome:

1. Interpret the evolution of OS functionality, structures and layers.
2. Apply various types of system calls and to find the stages of various process states.
3. Design a model scheduling algorithm to compute various scheduling criteria.
4. Apply and analyze communication between inter process and synchronization techniques.
5. Implement page replacement algorithms, memory management problems and segmentation.
6. Differentiate the file systems for applying different allocation and access techniques.
7. Representing virtualization and demonstrating the various Operating system tasks and the principle algorithms for enumerating those tasks.

Module:1	Introduction	3 hours

Introduction to OS: Functionality of OS - OS design issues - Structuring methods (monolithic, layered, modular, micro-kernel models) - Abstractions, processes, resources - Influence of security, networking, and multimedia.

Module:2	OS Principles	4 hours

System calls, System/Application Call Interface – Protection: User/Kernel modes - Interrupts - Processes - Structures (Process Control Block, Ready List etc.), Process creation, management in Unix – Threads: User level, kernel level threads and thread models.

Module:3	Scheduling	9 hours

Processes Scheduling - CPU Scheduling: Pre-emptive, non-pre-emptive - Multiprocessor scheduling – Deadlocks - Resource allocation and management - Deadlock handling mechanisms: prevention, avoidance, detection, recovery.

Module:4	Concurrency	8 hours

Inter-process communication, Synchronization - Implementing synchronization primitives (Peterson's solution, Bakery algorithm, synchronization hardware) - Semaphores – Classical synchronization problems, Monitors: Solution to Dining Philosophers problem – IPC in Unix, Multiprocessors and Locking - Scalable Locks - Lock-free coordination.

Module:5	Memory Management	7 hours

Main memory management, Memory allocation strategies, Virtual memory: Hardware support for virtual memory (caching, TLB) – Paging - Segmentation - Demand Paging - Page Faults - Page Replacement -Thrashing - Working Set.

Module:6	Virtualization and File System Management	6 hours

Virtual Machines - Virtualization (Hardware/Software, Server, Service, Network - Hypervisors - Container virtualization - Cost of virtualization - File system interface (access methods, directory structures) - File system implementation (directory implementation, file allocation methods) - File system recovery - Journaling - Soft updates - Log-structured file system - Distributed file system.		
Module:7	**Storage Management, Protection and Security**	**6 hours**
Disk structure and attachment – Disk scheduling algorithms (seek time, rotational latency based)- System threats and security – Policy vs mechanism - Access vs authentication - System protection: Access matrix – Capability based systems - OS: performance, scaling, future directions in mobile OS.		
Module:8	**Recent Trends**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	Abraham Silberschatz, Peter B. Galvin, Greg Gagne-Operating System Concepts, Wiley (2018).
Reference Books	
1.	Ramez Elmasri, A.Gil Carrick, David Levine, Operating Systems, A Spiral Approach - McGrawHill Higher Education (2010).
2.	Remzi H. Arpaci-Dusseau, Andrea C. Arpaci-Dusseau, Operating Systems, Three Easy Pieces, Arpaci-Dusseau Books, Inc (2015).
3.	Andrew S. Tanenbaum, Modern Operating Systems, Pearson, 4th Edition (2016).
4.	William Stallings, Operating Systems: Internals and Design Principles, Pearson, 9th Edition (2018).
Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar	

List of Experiments		
1.	Design a boot loader - to load a particular OS say TinyOS/ KolibriOS image - code to access from BIOS to loading the OS - involves little assembly code may use QEMU/virtual machines for emulation of hardware.	3 hours
2.	Allocate/free memory to processes in whole pages, find max allocatable pages, incorporate address translation into the program.	3 hours
3.	Create an interrupt to handle a system call and continue the previously running process after servicing the interrupt.	3 hours
4.	Write a Disk driver for the SATA interface. Take care to check readiness of the controller, locked buffer cache, accept interrupts from OS during the period, interrupting the OS again once done and clearing buffers.	3 hours
5.	Demonstrate the use of locks in conjunction with the IDE driver.	3 hours
6.	Run an experiment to determine the context switch time from one process to another and one kernel thread to another. Compare the findings	3 hours
7.	Determine the latency of individual integer access times in main memory, L1 Cache and L2 Cache. Plot the results in log of memory accessed vs average latency.	3 hours
8.	Compare the overhead of a system call with a procedure call. What is the cost of a minimal system call?	3 hours

9.	Compare the task creation times. Execute a process and kernel thread, determine the time taken to create and run the threads.	3 hours
10.	Determine the file read time for sequential and random access based of varying sizes of the files. Take care not to read from cached data - used the raw device interface. Draw a graph log/log plot of size of file vs average per-block time.	3 hours
	Total Laboratory Hours	30 hours

Mode of evaluation: Project/Activity			
Recommended by Board of Studies	09-09-2020		
Approved by Academic Council	No. 59	Date	24-09-2020

EEE1001	Basic Electrical and Electronics Engineering	L	T	P	J	C
		2	0	2	0	3
Pre-requisite	**NIL**	**Syllabus version**				
		v. 1.0				

Course Objectives:

1. To understand the various laws and theorems applied to solve electric circuits and networks
2. To provide the students with an overview of the most important concepts inElectrical and Electronics Engineering which is the basic need for every engineer

Expected Course Outcome:

1. Solve basic electrical circuit problems using various laws and theorems
2. Analyze AC power circuits and networks, its measurement and safety concerns
3. Classify and compare various types of electrical machines
4. Design and implement various digital circuits
5. Analyze the characteristics of semiconductor devices and comprehend the variousmodulation techniques in communication engineering
6. Design and conduct experiments to analyze and interpret data

Module:1	**DC circuits**	**5 hours**

Basic circuit elements and sources, Ohms law, Kirchhoff's laws, series and parallel connection of circuit elements, Node voltage analysis, Mesh current analysis, Thevenin's and Maximum power transfer theorem

Module:2	**AC circuits**	**6 hours**

Alternating voltages and currents, AC values, Single Phase RL, RC, RLC Series circuits, Power in AC circuits-Power Factor- Three Phase Systems – Star and Delta Connection- Three Phase Power Measurement – Electrical Safety –Fuses and Earthing, Residential wiring

Module:3	**Electrical Machines**	**7 hours**

Construction, Working Principle and applications of DC Machines, Transformers, Single phase and Three-phase Induction motors, Special Machines-Stepper motor, Servo Motor and BLDC motor

Module:4	**Digital Systems**	**5 hours**

Basic logic circuit concepts, Representation of Numerical Data in Binary Form- Combinational logic circuits, Synthesis of logic circuits

Module:5	**Semiconductor devices and Circuits**	**7 hours**

Conduction in Semiconductor materials, PN junction diodes, Zener diodes, BJTs, MOSFETs, Rectifiers, Feedback Amplifiers using transistors. Communication Engineering: Modulation and Demodulation - Amplitude and Frequency Modulation

	Total Lecture hours:	**30 hours**	

Text Book(s)

1. 1. John Bird, „Electrical circuit theory and technology ', Newnes publications, 4 t h Edition, 2010.

Reference Books

1. Allan R. Hambley, „Electrical Engineering -Principles & Applications' Pearson Education, First Impression, 6/e, 2013

2.	Simon Haykin, „Communication Systems', John Wiley & Sons, 5 t h Edition, 2009.			
3.	Charles K Alexander, Mathew N O Sadiku, „Fundamentals of Electric Circuits', Tata McGraw Hill, 2012.			
4.	Batarseh, „Power Electronics Circuits', Wiley, 2003			
5.	H. Hayt, J.E. Kemmerly and S. M. Durbin, „Engineering Circuit Analysis', 6/e, Tata McGraw Hill, New Delhi, 2011.			
7.	Fitzgerald, Higgabogan, Grabel, „Basic Electrical Engineering', 5t h edn, McGraw Hill, 2009.			
8.	S.L.Uppal, „Electrical Wiring Estimating and Costing ', Khanna publishers, NewDelhi, 2008.			
Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar				
List of Challenging Experiments (Indicative)				
1.	Thevenin"s and Maximum Power Transfer Theorems – Impedance matching of source and load			3 hours
2.	Sinusoidal steady state Response of RLC circuits			3 hours
3.	Three phase power measurement for ac loads			3 hours
4.	Staircase wiring circuit layout for multi storey building			3 hours
5.	Fabricate and test a PCB layout for a rectifier circuit			3 hours
6.	Half and full adder circuits.			3 hours
7.	Full wave Rectifier circuits used in DC power supplies. Study the characteristics of the semiconductor device used			3 hours
8.	Regulated power supply using zener diode. Study the characteristics of the Zener diode used			3 hours
9.	Lamp dimmer circuit (Darlington pair circuit using transistors) used in cars. Study the characteristics of the transistor used			3 hours
10.	Characteristics of MOSFET			3 hours
			Total Laboratory Hours	**30 hours**
Mode of assessment: CAT / Assignment / Quiz / FAT / Project / Seminar				
Recommended by Board of Studies	**29/05/2015**			
Approved by Academic Council	**37th AC**	Date	**16/06/2015**	

MAT1014	Discrete Mathematics and Graph Theory	L	T	P	J	C
		3	1	0	0	4
Pre-requisite	Nil	Syllabus Version				
		1.0				

Course Objectives:

1. To address the challenge of the relevance of lattice theory, coding theory and algebraic structures to computer science and engineering problems.
2. To use number theory, in particular congruence theory to cryptography and computer science problems.
3. To understand the concepts of graph theory and related algorithm concepts.

Expected Course Outcome:

At the end of this course, students are expected to

1. form truth tables, proving results by truth tables, finding normal forms,
2. learn proof techniques and concepts of inference theory
3. understand the concepts of groups and application of group codes, use Boolean algebra for minimizing Boolean expressions.
4. learn basic concepts of graph theory, shortest path algorithms, concepts of trees and minimum spanning tree and graph colouring, chromatic number of a graph.
5. Solve Science and Engineering problems using Graph theory.

Module:1	Mathematical Logic and Statement Calculus	6 hours

Introduction-Statements and Notation-Connectives–Tautologies–Two State Devices and Statement logic -Equivalence - Implications–Normal forms - The Theory of Inference for the Statement Calculus.

Module:2	Predicate Calculus	4 hours

The Predicate Calculus - Inference Theory of the Predicate Calculus.

Module:3	Algebraic Structures	5 hours

Semigroups and Monoids - Groups – Subgroups – Lagrange's Theorem Homomorphism – Properties-Group Codes.

Module:4	Lattices	5 hours

Partially Ordered Relations -Lattices as Posets – Hasse Digram – Properties of Lattices.

Module:5	Boolean algebra	5 hours

Boolean algebra - Boolean Functions-Representation and Minimization of Boolean Functions – Karnaugh map – McCluskey algorithm.

Module:6	Fundamentals of Graphs	6 hours

Basic Concepts of Graph Theory – Planar and Complete graph - Matrix representation of Graphs – Graph Isomorphism – Connectivity–Cut sets-Euler and Hamilton Paths–Shortest Path algorithms.

Module:7	Trees, Fundamental circuits , Cut sets, Graph colouring, covering, Partitioning	12 hours

Trees – properties of trees – distance and centres in tree –Spanning trees – Spanning tree algorithms- Tree traversals- Fundamental circuits and cut-sets. Bipartite graphs - Chromatic number – Chromatic partitioning – Chromatic polynomial - matching – Covering– Four Colour problem.		
Module:8	**Contemporary Issues**	**2 hours**
Industry Expert Lecture		
	Total Lecture hours:	**45 hours**
Tutorial	• A minimum of 10 problems to be worked out by students in every Tutorial class. • Another 5 problems per Tutorial Class to be given as home work.	**15 hours**

Mode of Evaluation

Individual Exercises, Team Exercises, Online Quizzes, Online, Discussion Forums

Text Book(s)

1. Discrete Mathematical Structures with Applications to Computer Science, J .P. Trembleyand R. Manohar, Tata McGraw Hill-35th reprint, 2017.
2. Graph theory with application to Engineering and Computer Science, Narasing Deo, Prentice Hall India 2016.

Reference Books

1. Discrete Mathematics and its applications, Kenneth H. Rosen, 8th Edition, Tata McGraw Hill, 2019.
2. Discrete Mathematical Structures, Kolman, R.C.Busby and S.C.Ross, 6th Edition, PHI,2018.
3. Discrete Mathematics, Richard Johnsonbaugh, 8th Edition, Prentice Hall, 2017.
4. Discrete Mathematics, S. Lipschutz and M. Lipson, McGraw Hill Education (India) 2017.
5. Elements of Discrete Mathematics–A Computer Oriented Approach, C.L.Liu, Tata McGraw Hill, Special Indian Edition, 2017.
6. Introduction to Graph Theory, D. B. West, 3rd Edition, Prentice-Hall, Englewood Cliffs, NJ, 2015.

Mode of Evaluation

Digital Assignments, Quiz, Continuous Assessments, Final Assessment Test

Recommended by Board of Studies	03-06-2019		
Approved by Academic Council	No.55	Date	13-06-2019

MAT2002	Applications of Differential and Difference Equations	L	T	P	J	C
		3	0	2	0	4

Pre-requisite	MAT1011 - Calculus for Engineers	Syllabus Version
		v1.0

Course Objectives:

The course is aimed at

1. Presenting the elementary notions of Fourier series, which is vital in practical harmonic analysis
2. Imparting the knowledge of eigenvalues and eigen vectors of matrices and thetransform techniques to solve linear systems, that arise in sciences and engineering
3. Enriching the skills in solving initial and boundary value problems
4. Impart the knowledge and application of difference equations and the Z-transform in discrete systems, that are inherent in natural and physical processes

Expected Course Outcomes:

At the end of the course the student should be able to

1. Employ the tools of Fourier series to find harmonics of periodic functions from the tabulated values
2. Apply the concepts of eigenvalues, eigen vectors and diagonalisation in linear systems
3. Know the techniques of solving differential equations
4. Understand the series solution of differential equations and finding eigen values, eigen functions of Strum-Liouville's problem
5. Know the Z-transform and its application in population dynamics and digital signal processing
6. Demonstrate MATLAB programming for engineering problems

Module:1	Fourier series	6 hours

Fourier series - Euler's formulae - Dirichlet's conditions - Change of interval - Half range series – RMS value – Parseval's identity – Computation of harmonics

Module:2	Matrices	6 hours

Eigenvalues and Eigen vectors - Properties of eigenvalues and eigen vectors – Cayley-Hamilton theorem - Similarity of transformation - Orthogonal transformation and nature of quadratic form

Module:3	Solution of ordinary differential equations	6 hours

Linear second order ordinary differential equation with constant coefficients – Solutions of homogenous and non-homogenous equations - Method of undetermined coefficients – method of variation of parameters – Solutions of Cauchy-Euler and Cauchy-Legendre differential equations

Module:4	Solution of differential equations through Laplace transform and matrix method	8 hours

Solution of ODE's - Nonhomogeneous terms involving Heaviside function, Impulse function - Solving nonhomogeneous system using Laplace transform – Reduction of *n*th order differential equation to first order system - Solving nonhomogeneous system of first order differential equations $(X' = AX + G)$ and

Module:5	Strum Liouville's problems series Solutions	6 hours
The Strum-Liouville's Problem - Orthogonality of Eigen functions - Series solutions of differential equations about ordinary and regular singular points - Legendre differential equation - Bessel's differential equation		

Module:6	Z-Transform	6 hours
Z-transform -transforms of standard functions - Inverse Z-transform: by partial fractions and convolution method		

Module:7	Difference equations	5 hours
Difference equation - First and second order difference equations with constant coefficients - Fibonacci sequence - Solution of difference equations - Complementary function - Particular integral by the method of undetermined coefficients - Solution of simple difference equations using Z-transform		

Module:8	Contemporary Issues	2 hours
Industry Expert Lecture		

Total Lecture hours:	45 hours

Text Book(s)

1.	Advanced Engineering Mathematics, Erwin Kreyszig, 10th Edition, John Wiley India, 2015

Reference Books

1	Higher Engineering Mathematics, B. S. Grewal, 43rd Edition, Khanna Publishers, India, 2015
2	Advanced Engineering Mathematics by Michael D. Greenberg, 2nd Edition, Pearson Education, Indian edition, 2006

Mode of Evaluation

Digital Assignments (Solutions by using soft skills), Continuous Assessment Tests, Quiz, Final Assessment Test	

1.	Solving Homogeneous differential equations arising in engineering problems	2 hours
2.	Solving non-homogeneous differential equations and Cauchy, Legendre equations	2 hours
3.	Applying the technique of Laplace transform to solve differential equations	2 hours
4.	Applications of Second order differential equations to Mass spring system (damped, undamped, Forced oscillations), LCR circuits etc.	2 hours
5.	Visualizing Eigen value and Eigen vectors	2 hours
6.	Solving system of differential equations arising in engineering applications	2 hours
7.	Applying the Power series method to solve differential equations arising in engineering applications	3 hours
8.	Applying the Frobenius method to solve differential equations arising in engineering applications	3 hours
9.	Visualising Bessel and Legendre polynomials	3 hours
10.	Evaluating Fourier series-Harmonic series	3 hours
11.	Applying Z-Transforms to functions encountered in engineering	3 hours
12.	Solving Difference equations arising in engineering applications	3 hours
	Total Laboratory Hours	**30 hours**

Mode of Evaluation: Weekly Assessment, Final Assessment Test			
Recommended by Board of Studies	25-02-2017		
Approved by Academic Council	No. 47	Date	05-10-2017

MAT3004	Applied Linear Algebra	L	T	P	J	C
		3	2	0	0	4

Pre-requisite	MAT2002 Applications of Differential and Difference Equations	Syllabus Version
		v1.0

Course Objectives

1. Understanding basic concepts of linear algebra to illustrate its power and utility through applications to computer science and Engineering.
2. apply the concepts of vector spaces, linear transformations, matrices and inner product spaces in engineering.
3. solve problems in cryptography, computer graphics and wavelet transforms

Expected Course Outcomes

At the end of this course the students are expected to learn

1. the abstract concepts of matrices and system of linear equations using decomposition methods
2. the basic notion of vector spaces and subspaces
3. apply the concept of vector spaces using linear transforms which is used incomputer graphics and inner product spaces
4. applications of inner product spaces in cryptography
5. Use of wavelet in image processing.

Module:1	System of Linear Equations:	6 hours

Gaussian elimination and Gauss Jordan methods - Elementary matrices- permutation matrix - inverse matrices - System of linear equations - - LU factorizations.

Module:2	Vector Spaces	6 hours

The Euclidean space R^n and vector space- subspace –linear combination-span-linearly dependent-independent- bases - dimensions-finite dimensional vector space.

Module:3	Subspace Properties:	6 hours

Row and column spaces -Rank and nullity – Bases for subspace – invertibility- Application in interpolation.

Module:4	Linear Transformations and applications	7 hours

Linear transformations – Basic properties-invertible linear transformation - matrices of linear transformations - vector space of linear transformations – change of bases – similarity

Module:5	Inner Product Spaces:	6 hours

Dot products and inner products – the lengths and angles of vectors – matrix representations of inner products- Gram-Schmidt orthogonalisation

Module:6	Applications of Inner Product Spaces:	6 hours

QR factorization- Projection - orthogonal projections – relations of fundamental subspaces – Least Square solutions in Computer Codes

Module:7	**Applications of Linear equations** :	**6 hours**
An Introduction to coding - Classical Cryptosystems –Plain Text, Cipher Text, Encryption, Decryption and Introduction to Wavelets (only approx. of Wavelet from Raw data)		
Module:8	**Contemporary Issues:**	**2 hours**
Industry Expert Lecture		
	Total Lecture hours:	**45 hours**
Tutorial	• A minimum of 10 problems to be worked out by students in every Tutorial Class • Another 5 problems per Tutorial Class to be given as home work.	**15 hours**

Text Book(s)

1. Linear Algebra, Jin Ho Kwak and Sungpyo Hong, Second edition Springer(2004). (Topics in the Chapters 1,3,4 &5)
2. Introductory Linear Algebra- An applied first course, Bernard Kolman and David, R. Hill, 9th Edition Pearson Education, 2011.

Reference Books

1. Elementary Linear Algebra, Stephen Andrilli and David Hecker, 5th Edition, Academic Press(2016)
2. Applied Abstract Algebra, Rudolf Lidl, Guter Pilz, 2nd Edition, Springer 2004.
3. Contemporary linear algebra, Howard Anton, Robert C Busby, Wiley 2003
4. Introduction to Linear Algebra, Gilbert Strang, 5th Edition, Cengage Learning (2015).

Mode of Evaluation

Digital Assignments, Continuous Assessments, Final Assessment Test

Recommended by Board of Studies	25-02-2017		
Approved by Academic Council	No. 47	Date	05-10-2017

CSE1006	BLOCKCHAIN AND CRYPTOCURRENCY TECHNOLOGIES	L	T	P	J	C
		3	0	0	0	3
Pre-requisite	**NIL**	**Syllabus version**				
		v1.0				

Course Objectives:

1. To understand the mechanism of Blockchain and Cryptocurrency.
2. To understand the functionality of current implementation of blockchain technology.
3. To understand the required cryptographic background.
4. To explore the applications of Blockchain to cryptocurrencies andunderstanding limitations of current Blockchain.
5. An exposure towards recent research.

Expected Course Outcome:

1. To Understand and apply the fundamentals of Cryptography in Cryptocurrency
2. To gain knowledge about various operations associated with the life cycle of Blockchain and Cryptocurrency
3. To deal with the methods for verification and validation of Bitcoin transactions
4. To demonstrate the general ecosystem of several Cryptocurrency
5. To educate the principles, practices and policies associated Bitcoin business

Module:1	**Introduction to Cryptography and Cryptocurrencies**	**5 hours**

Cryptographic Hash Functions, Hash Pointers and Data Structures, Digital Signatures, Public Keys as Identities, A Simple Cryptocurrency.

Module:2	**How Blockchain Achieves and How to Store and Use**	**7 hours**

Decentralization-Centralization vs. Decentralization-Distributed consensus, Consensus with- out identity using a blockchain, Incentives and proof of work. Simple Local Storage, Hot and Cold Storage, Splitting and Sharing Keys, Online Wallets and Exchanges, Payment Services, Transaction Fees, Currency Exchange Markets.

Module:3	**Mechanics of Bitcoin**	**5 hours**

Bitcoin transactions, Bitcoin Scripts, Applications of Bitcoin scripts, Bitcoin blocks, The Bit- coin network, Limitations and improvements.

Module:4	**Bitcoin Mining**	**5 hours**

The task of Bitcoin miners, Mining Hardware, Energy consumption and ecology, Mining pools, Mining incentives and strategies

Module:5	**Bitcoin and Anonymity**	**5 hours**

Anonymity Basics, How to De-anonymize Bitcoin, Mixing, Decentralized Mixing, Zerocoin and Zerocash.

Module:6	**Community, Politics, and Regulation**	**9 hours**

Consensus in Bitcoin, Bitcoin Core Software, Stakeholders: Who's in Charge, Roots of Bitcoin, Governments Notice on Bitcoin, Anti Money Laundering Regulation, New York"s Bit License Proposal. Bitcoin as a Platform: Bitcoin as an Append only Log, Bitcoins as Smart Property, Secure Multi Party Lotteries in Bitcoin, Bitcoin as Public Randomness, Source-Prediction Markets, and Real World Data Feeds.

Module:7	**Altcoins and the Cryptocurrency Ecosystem**		**7 hours**
Altcoins: History and Motivation, A Few Altcoins in Detail, Relationship Between Bitcoin and Altcoins, Merge Mining-Atomic Crosschain Swaps-6 BitcoinBacked Altcoins, Side Chains, Ethereum and Smart Contracts.			
Module:8	**Recent Trends and applications**		**2 hours**
	Total Lecture hours:	**45 hours**	

Text Book(s)	
1.	Narayanan, A., Bonneau, J., Felten, E., Miller, A., and Goldfeder, S. (2016). Bitcoin and cryptocurrency technologies: a comprehensive introduction. Princeton University Press.
Reference Books	
1.	Antonopoulos, A. M. (2014). Mastering Bitcoin: unlocking digital cryptocurrencies. OReilly Media, Inc.".
2.	Franco, P. (2014). Understanding Bitcoin: Cryptography, engineering and economics. John Wiley and Sons.

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar			
Recommended by Board of Studies	10-08-2018		
Approved by Academic Council	No. 52	Date	14-09-2018

CSE3001	SOFTWARE ENGINEERING	L	T	P	J	C
		2	0	2	4	4
Pre-requisite	**NIL**	**Syllabus version**				
		v1.0				

Course Objectives:

1. To introduce the essential software engineering concepts involved
2. To impart skills inthe design and implementation of efficient software systems across disciplines
3. To familiarize engineering practices and standards used in developing software products and components

Expected Course Outcome:

1. Apply the principles of the engineering processes in software development.
2. Demonstrate software project management activities such as planning,scheduling and Estimation.
3. Model the requirements for the software projects.
4. Design and Test the requirements of the software projects.
5. Implement the software development processes activities from requirements tovalidation and verification.
6. Apply and evaluate the standards in process and in product.

Module:1	OVERVIEW OF SOFTWARE ENGINEERING	5 hours

Nature of Software, Software Engineering, Software process, project, product, Process Models Classical Evolutionary models, Overview of System Engineering

Module:2	INTRODUCTION TO SOFTWARE PROJECT MANAGEMENT	3 hours

Planning scope, milestones deliverables, Risk Management, Metrics Measurement

Module:3	MODELLING REQUIREMENTS	6 hours

Requirements Engineering process Requirement Elicitation, System Modelling - Requirements Specification and Requirement Validation

Module:4	SOFTWARE DESIGN	4 hours

Design concepts and principles - Abstraction - Refinement - Modularity Cohesion coupling, Architectural design, Detailed Design Transaction Transformation, Refactoring of designs, Object-oriented Design User-Interface Design

Module:5	VALIDATION and VERIFICATION	4 hours

Strategic Approach to Software Testing, Testing Fundamentals Test Plan, Test Design, Test Execution, Reviews, Inspection Auditing

Module:6	SOFTWARE EVOLUTION	4 hours

Software Maintenance, Types of Maintenance, Software Configuration Management, Overview of RE-engineering Reverse Engineering

Module:7	QUALITY ASSURANCE	2 hours

Product Process Metrics, Quality Standards Models ISO, TQM, Six-Sigma

Module:8	RECENT TRENDS	2 hours

Recent Trends in Software Design/Specialized Software Testing, Related Tools and Standards				
	Total Lecture hours:	**30 hours**		
Text Book(s)				
1.	Roger Pressman, Software Engineering: A Practitioner's Approach, 7th Edition, McGraw-Hill, 2010.			
Reference Books				
1.	Ian Sommerville, Software Engineering, 9th Edition, Addision-Wesley, 2016			
2.	Pankaj Jalote, A Concise Introduction to Software Engineering, Springer, 2008			
3.	William E. Lewis , Software Testing and Continuous Quality Improvement, Third Edition, Auerbach Publications, 2008			
Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar				
List of Challenging Experiments (Indicative)				
1.	Work Break-down Structure (Process Based, Product Based, Geographic Based and Role Based)			3 hours
2.	Estimations Cost and Schedule			3 hours
3.	Entity Relationship Diagram, Context flow diagram, DFD (Structural Modeling and Functional Modeling)			4 hours
4.	State Transition Diagrams (Behavioral Modeling)			4 hours
5.	System Requirements Specification			4 hours
6.	UML diagrams for OO Design			4 hours
7.	Tools for Version Control			3 hours
8.	Black-box, White-box testing			3 hours
9.	Non-functional testing			2 hours
			Total Laboratory Hours	30 hours
Mode of assessment: Project/Activity				
Recommended by Board of Studies	04-04-2014			
Approved by Academic Council	No. 37	Date	16-06-2015	

CSE2015	Internet Programming and Web Technologies	L	T	P	J	C
		3	0	2	0	4
Pre-requisite		**Syllabus version**				
Anti-requisite	**CSE3002**	v1.0				

Course Objectives:

1. To comprehend and analyze the basic concepts of web programming and internet Protocols.
2. To describe how the client-server model of Internet programming works.
3. To demonstrates the uses of scripting languages and their limitations.

Expected Course Outcome:

After successfully completing the course the student should be able to

1. Know the different web protocols and web architecture.
2. Apply HTML and CSS effectively to create dynamic websites.
3. Create event responsive webpages using AJAX and JQuery.
4. Implement server-side programming like session, cookies, file handling and database connectivity using PHP.
5. Learn web data storage and transfer technologies using Angular
6. Develop web applications using advanced technologies such as Node JS

Module:1	**Introduction to Internet**	**4 hours**

Internet Overview- Networks – WWW –Web Protocols — Web Organization and Addressing – Internet Service Providers, DNS Servers, Connection Types, Internet Addresses - Web Browsers and Web Servers -Security and Vulnerability-Web System Architecture – URL - Domain Name – Web Content Authoring - Webserver Administration – Search Engines

Module:2	**Web Designing**	**8 hours**

HTML5 – Text tags; Graphics, Form elements, HTML 5 Input types, HTML 5 Input types, semantic tags, CSS3 - Selectors, Box Model, Backgrounds and Borders, Text Effects, Animations, Cascading and inheritance of style properties - Normal Flow Box Layout-Beyond the Normal Flow – Introduction to responsive design - bootstrap

Module:3	**Client Side Scripting**	**7 hours**

JavaScript -Variables and Data Types - Statements – Operators- Literals- Functions- Objects- Arrays- Built-in Objects, DOM – BOM - Regular Expression Exceptions, Event handling, Validation - JQuery

Module:4	**Developing Interactive Web Applications**	**5 hours**

AJAX –AJAX calls - XML http – request – response – AJAX with PHP - Data Formats - AJAX with Database – Processing Server Response - AJAX Security

Module:5	**Server Side Scripting**	**7 hours**

Introduction to Node.js- NPM - Events, Timers, and Callbacks in Node.js – file upload – email – Express framework – request –response –routing - templates- view engines. Introduction to Mongo DB- creating DB, collection – CRUD operations - Accessing MongoDB from Node.js. – Accessing online Mongo DB from Node JS.

Module:6	**React Web Framework**	**6 hours**

Introduction – Environment setup – JSX – React DOM – React Elements - Components – react state – Props – Hooks – Component life cycle		
Module:7	**React App Development**	**6 hours**
React Router – event handlers - React lists – react forms – react HTML render – react refs – react CSS – Array immutability – Lazy loading – Storing to local storage – Create a sample React App		
Module:8	**Recent Trends**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	Paul J. Deitel, Harvey Deitel, Internet and World Wide Web How To Program, 6th Edition, Pearson, 2020.
2.	Vasan Subramanian, Pro MERN Stack - Full stack web app development, 2nd Edition, 2019
Reference Books	
1.	Jessica Minnick, Responsive Web Design with HTML 5 & CSS, Cengage Learning, 2020.
2.	Frank Zammetti, Modern Full-Stack Development: TypeScript, React, Node.js, 1st Edition, Apress,2020
Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar	

List of Experiments (Indicative)		
1.	HTML form validation with JavaScript	3 hours
2.	PHP : Forms and File handling	3 hours
3	PHP : Session Management and Cookies, Databases	3 hours
4.	Custom Services in Applications using AJAX	6 hours
5.	Database and Server Response with AJAX	6 hours
6.	React : Content projection, Manipulating Data With Pipes	6 hours
7.	Node JS and Mongo DB	6 hours
	Total Laboratory Hours	30 hours
Mode of assessment: Project/Activity		

Recommended by Board of Studies	11-02-2021		
Approved by Academic Council	No. 61	Date	18-02-2021

Course Code	Course Title	L	T	P	J	C
CSE3044	Cryptography and Network Security	3	0	0	0	3
Pre-requisite	Nil	Syllabus Version				
		v1.0				

Course Objectives:

1. To acquaint students with the basic concepts in security mechanism, classical and traditional Encryption techniques.
2. To teach students the significance of message authentication and digital signature in cryptography.
3. To acquaint the students to the different types of network security and its significance

Expected Course Outcome:

1. Learn to analyze the security of the in-built cryptosystems.
2. Know the fundamental mathematical concepts related to security.
3. Develop cryptographic algorithms for information security.
4. Comprehend the various types of data integrity and authentication schemes.
5. Understand the various types of network security, threats and attacks.

Module:1	Introduction to Security	5 hours

Security properties (confidentiality, integrity and availability), security vulnerabilities, threats and attacks, security models, policies and mechanisms Security Services and Mechanisms, Encryption Techniques, Basic notions of security protocol

Module:2	Number Theory Concepts	8 hours

Number theory - Group, Rings, Fields, Galois field, Euclidean algorithm, Principles of Pseudorandom Number Generation, Fermat's and Euler's Theorems, The Chinese Remainder Theorem, Discrete Logarithms, Elliptic Curve Arithmetic

Module:3	Symmetric Ciphers	6 hours

Block Ciphers - DES, AES, Blowfish, modes of operation, Stream Ciphers-RC4, Linear and Differential cryptanalysis, Homomorphic encryption, PALISADE, SEAL, and HElib.

Module:4	Asymmetric Ciphers	6 hours

Public-Key Cryptography – RSA - Diffie-Hellman Key Exchange, ElGamal Cryptosystem, Elliptic Curve Cryptography, PKI, Privacy Preservation, Perturbation, K-anonymity, L-diversity, Randomization, Taxonomy tree, Condensation, and Cryptographic approach

Module:5	Data Integrity and Key Management	6 hours

Data Integrity in storage - Mirroring – RAID parity- Check summing - Access control for maintenance of integrity – Role based Access control- Discretionary Access control and Rule based access control - Cryptographic Hash Functions, Message Authentication Codes, SHA-3 algorithm, Digital Signatures- DSA algorithm, Key Management and Distribution, User Authentication Protocols, Kerberos – Key Distribution Centre- Trust Management

Module:6	Network Security	6 hours

E-Mail Security-PGP,S/MIME, Transport-Level Security, IP Security, WLAN Security – Firewalls, Web Security

Module:7	Threats & Attacks	6 hours

Buffer overflow, DoS, DDoS, birthday attack, Intrusion Detection and Prevention, SQL

Injections- Phishing-Password Attacks – Computer Virus		
Module:8	**Recent Trends**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	Stallings, William, “Cryptography and network security: principles and practice”, Pearson, 2017.
2	Behrouz A.Forouzan : Cryptography & Network Security – The McGraw Hill Company, 2010.
Reference Books	
1	Wade Trappe, Lawrence C. Washington, Introduction to Cryptography with Coding Theory, 3rd Edition, Pearson, 2020.
2	Neal Koblitz, A course in number theory and cryptography, Springer, 1994.
3	Shreya Dey, Ashraf Hossain, “Session-Key Establishment and Authentication in a Smart Home Network Using Public Key Cryptography”, IEEE Sensors Letters, Volume: 3, Issue: 4, April 2019.

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar			
Mode of evaluation: Project/Activity			
Recommended by Board of Studies	11-02-2021		
Approved by Academic Council	No. 61	Date	18-02-2021

Course Code	Course Title	L	T	P	J	C
CSE3045	Mathematical Modeling for Data Science	2	0	2	0	3
Pre-requisite		Syllabus Version				
		v1.0				

Course Objectives:

1. To introduce the various mathematical concepts and models, and provide skills required to implement the models.
2. To undertake a critical evaluation of a wide range of numerical and data.
3. To develop designing skills for modeling non-deterministic problems.

Expected Course Outcome:

1. Demonstrate understanding of basic mathematical concepts in data science, relating to linear algebra, probability, and calculus and employ them.
2. Apply linear models for regression and linear models for classification
3. Employ kernel models, SVM and RVM
4. Conceptualize problems as graphical models, mixture models and analyse using estimation-maximation algorithms
5. Demonstrate with illustrative examples PCA

Module:1	Linear Algebra	3 hours

Matrices, solving linear equations, vector spaces, linear independence, basis and rank, linear mappings, affine spaces, norms, inner products, orthogonality, orthonormal basis, inner product of functions, orthogonal projections

Module:2	Matrix Decompositions	4 hours

Determinant and trace, Eigen values and Eigen vectors, Cholesky decomposition, Eigen decomposition, Singular value decomposition, matrix approximation

Module:3	Vector Calculus	4 hours

Differentiation of Univariate Functions, Partial Differentiation and Gradients, Gradients of Vector-Valued Functions, Gradients of Matrices, Useful Identities for Computing Gradients, Backpropagation and Automatic Differentiation, Higher-Order Derivatives, Linearization and Multivariate Taylor Series.

Module:4	Probability, Distributions and optimizations	4 hours

Construction of a Probability Space, Discrete and Continuous Probabilities, Sum Rule, Product Rule, and Bayes' Theorem, Summary Statistics and Independence, Gaussian Distribution, Conjugacy and the Exponential Family, Change of Variables/Inverse Transform, Continuous Optimization, Optimization Using Gradient Descent, Constrained Optimization and Lagrange Multipliers, Convex Optimization

Module:5	Data Models	4 hours

Data, Models, and Learning, Empirical Risk Minimization, Parameter Estimation, Probabilistic Modeling and Inference, Directed Graphical Models, Model Selections

Module:6	Linear Regression and Dimensionality Reduction	5 hours

Linear Regression - Problem Formulation, Parameter Estimation, Bayesian Linear Regression, Maximum Likelihood as Orthogonal Projection, Dimensionality Reduction with Principal Component

Analysis, Maximum Variance Perspective, Projection Perspective, Eigenvector Computation and Low-Rank Approximations, PCA in High Dimensions, Key Steps of PCA in Practice, Latent Variable Perspective		
Module:7	**Gaussian Mixture Models and Support Vector Machines**	**4 hours**
Gaussian Mixture Model, Parameter Learning via Maximum Likelihood, EM Algorithm, Latent-Variable Perspective, SVM - Separating Hyperplanes, Primal Support Vector Machine, Dual Support Vector Machine, Kernels		
Module:8	**Recent Trends**	**2 hours**
	Total Lecture Hours:	**30 hours**

Text Book(s)

1.	Marc Peter Deisenroth, A. Aldo Faisal, and Cheng Soon Ong, Mathematics for Machine Learning, Cambridge University Press, 2020.

Reference Books

1.	Matthias Dehmer, Salissou Moutari, Frank Emmert-Streib, Mathematical Foundations of Data Science Using R, De Gruyter Oldenbourg, 2020.
2.	Norman Matloff, Probability and Statistics for Data Science: Math + R + Data, CRC Data Science Series, 2019.

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar

List of Experiments

1.	Linear Algebra – solving linear equations	3 hours
2.	Eigen values and Eigen vectors	3 hours
3.	Eigen decomposition	3 hours
4.	Linear Models for Classification	3 hours
5.	Probabilistic Modeling	3 hours
6.	Dimensionality Reduction with Principal Component Analysis	3 hours
7.	Gaussian Mixture Model	3 hours
8.	EM algorithms	3 hours
9.	Support Vector Machines	3 hours
10.	Dual Support Vector Machine	3 hours
	Total Laboratory Hours	30 hours

Mode of evaluation: Project/Activity

Recommended by Board of Studies	11-02-2021		
Approved by Academic Council	No. 61	Date	18-02-2021

Course code	Course Title	L	T	P	J	C
CSE3046	Programming for Data Science	3	0	2	0	4
Pre-requisite	NIL	Syllabus version				
		v1.0				

Course Objectives:

1. To provide necessary knowledge on data manipulation and to perform analysis on the practical problems using statistical and machine learning approach
2. To generate report and visualize the results in graphical form using programming tool

Expected Course Outcome:

1. Ability to gain basic knowledge on data science
2. Convert the real time data into suitable form for analysis
3. Gain the insights from the data through statistical inferences
4. Develop suitable models using machine learning techniques and to analyze its performance
5. Identify the requirement and visualize the results
6. Analyze on the performance of the model and the quality of the results

Module:1	**INTRODUCTION**	**4 hours**

Data Science: Introduction to Data Science – Digital Universe – Sources of Data – Information Commons – Data Science Project Life Cycle: OSEMN Framework

Module:2	**DATA PREPROCESSING**	**6 hours**

Introduction to Data Preprocessing – Reading, Selecting, Filtering Data – Filtering Missing Values – Manipulating, Sorting, Grouping, Rearranging, Ranking Data

Module:3	**CONCEPT LEARNING**	**7 hours**

Formulation of Hypothesis – Probabilistic Approximately Correct Learning - VC Dimension – Hypothesis elimination – Candidate Elimination Algorithm

Module:4	**ESSENTIALS OF R**	**8 hours**

R Basics - data types and objects - control structures – data frame -Feature Engineering - scaling, Label Encoding and One Hot Encoding, Reduction

Module:5	**MODEL FIT USING R**	**8 hours**

Regression Models- Linear and Logistic Model, Classification Models – Decision Tree, Naïve Bayes, SVM and Random Forest, Clustering Models – K Means and Hierarchical clustering

Module:6	**VISUALIZATION**	**6 hours**

Data visualization: Box plot, histogram, scatter plot, heat map – Working with Tableau – Outlier detection – Data Balancing

Module:7	**PERFORMANCE EVALUATION in R**	**4 hours**

Loss Function and Error: Mean Squared Error, Root Mean Squared Error – Model Selection and Evaluation criteria: Accuracy, Precision, F1 score, Recall Score – Binary Predictive Classification – Sensitivity – Specificity.

Module:8	**RECENT TRENDS**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)				
1.	Ethem Alpaydin, Introduction to Machine Learning, Fourth Edition, MIT Press, 2020			
2.	Hadley Wickham, Garrett Grolemund, R for data science : Import, Tidy, Transform, Visualize, And Model Data Paperback, 2017			
Reference Books				
1.	Han, J., Kamber, M., Pei, J. Data mining concepts and techniques. Morgan Kaufmann. 2011			
2.	Carl Shan, Henry Wang, William Chen, Max Song. The Data Science Handbook: Advice and Insight from 25 Amazing Data Scientists. The Data Science Bookshelf. 2016			
3.	James, G., Witten, D., T., Tibshirani, R. An Introduction to statistical learning with applications in R. Springer. 2013			
Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar				
List of Experiments				
1.	House rent prediction using linear regression			3 hours
2.	Medical diagnosis for disease spread pattern			3 hours
3.	Automate email classification and response			2 hours
4.	Customer segmentation in business model based on their demographic, psychographic and behavior data			3 hours
5.	Analysis of tweet and retweet data to identify the spread of fake news			2 hours
6.	Analyze crime data using suitable technique on reported incidents of crime based on time and location			2 hours
7.	Construct a recommendation system based on the customer transaction using Association rule mining			2 hours
8.	Perform analysis on power consumption data to suggest for minimizing the usage			2 hours
9.	Behavioral analysis of customers for any online purchase model			3 hours
10	Agricultural data analysis for yield prediction and crop selection on Indian terrain data set			3 hours
11.	Develop a recommender system for any real-world problem (when a user queries to find the university that offers Python, the system should display rank wise list of the university based on the review given by the customers)			3 hours
12.	Develop a business model to predict the trend in Investment and Funding			2 hours
			Total Laboratory Hours	**30 hours**
Mode of Evaluation: Project/Activity				
Recommended by Board of Studies	11-02-2021			
Approved by Academic Council	No. 61	Date	18-02-2021	

Course Code	Course Title	L	T	P	J	C
CSE3047	Predictive Analytics	2	0	0	4	3
Pre-requisite	Nil	Syllabus version				
		v1.0				

Course Objectives:

1. Learn the fundamental principles of analytics for business
2. Visualize and explore data to better understand relationships among variables
3. To understand the principles and techniques for predictive modelling
4. Examine how predictive analytics can be used in decision making
5. Apply predictive models to generate predictions for new data

Expected Course Outcome:

1. Understand the importance of predictive analytics
2. Able to prepare and process data for the models
3. Learn about statistical analysis techniques used in predictive models
4. Ability to model data and establish baseline performance
5. Apply regression and classification model on applications for decision making and evaluate the performance
6. Build and apply time series forecasting models in a variety of business contexts

Module:1	Introduction	2 hours

Introduction to predictive analytics – Business analytics: types, applications- Models: predictive models – descriptive models – decision models - applications - analytical techniques

Module:2	Understanding Data	3 hours

Data types and associated techniques – complexities of data – data preparation, pre-processing – exploratory data analysis

Module:3	Principles and Techniques	4 hours

Predictive modeling: Propensity models, cluster models, collaborative filtering, applications and limitations - Statistical analysis: Univariate Statistical analysis, Multivariate Statistical analysis

Module:4	Model Selection	4 hours

Preparing to model the data: supervised versus unsupervised methods, statistical and data mining methodology, cross-validation, overfitting, bias-variance trade-off, balancing the training dataset, establishing baseline performance.

Module:5	Regression Models	5 hours

Measuring Performance in Regression Models - Linear Regression and Its Cousins - Non-Linear Regression Models - Regression Trees and Rule-Based Models Case Study: Compressive Strength of Concrete Mixtures

Module:6	Classification Models	5 hours

Measuring Performance in Classification Models - Discriminant Analysis and Other Linear Classification Models - Non-Linear Classification Models - Classification Trees and Rule-Based Models – Model Evaluation Techniques

Module:7	Time Series Analysis	5 hours

Time series Model: ARMA, ARIMA, ARFIMA - Temporal mining - Box Jenkinson method, temporal reasoning, temporal constraint networks

Module:8	**Recent Trends**	**2 hours**
	Total Lecture Hours:	**30 hours**

Text Book(s)

1. Jeffrey Strickland, Predictive analytics using R, Simulation educators, Colorado Springs, 2015
2. Max Kuhn and Kjell Johnson, Applied Predictive Modeling, 1st edition Springer, 2013.

Reference Books

1. Anasse Bari, Mohamed Chaouchi, Tommy Jung, Predictive analytics for dummies, 2nd edition Wiley, 2016.
2. Dinov, ID., Data Science and Predictive Analytics: Biomedical and Health Applications using R, Springer, 2018.
3. Daniel T.Larose and Chantal D.Larose, Data Mining and Predictive analytics, 2nd edition Wiley, 2015.

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar

Project Component:
Students should identify a problem to address through predictive analytics. The goal is to select appropriate models and model specifications and apply the respective methods to enhance data-driven decision making related to the business problem. Students will identify the potential use of predictive analytics, formulate the problem, identify the right sources of data, analyze data, and prescribe actions to improve not only the process of decision making but also the outcome of decisions. Students can use any analytics tool to generate predictions.

Mode of evaluation: Project/Activity

Recommended by Board of Studies	11-02-2021		
Approved by Academic Council	No. 61	Date	18-02-2021

Course code	Course Title	L	T	P	J	C
CSE3050	Data Visualization and Presentation	3	0	2	0	4
		Syllabus version				
Anti-requisite	CSE3020-Data Visualization	v1.0				

Course Objectives:

1. Understand the various types of data, apply and evaluate the principles of data visualization.
2. Acquire skills to apply visualization techniques to a problem and its associated dataset.
3. Apply structured approach to create effective visualizations.
4. Learn how to bring valuable insight from the massive dataset using visualization.
5. Learn how to build visualization dashboard to support decision making.
6. Create interactive visualization for better insight using various visualization tools.

Expected Course Outcome:

After successfully completing the course the student should be able to

1. Identify the different data types, visualization types to bring out the insight.
2. Relate the visualization towards the problem based on the dataset to analyze and bring out valuable insight on large dataset.
3. Design visualization dashboard to support the decision making on large scale data.
4. Demonstrate the analysis of large dataset using various visualization techniques and tools.
5. Identify the different attributes and showcasing them in plots. Identify and create various visualizations for geospatial and table data.
6. Ability to create and interpret plots using R/Python.

Module:1	Introduction to Data Visualization	5 hours

Overview of data visualization - Data Abstraction - Task Abstraction - Analysis: Four Levels for Validation

Module:2	Visualization Techniques	7 hours

Scalar and Point techniques – Color maps – Contouring – Height Plots - Vector visualization techniques – Vector properties – Vector Glyphs – Vector Color Coding – Matrix visualization techniques

Module:3	Visual Analytics	6 hours

Visual Variables- Networks and Trees - Map Color and Other Channels- Manipulate View- Heat Map

Module:4	Visualization Tools & Techniques	5 hours

Introduction to various data visualization tools: R –basics, Data preprocessing, Statistical analysis, Plotly and ggplot library, Tableau, D3.js, Gephi.

Module:5	Diverse Types of Visual Analysis	6 hours

Time- Series data visualization – Text data visualization – Multivariate data visualization and case studies

Module:6	Visualization of Streaming Data	7 hours

Best practices of Data Streaming, processing streaming data for visualization, presenting streaming data, streaming visualization techniques, streaming analysis.

Module:7	**Geo Spatial Visualization**	**7 hours**
Chloropleth map, Hexagonal Binning, Dot map, Cluster map, cartogram map **Visualization Dashboard Creations -** Dashboard creation using visualization tools for the use cases: Finance-marketing-insurance-healthcare etc.,		
Module:8	**Recent Trends**	**2 hours**
	Total Lecture Hours:	**45 hours**

Text Book(s)	
1.	Tamara Munzer, Visualization Analysis and Design, CRC Press 2014.
2.	Aragues, Anthony. Visualizing Streaming Data: Interactive Analysis Beyond Static Limits. O'Reilly Media, Inc., 2018
Reference Books	
1.	Dr.Chun-hauh Chen, W.K.Hardle, A.Unwin, Handbook of Data Visualization, Springer publication, 2016.
2.	Christian Toninski, Heidrun Schumann, Interactive Visual Data Analysis, CRC press publication,2020
3.	Alexandru C. Telea, Data Visualization: Principles and Practice, AK Peters, 2014.
Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar	

List of Experiments		
1.	Acquiring and plotting data.	2 hours
2.	Statistical Analysis – such as Multivariate Analysis, PCA, LDA, Correlation regression and analysis of variance	4 hours
3.	Financial analysis using Clustering, Histogram and HeatMap	4 hours
4.	Time-series analysis – stock market	4 hours
5.	Visualization of various massive dataset - Finance - Healthcare - Census - Geospatial	4 hours
6.	Visualization on Streaming dataset (Stock market dataset, weather forecasting)	4 hours
7.	Market-Basket Data analysis-visualization	4 hours
8.	Text visualization using web analytics	4 hours
	Total Laboratory Hours	**30 hrs**
Mode of assessment: Project/Activity		

Recommended by Board of Studies	11-02-2021		
Approved by Academic Council	No. 61	Date	18-02-2021

Course code	Course title	L	T	P	J	C
CSE2016	Microprocessor and Microcontrollers	3	0	2	0	4
Pre-requisite		Syllabus version				
Anti-requisite	CSE2006 – Microprocessor and interfacing	v1.0				

Course Objectives:

1. Students will gain knowledge on architecture, accessing data and instruction from memory for processing
2. Ability to do programs with instruction set and control the external devices through I/O interface
3. Generate a system model for real world problems with data acquisition, processing and decision making with aid of microcontrollers and advanced processors

Expected Course Outcome:

1. Recall the basics of processor, its ways of addressing data for operation by instruction set.
2. Execute basic and advanced assembly language programs.
3. Learn the ways to interface I/O devices with processor for task sharing.
4. Learn the advanced features of Co-Processor and SHARC - Digital signal Processor
5. Recognize the functionalities of microcontroller, latest version processors and its application.
6. Acquire design thinking capability, ability to design a component with realistic constraints, to solve real world engineering problems and analyze the results.

Module:1	Overview of MICROPROCESSOR and ALP	7 hours

Microprocessor pin diagram, Architecture, **Memory Interfacing**- addressing mode and Instruction set-Tools- Assembler Directives, Editor, assembler, debugger, simulator and emulator. E.g., ALP Programs-Arithmetic Operations and Number System Conversions, Programs using Loops, If then else, for loop structures.

Module:2	Introduction to ARM Architecture	6 hours

Basic ARM Architecture-ARM organization Core Data Flow Model-ARM Register Organization-Modes and states-Pipeline and Related Issues-Interrupts and Exceptions

Module:3	ARM and TUUMB Instruction Sets	4 hours

Data Processing Instructions-Conditional Executions-Load and Store Instructions-Multiplication Instructions-Software Interrupt Instructions-Branching Instructions-Barrel Shifting Operations-Stack in ARM-Programs with ARM Core-THUMB State in ARM Core

Module:4	SHARC- Digital signal Processor	6 hours

How DSPs are Different from Other Microprocessors-Circular Buffering-Architecture of the Digital Signal Processor-Fixed versus Floating Point-C versus Assembly-How Fast are DSPs?-The Digital Signal Processor Market.

Module:5	Introduction to Microcontroller	8 hours

8051 Microcontroller Architecture, PSW and Flag Bits, 8051 Register Banks and Stack, Internal Memory Organization of 8051, I/O Ports in 8051, Types of Special Function Registers and their uses in 8051- Interfacing of Timer, Serial data transfer and Interrupt- ADC and DAC.

Module:6	Prototype development with Microcontroller 1	6 hours

Setting Up Arduino- Controlling a Relay Using an Arduino- Controlling an LED with an Arduino- Playing a Sound with an Arduino-Using an Alphanumeric LCD Shield with Arduino.

Module:7	**Prototype development with Microcontroller 2**	**6 hours**
Setting Up a Raspberry Pi- Connecting to Your Pi from a Second Computer- Blinking an LED- Controlling a Relay with Raspberry Pi.		
Module:8	**Contemporary issues: Recent trends**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	D.P. Kothari, Shriram K .Vasudevan, subashri V, sivaraman Ramachandran "Analysis of Microcontrollers" Scientific International PVT. LTD. First edition 2013
2.	Simon Monk, Hacking Electronics: Learning Electronics with Arduino and Raspberry Pi, 2nd Edition, McGraw-Hill Education, 2017

Reference Books	
1.	Douglas V. Hall, SSSP Rao" Microprocessors and Interfacing Programming and Hardware". Tata McGraw Hill, Third edition, 2012.
2.	Smith, Steven W. "Digital Signal Processing: A Practical Guide for Engineers and Scientists" 1st edition Newnes, 2013

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar

List of Experiments		
1.	Arithmetic operations 8/16 bit using different addressing modes.	1.5 hours
2.	Finding the factorial of an 8 /16 bit number.	1.5 hours
3.	(a) Solving nCr and nPr (b) Compute nCr and nPr using recursive procedure. Assume that 'n' and 'r' are non-negative integers	1.5 hours
4.	Fibonacci series	1.5 hours
5.	Sorting in ascending and descending order	1.5 hours
	(a) Search a given number or a word in an array of given numbers. (b) Search a key element in a list of „n" 16-bit numbers using the Binary search algorithm.	2.5 hours
7.	To find the smallest and biggest numbers in a given array.	1.5 hours
8.	ALP for number system conversions	2.5 hours
9.	(a) String operations(String length, reverse, comparison, concatenation, palindrome)	1.5 hours
10.	Password checking	2.5 hours
11.	Convert a 16-bit binary value (assumed to be an unsigned integer) to BCD and display it from left to right and right to left for specified number of times .	2.5 hours
12.	Stepper motor interface using 8086/ Arduino	2.5 hours
13	To build a 2 digit up down counter circuit using Microcontroller	2.0 Hours
14	Interface ADC converter with Raspberry Pi	2.5 hours
15	To interfacing an 8X8 LED matrix with Arduino and displaying a message in the form of scrolling text	2.5 hours
	Total Laboratory Hours	30 hours

Mode of assessment:			
Recommended by Board of Studies	11-02-2021		
Approved by Academic Council	No.61	Date	18-02-2021

Course Code	Course Title	L	T	P	J	C
CSE3048	Computer Graphics	3	0	0	0	3
Pre-requisite	Nil	Syllabus Version				
		v1.0				

Course Objectives:

1. To comprehend the fundamental concepts of graphics and animation.
2. To gain and understand the acquired knowledge pertaining to 2D and 3D concepts in graphics.
3. To understand the basic 3D modeling and rendering techniques.

Expected Course Outcome:

1. To understand the concepts of computer graphics primitives and various graphics algorithms.
2. Design and demonstrate the 2D object transformation and viewing through graphics principles.
3. To understand the various color models and comprehend the complexities of illumination in virtual scenes.
4. Have the ability to model the hidden surface and render the respective 3D objects so as to project it on to the screen.
5. To understand the fractal models for construct 2D and 3D virtual objects and to comprehend various 2D and 3D computer animation.

Module:1	Fundamentals of Computer Graphics	5 hours

Attributes of Graphics Primitives, Implementation Algorithms for Graphics primitives and attributes-Line drawing: DDA, Bresenham's, Circle generation, Ellipse generation, Implementation style for fill styles: Scan line polygon filling algorithm, Boundary fill and Flood fill, Implementation methods for Antialiasing.

Module:2	2D Transformation and Viewing	7 hours

2D transformation: Translation, Scaling, Rotation, Composite transformation, Reflection, Shearing, Raster Transformation - 2D Viewing: Pipeline, Normalization and viewport transformation, 2D Clipping Algorithms: Point, Line, Polygon, Curve, Text.

Module:3	3D Transformation and Viewing	7 hours

3D Transformation: Translation, Scaling, Rotation, Reflection, Shearing, 3D Viewing: Projection, Three-Dimensional Viewing concepts, 3D Viewing pipe line, Three-Dimensional viewing coordinate parameters, Projection transformation: Parallel projection, Orthogonal projection: oblique, Perspective projection, View volume.

Module:4	Color Models and Illumination	6 hours

Color Models: Chromaticity Diagram, RGB model, YIQ model, CMY model, CMYK model, HSV model, HLS model, Transformation between color models. Illumination models: Lighting Models, Basic Illumination models: Ambient Light, Diffusion Light, Specular reflection.

Module:5	Visible Surface Detection and Surface Rendering	6 hours

Visible Surface Detection Methods: Back face detection, Depth buffer method, A-Buffer method, Scan-line method, Depth-sorting method, BSP-Tree method, Area-subdivision method, Octree method, Ray-casting method, Curve and Line frame detection, Polygon rendering method – Constant intensity, Gouraud surface

rendering, Phong surface rendering and Fast Phong surface rendering.			
Module:6	**Algorithmic Modeling**		**6 hours**
Fractal-Geometry methods: Fractal Generation Procedures, Classification of Fractals, Fractal dimension, Geometric construction of deterministic self-similar fractals, Geometric construction of Statistically self-similar fractals, Controlling terrain topography. Particle systems: Grammar based modeling methods.			
Module:7	**Computer Animation**		**6 hours**
Computer Animation: Raster methods of Animation, Design of Animation sequence, traditional Animation sequence, Key frame animation sequence, Key frame system, Motion Specification: Direct motion specification, Goal-Directed systems, Kinematics and Dynamics.			
Module:8	**Recent Trends**		**2 hours**
	Total Lecture Hours:	**45 hours**	

Text Book(s)	
1.	Donald D. Hearn, Pauline Baker, Warren Carithers - Computer graphics with Open GL.- Pearson New International Edition, 4th Edition, Pearson Education Ltd., 2014.
2.	Sumanta Guha, Computer Graphics Through OpenGL - From Theory to Experiments, 3rd Edition, CRC Press, 2019.
Reference Books	
1.	JungHyun Han, Introduction to Computer Graphics with OpenGL-ES, CRC Press, 2018.
2.	Steve Marschner, Peter Shirley, Fundamentals of Computer Graphics, Fourth Edition, CRC Press, 2016.
3.	Edward Angel, Dave Shreiner, Interactive Computer Graphics - A Top-Down Approach with Shader-Based OPENGL, 6th Edition, Addison-Wesley, 2012.

Mode of Evaluation: CAT / Assignment / Quiz / Seminar / FAT			
Mode of evaluation: Project/Activity			
Recommended by Board of Studies	11-02-2021		
Approved by Academic Council	No. 61	Date	18-02-2021

Course code	Course Title	L	T	P	J	C
CSE3035	Principles of Cloud computing	3	0	2	0	4
Pre-requisite					Syllabus version	
					V 1.0	

Course Objectives:

1. To introduce the cloud computing concepts and map reduce programming model.
2. To provide skills and knowledge about operations and management in cloud technologies so as to implement large scale systems.
3. To provide skills to design suitable cloud infrastructure that meets the business services and customer needs.

Expected Course Outcome:

1. Understand the evolution, principles, and benefits of Cloud Computing in order to assess existing cloud infrastructures to choose an appropriate architecture that meets business needs.
2. Decide a suitable model to capture the business needs by interpreting different service delivery and deployment models.
3. Understand virtualization foundations to cater the needs of elasticity, portability and resilience by cloud service providers.
4. Infer architectural style, work flow of real world applications and to implement the cloud applications using map reduce programming models.
5. Design a cloud framework with appropriate resource management policies and mechanism.
6. Compare operation and economic models of various trending cloud platforms prevailing in IT industry.

Module:1	Foundations of cloud	6 hours

Inception and need for cloud computing: Motivations from distributed computing predecessors - Evolution - Characteristics - Business Benefits – Challenges in cloud computing - Exploring the Cloud Computing Stack - Fundamental Cloud Architectures – Advanced Cloud Architectures - Specialized Cloud Architectures

Module:2	Service Delivery and Deployment Models	5 hours

Service Models (XaaS): Infrastructure as a Service (IaaS) - Platform as a Service (PaaS) - Software as a Service(SaaS) - Deployment Models: Types of cloud - Public cloud - Private cloud - Hybrid cloud – Service level agreements - Types of SLA – Lifecycle of SLA- SLA Management

Module:3	Cloud Resource Virtualization	5 hours

Virtualization as Foundation of Cloud – Understanding Hypervisors – Understanding Machine Image and Instances - Managing Instances – Virtual Machine Provisioning and Service Migrations

Module:4	Cloud Computing: Applications and Paradigms	8 hours

Existing Cloud Applications and Opportunities for New Applications - Architectural Styles for Cloud Applications - Workflows: Coordination of Multiple Activities - Coordination Based on a State Machine Model: The ZooKeeper - The MapReduce Programming Model - A Case Study: The GrepTheWeb Application

Module:5	Resource Management and Scheduling in Cloud	6 hours

Policies and Mechanisms for Resource Management – Stability of a Two-Level Resource Allocation Architecture- Feedback Control Based on Dynamic Thresholds - Coordination of Specialized Autonomic

Performance Managers - A Utility-Based Model for Cloud-Based Web Services - Resource Bundling: Combinatorial Auctions for Cloud Resources – Scheduling Algorithms for Computing Clouds - Resource Management and Dynamic Application Scaling		
Module:6	**Cloud Platforms and Application Development**	**9 hours**
Comparing Amazon web services, Google AppEngine, Microsoft Azure from the perspective of architecture (Compute, Storage Communication) services and cost models. Cloud application development using third party APIs, Working with EC2 API – Google App Engine API - Facebook API, Twitter API.		
Module:7	**Advances is Cloud**	**4 hours**
Media Clouds - Security Clouds - Computing Clouds - Mobile Clouds – Federated Clouds – Hybrid Clouds		
Module:8	**Recent Trends**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	Rajkumar Buyya, James Broberg, Andrzej, M. Goscinski, Cloud Computing: Principles and Paradigms, Wiley, 1st Edition, 2013.
2.	Sosinsk, Barrie, Cloud Computing Bible, John Wiley & Sons, 1st Edition, 2011.
Reference Books	
1.	Marinescu, Dan C. Cloud Computing: Theory and Practice. Morgan Kaufmann, 2017.
2.	Toby Velte, Anthony Velte, Robert Elsenpeter, Cloud Computing: A Practical Approach, Mc Graw Hill Education, 1st Edition, 2017.
3.	Buyya, Rajkumar, Christian Vecchiola, and S. Thamarai Selvi. Mastering Cloud Computing: Foundations and Applications Programming, Tata Mcgraw Hill, 1st Edition, 2017.
Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar	

List of Experiments		
1.	Configure a VM instance in your local machine and in cloud (by creating a cloud account). Allocate CPU, memory and storage space as per a specified requirement. Install Guest OS image in that instance, launch the same and confirm the successful installation of the OS by performing few OS commands.	3 hours
2.	Configure a Nested Virtual Machine (VM under another VM) in cloud and local machine. Install OS images and work with few OS commands.	2 hours
3	Create a ssh tunnel between your server in local machine and remote clients in EC2 instances and test the connections with programs using X11 traffic	3 hours
4.	Install the Hadoop framework and create an application using Map Reduce Programming Model	2 hours
5.	Perform live QEMU-KVM VM migrations using NFS	3 hours
6.	Experiment cloud scheduling algorithms using Cloud Sim/ OPNET / CloudAnalyst tool.	3 hours
7.	Experiment cloud load balancing algorithms using Cloud Sim/ OPNET/ CloudAnalyst tool.	2 hours
8.	Monitor, visualize and analyze performance of resource utilization in cloud platforms using Grafana tool.	2 hours
9.	Configure a VLAN using cisco packet tracer and analyze traffic issues	2 hours
10.	Build container images, launch the container instance in the cloud and run an application inside the container instance in cloud	2 hours

11.	EC2 AWS – Instance Creation, Migration			2 hours
12.	DaaS – Deployment of a basic web app and add additional Functionality (Javascripts based)			2 hours
13.	SaaS – Deployment of any SaaS application for a online Collaborative tool			2 hours
			Total Laboratory Hours	30 hours
Mode of evaluation: Project/Activity				
Recommended by Board of Studies	11-02-2021			
Approved by Academic Council	No. 61	Date	18-02-2021	

Course Code	Course Title	L	T	P	J	C
CSE3052	Software Quality And Testing	3	0	0	0	3
Pre-requisite	Nil	Syllabus Version				
		v1.0				

Course Objectives:

1. To make students to learn how to establish polices for entire software development process.
2. To impart design and validate test cases for diversified application.
3. To enable the students to use various testing tool for automation of testing process.
4. To make students to be familiar with the software quality infrastructure and the management components of software quality.

Expected Course Outcome:

1. Ability to apply software testing and quality knowledge and engineering methods for various applications.
2. Ability to understand fundamental software testing methods and modern software testing tools for testing projects.
3. Ability to identify the need of software test automation and develop a test tool to support test automation.
4. Evaluate basic understanding and knowledge of contemporary issues in advance software testing and quality methodologies.
5. Ability to apply various communication methods and skills to communicate with the teammates to conduct practice-oriented software testing projects.

Module:1	Software Testing and its Techniques	7 hours

Definition, Types and Levels of testing – Software Testing Techniques: White Box Techniques, Black Box techniques, Structural, Functional, Non-Functional, Technique, Exploratory Testing, Penetration testing, Regression testing, Verification, Validation , Static Dynamic Testing, User-Acceptance Testing, Debugging/Mutation Testing Examples of Specific Testing Techniques

Module:2	Test Planning and Design	6 hours

Test Plans - Test Design Specifications - Test Cases: Types- Positive and Negative test cases, UI Test Cases, Usability Test Cases, Field Validation, Functional Test Cases; Test data mining, Test execution, Test Reporting, Defect Management, Test Coverage – Traceability matrix. Test Plan Document.

Module:3	Test Metrics and Management	6 hours

Need of Test Metrics, Test Metrics types, Manual metric types, Derivative metrics, Test Economic Metrics, Test team metrics, Test Metrics Life Cycle, How to calculate test metric, Test Metric examples.

Pre-process metrics: Estimation, In-process metrics: Process Management End-process metrics: Process Improvement, Test Management, Test planning, resource management, test reporting, tools

Module:4	Software Test Automation and Tools	8 hours

Basics of automation testing – why, when and how to perform automation testing, AI in testing, Agile testing, Real-time and Embedded system Testing, Continuous Testing, Mobile app testing, Testing APIs and distributed systems.

Factors for choosing a particular Testing Tools: need, categorization, selection and cost in testing tool, guidelines for testing tools. Study of testing tools: JIRA, Bugzilla, TestDirector and IBM

Rational Functional Tester, Selenium.		
Module:5	**Software Quality Models**	**7 hours**
Software Development methodologies – Quality assurance activities in the development process- Verification & Validation – Reviews – Software Testing – Software Testing implementations – Quality of software maintenance – Pre-Maintenance of software quality components – Quality assurance tools – CASE tools for software quality – Software maintenance quality – Project Management		
Module:6	**Software Quality Assurance and Metrics**	**4 hours**
Software Quality- Software Quality Assurance, Components of Software Quality Assurance Software Quality Assurance Plan: Steps to develop and implement a Software Quality Assurance Plan Quality Standards: ISO 9000 and Companion ISO Standards CMM. Product Quality metrics, In-Process Quality Metrics ,Metrics for Software Maintenance		
Module:7	**Software Quality Infrastructure**	**5 hours**
Procedures and work instructions – Templates – Checklists – 3S development – Staff training and certification Corrective and preventive actions – Configuration management – Software change control – Configuration management audit -Documentation control – Storage and retrieval.		
Module:8	**Recent Trends**	**2 hours**
	Total Lecture Hours:	**45 hours**

Text Book(s)

1.	JJ Shen, Software Testing: Techniques, Principles, and Practices, 2019
2	Abu Sayed Mahfuz, Software Quality Assurance: Integrating Testing, Security, and Audit (Internal Audit and IT Audit) 1st Edition, 2016

Reference Books

1.	Solis Tech, Quality Assurance:Software Quality Assurance made easy,Kindle Edition,2016
2.	Ivan Mistrik Richard M Soley , Nour Ali , John Grundy , Bedir Tekinerdogan, Software Quality Assurance: In Large Scale and Complex Software-intensive Systems, Morgan Kaufmann, 2015
3.	Macque Terrain , Essentials of Software Quality Management: Top 100 Real Life Project Scenarios and Tips : Extracted from Latest Projectsby Publications, 2020

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar

Recommended by Board of Studies	11-02-2021		
Approved by Academic Council	No. 61	Date	18-02-2021

Course Code	Course Title	L	T	P	J	C
CSE3034	Nature Inspired Computing	3	0	0	0	3
Pre-requisite		Syllabus Version				
		v1.0				

Course Objectives:

1. To establish basic knowledge in NP hard problems and understand the need for approximation algorithms.
2. Design algorithms that include operators, representations, fitness functions and potential hybridizations for non-trivial problems.
3. Design algorithms that utilize the collective intelligence of simple organisms to solve problems.
4. Design and implement an artificial neural network that employs learning to solve non-trivial problems.

Expected Course Outcome:

1. Understand fundamental concepts of NP-hardness and computational complexity
2. Understand the strengths, weaknesses and appropriateness of nature-inspired algorithms.
3. Apply nature-inspired algorithms to optimization, design and learning problems.
4. Analyze the Behavior systems of nature inspired algorithm applied in real world problems.
5. Understand the theory behind the design of immune networks and DNA computing and their potential applications.

Module:1	Introduction to Computational Problems	3 hours

Computational Problems, Decision Problem, Optimization Problem, Hardness in Optimization Problems, NP class, NP-Hard, examples for NP-Hard problems, tackling NP-Hard problems, Rationale for seeking inspiration from nature

Module:2	Evolutionary Systems	7 hours

Pillars of Evolutionary Theory, The Genotype , Artificial Evolution, Genetic representations, Initial Population ,Fitness Functions, Selection and Reproduction ,Genetic Operators ,Evolutionary Measures ,Types of Evolutionary Algorithms

Module:3	Collective Systems	7 hours

Particle Swarm Optimization Algorithm, Hybrid PSO algorithms, Ant Colony Optimization, Artificial Bee Colony, Firefly Algorithm

Module:4	Artificial Neural Networks	6 hours

History, Mathematical model of neuron, ANN architectures, Learning rules Backpropagation network, Backpropagation learning and its applications, Variants of BPA.

Module:5	Behavioral systems	7 hours

Behavior in Cognitive Science , Behavior in Artificial Intelligence , Behavior-Based Robotics , Biological Inspiration for Robots , Robots as Biological Models, Robot Learning , Evolution of Behavioral Systems Evolution and Learning in Behavioral Systems , Evolution and Neural Development in Behavioral Systems.

Module:6	Immuno Computing	6 hours

Introduction- Immune System, Physiology and main components, Immune Network Theory- Danger Theory, Evaluation Interaction- Immune Algorithms, Bone Marrow Models , Forest's Algorithm, Artificial Immune Networks.		
Module:7	**DNA Computing**	**7 hours**
DNA Computing: Motivation, DNA Molecule , Adleman's experiment , Test tube programming language, Universal DNA Computers , PAM Model , Splicing Systems , Lipton's Solution to SAT Problem , Scope of DNA Computing , From Classical to DNA Computing.		
Module:8	**Recent Trends**	**2 hours**
	Total Lecture Hours:	**45 hours**

Text Book(s)	
1.	Xin-She Yang, “Nature-Inspired Computation and Swarm Intelligence Algorithms, Theory and Applications”, Elsevier, Academic Press, 2020.
Reference Books	
1.	Leandro Nunes de Castro, "Fundamentals of Natural Computing, Basic Concepts, Algorithms and Applications", Chapman & Hall/ CRC, Taylor and Francis Group, 2007.
2.	Floreano D. and Mattiussi C., "Bio-Inspired Artificial Intelligence: Theories, Methods, and Technologies", MIT Press, Cambridge, MA, 2008.
3.	Licheng Jiao, Ronghua Shang , Fang Liu , Weitong Zhang , Brain and Nature-Inspired Learning, Computation and Recognition, Elsevier, 2020.

Recommended by Board of Studies	11-02-2021		
Approved by Academic Council	No. 61	Date	18-02-2021

Course Code	Course Title	L	T	P	J	C
BCD3001	Bayesian Data Analysis	3	0	0	4	4
Pre-requisite	Nil	Syllabus Version				
		v1.0				

Course Objectives:

1. To introduce the Bayesian concepts and methods with emphasis on data analysis.
2. To come to an inference by assessing both prior distributions as well as posterior means.
3. To determine the best possible model among available options.

Expected Course Outcome:

1. Understand the basics of probability and relate it to the Bayesian inference.
2. Apply the inference rules customized for single parameter models..
3. Design a simulation environment for generation of inferences by utilizing various algorithms.
4. Scaling up the inference mechanism for multi-parameter and hierarchical models.
5. Implement multiple modeling algorithms and for predictive analysis and evaluate the outcome metrics
6. Demonstrate how the inference mechanism can be effectively represented in different non-linear models as witnessed in real world scenarios.

Module:1	Introduction	3 hours

Introduction to Probability, Priors and Posterior Analysis, Statistical Models, The Bayes inference

Module:2	Single Parameter Models	5 hours

Bayes Rule, Normal model, Conjugate model, Binomial model, Posterior Distribution and Inferences

Module:3	Simulation	8 hours

Markov Chain Monte Carlo simulation, Introduction to R and Jags, The Metropolis-Hasting algorithm, Gibbs Sampler, Approximation based on posterior modes

Module:4	Multi-Parameter and Hierarchical Models	8 hours

Multi-parameter -Normal data with non-informative, conjugate, and semi-conjugate prior distributions, Multivariate normal model, Hierarchical - Exchangeability and setting up, Computation.

Module:5	Fundamentals of Bayesian Data Analysis	7 hours

Model checking, Evaluating, comparing, and expanding models, Modeling accounting for data collection, Decision analysis

Module:6	Non-Linear Models	6 hours

Mixture models- Setting up and interpreting mixture models, Gaussian process models Multivariate models- Non-normal models and multivariate regression surfaces

Module:7	Comparison of Population	6 hours

Inference for Proportions, Inference for Normal Populations, Inference for Rates, Sample Size Determination

Module:8	Recent Trends	2 hours

	Total Lecture Hours:	**45 hours**

Text Book(s)

1	Ronald Christensen, Wesley Johnson, Adam Branscum, Timothy E Hanson, Bayesian Ideas and Data Analysis. An Introduction for Scientists and Statisticians. CRC Press, 2011
2	Andrew Gelman, John B, Carlin,Chapman ,Bayesian Data Analysis, Hall/CRC Publication, 2013

Reference Books

1.	Gelman, A., Carlin, J. B., Stern, H. S., Rubin, D. B.Bayesian Data Analysis, Third Edition, Chapman & Hall/CRC.2013
2.	Gill, Jeff. Bayesian Methods: A Social and Behavioral Science Approach. CRC. 3rd Edition.2013
3.	Peter D. Hoff (2009) A First Course in Bayesian Statistical Methods, Springer

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar

Project Component:
This course aims to equip students with the skills to perform and interpret Bayesian data analyses. The prescribed hands-on projects will help the students to understand the fundamentals of Bayesian inference by examining some simple Bayesian models. Students will develop the skill of interpreting the visual graph, and will be able to interpret those graphs concerning the Bayesian Data Analysis perspective. More advanced models will then be explored by the students through these projects, including linear regression and hierarchical models in a Bayesian framework. Bayesian computational methods, especially Markov Chain Monte Carlo methods will progressively be introduced as practical hands-on programming. Special emphasis will be given on how students choose evaluation metrics and how they evaluate those prescribed models influenced by Bayesian framework.

Mode of evaluation: Project/Activity

Recommended by Board of Studies	11-02-2021		
Approved by Academic Council	No. 61	Date	18-02-2021

CSE3053	Big Data Analytics	L	T	P	J	C
		3	0	0	4	4
Pre-requisite	**NIL**	**Syllabus Version**				
		v1.0				

Course Objectives:

1. To understand the need of Hadoop framework to process the Big Data
2. Introduction to theoretical techniques and practical tools used in data analytics
3. Applications in various engineering and scientific domains.

Expected Course Outcome:

1. Discuss the challenges and their solutions in Big Data and work on Hadoop Framework
2. Understand the concepts of R programming and its applications.
3. Implement different statistical methods on sample data using R Programming library.
4. Analyse the Big Data using Map-reduce programming in Both Hadoop and Spark framework.
5. Demonstrate spark programming with different programming languages.
6. Lab: Practice different analytics tools and implement data analysis applications/models by taking sample data sets.

Module:1	**Introduction Big Data**	**3 hours**

Data Storage and Analysis - Characteristics of Big Data – Big DataAnalytics - Typical Analytical Architecture – Requirement fornew analytical architecture – Challenges in Big Data Analytics – Need of big data frameworks, Introduction to Hadoop ecosystems.

Module:2	**Hadoop Framework**	**6 hours**

Hadoop Framework: Hadoop – Requirement of Hadoop Framework - Design principle of Hadoop –Comparison with other system - Hadoop Components –Hadoop Daemon's – Working with HDFS Commands

Module:3	**Mapreduce Programming**	**7 hours**

Map Reduce working principle, Map Reduce types and formats, MapReduce features, Combiner optimization,Map side join, Reduce SideJoin, Secondary sorting, Pipelining MapReduce jobs.

Module:4	**R Programming**	**6 hours**

History and overview of R , Install and configuration of R programming environment , Basic language elements and data structures, Data input/output, Data storage formats , Subsettingobjects.

Module:5	**Visualization Using R**	**7 hours**

Vectorization, Control structures, Functions, Scoping Rules, Loop functions, R Graphs and visualization using lattice, ggplot2

Module:6	**Spark Framework**	**7 hours**

Overview of Spark – Hadoop vs Spark – Cluster Design – ClusterManagement – performance,Application Programming interface(API): Spark Context, Resilient Distributed Datasets, Creating RDD,RDD Operations, Saving RDD - Lazy Operation – Spark Jobs-spark ML library.

Module:7	**Data Analysis Models**	**7 hours**

Association and correlation analysis- regression models- Predictive analytics -Exploratory analysis. Prescriptive analysis.		
Module:8	**Recent Trends**	**2 hours**
	Total Lecture Hours:	**45 hours**

Text Book(s)

1. Garrett Grolemund, "Hands-On Programming with R" , O'Reilly Media, Inc, 2014.
2. Seema Acharya, SubhashiniChellapan, "Big Data and Analytics", Wiley, 2015.
3. Mike Frampton, "Mastering Apache Spark", Packt Publishing, 2015.

Reference Books

1. Nick Pentreath, Machine Learning with Spark, Packt Publishing, 2015.
2. Donald Miner, Adam Shook, "MapReduce Design Pattern", O'Reilly, 2012
3. Raj Kamal, PreetiSaxena ,"Big Data Analytics:Introduction to Hadoop, Spark, and Machine-Learning", McGraw-Hill Education, 2019.

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar

Project Component:
Projects may be given as group projects.

The project component should be taken as real time applications like e-commerce, social medial, streaming data and so on . The students should use the technologies learnt in theory to develop and implement the project.

Mode of assessment: Project/Activity

Recommended by Board of Studies	11-02-2021		
Approved by Academic Council	No. 61	Date	18-02-2021

Course Code	Course Title	L	T	P	J	C
CSE3054	Data Mining-Concepts and Techniques	3	0	0	4	4
Pre-requisite	Nil	Syllabus Version				
		v1.0				

Course Objectives:

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

Expected Course Outcome:

1. Interpret the contribution of data warehousing and data mining to the decision-support systems.
2. Prepare the data needed for data mining using preprocessing techniques.
3. Extract useful information from the labeled data using various classifiers.
4. Compile unlabeled data into clusters applying various clustering algorithms.
5. Discover interesting patterns from large amounts of data using Association Rule Mining
6. Demonstrate capacity to perform a self-directed piece of practical work that requires the application of data mining techniques.

Module:1	Fundamental to Data Lake	6 hours

Different data repositories- Data warehouse- Data warehouse architecture: Multitiered Architecture-Data warehouse models - Extraction, Transformation, and Loading- Metadata repository - Data warehouse modeling: Data cube and OLAP-Data warehouse design and usage

Module:2	Introduction to Data Mining	3 hours

Introduction to data mining-Data mining functionalities-Steps in data mining process-Classification of data mining systems-Major issues in data mining

Module:3	Data Wrangling and Preprocessing	5 hours

Data Preprocessing: An overview-Data cleaning-Data integration-Data reduction-Data transformation and Data discretization

Module:4	Predictive Modeling	6 hours

General approach to classification-Decision tree induction- Bayes classification methods-advanced classification methods: Bayesian belief networks- Classification by Backpropagation-Support Vector Machines-Lazy learners

Module:5	Descriptive Modeling	8 hours

Types of data in cluster analysis-Partitioning methods- Hierarchical methods-Advanced cluster analysis: Probabilistic model-based clustering- Clustering high-dimensional data-Outlier analysis

Module:6	Discovering Patterns and Rules	7 hours

Frequent Pattern Mining: Basic Concepts and a Road Map - Efficient and scalable frequent item set mining methods: Apriori algorithm, FP-Growth algorithm- Mining frequent itemsets using vertical data format- Mining closed and max patterns- Advanced Pattern Mining: Pattern Mining in Multilevel, Multidimensional Space

Module:7	Data Mining Trends and Research Frontiers	8 hours

Other methodologies of data mining: Web mining-Temporal mining-Spatial mining-Statistical data mining- Visual and audio data mining- Data mining applications- Data mining and society: Ubiquitous and invisible data mining- Privacy, Security, and Social Impacts of data mining		
Module:8	**Recent Trends**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	Jiawei Han and Micheline Kamber, Data Mining: Concepts and Techniques, Morgan Kaufmann Publishers, third edition ,2013
2.	Pang-Ning Tan,Michael Steinbach, Anuj Karpatne, Vipin Kumar, Introduction to Data Mining, second edition, Pearson, 2019
Reference Books	
1.	Ian.H.Witten, Eibe Frank and Mark.A.Hall, Data Mining:Practical Machine Learning Tools and Techniques,third edition , 2017
2.	Alex Berson and Stephen J. Smith, Data Warehousing, Data Mining & OLAP, Tata McGraw Hill Edition, Tenth Reprint, 2008.
3.	Hand, D., Mannila, H. and Smyth, P. Principles of Data Mining, MIT Press: Massachusets. third edition, Pearson, 2013

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar

Project Component:
Students should identify a problem to address through data mining concepts. The goal is to select appropriate techniques and model specifications and apply the respective methods to extract the knowledge related to the real word problem. Students will identify the potential use of data mining techniques, formulate the problem, identify the right sources of data, preprocess data, and prescribe actions to improve not only the process of decision making but also the outcome of decisions. Students can use any data mining tool to generate better business decision.

Mode of evaluation: Project/Activity

Recommended by Board of Studies		18-02-2021	
Approved by Academic Council	No. 61	Date	18-02-2021

Course Code	Course Title	L	T	P	J	C
BCD3002	Business Intelligence and Analytics	3	0	0	0	3
Pre-requisite	Nil	Syllabus Version				
		v1.0				

Course Objectives:

1. Introduce the Business intelligence concepts ,techniques and models
2. Uunderstand the modeling process behind business analytics
3. To analyze different data analysis tools and techniques

Expected Course Outcomes:

1. Understand the fundamental of Business Intelligence and to design a customized solution.
2. Familiarize on the concepts, techniques and reporting methods of descriptive analytics and predictive analytics
3. Explore the methods used to analyze speech and text and implement optimized search engines
4. Design and implement Decision Support systems
5. Familiarize on the processes needed to develop, report, and analyze business data.

Module:1	Introduction To Business Intelligence	3 hours

Introduction to Business Intelligence – Designing Business Intelligence Application- Requirements Gathering, Establishing the Technical Architecture, Designing a Business Intelligence Solution , Designing Dimensional Models , Designing the Physical Databases

Module:2	Descriptive Analytics	4 hours

Data Warehousing- Definitions and Concepts -- Data Warehousing Architectures - Data Integration and the Extraction, Transformation, and Load (ETL) Processes - Transaction processing- Data Warehouse Development Approaches - Data Warehousing Implementation Issues - Data Warehouse Administration, Security Issues, and Future Trends- Business Reporting, Visual Analytics, and Business Performance Management

Module:3	Predictive Analytics	9 hours

Data Mining Concepts- Definitions, Characteristics, and Benefits - How Data Mining Works - Data Mining Versus Statistics Data Mining Process - Data Mining Methods - Data Mining and Privacy Issues - Regression – Classification –Association Rules – clustering -Techniques for Predictive Modeling – ANN- SVM

Module:4	Text Analytics, Text Mining, And Sentiment Analysis	8 hours

Text Analytics, Text Mining, and Sentiment Analysis - Natural Language Processing - Text Mining Process- tools - Sentiment Analysis -Overview, Process, Applications - Speech Analytics – Rule based, Multi, Layer, Hybrid Sentimental analysis – Machine Learning in Sentimental analysis

Module:5	Web Analytics and Web Mining	7 hours

Web Mining Overview - Web Content and Web Structure Mining - Search Engines - Search Engine Optimization - Web Analytics Technologies, metrics - Web Analytics Maturity Model and Web Analytics Tools

Module:6	Prescriptive Analytics	6 hours

Decision Support Systems Modeling - Mathematical Models for Decision Support - Certainty, Uncertainty, and Risk- Decision Modeling with Spreadsheets - Mathematical Programming Optimization - Decision Analysis with Decision Tables and Decision Trees - Problem-Solving Search Methods - Problem-Solving Search Methods		
Module:7	**Knowledge Management and Big Data Analytics**	**6 hours**
Knowledge Management –Concepts, Definitions , Approaches, tools and techniques - Big Data and Analytics- Fundamentals of Big Data Analytics – Technologies - Data Scientist - Big Data and Data Warehousing - Automated Decision Systems and Expert Systems - Business Analytics: Emerging Trends and Future Impacts		
Module:8	**Recent Trends**	**2 hours**
	Total Lecture Hours:	**45 hours**

Text Book(s)	
1.	Efraim Turban, Ramesh Sharda, Dursun Delen, "Business Intelligence and Analytics", 10th Edition, Pearson , 2015.
Reference Books	
1	S. Christian Albright, Wayne L. Winston, Business Analytics: Data Analysis & Decision Making, 6th Edition, CENGAGE INDIA , 2017
2	Dinabandhu Bag, Business Analytics, Routledge, 1st edition, 2016
3	Rick Sherman, Business Intelligence Guidebook: From Data Integration to Analytics, Morgan Kaufmann, 1st edition 2014

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar			
Mode of evaluation: Project/Activity			
Recommended by Board of Studies	11-02-2021		
Approved by Academic Council	No. 61	Date	18-02-2021

Course Code	Cognitive Systems	L	T	P	J	C
BCD3003		3	0	0	4	4
Pre-requisite				Syllabus Version		
				v1.0		

Course Objectives:

1. To study the basic concepts and approaches in the field of cognitive science
2. To apply the concepts of planning, reasoning and learning models in cognitive applications
3. To analyze language and semantic models of cognitive process.

Expected Course Outcome:

1. Students will be able to understand the basic concept of cognitive science
2. Learn and understand the learning model and apply the same to appropriate real world applications
3. Apply reasoning methodology to real world applications
4. Students will understand and apply declarative and logic models
5. Envisage the concept of cognitive learning
6. Acquire knowledge in language processing and understanding

Module:1	Introduction to Cognitive Science	5 hours

A Brave New World – Introduction Cognitive Science –Representation: Digital, Analog, Dual-Coding and Propositional – Computation - Interdisciplinary Perspective - Cognitive Approach: Mind as an Information Processor - Modularity of Mind - Theories of Vision and Pattern Recognition

Module:2	History, Vision, and Attention	5 hours

Rise of Cognitive Psychology - Mind as an Information Processor - Evaluating the Modular Approach - Theories of Vision and Pattern Recognition - Theories of Attention - Evaluating the Model-Building Approach

Module:3	Memory, Imagery, and Problem Solving	5 hours

Types of Memory – Memory Models - Visual Imagery - Problem Solving - Overall Evaluation of the Cognitive Approach

Module:4	Neuroscience Approach:	7 hours

Methodology in Neuroscience - Brain Recording Techniques - Brain Anatomy - Visual Object Recognition - Neuroscience of Attention

Module:5	Network Approach	7 hours

Principles Underlying Artificial Neural Networks (ANN) - Characteristics of ANN - Conceptions of Neural Networks - Back Propagation and Convergent Dynamics - ANN Typologies - Evaluating the Connectionist Approach - Semantic Networks - Characteristics of Semantic Networks - Evaluation of the network approach

Module:6	Linguistic Approach: Language and Cognitive Science	7 hours

Importance of Language – Nature Language - Language Use in Primates - Language Acquisition - Language Deprivation - Cognition and Linguistics: The Role of Grammar - Neuroscience and Linguistics - Artificial Intelligence and Linguistics – Speech Recognition - Evaluation of Natural Language Processing

Module:7	Artificial Intelligence and Cognitive Science	7 hours

Definition of AI – History - Practical World of Artificial Intelligence - Approaches to the Design of Intelligent Agents - Machine Representation of Knowledge - Machine Reasoning - Logical Reasoning - Inductive Reasoning - Expert Systems		
Module:8	**Recent Trends**	**2 hours**
	Total Lecture Hours:	**45 hours**

Text Book(s)

1.	Jay Friedenberg and Gordon Silverman "Cognitive Science: An Introduction to the Science of the Mind", Cambridge University Press, New York, 2015.
2.	Stuart J. Russell, Peter Norvig, "Artificial Intelligence - A Modern Approach", Third Edition, Pearson Publishers, 2015.

Reference Books

1.	Paul Miller, "An Introductory Course in Computational Neuroscience", MIT Press, 2018.
2.	Jerome R. Busemeyer, Zheng Wang, James T. Townsend, Ami Eidels(Ed), "The Oxford Handbook of Computational and Mathematical Psychology",Oxford University Press
3.	(2015). Neil Stillings, Steven E. Weisler, Christopher H. Chase and Mark H. Feinstein, "Cognitive Science: An Introduction", Second Edition, MIT press ,1995.

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar

Project Component:
Projects may be given as group projects.

List of sample projects as follows:

1. Probabilities and Ranks in Human Non-Monotonic Reasoning
2. Predictive models for individual human reasoning
3. Genetic programming for automatic generation of heuristics
4. Formalization and Evaluation of Cognitive Theories
5. Modelling Reasoning in the Neural Engineering Framework
6. Modeling common sense reasoning
7. Predictor Analysis in Syllogistic Reasoning

Mode of evaluation:

Recommended by Board of Studies	11-02-2021		
Approved by Academic Council	No. 61	Date	18-02-2021

Course code	Course Title	L	T	P	J	C
BCD3004	Data Modeling and Simulation	3	0	0	0	3
Pre-requisite	Nil				Syllabus version	
					v1.0	

Course Objectives:

1. To provide computer simulation needs, and to implement it.
2. To provide skills and knowledge to test a variety of simulation and data analysis libraries and programs.
3. To provide skills to use tools to view and control simulations and their results.

Expected Course Outcome:

1. Understand basic probability and Statistics, perform Hypothesis Tests
2. Assess Homogeneity of Different Data Sets.
3. Test Generators and Generate Random variates
4. Understand the nature of Simulation and simulate a study
5. Design a complex Simulation model

.

Module:1	Basic Statistics and System Concepts	6 hours	

Introduction - Random Variables and Their Properties -Simulation Output Data and Stochastic Processes - System and System Environment: Component of a System – Continuous and discrete systems – Types of model; Steps in Simulation study; Simulation of an event occurrence using random number table – Single server queue –two server queues – inventory system

Module:2	Probability Distributions	7 hours	

Introduction - Continuous Distributions – Discrete Distributions – Empirical Distributions - Hypothesizing Families of Distributions - Estimation of Parameters - Fitted Distributions - Assessing the Homogeneity of Different Data Sets

Module:3	Random Number Generators and Generating Random Variates	6 hours	

Linear Congruential Generators - Testing Random-Number Generators - General Approaches to Generating Random Variates - Generating Continuous, Discrete, Correlated Random Variates

Module:4	Basic Simulation Modeling	6 hours	

The Nature of Simulation- Discrete-Event Simulation- Event Scheduling / Time Advance Mechanism – Distributed Simulation- Steps in a Simulation Study- Advantages, Disadvantages, and Pitfalls of Simulation

Module:5	Simulation Software	5 hours	

Simulation Software – Comparison and Classification of Simulation Languages – General Purpose Simulation Package – Arena/Extend – Object Oriented Simulation

Module:6	Modeling Complex Systems	5 hours	

List Processing in Simulation - A Simple Simulation Language, SIMLIB - Single-Server Queueing Simulation with SIMLIB - Time-Shared Computer Model

Module:7	Building Valid and Credible Simulation Models	8 hours	

Principles of Valid Simulation Modeling - Verification of Simulation - Techniques for Increasing Model Validity and Credibility - Statistical Procedures for Comparing Real-World Observations and Simulation Output Data - - Selecting Input Probability Distributions - Output Data Analysis for a Single System -

Estimating Measures of Performance		
Module:8	**Recent Trends**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	Averill M. Law, Simulation Modeling and Analysis, Fifth Edition, McGraw-Hill Education, 2015
Reference Books	
1.	Steven I. Gordon, Brian Guilfoos, Introduction to Modeling and Simulation with MATLAB® and Python, Chapman and Hall/CRC, 2020.
2.	John A. Sokolowski, Catherine M. Banks, Principles of Modeling and Simulation: A Multidisciplinary Approach, Wiley, 2011
3.	John A. Sokolowski, Catherine M. Banks, Modeling and Simulation Fundamentals: Theoretical Underpinnings and Practical Domains, Wiley, 2010.

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Seminar			
Recommended by Board of Studies	11-02-2021		
Approved by Academic Council	No. 61	Date	18-02-2021

Course Code	Course Title	L	T	P	J	C
CSE3055	Deep Learning	3	0	0	4	4
Prerequisite:	Nil	Syllabus Version				
Antirequisite:		v1.0				

Course Objectives:

1. To present theoretical foundations, algorithms, methodologies, and applications of neural networks and deep Learning.
2. To design and develop an application-specific deep learning models and to provide the practical knowledge
3. To apply the deep learning models in various real world applications.

Expected Course Outcomes:

1. Recognize the characteristics of deep learning models that are useful to solve real-world problems.
2. Understand different methodologies to create application-specific Deep Neural Networks
3. Identify and apply appropriate deep learning algorithms for analyzing the data for variety of problems.
4. Design and Implement different deep learning algorithms.
5. Develop deep learning models to encode the original data and reconstruct data.
6. Generate the generative models for unsupervised learning task and choose appropriate models for real world problems.

Module:1	Machine Learning Basics	4 hours

Learning algorithms, Maximum likelihood estimation, Building machine learning algorithm, Neural Networks Multilayer Perceptron, Back-propagation algorithm and its variants Stochastic gradient decent, Curse of Dimensionality

Module:2	Introduction to Deep Learning & Architectures	8 hours

Machine Learning Vs. Deep Learning, Representation Learning, Width Vs. Depth of Neural Networks, Activation Functions: RELU, LRELU, ERELU, Unsupervised Training of Neural Networks, Regularization- dropout, drop connect, optimization methods for neural networks- Adagrad, adadelta, rmsprop, adam, NAG.

Module:3	Convolutional Neural Networks & Transfer Learning	8 hours

Architectural Overview – Motivation - Layers – Filters – Parameter sharing – Regularization, Popular CNN Architectures: LeNet, ResNet, Vggnet, AlexNet. Transfer learning Techniques - DenseNet, PixelNet.

Module:4	Training Neural Networks	9 hours

Deep Learning Hardware and Software - CPUs, GPUs, TPUs, PyTorch, TensorFlow, Dynamic vs Static computation graphs, Data Preprocessing-Data Augmentation, batch normalization, Transfer Learning- Deep Transfer Learning Strategies, Update rules, hyperparameter tuning, Learning rate scheduling, variants of CNN- ResNet, GoogleNet, Xception, etc

Module:5	Sequence Modelling – Recurrent and Recursive Nets	6 hours

Recurrent Neural Networks, Bidirectional RNNs – Encoder-decoder sequence to sequence architechures - Backpropagation Through Time for training RNN, Long Short Term Memory

Networks.		
Module:6	**Auto Encoders**	**6 hours**
Under complete Autoencoders, Regulraized Autoencoders, Sparse Autoencoders, Denoising Autoencoders, Representational Power, Layer, Size, and Depth of Autoencoders, Stochastic Encoders and Decoders – Contractive Encoders.		
Module:7	**Deep Generative Models**	**2 hours**
Deep Belief networks – Boltzmann Machines – Deep Boltzmann Machine - Generative Adversial Networks.		
Module:8	**Recent Trends**	**2 hours**
	Total Lecture Hours:	**45 hours**
Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar		

Text Books	
1.	Ian Goodfellow, Yoshua Bengio and Aaron Courville, " Deep Learning", MIT Press, 2017.
2.	Josh Patterson, Adam Gibson "Deep Learning: A Practitioner's Approach", O'Reilly Media, 2017
Reference Books	
1.	Kevin P. Murphy "Machine Learning: A Probabilistic Perspective", The MIT Press, 2012.
2.	Ethem Alpaydin,"Introduction to Machine Learning", MIT Press, Prentice Hall of India, Third Edition 2014.
3.	Giancarlo Zaccone, Md. Rezaul Karim, Ahmed Menshawy "Deep Learning with TensorFlow: Explore neural networks with Python", Packt Publisher, 2017.
Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar	
Project Component: The following is the sample project that can be given to students to be implemented: 1. Applying the Convolution Neural Network on computer vision problems 2. Applying the Deep Learning Models in the field of Natural Language Processing 3. Applying the Autoencoder algorithms for encoding the real-world data 4. Applying Generative Adversial Networks for image generation and unsupervised tasks.	
Mode of evaluation: Project/Activity	

Recommended by Board of Studies		11-02-2021	
Approved by Academic Council	No. 61	Date	18-02-2021

Course Code CSE3049	Distributed Computing Systems	L	T	P	J	C
		3	0	0	0	3
Pre-requisite	Nil	Syllabus Version				
		v1.0				

Course Objectives:

1. To learn the fundamentals of distributed and parallel computing paradigms
2. To understand distributed architectures and technologies.
3. To develop and execute basic parallel and distributed applications using basic program models and tools

Expected Course Outcome:

1. Implement the distributed computing systems
2. Categorization of different models of distributed systems
3. Develop the distributed algorithms
4. Identify the classes of parallel computers
5. Learn to use parallel programming model for distributed applications

Module:1	Introduction	6 hours

Parallel computing introduction, parallel programming models , Characterization of distributed systems-Introduction, examples of distributed systems, trends in distributed systems, challenges, clock synchronization, case study: WWW(world wide web)

Module:2	System Models	6 hours

Introduction, physical models, architectural models, fundamental models

Module:3	Networking and Internetworking	6 hours

Introduction, types of network, network principles, internet protocols, inter process communication,case study: MPI

Module:4	Remote Invocation	6 hours

Introduction, request reply protocols, RPC and RMI , Indirect communication, shared memory and distributed memory approaches

Module:5	Operating System Support	7 hours

Introduction, the operating system layer, processes and threads, virtualization at the operating system level

Module:6	Transaction And Concurrency Control	5 hours

Introduction, transactions, nested transactions, locks, optimistic concurrency control, distributed transactions introduction

Module:7	Distributed File Systems	7 hours

Introduction to distributed data bases, distributed file systems, File access models, fault tolerance, atomic transactions, design principles, security, potential attacks, cryptography, authentication, access control and digital signatures.

Module:8	**Recent Trends**		**2 hours**
	Total Lecture Hours:	**45 hours**	

Text Book(s)

1.	Andrew S. Tanenbaum, Maarten Van Steen, "Distributed Systems: Principles and Paradigms", 2016
2.	Pradeep K.Sinha, "Distributed Operating Systems-concepts and design" Eastern economy edition, PHI Learning private Ltd, 2012.

Reference Books

1.	George Coulouris, Jean Dollimore , Tim Kindberg, Gordon Blair, "Distributed Systems: Concepts and Design", Pearson, 2011.
2	Pascale Vicat-Blanc, Sébastien Soudan, Romaric Guillier, Brice Goglin, "Computing Networks: from cluster to cloud computing", Wiley International , 2013,
3	M.Tamer ozsu, Patrick valduriez, "Principles of distributed database systems", 2nd edition, prentice hall international, 1999.

Mode of Evaluation: CAT1, CAT2, Assignment, Quiz, FAT, Project

Recommended by Board of Studies	11-02-2021		
Approved by Academic Council	No. 61	Date	18-02-2021

Course Code	Course Title	L	T	P	J	C
CSE4007	Mobile Computing	3	0	0	4	4
Pre-requisite	Nil	Syllabus Version				
		v1.0				

Course Objectives:

1. Understand the basic concepts of mobile computing.
2. Learn the basics of mobile telecommunication system.
3. To be familiar with the mobile network layer protocols and Ad-Hoc networks.
4. Know the basis of mobile transport and application layer protocols.
5. Gain knowledge about different mobile platforms and application development.
6. Knowledge about different mobile security and future mobile networks

Expected Course Outcome:

1.Understand the concepts of Mobile Communication

2.Analyze the next generation Mobile telecommunication system

3.Understand network and transport layers of Mobile telecommunication system

4.Enable the students to apply the knowledge gained to design and develop a mobile application

5. Design and build an efficient and secure mobile computing environment.

6.Understand the concepts of future mobile networks

Module:1	Wireless Communication Fundamentals	5 hours

Introduction to Mobile Computing - Generations of Mobile Communication Technologies- Multiplexing – Spread spectrum -MAC Protocols – SDMA- TDMA- FDMA- CDMA- Novel applications of mobile computing - Limitations of mobile computing.

Module:2	Mobile Telecommunication System	7 hours

Introduction to Cellular Systems - GSM – Services & Architecture – Protocols – Connection Establishment – Frequency Allocation – Routing – Mobility Management –GPRS Architecture – 3G , 4G networks

Module:3	Mobile Network Layer	6 hours

Mobile IP – DHCP – AdHoc Networks– Proactive Routing protocol-DSDV, Reactive Routing Protocols – DSR, AODV , Hybrid routing –ZRP, Multicast Routing- ODMRP, Vehicular Ad Hoc networks (VANET) –MANET Vs VANET.

Module:4	Mobile Transport and Application Layer	6 hours

Mobile TCP– WAP – Architecture – WDP – WTLS – WTP –WSP – WAE – WTA Architecture – WML

Module:5	Mobile Platforms and Applications	7 hours

Mobile Device Operating Systems – Special Constraints & Requirements – Commercial Mobile Operating Systems – Software Development Kit: iOS, Android, BlackBerry, Windows Phone – MCommerce – Structure – Pros & Cons – Mobile Payment System – Security Issues

Module:6	Mobile Security	6 hours

Security, Analysis of existing wireless network -Information Security- Attacks, Components of Information Security - Security Techniques and Algorithms- Stream Ciphering and Block Ciphering, Symmetric Key Cryptography, Public Key Cryptography - Security Frame Works for Mobile

Environment- 3GPP Security, Mobile VPN, Multifactor Security, Smart Card Security, Mobile virus, Mobile Worm.		
Module:7	**Future Mobile Networks**	**6 hours**
Drone networking - Multi-UAV networks, architectures and civilian applications - Communication challenges and protocols for micro UAVs - Connected and autonomous cars - Wireless technologies for Vehicle-to-Infrastructure (V2I) and Vehicle-to-Vehicle (V2V) communications - Automotive surrounding sensing with GHz and THz signals.		
Module:8	**Recent Trends**	**2 hours**
	Total Lecture Hours:	**45hours**

Text Book(s)

1.	Prasant Kumar Pattnaik, Rajib Mall, Fundamentals of Mobile Computing, PHI Learning Pvt.Ltd, New Delhi – 2012.
2.	Raj Kamal, Mobile Computing, Oxford University Press; 3rd edition, 2019

Reference Books

1.	Asoke K Talukder and Roopa R. Yavagal, Mobile Computing – Technology, Applications and Service Creation; Tata McGraw Hill, 2010.
2.	Andre Perez ,Mobile Networks Architecture, Wiley, 2013
3.	Rishabh Anand, Mobile Computing, Khanna Publishing House, 1st Edition 2012
4.	David Thiel, Chris Clark, Himanshu Dwivedi, Mobile Application Security, McGraw-Hill, 2010

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar

Project Component:
Students should identify a problem to build novel commercial mobile applications. The goal is to select appropriate models and model specifications and apply the respective methods to develop the mobile security, mobile commerce, mobile payment system and future mobile network. Students will identify the potential use of mobile applications to formulate the problem, identify the right sources of data, analyze data, and prescribe actions to improve the outcome of decisions. Students can use any app development tool and software development kit like iOS, Android, BlackBerry, and Windows Phone.

Mode of evaluation: Project/Activity

Recommended by Board of Studies	11-02-2021		
Approved by Academic Council	No. 61	Date	18-02-2021

CSE4007	Open Source Programing	L	T	P	J	C
		3	0	2	0	4
Pre-requisite		Syllabus Version				
Anti-requisite		v1.0				

Course Objectives:

1. To comprehend and analyze the basic concepts of web frameworks
2. To describe how different frameworks work and to choose the framework depending on the application.
3. To demonstrates the uses of different web frameworks.

Expected Course Outcome:

After successfully completing the course the student should be able to

1. Use Django framework to create basic website.
2. Use Ruby on Rails framework to quickly develop websites.
3. Use Express framework along with Node JS to render webpages effectively
4. Use Mongo DB along with Express to display dynamic web content
5. Use Angular JS to extend an enhance HTML pages
6. Implementing web-based solution effectively using different web frameworks.

Module:1	Django Framework	6 hours

Django Introduction and Installation – MVT Structure – Creating a project and app in Django – Django Forms – creation of forms – render forms - form fields – form fields widgets – formsets – Django Templates – Template filters – Template Tags – Variables – Operators – for loop- If-Django Templates – Template inheritance

Module:2	Django Models	6 hours

Django Views – Function based views – Class based generic views – Models – ORM – Basic App Model – Intermediate fields - Uploading Images – Render Model – Build-in and custom field validations – Handling Ajax Request – Django Admin interface

Module:3	Ruby on Rails Framework	8 hours

Ruby of Rails introduction – Installation – MVC architecture - IDE – Rails scripts - Directory structure- Database setup – Active records - RVM – Bundler - Rails Migration – controllers –routes – views – layouts - scaffolding – sessions – file upload – filters - Ajax

Module:4	ExpressJS Framework	6 hours

ExpressJS Introduction – installation – Node JS Environment Setup – Routing – HTTP Methods – URL Building – Middleware – Templating – Different template Engines– Static Files – Form Data

Module:5	ExpressJS Framework and Database	5 hours

Database – Mongo DB – Mongoose – Cookies,sessions – Authentication – RESTFUL APIs – Scaffolding – Error Handling – File upload

Module:6	Angular JS	6 hours

Introduction – Environment setup – First application – Data binding & Directives – Expressions – Controllers – Scopes – Events – Services – Filters - Modules

Module:7	Angular JS - Routing	6 hours

HTML DOM -Forms – Validation – Routing – Includes – AJAX – Views – Dependency Injection- Custom Directives – Single Page applications		
Module:8	**Recent Trends**	**2 hour**
	Total Lecture Hours:	**45 hours**

Text Book(s)

1.	Aidas Bendoraitis, Jake Kronika, Django 3 Web Development Cookbook: Actionable solutions to common, Packt Publishing; 4th edition, 2020.
2.	Michael Hartl, Ruby on Rails Tutorial, Addison-Wesley Professional; 6th edition, 2020.
3.	Adam Freeman, Pro Angular 9: Build Powerful and Dynamic Web Apps, Apress, 4th Edition, 2020.

Reference Books

1.	Ethan Brown, Web Development with Node and Express, 2e: Leveraging the JavaScript Stack, O′Reilly; 2nd edition, 2019.
2.	Lopatin, Ben, Django Standalone Apps, Apress, 1st Edition, 2020.
3.	Simon D. Holmes and Clive Harbe, Getting MEAN with Mongo, Express, Angular, and Node, Second Edition, Manning Publications,2017.

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar

List of Experiments

1.	Virtual environment and deploying the web app using Django	4 hours
2.	URL Patterns & Views	4 hours
3.	Server side rendering	6 hours
4.	Express Route : Model and Static Methods	6 hours
5.	Web app integration with APIs for user authentication and analytics	6 hours
6.	AJAX Request Response Apps	4 hours
	Total Laboratory Hours	30 hours

Mode of assessment: Project/Activity

Recommended by Board of Studies	11-02-2021		
Approved by Academic Council	No. 61	Date	18-02-2021

Course Code	Course Title	L	T	P	J	C
CSE3092	Advanced Java Programming	3	0	2	0	4
Pre-requisite		Syllabus Version				
Anti-requisite		v1.0				

Course Objectives:

1. To demonstrate the use of Object Oriented Programming and threads concepts in Java.
2. To familiarize students with Graphical user interface, distributed application, web development using servlet and JSP.
3. To impart the core features of Spring and hibernate framework.

Expected Course Outcome:

After successfully completing the course the student should be able to

1. Choose the appropriate OOP technique for solving the given problem and use multithreads when required.
2. Design Graphical User Interface using AWT and Swing.
3. Build and Deploy distributed applications using RMI and CORBA.
4. Design, Develop and Deploy dynamic web applications using Servlets with JDBC.
5. Design and Develop applications using JSP and Enterprise Java Bean.
6. Recognize the capabilities of java framework to facilitate solving industrial applications using Spring framework.
7. Recognize the capabilities of java framework to facilitate solving industrial applications using Hibernate framework.

Module:1	Core Java and Multithread	7 hours

Class and object - Packages and sub packages– Abstract class and Interface. Multithreading: thread creation, thread priorities, synchronization and Inter thread communication.

Module:2	Abstract Window Toolkit and Swing	7 hours

Abstract Window Toolkit(AWT): AWT classes, Window fundamentals - Frame Windows - creating a frame window in applet, Creating a Windowed Program. Event Handling: Event Classes – Sources of Events – Event Listener Interfaces. Swing: Icons and Labels – Text Fields – Buttons – Combo Boxes – Tabbed Panes – Scroll Panes – Trees – Tables.

Module:3	Applications in Distributed Environment	6 hours

Java Remote Method Invocation – Invocation concept – Remote Interface – Passing Objects – Client Side and Server side RMI Process. Java Interface Definition Language and CORBA – The Concept of Object Request Brokerage – IDL and CORBA – Client side and Server side IDL Interface.

Module:4	Servlets with Database Connectivity	5 hours

Java Servlets – MVC Architecture – Container Architecture – Controller Components – Dynamic Forms – Servlet Context - The JDBC API: The API components, database operations like creating tables, CRUD(Create, Read, Update, Delete) operations using SQL – JDBC Drivers

Module:5	Java Server Pages and Enterprise JavaBeans	6 hours

JSP Scripting Elements – Tags - Variables and Objects – Methods – Control Statements – User Sessions – Cookies – Session Objects – JSTL and Servlets with JSP. Enterprise JavaBeans:

Deployment Descriptors – Session JavaBean – Entity JavaBean – Message and Driven Bean.		
Module:6	**Spring Framework**	**6 hours**
Introduction to Spring – Bean scope and lifecycle – Inversion of control – Dependency injection – Spring MVC: Building spring web Apps – Creating controllers and views – Request params and request mapping – Form tags and data binding.		
Module:7	**Hibernate Framework**	**6 hours**
Introduction to Hibernate – Hibernate CURD features – Advanced mappings – Hibernate Query Languages and Transactions. Spring Hibernate Integrations: Hibernate DAO implementation using Spring Framework.		
Module:8	**Recent Trends**	**2 hours**
	Total Lecture Hours:	**45 hours**

Text Book(s)	
1.	Herbert Schildt, "Java: The Complete Reference", McGraw-Hill Publishers, 11th Edition, 2019.
2.	Mahesh P. Matha "JSP and SERVLETS: A Comprehensive Study", PHI publication, 2015
Reference Books	
1.	D.T. Editorial Services "Java 8 Programming Black Book", Wiley, 2015
2.	Santosh Kumar K "Spring and Hibernate", Mc.Graw Hill Education, 2013

List of Experiments		
1.	Demonstrate the use of inheritance, interface and packages.	3 hours
2.	The concept of threads and multithreading in Java	3 hours
3.	GUI application using AWT.	3 hours
4.	Demonstrate GUI application using Swing.	3 hours
5.	Distributed application using RMI	3 hours
6.	Demonstrate distributed application using CORBA/IDL	3 hours
7.	Basic web application using Servlet and JDBC	3 hours
8.	Demonstrate basic web application using JSP	3 hours
9	The use of Spring framework.	3 hours
10	Demonstrate the use of Hibernate framework.	3 hours
	Total Laboratory Hours	**30 hrs**
Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar		

Recommended by Board of Studies	11-02-2021		
Approved by Academic Council	No. 61	Date	18-02-2021

CHY1701	Engineering Chemistry	L	T	P	J	C
		3	0	2	0	4
Pre-requisite	**Chemistry of 12th standard or equivalent**	**Syllabus version**				
		1.1				

Course Objectives:

1. To impart technological aspects of applied chemistry
2. To lay foundation for practical application of chemistry in engineering aspects

Expected Course Outcomes (CO): Students will be able to

1. Recall and analyze the issues related to impurities in water and their removal methods and apply recent methodologies in water treatment for domestic and industrial usage
2. Evaluate the causes of metallic corrosion and apply the methods for corrosion protection of metals
3. Evaluate the electrochemical energy storage systems such as lithium batteries, fuel cells and solar cells, and design for usage in electrical and electronic applications
4. Assess the quality of different fossil fuels and create an awareness to develop the alternative fuels
5. Analyze the properties of different polymers and distinguish the polymers which can be degraded and demonstrate their usefulness
6. Apply the theoretical aspects: (a) in assessing the water quality; (b) understanding the construction and working of electrochemical cells; (c) analyzing metals, alloys and soil using instrumental methods; (d) evaluating the viscosity and water absorbing properties of polymeric materials

Module:1	**Water Technology**	**5 hours**

Characteristics of hard water - hardness, DO, TDS in water and their determination – numerical problems in hardness determination by EDTA; Modern techniques of water analysis for industrial use - Disadvantages of hard water in industries.

Module:2	**Water Treatment**	**8 hours**

Water softening methods: - Lime-soda, Zeolite and ion exchange processes and their applications. Specifications of water for domestic use (ICMR and WHO); Unit processes involved in water treatment for municipal supply - Sedimentation with coagulant- Sand Filtration - chlorination; Domestic water purification – Candle filtration- activated carbon filtration; Disinfection methods- Ultrafiltration, UV treatment, Ozonolysis, Reverse Osmosis; Electro dialysis.

Module:3	**Corrosion**	**6 hours**

Dry and wet corrosion - detrimental effects to buildings, machines, devices & decorative art forms, emphasizing Differential aeration, Pitting, Galvanic and Stress corrosion cracking; Factors that enhance corrosion and choice of parameters to mitigate corrosion.

Module:4	**Corrosion Control**	**4 hours**

Corrosion protection - cathodic protection – sacrificial anodic and impressed current protection methods; Advanced protective coatings: electroplating and electroless plating, PVD and CVD.

Alloying for corrosion protection – Basic concepts of Eutectic composition and Eutectic mixtures - Selected examples – Ferrous and non-ferrous alloys.

Module:5	**Electrochemical Energy Systems**	**6 hours**

Brief introduction to conventional primary and secondary batteries; High energy electrochemical energy systems: Lithium batteries – Primary and secondary, its Chemistry, advantages and applications.

Fuel cells – Polymer membrane fuel cells, Solid-oxide fuel cells- working principles, advantages, applications.

Solar cells – Types – Importance of silicon single crystal, polycrystalline and amorphous silicon

solar cells, dye sensitized solar cells - working principles, characteristics and applications.		
Module:6	**Fuels and Combustion**	**8 hours**
Calorific value - Definition of LCV, HCV. Measurement of calorific value using bomb calorimeter and Boy"s calorimeter including numerical problems. Controlled combustion of fuels - Air fuel ratio – minimum quantity of air by volume and by weight-Numerical problems-three way catalytic converter- selective catalytic reduction of NO_X; Knocking in IC engines-Octane and Cetane number - Antiknocking agents.		
Module:7	**Polymers**	**6 hours**
Difference between thermoplastics and thermosetting plastics; Engineering application of plastics - ABS, PVC, PTFE and Bakelite; Compounding of plastics: moulding of plastics for Car parts, bottle caps (Injection moulding), Pipes, Hoses (Extrusion moulding), Mobile Phone Cases, Battery Trays, (Compression moulding), Fibre reinforced polymers, Composites (Transfer moulding), PET bottles (blow moulding); Conducting polymers- Polyacetylene- Mechanism of conduction – applications (polymers in sensors, self-cleaning windows)		
Module:8	**Contemporary issues:**	**2 hours**
Lecture by Industry Experts		
	Total Lecture hours:	**45 hours**

Text Book(s)

1. Sashi Chawla, A Text book of Engineering Chemistry, Dhanpat Rai Publishing Co., Pvt. Ltd., Educational and Technical Publishers, New Delhi, 3rd Edition, 2015.
2. O.G. Palanna, McGraw Hill Education (India) Private Limited, 9th Reprint, 2015.
3. B. Sivasankar, Engineering Chemistry 1st Edition, Mc Graw Hill Education (India), 2008
4. Photovoltaic solar energy : From fundamentals to Applications , Ang le Reinders, Pierre Verlinden, Wilfried van Sark, Alexandre Freundlich, Wiley publishers, 2017.

Reference Books

1. O.V. Roussak and H.D. Gesser, Applied Chemistry-A Text Book for Engineers and Technologists, Springer Science Business Media, New York, 2nd Edition, 2013.
2. S. S. Dara, A Text book of Engineering Chemistry, S. Chand & Co Ltd., New Delhi, 20th Edition, 2013.

Mode of Evaluation: Internal Assessment (CAT, Quizzes, Digital Assignments) & FAT

List of Experiments

	Experiment title	Hours
1.	Water Purification: Estimation of water hardness by EDTA method and its removal by ion-exchange resin	1 h 30 min
2. 3.	Water Quality Monitoring: Assessment of total dissolved oxygen in different water samples by Winkler's method Estimation of sulphate/chloride in drinking water by conductivity method	3 h
4/5.	Material Analysis: Quantitative colorimetric determination of divalent metal ions of Ni/Fe/Cu using conventional and smart phone digital-imaging methods	3h
6.	Analysis of Iron in carbon steel by potentiometry	1 h 30 min
7.	Construction and working of an Zn-Cu electrochemical cell	1 h 30 min

8.	Determination of viscosity-average molecular weight of different natural/synthetic polymers			1 h 30 min
9.	Arduino microcontroller based sensor for monitoring pH/temperature/conductivity in samples.			1 h 30 min
			Total Laboratory Hours	17 hours
Mode of Evaluation: Viva-voce and Lab performance & FAT				
Recommended by Board of Studies	31-05-2019			
Approved by Academic Council	54th ACM	Date	13-06-2019	

Course code	PROBLEM SOLVING AND PROGRAMMING	L	T	P	J	C
CSE1001		0	0	6	0	3
Pre-requisite	NIL	Syllabus version				
		v1.0				

Course Objectives:

1. To develop broad understanding of computers, programming languages and their generations
2. Introduce the essential skills for a logical thinking for problem solving
3. To gain expertise in essential skills in programming for problem solvingusing computer

Expected Course Outcome:

1. Understand the working principle of a computer and identify the purpose of a computer programming language.
2. Learn various problem solving approaches and ability to identify an appropriate approach to solve the problem
3. Differentiate the programming Language constructs appropriately to solve any problem
4. Solve various engineering problems using different data structures
5. Able to modulate the given problem using structural approach of programming
6. Efficiently handle data using flat files to process and store data for the given problem

List of Challenging Experiments (Indicative)

1	Steps in Problem Solving Drawing flowchart using yEd tool/Raptor Tool	4 Hours
2	Introduction to Python, Demo on IDE, Keywords, Identifiers, I/O Statements	4 Hours
3	Simple Program to display Hello world in Python	4 Hours
4	Operators and Expressions in Python	4 Hours
5	Algorithmic Approach 1: Sequential	4 Hours
6	Algorithmic Approach 2: Selection (if, elif, if.. else, nested if else)	4 Hours
7	Algorithmic Approach 3: Iteration (while and for)	6 Hours
8	Strings and its Operations	6 Hours
9	Regular Expressions	6 Hours
10	List and its operations	6 Hours
11	Dictionaries: operations	6 Hours
12	Tuples and its operations	6 Hours
13	Set and its operations	6 Hours
14	Functions, Recursions	6 Hours
15	Sorting Techniques (Bubble/Selection/Insertion)	6 Hours
16	Searching Techniques : Sequential Search and Binary Search	6 Hours
17	Files and its Operations	6 Hours
	Total hours:	**90 hours**

Text Book(s)

1. John V. Guttag., 2016. Introduction to computation and programming using python: with applications to understanding data. PHI Publisher.

Reference Books

1. Charles Severance.2016.Python for everybody: exploring data in Python 3, Charles Severance.
2. Charles Dierbach.2013.Introduction to computer science using python: a computational problem-solving focus. Wiley Publishers.

Mode of Evaluation: **PAT/ CAT/ FAT**

Recommended by Board of Studies	04-04-2014		
Approved by Academic Council	No. 38	Date	23-10-2015

CSE1002	PROBLEM SOLVING AND OBJECT ORIENTED PROGRAMMING	L	T	P	J	C
		0	0	6	0	3
Pre-requisite	**Nil**	**Syllabus version**				
		v1.0				

Course Objectives:

1. To emphasize the benefits of object oriented concepts.
2.To enable students to solve the real time applications using object oriented programmingfeatures
3.To improve the skills of a logical thinking and to solve the problems using any processing elements

Expected Course Outcome:

1. Demonstrate the basics of procedural programming and to represent the real world entitiesas programming constructs.
2.Enumerate object oriented concepts and translate real-world applications intographical representations.
3.Demonstrate the usage of classes and objects of the real world entities in applications.
4.Discriminate the reusability and multiple interfaces with same functionality based featuresto solve complex computing problems.
5. Illustrate possible error-handling constructs for unanticipated states/inputs and to use generic programming constructs to accommodate different datatypes.
6. Validate the program against file inputs towards solving the problem..

List of Challenging Experiments (Indicative)

1.	**Postman Problem** A postman needs to walk down every street in his area in order to deliver the mail. Assume that the distances between the streets along the roads are given. The postman starts at the post office and returns back to the post office after delivering all the mails. Implement an algorithm to help the post man to walk minimum distance for the purpose.	10 hours
2.	**Budget Allocation for Marketing Campaign** A mobile manufacturing company has got several marketing options such as Radio advertisement campaign, TV non peak hours campaign, City top paper network, Viral marketing campaign, Web advertising. From their previous experience, they have got a statistics about paybacks for each marketing option. Given the marketing budget (rupees in crores) for the current year and details of paybacks for each option, implement an algorithm to determine the amount that shall spent on each marketing option so thatthe company attains the maximum profit.	15 hours
3.	**Missionaries and Cannibals** Three missionaries and three cannibals are on one side of a river, along with a boat that can hold one or two people. Implement an algorithm to find a way to get everyone to the other side of the river, without ever leaving a group of missionaries in one place outnumbered by the cannibals in that place.	10 hours
4.	**Register Allocation Problem** A register is a component of a computer processor that can hold any type of	15 hours

	data and can be accessed faster. As registers are faster to access, it is desirable to use them to the maximum so that the code execution is faster. For each code submitted to the processor, a register interference graph (RIG) is constructed. In a RIG, a node represents a temporary variable and an edge is added between two nodes (variables) t1 and t2 if they are live simultaneously at some point in the program. During register allocation, two temporaries can be allocated to the same register if there is no edge connecting them. Given a RIG representing the dependencies between variables in a code, implement an algorithm to determine the number of registers required to store the variables and speed up the code execution	
5.	**Selective Job Scheduling Problem** A server is a machine that waits for requests from other machines and responds to them. The purpose of a server is to share hardware and software resources among clients. All the clients submit the jobs to the server for execution and the server may get multiple requests at a time. In such a situation, the server schedule the jobs submitted to it based on some criteria and logic. Each job contains two values namely time and memory required for execution. Assume that there are two servers that schedules jobs based on time and memory. The servers are named as Time Schedule Server and memory Schedule Server respectively. Design a OOP model and implement the time Schedule Server and memory Schedule Server. The Time Schedule Server arranges jobs based on time required for execution in ascending order whereas memory Schedule Server arranges jobs based on memory required for execution in ascending order	15 hours
6.	**Fragment Assembly in DNA Sequencing** DNA, or deoxyribonucleic acid, is the hereditary material in humans and almost all other organisms. The information in DNA is stored as a code made up of four chemical bases: adenine (A), guanine (G), cytosine (C), and thymine (T). In DNA sequencing, each DNA is sheared into millions of small fragments (reads) which assemble to form a single genomic sequence (superstring). Each read is a small string. In such a fragment assembly, given a set of reads, the objective is to determine the shortest superstring that contains all the reads. For example, given a set of strings, 000, 001, 010, 011, 100, 101, 110, 111 the shortest superstring is 0001110100. Given a set of reads, implement an algorithm to find the shortest superstring that contains all the given reads.	15 hours
7.	**House Wiring** An electrician is wiring a house which has many rooms. Each room has many power points in different locations. Given a set of power points and the distances between them, implement an algorithm to find the minimum cable required.	10 hours
	Total Laboratory Hours	**90 hours**
Text Book(s)		
1.	Stanley B Lippman, Josee Lajoie, Barbara E, Moo, C++ primer, Fifth edition, Addison-Wesley, 2012.	
2	Ali Bahrami, Object oriented Systems development, Tata McGraw - Hill Education, 1999.	
3	Brian W. Kernighan, Dennis M. Ritchie , The C programming Language, 2nd edition, Prentice Hall Inc., 1988.	
Reference Books		
1.	Bjarne stroustrup, The C++ programming Language, Addison Wesley, 4th edition, 2013	
2.	Harvey M. Deitel and Paul J. Deitel, C++ How to Program, 7th edition, Prentice Hall, 2010	

3.	Maureen Sprankle and Jim Hubbard, Problem solving and Programming concepts, 9th edition, Pearson Eduction, 2014.		
Mode of assessment: **PAT / CAT / FAT**			
Recommended by Board of Studies	29-10-2015		
Approved by Academic Council	No. 39	Date	17-12-2015

Course Code	Course Title	L	T	P	J	C
ENG1901	Technical English - I	0	0	4	0	2
Pre-requisite	Foundation English-II	Syllabus Version				
		1				

Course Objectives:

1. To enhance students' knowledge of grammar and vocabulary to read and write error-free language in real life situations.
2. To make the students' practice the most common areas of written and spoken communications skills.
3. To improve students' communicative competency through listening and speaking activities in the classroom.

Expected Course Outcome:

1. Develop a better understanding of advanced grammar rules and write grammatically correct sentences.
2. Acquire wide vocabulary and learn strategies for error-free communication.
3. Comprehend language and improve speaking skills in academic and social contexts.
4. Improve listening skills so as to understand complex business communication in a variety of global English accents through proper pronunciation.
5. Interpret texts, diagrams and improve both reading and writing skills which would help them in their academic as well as professional career.

Module:1	Advanced Grammar	4 hours

Articles, Tenses, Voice and Prepositions

Activity: Worksheets on Impersonal Passive Voice, Exercises from the prescribed text

Module:2	Vocabulary Building I	4 hours

Idioms and Phrases, Homonyms, Homophones and Homographs

Activity: Jigsaw Puzzles; Vocabulary Activities through Web tools

Module:3	Listening for Specific Purposes	4 hours

Gist, monologues, short conversations, announcements, briefings and discussions

Activity: Gap filling; Interpretations

Module:4	Speaking for Expression	6 hours

Introducing oneself and others, Making Requests & responses, Inviting and Accepting/Declining Invitations

Activity: Brief introductions; Role-Play; Skit.

Module:5	Reading for Information	4 hours

Reading Short Passages, News Articles, Technical Papers and Short Stories

Activity: Reading specific news paper articles; blogs

Module:6	Writing Strategies	4 hours

Joining the sentences, word order, sequencing the ideas, introduction and conclusion

Activity: Short Paragraphs; Describing familiar events; story writing

Module:7	Vocabulary Building II	4 hours

Enrich the domain specific vocabulary by describing Objects, Charts, Food, Sports and Employment. Activity: Describing Objects, Charts, Food, Sports and Employment		
Module:8	**Listening for Daily Life**	**4 hours**
Listening for statistical information, Short extracts, Radio broadcasts and TV interviews Activity: Taking notes and Summarizing		
Module:9	**Expressing Ideas and Opinions**	**6 hours**
Telephonic conversations, Interpretation of Visuals and describing products and processes. Activity: Role-Play (Telephonic); Describing Products and Processes		
Module: 10	**Comprehensive Reading**	**4 hours**
Reading Comprehension, Making inferences, Reading Graphics, Note-making, and Critical Reading. Activity: Sentence Completion; Cloze Tests		
Module: 11	**Narration**	**4 hours**
Writing narrative short story, Personal milestones, official letters and E-mails. Activity: Writing an E-mail; Improving vocabulary and writing skills.		
Module:12	**Pronunciation**	**4 hours**
Speech Sounds, Word Stress, Intonation, Various accents Activity: Practicing Pronunciation through web tools; Listening to various accents of English		
Module:13	**Editing**	**4 hours**
Simple, Complex & Compound Sentences, Direct & Indirect Speech, Correction of Errors, Punctuations. Activity: Practicing Grammar		
Module:14	**Short Story Analysis**	**4 hours**
"The Boundary" by Jhumpa Lahiri Activity: Reading and analyzing the theme of the short story.		
	Total Lecture hours	**60 hours**

Text Book / Workbook	
1.	Wren, P.C.; Martin, H.; Prasada Rao, N.D.V. (1973–2010). *High School English Grammar & Composition*. New Delhi: Sultan Chand Publishers.
2	Kumar, Sanjay,; Pushp Latha. (2018) English Language and Communication Skills for Engineers, India: Oxford University Press.

Reference Books	
1.	Guptha S C, (2012) *Practical English Grammar & Composition*, 1st Edition, India: Arihant Publishers
2.	Steven Brown, (2011) Dorolyn Smith**,** *Active Listening* ***3*****,** 3rd Edition, UK: Cambridge University Press.
3.	Liz Hamp-Lyons, Ben Heasley, (2010) *Study Writing*, 2nd Edition, UK: Cambridge University Pres.

4.	Kenneth Anderson, Joan Maclean, (2013) Tony Lynch, *Study Speaking*, 2nd Edition, UK: Cambridge, University Press.
5.	Eric H. Glendinning, Beverly Holmstrom, (2012) *Study Reading*, 2nd Edition, UK: Cambridge University Press.
6.	Michael Swan, (2017) *Practical English Usage* (Practical English Usage), 4th edition, UK: Oxford University Press.
7.	Michael McCarthy, Felicity O'Dell, (2015) *English Vocabulary in Use Advanced* (South Asian Edition), UK: Cambridge University Press.
8.	Michael Swan, Catherine Walter, (2012) *Oxford English Grammar Course Advanced*, Feb, 4th Edition, UK: Oxford University Press.
9.	Watkins, Peter. (2018) *Teaching and Developing Reading Skills: Cambridge Handbooks for Language teachers*, UK: Cambridge University Press.
10.	(*The Boundary by Jhumpa Lahiri)* URL: https://www.newyorker.com/magazine/2018/01/29/the-boundary?intcid=inline_amp

Mode of evaluation: Quizzes, Presentation, Discussion, Role play, Assignments and FAT

List of Challenging Experiments (Indicative)		
1.	Self-Introduction	**12 hours**
2.	Sequencing Ideas and Writing a Paragraph	**12 hours**
3.	Reading and Analyzing Technical Articles	**8 hours**
4.	Listening for Specificity in Interviews (Content Specific)	**12 hours**
5.	Identifying Errors in a Sentence or Paragraph	**8 hours**
6.	Writing an E-mail by narrating life events	**8 hours**
	Total Laboratory Hours	**60 hours**

Mode of evaluation: Quizzes, Presentation, Discussion, Role play, Assignments and FAT

Recommended by Board of Studies	08.06.2019	
Approved by Academic Council	55	Date: 13-06-2019

Course Code	Technical English - II	L	T	P	J	C
ENG 1902		0	0	4	0	2

Pre-requisite	71% to 90% EPT score	Syllabus Version
		1

Course Objectives:

1. To acquire proficiency levels in LSRW skills on par with the requirements forplacement interviews of high-end companies / competitive exams.
2. To evaluate complex arguments and to articulate their own positions on a range of technical and general topics.
3. To speak in grammatical and acceptable English with minimal MTI, as well as develop a vast and active vocabulary.

Expected Course Outcome:

1. Communicate proficiently in high-end interviews and exam situations and all social situations
2. Comprehend academic articles and draw inferences
3. Evaluate different perspectives on a topic
4. Write clearly and convincingly in academic as well as general contexts
5. Synthesize complex concepts and present them in speech and writing

Module:1	Listening for Clear Pronunciation	4 hours

Ice-breaking, Introduction to vowels, consonants, diphthongs.

Listening to formal conversations in British and American accents (BBC and CNN) as well as other 'native' accents

Activity: Factual and interpretive exercises; note-making in a variety of global English accents

Module:2	Introducing Oneself	4 hours

Speaking: Individual Presentations

Activity: Self-Introductions, Extempore speech

Module:3	Effective Writing	6 hours

Writing: Business letters and Emails, Minutes and Memos

Structure/ template of common business letters and emails: inquiry/ complaint/ placing an order; Formats of Minutes and Memos

Activity: Students write a business letter and Minutes/ Memo

Module:4	Comprehensive Reading	4 hours

Reading: Reading Comprehension Passages, Sentence Completion (Technical and General Interest), Vocabulary and Word Analogy

Activities: Cloze tests, Logical reasoning, Advanced grammar exercises

Module:5	Listening to Narratives	4 hours

Listening: Listening to audio files of short stories, News, TV Clips/ Documentaries, Motivational Speeches in UK/ US/ global English accents.

Activity: Note-making and Interpretive exercises

Module:6	Academic Writing and Editing	6 hours

Writing: Editing/ Proofreading

symbols Citation Formats

Structure of an Abstract and Research Paper

Activity: Writing Abstracts and research paper; Work with Editing/ Proofreading exercise

Module:7	**Team Communication**	**4 hours**
Speaking: Group Discussions and Debates on complex/ contemporary topics Discussion evaluation parameters, using logic in debates Activity: Group Discussions on general topics		
Module:8	**Career-oriented Writing**	**4 hours**
Writing: Resumes and Job Application Letters, SOP Activity: Writing resumes and SOPs		
Module:9	**Reading for Pleasure**	**4 hours**
Reading: Reading short stories Activity: Classroom discussion and note-making, critical appreciation of the short story		
Module: 10	**Creative Writing**	**4 hours**
Writing: Imaginative, narrative and descriptive prose Activity: Writing about personal experiences, unforgettable incidents, travelogues		
Module: 11	**Academic Listening**	**4 hours**
Listening: Listening in academic contexts Activity: Listening to lectures, Academic Discussions, Debates, Review Presentations, Research Talks, Project Review Meetings		
Module:1 2	**Reading Nature-based Narratives**	**4 hours**
Narratives on Climate Change, Nature and Environment Activity: Classroom discussions, student presentations		
Module:13	**Technical Proposals**	**4 hours**
Writing: Technical Proposals Activities: Writing a technical proposal		
Module:14	**Presentation Skills**	**4 hours**
Persuasive and Content-Specific Presentations Activity: Technical Presentations		
	Total Lecture hours:	**60 hours**

Text Book / Workbook	
1.	Oxenden, Clive and Christina Latham-Koenig. *New English File: Advanced Students Book*. Paperback. Oxford University Press, UK, 2017.
2	Rizvi, Ashraf. *Effective Technical Communication*. McGraw-Hill India, 2017.
Reference Books	
1.	Oxenden, Clive and Christina Latham-Koenig, *New English File: Advanced: Teacher's Book with Test and Assessment*. CD-ROM: Six-level General English Course for Adults. Paperback. Oxford University Press, UK, 2013.
2.	Balasubramanian, T. *English Phonetics for the Indian Students: A Workbook*. Laxmi Publications, 2016.

3	Philip Seargeant and Bill Greenwell, From Language to Creative Writing. Bloomsbury Academic, 2013.		
4	Krishnaswamy, N. Eco-English. Bloomsbury India, 2015.		
5	Manto, Saadat Hasan. Selected Short Stories. Trans. Aatish Taseer. Random House India, 2012.		
6	Ghosh, Amitav. The Hungry Tide. Harper Collins, 2016		
7	Ghosh, Amitav. The Great Derangement: Climate Change and the Unthinkable. Penguin Books, 2016.		
8	The MLA Handbook for Writers of Research Papers, 8th ed. 2016.		
	Online Sources: https://americanliterature.com/short-short-stories. (75 short short stories) http://www.eco-ction.org/dt/thinking.html (Leopold, Aldo."Thinking like a Mountain") /www.esl-lab.com/; www.bbc.co.uk/learningenglish/; /www.bbc.com/news; /learningenglish.voanews.com/a/using-voa-learning-english-to-improve-listening-skills/3815547.html		
	Mode of evaluation: Quizzes, Presentation, Discussion, Role play, Assignments and FAT		
	List of Challenging Experiments (Indicative)		
1	Self-Introduction using SWOT		**12 hours**
2	Writing minutes of meetings		**10 hours**
3	Writing an abstract		**10 hours**
4	Listening to motivational speeches and interpretation		**10 hours**
5	Cloze Test		**6 hours**
6	Writing a proposal		**12 hours**
			60 hours
Mode of evaluation: Quizzes, Presentation, Discussion, Role play, Assignments and FAT			
Recommended by Board of Studies	08.06.2019		
Approved by Academic Council	55	Date: 13-06-2019	

HUM1021	ETHICS AND VALUES	L	T	P	J	C
		2	0	0	0	2
Pre-requisite	Nil	**Syllabus version**				
		1.1				

Course Objectives:

1. To understand and appreciate the ethical issues faced by an individual in profession, society andpolity
2. To understand the negative health impacts of certain unhealthybehaviors
3. To appreciate the need and importance of physical, emotional health and social health

Expected Course Outcome:

Students will be able to:

1. Follow sound morals and ethical values scrupulously to prove as goodcitizens
2. Understand various social problems and learn to actethically
3. Understand the concept of addiction and how it will affect the physical and mental health
4. Identify ethical concerns in research and intellectual contexts, including academic integrity, useand citation of sources, the objective presentation of data, and the treatment of human subjects
5. Identify the main typologies, characteristics, activities, actors and forms ofcybercrime

Module:1	**Being Good and Responsible**	**5 hours**

Gandhian values such as truth and non-violence – Comparative analysis on leaders of past and present – Society"s interests versus self-interests - Personal Social Responsibility: Helping the needy, charity and serving the society

Module:2	**Social Issues 1**	**4 hours**

Harassment – Types - Prevention of harassment, Violence and Terrorism

Module:3	**Social Issues 2**	**4 hours**

Corruption: Ethical values, causes, impact, laws, prevention – Electoral malpractices;
White collar crimes - Tax evasions – Unfair trade practices

Module:4	**Addiction and Health**	**5 hours**

Peer pressure - Alcoholism: Ethical values, causes, impact, laws, prevention – Ill effects of smoking - Prevention of Suicides;
Sexual Health: Prevention and impact of pre-marital pregnancy and Sexually Transmitted Diseases

Module:5	**Drug Abuse**	**3 hours**

Abuse of different types of legal and illegal drugs: Ethical values, causes, impact, laws and prevention

Module:6	**Personal and Professional Ethics**	**4 hours**

Dishonesty - Stealing - Malpractices in Examinations – Plagiarism

Module:7	**Abuse of Technologies**	**3 hours**

Hacking and other cyber crimes, Addiction to mobile phone usage, Video games and Social networking websites

Module:8	**Contemporary issues:**	**2 hours**

Guest lectures by Experts

	Total Lecture hours:	**30 hours**	

Reference Books

1. Dhaliwal, K.K , "Gandhian Philosophy of Ethics: A Study of Relationship between his Presupposition and Precepts,2016, Writers Choice, New Delhi, India.
2. Vittal, N, "Ending Corruption? - How to Clean up India?", 2012, Penguin Publishers, UK.
3. Pagliaro, L.A. and Pagliaro, A.M, "Handbook of Child and Adolescent Drug and Substance Abuse: Pharmacological , Developmental and Clinical Considerations", 2012Wiley Publishers, U.S.A.
4. Pandey, P. K (2012), "Sexual Harassment and Law in India", 2012, Lambert Publishers, Germany.

Mode of Evaluation: CAT, Assignment, Quiz, FAT and Seminar			
Recommended by Board of Studies	26-07-2017		
Approved by Academic Council	No. 46	Date	24-08-2017

MAT-1011	Calculus for Engineers	L	T	P	J	C
		3	0	2	0	4
Pre-requisite	**10+2 Mathematics or MAT1001**	**Syllabus Version**				
		1.0				

Course Objectives :

1. To provide the requisite and relevant background necessary to understand theother important engineering mathematics courses offered for Engineers and Scientists.
2. To introduce important topics of applied mathematics, namely Singleand Multivariable Calculus and Vector Calculus etc.
3. To impart the knowledge of Laplace transform, an important transform technique for Engineers which requires knowledge of integration

Expected Course Outcomes:

At the end of this course the students should be able to

1. apply single variable differentiation and integration to solve applied problems in engineering and find the maxima and minima of functions
2. understand basic concepts of Laplace Transforms and solve problems with periodic functions, step functions, impulse functions and convolution
3. evaluate partial derivatives, limits, total differentials, Jacobians, Taylor series and optimization problems involving several variables with or without constraints
4. evaluate multiple integrals in Cartesian, Polar, Cylindrical and Spherical coordinates.
5. understand gradient, directional derivatives, divergence, curl and Greens', Stokes, Gauss theorems
6. demonstrate MATLAB code for challenging problems in engineering

Module:1	**Application of Single Variable Calculus**	**9 hours**

Differentiation- Extrema on an Interval-Rolle's Theorem and the Mean Value Theorem-Increasing and Decreasing functions and First derivative test-Second derivative test-Maxima and Minima-Concavity. Integration-Average function value - Area between curves - Volumes of solids of revolution - Beta and Gamma functions–interrelation

Module:2	**Laplace transforms**	**7 hours**

Definition of Laplace transform-Properties-Laplace transform of periodic functions-Laplace transform of unit step function, Impulse function-Inverse Laplace transform-Convolution.

Module:3	**Multivariable Calculus**	**4 hours**

Functions of two variables-limits and continuity-partial derivatives –total differential-Jacobian and its properties.

Module:4	**Application of Multivariable Calculus**	**5 hours**

Taylor's expansion for two variables–maxima and minima–constrained maxima and minima-Lagrange's multiplier method.

Module:5	**Multiple integrals**	**8 hours**

Evaluation of double integrals–change of order of integration–change of variables between Cartesian and polar co-ordinates - Evaluation of triple integrals-change of variables between Cartesian and cylindrical and spherical co-ordinates- evaluation of multiple integrals using gamma and beta functions.

Module:6	**Vector Differentiation**	**5 hours**
Scalar and vector valued functions – gradient, tangent plane–directional derivative-divergence and curl–scalar and vector potentials–Statement of vector identities-Simple problems		
Module:7	**Vector Integration**	**5 hours**
line, surface and volume integrals - Statement of Green's, Stoke's and Gauss divergence theorems -verification and evaluation of vector integrals using them.		
Module:8	**Contemporary Issues:**	**2 hours**
Industry Expert Lecture		
	Total Lecture hours:	**45 hours**

Text Book(s)

[1] Thomas' Calculus, George B.Thomas, D.Weir and J. Hass, 13th edition, Pearson, 2014.
[2] Advanced Engineering Mathematics, Erwin Kreyszig, 10th Edition, Wiley India, 2015.

Reference Books

1. Higher Engineering Mathematics, B.S. Grewal, 43rd Edition ,Khanna Publishers, 2015
2. Higher Engineering Mathematics, John Bird, 6th Edition, Elsevier Limited, 2017.
3. Calculus: Early Transcendentals, James Stewart, 8th edition, Cengage Learning, 2017.
4. Engineering Mathematics, K.A.Stroud and Dexter J. Booth, 7th Edition, Palgrave Macmillan (2013)

Mode of Evaluation

Digital Assignments, Quiz, Continuous Assessments, Final Assessment Test

List of Challenging Experiments (Indicative)		
1.	Introduction to MATLAB through matrices, and general Syntax	2 hours
2	Plotting and visualizing curves and surfaces in MATLAB – Symbolic computations using MATLAB	2 hours
3.	Evaluating Extremum of a single variable function	2 hours
4.	Understanding integration as Area under the curve	2 hours
5.	Evaluation of Volume by Integrals (Solids of Revolution)	2 hours
6.	Evaluating maxima and minima of functions of several variables	2 hours
7.	Applying Lagrange multiplier optimization method	2 hours
8.	Evaluating Volume under surfaces	2 hours
9.	Evaluating triple integrals	2 hours
10.	Evaluating gradient, curl and divergence	2 hours
11.	Evaluating line integrals in vectors	2 hours
12.	Applying Green's theorem to real world problems	2 hours
	Total Laboratory Hours	**24 hours**

Mode of Assessment:

Weekly assessment, Final Assessment Test

Recommended by Board of Studies	12-06-2015		
Approved by Academic Council	No. 37	Date	16-06-2015

MAT2001	Statistics for Engineers	L	T	P	J	C
		3	0	2	0	4
Prerequisites	**MAT1011 – Calculus for Engineers**	**Syllabus Version**:				1.0

Course Objectives :

1. To provide students with a framework that will help them choose the appropriate descriptive methods in various data analysis situations.
2. To analyse distributions and relationship of real-time data.
3. To apply estimation and testing methods to make inference and modelling techniques for decision making.

Expected Course Outcome:

At the end of the course the student should be able to:

1. Compute and interpret descriptive statistics using numerical and graphical techniques.
2. Understand the basic concepts of random variables and find an appropriate distribution for analysing data specific to an experiment.
3. Apply statistical methods like correlation, regression analysis in analysing, interpreting experimental data.
4. Make appropriate decisions using statistical inference that is the central to experimental research.
5. Use statistical methodology and tools in reliability engineering problems.
6. demonstrate R programming for statistical data

Module: 1	Introduction to Statistics	6 hours

Introduction to statistics and data analysis-Measures of central tendency –Measures of variability-[Moments-Skewness-Kurtosis (Concepts only)].

Module: 2	Random variables	8 hours

Introduction -random variables-Probability mass Function, distribution and density functions - joint Probability distribution and joint density functions- Marginal, conditional distribution and density functions- Mathematical expectation, and its properties Covariance , moment generating function – characteristic function.

Module: 3	Correlation and regression	4 hours

Correlation and Regression – Rank Correlation- Partial and Multiple correlation- Multiple regression.

Module: 4	Probability Distributions	7 hours

Binomial and Poisson distributions – Normal distribution – Gamma distribution – Exponential distribution – Weibull distribution.

Module: 5	Hypothesis Testing I	4 hours

Testing of hypothesis – Introduction-Types of errors, critical region, procedure of testing hypothesis-Large sample tests- Z test for Single Proportion, Difference of Proportion, mean and difference of means.

Module: 6	Hypothesis Testing II	9 hours

Small sample tests- Student's t-test, F-test- chi-square test- goodness of fit - independence of attributes- Design of Experiments - Analysis of variance – one and two way classifications - CRD-RBD- LSD.

Module: 7	Reliability	5 hours

Basic concepts- Hazard function-Reliabilities of series and parallel systems- System Reliability - Maintainability-Preventive and repair maintenance- Availability.

Module: 8	**Contemporary Issues**	**2 hours**
Industry Expert Lecture		
	Total Lecture hours	**45 hours**

Text book(s)

- Probability and Statistics for engineers and scientists, R.E.Walpole, R.H.Myers, S.L.Mayers and K.Ye, 9th Edition, Pearson Education (2012).
- Applied Statistics and Probability for Engineers, Douglas C. Montgomery, George C. Runger, 6th Edition, John Wiley & Sons (2016).

Reference books

- Reliability Engineering, E.Balagurusamy, Tata McGraw Hill, Tenth reprint 2017.
- Probability and Statistics, J.L.Devore, 8th Edition, Brooks/Cole, Cengage Learning (2012).
- Probability and Statistics for Engineers, R.A.Johnson, Miller Freund's, 8th edition, Prentice Hall India (2011).
- Probability, Statistics and Reliability for Engineers and Scientists, Bilal M. Ayyub and Richard H. McCuen, 3rd edition, CRC press (2011).

Mode of Evaluation

Digital Assignments, Continuous Assessment Tests, Quiz, Final Assessment Test.

List of Experiments (Indicative)		
•	Introduction: Understanding Data types; importing/exporting data.	2 hours
•	Computing Summary Statistics /plotting and visualizing data using Tabulation and Graphical Representations.	2 hours
•	Applying correlation and simple linear regression model to real dataset; computing and interpreting the coefficient of determination.	2 hours
•	Applying multiple linear regression model to real dataset; computing and interpreting the multiple coefficient of determination.	2 hours
•	Fitting the following probability distributions: Binomial distribution	2 hours
•	Normal distribution, Poisson distribution	2 hours
•	Testing of hypothesis for One sample mean and proportion from real-time problems.	2 hours
•	Testing of hypothesis for Two sample means and proportion from real-time problems	2 hours
•	Applying the t test for independent and dependent samples	2 hours
•	Applying Chi-square test for goodness of fit test and Contingency test to real dataset	2 hours
•	Performing ANOVA for real dataset for Completely randomized design, Randomized Block design ,Latin square Design	2 hours
	Total laboratory hours	**22 hours**

Mode of Evaluation

Weekly Assessment, Final Assessment Test

Recommended by Board of Studies	25-02-2017		
Approved by Academic Council	47	Date:	05-10-2017

PHY1701	Engineering Physics	L	T	P	J	C
		3	0	2	0	4

Pre-requisite	None	Syllabus version
		V.2.1

Course Objectives:

To enable the students to understand the basics of the latest advancements in Physics viz., Quantum Mechanics, Nanotechnology, Lasers, Electro Magnetic Theory and Fiber Optics.

Expected Course Outcome: Students will be able to

1. Comprehend the dual nature of radiation and matter.
2. Compute Schrodinger's equations to solve finite and infinite potential problems.
3. Analyze quantum ideas at the nanoscale.
4. Apply quantum ideas for understanding the operation and working principle ofoptoelectronic devices.
5. Recall the Maxwell's equations in differential and integral form.
6. Design the various types of optical fibers for different Engineering applications.
7. Explain concept of Lorentz Transformation for Engineering applications.
8. Demonstrate the quantum mechanical ideas

Module:1	Introduction to Modern Physics	6 hours

Planck's concept (hypothesis), Compton Effect, Particle properties of wave: Matter Waves, Davisson Germer Experiment, Heisenberg Uncertainty Principle, Wave function, and Schrodinger equation (time dependent & independent).

Module:2	Applications of Quantum Physics	5 hours

Particle in a 1-D box (Eigen Value and Eigen Function), 3-D Analysis (Qualitative), Tunneling Effect (Qualitative) (AB 205), Scanning Tunneling Microscope (STM).

Module:3	Nanophysics	5 hours

Introduction to Nano-materials, Moore's law, Properties of Nano-materials, Quantum confinement, Quantum well, wire & dot, Carbon Nano-tubes (CNT), Applications of nanotechnology in industry.

Module:4	Laser Principles and Engineering Application	6 hours

Laser Characteristics, Spatial and Temporal Coherence, Einstein Coefficient & its significance, Population inversion, Two, three & four level systems, Pumping schemes, Threshold gain coefficient, Components of laser, Nd-YAG, He-Ne, CO2 and Dye laser and their engineering applications.

Module:5	Electromagnetic Theory and its application	6 hours

Physics of Divergence, Gradient and Curl, Qualitative understanding of surface and volume integral, Maxwell Equations (Qualitative), Wave Equation (Derivation), EM Waves, Phase velocity, Group velocity, Group index , Wave guide (Qualitative)

Module:6	Propagation of EM waves in Optical fibers and Optoelectronic Devices	10 hours

Light propagation through fibers, Acceptance angle, Numerical Aperture, Types of fibers - step

index, graded index, single mode & multimode, Attenuation, Dispersion-intermodal and intramodal. Sources-LED & Laser Diode, Detectors-Photodetectors- PN & PIN - Applications of fiber optics in communication- Endoscopy.		
Module:7	**Special Theory of Relativity**	**5 hours**
Frame of reference, Galilean relativity, Postulate of special theory of relativity, Simultaneity, length contraction and time dilation.		
Module:8	**Contemporary issues:**	**2 hours**
Lecture by Industry Experts		
	Total Lecture hours:	**45 hours**

Text Book(s)

1.	Arthur Beiser et al., Concepts of Modern Physics, 2013, Sixth Edition, Tata McGraw Hill.
2.	William Silfvast, Laser Fundamentals, 2008, Cambridge University Press.
3.	D. J. Griffith, Introduction to Electrodynamics, 2014, 4th Edition, Pearson.
4.	Djafar K. Mynbaev and Lowell L.Scheiner, Fiber Optic Communication Technology, 2011, Pearson

Reference Books

1.	Raymond A. Serway, Clement J. Mosses, Curt A. Moyer Modern Physics, 2010, 3rd Indian Edition Cengage learning.
2.	John R. Taylor, Chris D. Zafiratos and Michael A. Dubson, Modern Physics for Scientists and Engineers, 2011, PHI Learning Private Ltd.
3.	Kenneth Krane Modern Physics, 2010, Wiley Indian Edition.
4.	Nityanand Choudhary and Richa Verma, Laser Systems and Applications, 2011, PHI
5.	Learning Private Ltd.
6.	S. Nagabhushana and B. Sathyanarayana, Lasers and Optical Instrumentation, 2010, I.K. International Publishing House Pvt. Ltd.,
7.	R. Shevgaonkar, Electromagnetic Waves, 2005, 1st Edition, Tata McGraw Hill
8.	Principles of Electromagnetics, Matthew N.O. Sadiku, 2010, Fourth Edition, Oxford. Ajoy Ghatak and K. Thyagarajan, Introduction to Fiber Optics, 2010, Cambridge University Press.

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar

List of Experiments

1.	Determination of Planck's constant using electroluminescence process	2 hrs
2.	Electron diffraction	2 hrs
3.	Determination of wavelength of laser source (He -Ne laser and diode lasers of different wavelengths) using diffraction technique	2 hrs
4.	Determination of size of fine particle using laser diffraction	2 hrs
5.	Determination of the track width (periodicity) in a written CD	2 hrs
6.	Optical Fiber communication (source + optical fiber + detector)	2 hrs
7.	Analysis of crystallite size and strain in a nano -crystalline film using X-ray diffraction	2 hrs
8.	Numerical solutions of Schrödinger equation (e.g. particle in a box problem) (can be given as an assignment)	2 hrs
9.	Laser coherence length measurement	2 hrs
10.	Proof for transverse nature of E.M. waves	2 hrs
11.	Quantum confinement and Heisenberg's uncertainty principle	2 hrs
12.	Determination of angle of prism and refractive index for various colour – Spectrometer	2 hrs
13.	Determination of divergence of a laser beam	2 hrs

14.	Determination of crystalline size for nanomaterial (Computer simulation)			2 hrs
15.	Demonstration of phase velocity and group velocity (Computer simulation)			2 hrs
			Total Laboratory Hours	30 hrs
Mode of evaluation: CAT / FAT				
Recommended by Board of Studies	04-06-2019			
Approved by Academic Council	No. 55	Date	13-06-2019	