CHAITANYA BHARATHI INSTITUTE OF TECHNOLOGY

In line with AICTE Model Curriculum with effect from AY 2023-24

B.E. -Artificial Intelligence &Machine Learning

SEMESTER – III

S. No	Course Code	Title of the Course	Scheme of Instruction			Scheme of Examination			Credits
			Hours per Week			Duration ofSEE in Hours	Maximum Marks		
			L	T	P/D		CIE	SEE	
THEORY									
1	22CSC05	Data Structures	3	0	0	3	40	60	3
2	22CSC11	Database Management Systems	3	0	0	3	40	60	3
3	22CSC32	Discrete Mathematics	3	0	0	3	40	60	3
4	22MBC01	Engineering Economics & Accountancy	3	0	0	3	40	60	3
5	22ECC38	Analog & Digital Electronics	3	0	0	3	40	60	3
6	22MEC39	Design Thinking	3	0	0	3	40	60	3
PRACTICAL									
7	22CSC31	Data Structures Lab	0	0	2	3	50	50	1
8	22CSC33	Database Management Systems Lab	0	0	2	3	50	50	1
9	22MEC40	Design Thinking Lab	0	0	2	3	50	50	1
10	22AMI01	MOOCs/ Training/ Internship	0	0	4	-	-	50	2
TOTAL			**18**	**0**	**10**		**390**	**560**	**23**
Clock Hours Per Week: 28									

L: Lecture **T: Tutorial** **P: Practical**

CIE - Continuous Internal Evaluation **SEE - Semester End Examination**

22CSC05

DATA STRUCTURES
(Common to CSE-AIML, AIML)

Instruction	3 Hours per week
Duration of End Examination	3 Hours
Semester End Examination	60 Marks
Continuous Internal Evaluation	40 Marks
Credits	3

Pre-requisites: Basic knowledge of programming language such as python.

Course Objectives:
This course aims to:
1. Study various linear and non-linear data structures.
2. Understand the performance of operations on data structures.
3. Explore various searching and sorting techniques.

Course Outcomes:
Upon completion of this course, students will be able to:
1. Understand the basic concepts and types of data structures.
2. Analyze various linear and nonlinear data structures.
3. Identify the applications of linear and nonlinear data structures and significance of balanced search trees, hashing.
4. Evaluate various searching and sorting techniques.
5. Use appropriate data structures to design efficient algorithms.

Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes:

PO/PSO / CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	3	-	-	-	-	-	-	-	-	-	-	1	1	1
CO 2	3	3	-	-	-	-	-	-	-	-	-	-	1	1	1
CO 3	3	2	-	-	-	-	-	-	-	-	-	-	2	1	1
CO 4	3	2	-	-	-	-	-	-	-	-	-	-	2	2	1
CO 5	3	3	1	-	-	-	-	-	-	-	-	-	1	2	1

UNIT-I
Introduction: Data structures, Classification of data structures, Abstract Data Types, Analysis of Algorithms; **Recursion**: Examples illustrating Recursion (Factorial, Binary Search), Analyzing Recursive Algorithms; **Sorting:** Quick sort, Merge Sort, Selection Sort, Radix sort, Comparison of Sorting Algorithms.

UNIT–II
Stacks: Stack ADT, Applications of stack, Array based stack implementation**; Queues:** Queue ADT, applications of queues, Array based queue implementation, Double Ended Queues, Circular queues.

UNIT-III
Linked Lists: Introduction, Linked lists, Representation of linked list, types of linked list, singly linked lists, implementing stack with a singly linked list and Queue, Circular linked lists, doubly linked lists, Applications of linked lists.

UNIT-IV
Trees: General Trees, Binary Trees, Implementing Trees, Tree traversals; **Search Trees:** Binary Search Trees, Balanced search trees- AVL trees, B- trees; **Priority Queue and Heaps:** Priority queue ADT, Priority queue applications, Heap Trees, implementing a priority queue with a Heap, Heap Sort.

UNIT-V
Graphs: Introduction, Applications of graphs, Graph representations, graph traversals.

Hashing: Introduction, Hash Functions-Modulo, Middle of Square, Folding, Collision Resolution Techniques-Separate Chaining, Open addressing,- LinearProbing, Quadratic Probing, Double Hashing.

Text Books:

1. Michael T. Goodrich, Roberto Tamassia, Michael H. Goldwasser, "Data Structure and Algorithms in Python", Wiley, 2021.
2. Narasimha karumanchi, "Data Structures and Algorithms Made Easy", Career Monk Publications, 2020
3. S. Sahni and Susan Anderson-Freed, "Fundamentals of Data structures in C", E. Horowitz, Universities Press, 2nd Edition, .
4. Reema Thareja, "Data Structures using C", Oxford University Press, 2nd Edition, 2014.

Suggested Reading:

1. D. S. Kushwaha and A K. Misra, "Data structures A Programming Approach with C", PHI, 2nd edition, 2014.
2. Seymour Lipschutz, "Data Structures with C", Schaums Outlines, MGH, Kindle Edition, 2017.
3. Kenneth A. Lambert, " Fundamentals of Python: Data Structures", Cengage Learning, 2018
4. D. Samantha, "Classic Data Structures", Prentice Hall India, 2nd Edition, 2013

Online Resources:

1. https://www.tutorialspoint.com/data_structures_algorithms/index.htm
2. https://www.edx.org/course/foundations-of-data-structures
3. https://sites.google.com/site/merasemester/data-structures/data-structures-#DS
4. https://www.cs.usfca.edu/~galles/visualization/Algorithms
5. https://www.coursera.org/specializations/data-structures-algorithms

22CSC11

DATA BASE MANAGEMENT SYSTEMS

Instruction	3 Hours per week
Duration of End Examination	3 Hours
Semester End Examination	60 Marks
Continuous Internal Evaluation	40 Marks
Credits	3

Pre-requisites: Discrete mathematics of computer science, Programming and Data Structures.

Course Objectives:
This course aims to:
1. Familiarize students with fundamental concepts of database management. These concepts include aspects of database design, database languages and database-system implementation.
2. Understand about data storage techniques and indexing.
3. Impart knowledge in transaction management, concurrency control techniques and recovery procedures.

Course Outcomes:
Upon completion of this course, students will be able to:
1. Design database schema for an application using RDBMS concepts.
2. Write SQL queries for tasks of various complexities.
3. Build applications using database system as backend.
4. Understand internal working of a DBMS including data storage, indexing, query processing, transaction processing, concurrency control and recovery mechanisms.
5. Analyze non-relational and parallel/distributed data management systems with a focus on scalability.

Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes:

PO/PSO / CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	2	2	2	2	3	-	-	-	-	-	-	1	1	1	1
CO 2	2	3	2	2	3	-	-	-	-	-	-	1	1	1	1
CO 3	2	1	2	1	3	-	-	-	-	-	-	-	2	2	2
CO 4	2	1	1	-	-	-	-	-	-	-	-	-	2	2	2
CO 5	2	1	-	1	-	-	-	-	-	-	-	-	2	2	1

UNIT - I
Introduction: Motivation, Introduction to Data Models (Relational, Semi structured, ER).
Relational Data Bases: Relational Data Model, Relational Algebra, Relational Calculus.

UNIT - II
SQL + Interaction with Database: SQL Data Types, Basic Structure of SQL Queries, Modification of the Database, Set Operations, Aggregate Functions, Data-Definition Language, Integrity Constraints, Null Values, Views, Join Expression. Index Definition in SQL.
Simple Queries (select/project/join/ aggregate queries), Complex queries (With Clause, Nested Subqueries, Views), Programming in a standard language and interfacing with a DB backend.

UNIT- III
Big Data: Key-value Stores and Semi structured Data, using JSON and MongoDB, or other combinations
Database Design: Introduction to ER model, Mapping from ER to relational model, Functional Dependencies, Normalization.

UNIT - IV
Physical Design: Overview of Physical Storage (Hard Disks, Flash/SSD/RAM), sequential vs random I/O, Reliability via RAID, Storage Organization (Records, Pages and Files), Database Buffers, Database Metadata, Indexing, B+-Trees.

UNIT - V

Query Processing and Optimization: Query Processing, External sort, Joins using nested loops, indexed nested loops.

Overview of Query Optimization: Equivalent expressions and concept of cost based optimization.

Transaction Processing: Concept of transactions and schedules, ACID properties, Conflict-serializability, C**oncurrency control:** locks, 2PL, Strict 2PL, optional: isolation levels, Recovery using undo and redo logs.

Text Books:

1. Silberschatz, Korth and Sudarshan, "Database System Concepts", 7th Edition, McGraw-Hill. Indian Edition, 2021
2. Elmasri and Navathe, "Fundamentals of Database Systems", 7th Edition, Pearson Pubs, 2017
3. Lemahieu, Broucke and Baesens, "Principles of Database Management", Cambridge University Press, 2018
4. RP Mahapatra, "Database Management Systems", Khanna Publishing House, 2020.
5. Krishnan, "Database Management Systems", McGraw Hill.

Suggested Reading:

1. MySQL Explained: Your Step By Step Guide To Database Design
2. Pro SQL Server 2008 Relational Database Design and Implementation (Expert's Voice in SQL Server) 1st Edition

Online Resources:

1. http://www.nptelvideos.in/2012/11/database-managementsystem.html.
2. https://www.oracle.com/news/connect/json-database-semistructured-sql.html

22CSC32

DISCRETE MATHEMATICS

Instruction	3 Hours per week
Duration of End Examination	3 Hours
Semester End Examination	60 Marks
Continuous Internal Evaluation	40 Marks
Credits	3

Course Objectives:
This course aims to:

1. Introduce Propositional and Predicate Logic
2. Introduce various proof techniques for validation of arguments.
3. Develop an understanding of counting, functions and relations.
4. Familiarize with fundamental notions and applicability of graph theory and algebraic systems

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

1. Describe rules of inference for Propositional and Predicate logic.
2. Demonstrate use of Set Theory, Venn Diagrams, and relations in Real-world scenarios.
3. Model solutions using Generating Functions and Recurrence Relations.
4. Determine the properties of graphs and trees to solve problems arising in computer science applications.
5. Distinguish between groups, semi groups and monoids in algebraic systems

Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes:

PO/PSO / CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	3	2	3	1	-	-	-	-	2	-	-	2	1	2
CO 2	3	3	1	3	-	-	-	-	-	-	-	1	1	1	1
CO 3	2	3	1	3	1	-	-	-	-	-	-	-	2	1	2
CO 4	3	3	2	3	1	-	-	-	-	-	-	1	2	2	2
CO 5	3	3	1	1	-	-	-	-	-	-	-	-	1	1	1

UNIT – I
Introduction to Propositional Calculus: Basic Connectives and Truth tables, Logical Equivalence: Laws of Logic, Logical Implication; Rules of Inference. Predicates: The Use of Quantifiers, Quantifiers, Definitions and the Proofs of Theorems

UNIT – II
Sets: Sets and Subsets, Operations on sets and the Laws of Set Theory, Counting and Venn Diagrams. **Relations**: Cartesian Products and Relations. Partial ordering relations, POSET, Hasse diagrams, Lattices as Partially Ordered Sets, Equivalence relations. Pigeon hole principle.

UNIT – III
Generating Functions: Generating Functions, Calculating Coefficient of generating functions.
Recurrence Relations: The First Order Linear Recurrence Relation, Second Order Linear. Homogeneous Recurrence relations with constant coefficients, Non Homogeneous Recurrence relations.

UNIT – IV
Introduction to Graphs: Graphs and their basic properties- degree, path, cycle, Sub graphs, Complements and Graph Isomorphism, Euler trails and circuits, Hamiltonian paths and cycles, planar graphs, Euler formula, Graph Coloring.
Trees: Definitions, Properties, Spanning Trees, Minimum Spanning trees: The Algorithms of Kruskal and Prims

UNIT - V
Algebraic Structures: Algebraic Systems, Examples and General Properties, Semi groups and Monoids. Groups:

Definitions and Examples, Subgroups, Homomorphisms and cyclic groups.

Text Books:

1. Ralph P. Grimaldi, "Discrete and Combinatorial Mathematics- An Applied Introduction", 5th Edition, Pearson Education, 2016.
2. Rosen, K. H. (2019). Discrete Mathematics and Its Applications. (8th Edition) ISBN10: 125967651X ISBN13: 9781259676512.
3. J. P. Tremblay, R. Manohar, "Discrete Mathematical Structures with Applications to Computer Science", TATA Mc Graw-Hill Edition, 1995.

Suggested Reading:

1. Singh, S.B., Discrete Mathematics, Khanna Book Publishing Company, New Delhi. SBN: 9789382609407, 9789382609407, 3rd Edition, 2019
2. R. K. Bisht, H. S. Dhami, "Discrete Mathematics", Oxford University Press, Published in 2015.
3. David D. Railey, Kenny A. Hunt, "Computational Thinking for the Modern Problem Solving", CRC Press, 2014
4. Joe L. Mott, Abraham Kandel, Theodore P. Baker, "Discrete Mathematics for Computer Scientists & Mathematicians", 8th Edition, PHI, 1986

Online Resources:

1. https://nptel.ac.in/courses/111107058/
2. https://nptel-discrete-mathematics-5217

22MBC01

ENGINEERING ECONOMICS AND ACCOUNTANCY

Instruction	3 Hours per week
Duration of End Examination	3 Hours
Semester End Examination	60 Marks
Continuous Internal Evaluation	40 Marks
Credits	3

Course Objectives:

This course aims to:

1. To demonstrate the importance of Managerial Economics in Decision Making.
2. To explain the concept of Accountancy and provide basic knowledge on preparation of Final accounts.
3. To understand the importance of Project Evaluation in achieving a firm's Objective.

Course Outcomes:

Upon completion of this Course, student will be able to:

1. Apply fundamental knowledge of Managerial Economics concepts and tools.
2. Analyze various aspects of Demand Analysis, Supply and Demand Forecasting.
3. Understand Production and Cost relationships to make best use of resources available.
4. Apply Accountancy Concepts and Conventions and preparation of Final Accounts.
5. Evaluate Capital and Capital Budgeting decision based on any technique.

Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes:

PO/PSO / CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	1	1	3	1	1	1	1	1	1	1	-	-	1	1	-
CO 2	2	2	2	2	-	1	1	1	-	1	-	1	1	1	-
CO 3	1	2	1	2	2	-	2	1	-	1	-	-	-	1	1
CO 4	2	2	1	2	2	1	1	3	-	1	-	-	-	-	1
CO 5	1	3	1	2	1	1	2	-	-	1	2	1	1	1	1

UNIT-I

Introduction to Managerial Economics: Introduction to Economics and its evolution - Managerial Economics - its Nature and Scope, Importance; Relationship with other Subjects. Its usefulness to Engineers; Basic concepts of Managerial economics - Incremental, Time perspective, Discounting Principle, Opportunity Cost, Equimarginal Principle, Contribution, Negotiation Principle.

UNIT-II

Demand and Supply Analysis: Demand Analysis - Concept of Demand, Determinants, Law of demand - Assumptions and Exceptions; Elasticity of demand - Price, Income and Cross elasticity - simple numerical problems; Concept of Supply - Determinants of Supply, Law of Supply; Demand Forecasting - Methods.

UNIT-III

Production and Cost Analysis: Theory of Production - Production function - Isoquants and Isocosts, MRTS, Input-Output Relations; Laws of returns.

Cost Analysis: Cost concepts – Types of Costs, Cost-Output Relationship – Short Run and Long Run; Market structures – Types of Competition, Features of Perfect Competition, Price Output Determination under Perfect Competition, Features of Monopoly Competition, Price Output Determination under Monopoly Competition Break-even Analysis – Concepts, Assumptions, Limitations, Numerical problems.

Unit-IV

Accountancy: Book-keeping, Principles and Significance of Double Entry Bookkeeping, Accounting Concepts and Conventions, Accounting Cycle, Journalization, Ledger accounts, Trial Balance concept and preparation of Final Accounts with simple adjustments.

Unit-V Capital and Capital Budgeting: Capital and its Significance, Types of Capital, Estimation of Fixed and Working capital requirements, Methods and sources of raising finance. Capital Budgeting, Methods: Traditional and Discounted Cash Flow Methods - Numerical problems.

Text Books:

1. Mehta P.L.,"Managerial Economics: Analysis, Problems and Cases", Sultan Chand & Son's Educational publishers, 2016.
2. Maheswari S.N. "Introduction to Accountancy", Vikas Publishing House, 12th Edition, 2018.

Suggested Readings:

1. Panday I.M. "Financial Management", 11th edition, VikasPublishing House, 2016.
2. Varshney and K L Maheswari, Managerial Economics, Sultan Chand, 2014.
3. M. Kasi Reddy and S. Saraswathi, Managerial Economics and Financial Accounting, Prentice Hall of India Pvt Ltd, 2007.
4. A R. Aryasri, Managerial Economics and Financial Analysis, McGraw-Hill, 2018.

22ECC38

ANALOG AND DIGITAL ELECTRONICS

Instruction	3 Hours per week
Duration of End Examination	3 Hours
Semester End Examination	60 Marks
Continuous Internal Evaluation	40 Marks
Credits	3

Prerequisite: Knowledge of Electronic device concepts.

Course Objectives: **This course aims to:**

1. Learn basic concepts and working principles of analog devices.
2. Learn various techniques for logic minimization.
3. Comprehend the concepts of various combinational circuits and sequential circuits.

Course Outcomes:

Upon completion of this course, students will be able to:

1. Understand the basic concepts related analog devices and digital circuits.
2. Design the combinational and sequential circuits.
3. Examine the behavior of logic gates.
4. Analyze the behavior of the digital system design.
5. Evaluate the performance of real time combinational circuits and sequential circuits.

Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes:

PO/ PSO CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	2	1	1	3	1	1	1	2	1	2	2	1	-	-
CO2	2	3	3	3	3	-	1	1	3	1	1	2	2	1	1
CO3	1	2	1	1	1	-	1	1	-	-	2	2	1	1	-
CO4	1	3	1	2	1	-	-	1	1	1	2	2	1	1	1
CO5	2	1	2	1	2	-	1	1	1	-	2	2	1	1	1

UNIT -I

Devices: Concepts of semiconductors, V-I Characteristics of P-N Junction diode, current equation. Characteristics of Zener Diodes, Special diodes: LED, Photo Diode.

Applications: Zener Diode as a voltage regulator, Half Wave Rectifier and Full Wave Rectifier.

UNIT-II

Bipolar Junction Transistors: Classification, Operation of Bipolar Junction Transistor, Configurations: CB, CE Characteristics, Applications.

Field Effect Transistor: Junction Field Effect Transistor: Principle of Operation, Characteristics of JFET, parameters and Operation of MOSFET

UNIT-III

Boolean Algebra and Logic Simplification: Number system representation and conversion, Binary Arithmetic, Complements, Review of Boolean Algebra and De Morgan's Theorem, SOP & POS forms, Canonical forms, Introduction to all Logic Gates, Minimization of Switching Functions: Karnaugh map method, Logic function realization: AND-OR, OR-AND and NAND/NOR realizations.

UNIT-IV

Introduction to Combinational Design: Binary Adders, Subtractors, Code converters Binary to Gray, Gray to Binary, BCD to excess3, BCD to Seven Segment display, Decoders, Encoders, Priority Encoders, Multiplexers, Demultiplexers.

UNIT-V

Sequential Logic Design: Latches, Flipflops, Difference between latch and flipflop, types of flipflops like S-R, D, T JK and Master-Slave JK FF, flipflop conversions, Ripple and Synchronous counters, Shift registers.

Text Books:

1. Robert L.Boylestad, Louis Nashelsky, "Electronic Devices and Circuits Theory", Pearson Education, 9th Edition, LPE, Reprinted, 2006.
2. Morris Mano M. and Michael D.Ciletti, "Digital Design, With an Introduction to Verilog HDL", 5th Edition, Pearson 2013.

Suggested Reading:

1. R.P. Jain, "Modern digital Electronics", Tata McGraw Hill, 4th Edition, 2009.
2. Thomas L. Floyd, "Digital Fundamentals", Pearson, 11th Edition, 2015.

22MEC39

DESIGN THINKING

Instruction	3 Hours per week
Duration of End Examination	3 Hours
Semester End Examination	60 Marks
Continuous Internal Evaluation	40 Marks
Credits	3

Objectives:

1. Create awareness of design thinking approaches
2. Identify a systematic approach for defining/identifying a problem
3. Create design thinking teams and conduct design thinking sessions collaboratively
4. Apply both critical thinking and design thinking in parallel to solve problems
5. Motivate to apply design thinking concepts to their real life scenarios

Outcomes: Upon completion of this course, the students are able to

1. Understand design thinking and its phases as a tool of innovation
2. Empathize on the needs of the users
3. Define the problems for stimulating ideation
4. Ideate on problems to propose solutions by working as a design thinking team
5. Prototype and test the proposed solutions focusing on local or global societal problems

Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes:

PO/PSO / CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	2	1	2	2	2	2	2	2	2	2	2	2	2	1	2
CO 2	2	2	1	2	1	3	2	2	1	2	1	2	1	2	2
CO 3	2	2	2	2	1	2	2	1	2	2	1	2	2	2	2
CO 4	2	1	1	2	1	2	2	2	2	2	1	2	2	2	2
CO 5	2	1	2	2	2	2	2	1	2	2	2	2	2	2	2

UNIT – I

Introduction to Engineering & Thinking: Engineering for social and economic development; impact of science/engineering. Thinking and behaviour; Types of thinking – Linear thinking, lateral thinking, systems thinking, design thinking.

Introduction to Design Thinking: Importance of Design Thinking & Human centric approach – Phases in design thinking process, five-stage model as iterative method, applications of design thinking in various domains.

UNIT – II

Empathize phase: Understanding the unique needs of the user, empathize with the users, steps in empathize phase, developing empathy towards people, assuming a beginner's mind-set (what? why?), steps in immersion activity, body storming; Case studies.

UNIT – III

Define phase: Define the problem and interpret the result, analysis and synthesis, Personas – Four different perspectives on Personas, steps to creating personas, problem statement, affinity diagrams, empathy mapping; Point of View – "How might we" questions, Why-how laddering; Case studies.

UNIT – IV

Ideation phase: What is ideation, need, uses, ideation methods; Brainstorming, rules for brainstorming; Mind maps, guidelines to create mind maps; Ideation games; Six Thinking Hats; Doodling, use of doodling in expressing creative ideas; Case studies.

UNIT – V

Prototyping phase: Types of prototyping, guidelines for prototyping, storytelling, characteristics of good stories, reaching users through stories, importance of prototyping in design thinking; Value proposition, guidelines to write value proposition; Case studies.

Testing phase: Necessity to test, user feedback, conducting a user test, guidelines for planning a test, how to test, desirable, feasible and viable solutions, iterate phase.

Text Books:

1. Tim Brown, Change by Design: How Design Thinking Transforms Organizations and Inspires, 1st Edition, HarperCollins, 2009.
2. Michael Luchs, Scott Swan, Abbie Griffin, Design thinking: New product development essentials from the PDMA. John Wiley & Sons, 2015.
3. Pavan Soni, Design Your Thinking: The Mindsets, Toolsets and Skill Sets for Creative Problem-solving, Penguin Random House India Private Limited, 2020.
4.

Suggested Reading:

1. Jeanne Liedtka, Andrew King, Kevin Bennett, Solving problems with design thinking: Ten stories of what works. Columbia University Press, 2013.
2. Bala Ramadurai, Karmic Design Thinking - A Buddhism-Inspired Method to Help Create Human-Centered Products & Services, Edition 1, 2020.

22CSC31

DATA STRUCTURES LAB

Instruction	2 Hours per week
Duration of End Examination	2 Hours
Semester End Examination	50 Marks
Continuous Internal Evaluation	50 Marks
Credits	1

Pre-requisites: Any Programming Language.

Course Objectives:

This course aims to:

1. Understand the basic concepts of data structures and abstract data types.
2. Explore linear and non-linear data structures.
3. Study various searching, sorting and hashing techniques.

Course Outcomes:

Upon completion of this course, students will be able to:

1. Implement the abstract data type.
2. Implement linear and non-linear data structures.
3. Evaluate various sorting techniques.
4. Analyze various algorithms of linear and nonlinear data structures.
5. Choose or create appropriate data structures to solve real world problems.

Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes:

PO/PSO / CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	2	2	-	-	-	-	-	-	-	-	-	-	1	1	1
CO 2	3	3	-	-	-	-	-	-	-	-	-	-	1	1	1
CO 3	2	3	-	-	-	-	-	-	-	-	-	-	2	1	1
CO 4	2	3	-	-	-	-	-	-	-	-	-	-	2	2	1
CO 5	2	3	1	-	-	-	-	-	-	-	-	-	1	2	1

List of Experiments

1. Implementation of Quick sort, Merge sort and Selection sort.
2. Implementing Stack using array.
3. Conversion of Infix expression to Postfix expression.
4. Implement the algorithm for Evaluation of Postfix.
5. Implementing Queues using array
6. Implementation of Insert, Delete and Display operations on Single Linked List.
7. Implementation of Stack and Queue using linked list.
8. Implementation of Insert, Delete and Display operations on doubly Linked List.
9. Implementation of Binary Search Tree operations.
10. Implementation of Heap Sort.

Text Books:

1. Michael T. Goodrich, Roberto Tamassia, Michael H. Goldwasser, “Data Structure and Algorithms in Python”, Wiley, 2021.
2. Narasimha karumanchi, “Data Structures and Algorithms Made Easy”, Career Monk Publications, 2020.

22CSC33

DATA BASE MANAGEMENT SYSTEMS LAB

Instruction	2 Hours per week
Duration of End Examination	3 Hours
Semester End Examination	50 Marks
Continuous Internal Evaluation	50 Marks
Credits	1

Course Objectives:

This course aims to:

1. Become familiar with the concepts of structured query language.
2. Understand about programming language / structured query language (PL/SQL).
3. Become familiar with generation of form and open database connectivity.
4. Add constraints on Databases implement DCL, TCL and advanced SQL commands.
5. Develop programs using cursors, triggers, exceptions, procedures and functions in PL/SQL.

Course Outcomes:

Upon completion of this course, students will be able to:

1. Outline the built-in functions of SQL and apply these functions to write simple and complex queries usingSQL operators.
2. Demonstrate Queries to Retrieve and Change Data using Select, Insert, Delete and Update. ConstructQueries using Group By, Order By and Having Clauses.
3. Demonstrate Commit, Rollback, Save point commands, SQL Plus Reports and formulate the Queries forCreating, Dropping and Altering Tables, Views, constraints.
4. Develop queries using Joins, Sub-Queries and Working with Index, Sequence, Synonym, Controlling Access and Locking Rows for Update, Creating Password and Security features.
5. Develop PL/SQL code using Cursors, Exception, Composite Data Types and Procedures, Functions andPackages.

Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes:

PO/PSO / CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	2	2	2	3	-	-	-	2	-	1	3	1	1	1
CO 2	3	3	2	3	3	-	-	-	2	-	1	3	1	1	2
CO 3	3	2	2	2	3	-	-	-	2	-	1	1	2	1	1
CO 4	3	1	1	1	-	-	-	-	2	-	1	-	2	2	2
CO 5	3	1	-	1	-	-	-	-	1	-	1	-	2	2	1

List of Experiments

SQL:

1. Queries using Built-In functions, like aggregate functions, String Functions, Numeric Functions, DataFunctions, Conversion Functions and other miscellaneous.
2. Queries using operators in SQL.
3. Queries to Retrieve and Change Data: Select Insert, Delete and Update.
4. Queries using Group By, Order By and Having Clauses.
5. Queries on Controlling Data: Commit, Rollback and Save point.
6. Queries to Build Report in SQL *PLUS.
7. Queries for Creating, Dropping and Altering Tables, Views and Constraints.
8. Queries on Joins and Correlated Sub-Queries.
9. Queries on Working with Index, Sequence, Synonym, Controlling Access and Locking Rows for Update,
10. Creating Password and Security features.
11. Querying in NoSql

PL/SQL:

1. Write a PL/SQL code using Basic Variable, Anchored Declarations and Usage of Assignment Operation.
2. Write a PL/SQL code Bind and Substitution Variables, Printing in PL/SQL.
3. Write a PL/SQL block using SQL and Control Structures in PL/SQL.
4. Write a PL/SQL code using Cursors, Exception and Composite Data Types.
5. Write a PL/SQL code using Procedures, Functions and Packages.

Note: The creation of sample database for the purpose of the experiments is expected to be pre-decided by the instructor.

Text Books / Suggested Reading:

1. "Oracle: The complete Reference", by Oracle Press.
2. Nilesh Shah, "Database Systems Using Oracle", PHI, 2007.
3. Rick F Vander Lans, "Introduction to SQL", Fourth Edition, Pearson Education, 2007.

22MEC40

DESIGN THINKING LAB

Instruction	2 Hours per week
Duration of End Examination	2 Hours
Semester End Examination	50 Marks
Continuous Internal Evaluation	50 Marks
Credits	1

Objectives:

1. Create awareness of design thinking approaches
2. Identify a systematic approach for defining/identifying a problem
3. Create design thinking teams and conduct design thinking sessions collaboratively
4. Apply both critical thinking and design thinking in parallel to solve problems
5. Motivate to apply design thinking concepts to their real life scenarios

Outcomes: Upon completion of this course, the students are able to

1. Understand the key principles of design thinking and apply in problem solving.
2. Empathize on the needs of the customers and use human centric approach in developing solutions.
3. Develop and apply customer journey maps for proposing innovative solutions.
4. Ideate on problems to propose solutions by working in collaboration.
5. Test the proposed solutions by focusing on local or global societal problems through prototyping.

Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes:

PO/PSO / CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2
CO 2	1	1	2	1	2	2	2	2	1	2	2	2	2	2	2
CO 3	1	1	2	2	1	2	2	2	1	2	2	1	2	2	2
CO 4	2	1	2	2	1	2	2	2	1	2	2	2	2	2	2
CO 5	2	1	2	2	1	2	2	2	1	2	2	2	2	2	2

List of Experiments:

1. Innovation exercises for thinking outside the box.
2. Creating a persona step by step for guiding design thinking process.
3. Creating customer Journey Maps
4. How might we …? Exercise.
5. Exercise on Ideation Matrix – creative matrix.
6. Creating Idea Napkin.
7. Six Thinking Hats.
8. Testing the concepts using prototypes.
9. Advanced exercises in 3D printing.
10. Open ended exercise: Proposing innovative solutions to simple problems related to a product /service.

Text Books:

1. Tim Brown, Change by Design: How Design Thinking Transforms Organizations and Inspires, 1st Edition, HarperCollins, 2009.
2. Pavan Soni, Design Your Thinking: The Mindsets, Toolsets and Skill Sets for Creative Problem-solving, Penguin Random House India Private Limited, 2020.
3. Christian Müller-Roterberg Hochschule Ruhr West, Handbook of Design Thinking, Kindle Direct Publishing ISBN: 978-1790435371, November 2018

Suggested Reading:

3. Jeanne Liedtka, Andrew King, Kevin Bennett, Solving problems with design thinking: Ten stories of what works. Columbia University Press, 2013.
4. Bala Ramadurai, Karmic Design Thinking - A Buddhism-Inspired Method to Help Create Human-Centered Products & Services, Edition 1, 2020.

22AMI01

INTERNSHIP-I
(MOOCs/Training/Internship)

Instruction	90 hours
Continuous Internal Evaluation	50 Marks
Credits	2

Course Objectives:
This course aims to:

1. Exposing the students to the industrial environment and technologies
2. Provide possible opportunities to learn, make them to understand and sharpen them to the real time technical/ managerial skills required at the job
3. Expose with the current technological developments relevant to program domain
4. Understand Engineer's responsibilities and ethics and provide opportunity to interact with the people of industry/society to understand the real conditions.

Course Outcomes:
Upon completion of this course, student will be able to:

1. Learn new technologies and solve real time projects.
2. Expose to the industrial environment problems and technologies
3. Gain knowledge on contemporary technologies industrial requirements.
4. Identify , Design and Develop solutions for real world problems
5. Communicate their ideas and learning experiences through reports and presentation.

Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes:

PO/PSO CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	3	3	3	2	2	1	1	3	2	3	3	3	2	3
CO 2	2	2	2	1	1	2	2	1	3	2	3	3	3	2	3
CO 3	3	2	1	1	1	2	2	1	2	2	3	3	3	2	2
CO 4	2	3	3	3	1	2	1	-	3	3	3	3	3	2	3
CO 5	1	1	1	1	1	1	-	-	2	3	3	3	2	2	3

Process to be followed for carrying out Instructions to Students:

1. Students may apply for internships through the AICTE Portal or through CDC of the institute by filling the application form IAP-101.
2. Industry shall scrutinize the students based on their criteria and communicate a provisional offer or confirmation letter to the student.
3. If students apply through CDC, then CDC shall nominate the students for various opportunities accordingly by issuing NOC (IAP-104).
4. The respective head of the department shall assign a faculty mentor.
5. Student shall undergo internship/industrial training at the concerned Industry/Organization by submitting the form, IAP-103.
6. During the internship, Faculty Mentor will evaluate the performance of students twice either by visiting the Industry/Organization or through obtaining periodic reports from students.
7. Student shall submit internship report to the industry/organization at the end of internship program.
8. On successful completion of the Internship, Industry/Organization shall issue Internship Certificate to the students
9. All the students should maintain discipline, professional ethics and follow the health and safety precautions during internship
10. Students should get approval for MOOCS and Training Programs and same evaluation process will be followed

Student shall maintain diary during the internship and submit the internship report at the end of the internship. The report will be evaluated by the supervisor on the basis of the following criteria:

- Originality
- Adequacy and purposeful write-up
- Organization, format, drawings, sketches, style, language etc.
- Variety and relevance of learning experience
- Practical applications, relationships with basic theory and concepts taught in the course

Evaluation of Internship: The internship of the students will be evaluated in three stages:

a. Evaluation by the Industry (in the scale of 1 to **10** where 1-Unsatisfactory; 10-Excellent)
b. Evaluation by faculty Mentor on the basis of site visit(s) or periodic communication (**15** marks)
c. Evaluation through seminar presentation/Viva-Voce at the Institute(This can be reflected through marks assigned by Faculty Mentor (**25 marks**)

For further details regarding templates, assessment guidelines please refer to the document from page number 16 onwards available at: https://www.cbit.ac.in/wp-content/uploads/2019/04/R22-Rules-with-internship-guidelines-10-11-2022..pdf

CHAITANYA BHARATHI INSTITUTE OF TECHNOLOGY

In line with AICTE Model Curriculum with effect from AY 2023-24

B.E.-Artificial Intelligence &Machine Learning

SEMESTER – IV

S. No	Course Code	Title of the Course	Scheme of Instruction			Scheme of Examination			Credits
			Hours per Week			Duration of SEE in Hours	Maximum Marks		
			L	T	P/D		CIE	SEE	
THEORY									
1	22AMC01	Computer Architecture and Microprocessor	3	0	0	3	40	60	3
2	22AMC02	Principles of Artificial Intelligence	3	0	0	3	40	60	3
3	22AMC03	Introduction to Machine Learning	3	0	0	3	40	60	3
4	22AMC08	Agile Software Development	3	0	0	3	40	60	3
5	22CSC15	Operating Systems	3	0	0	3	40	60	3
6	22MTC13	Mathematical Foundation for Data Science & Security	3	0	0	3	40	60	3
PRACTICAL									
7	22AMC04	Principles of Artificial Intelligence Lab	0	0	3	3	50	50	1.5
8	22AMC05	Introduction to Machine Learning Lab	0	0	3	3	50	50	1.5
9	22AMC09	Principles of Operating Systems Lab	0	0	2	3	50	50	1
10	22MTC14	Mathematical Foundation for Data Science & Security Lab	0	0	2	3	50	50	1
TOTAL			**18**	**0**	**10**		**440**	**560**	**23**
Clock Hours Per Week: 28									

L: Lecture **T: Tutorial** **P: Practical**

CIE - Continuous Internal Evaluation **SEE - Semester End Examination**

22AMC01

COMPUTER ARCHITECTURE AND MICROPROCESSOR

Instruction	3 Hours per week
Duration of End Examination	3 Hours
Semester End Examination	60 Marks
Continuous Internal Evaluation	40 Marks
Credits	3

Pre-requisites: Analog and digital circuits.

Course Objectives: The objectives of this course are

1. To understand the basic principles of Instruction Level Architecture and Instruction Execution, MemorySystem Design.
2. To learn various I/O devices and its operations, knowledge on Instruction Level Parallelism.
3. To impart the knowledge on Micro Programming and Pipelining techniques.

Course Outcomes: Upon completion of this course, student will be able to

1. Understand the functional block diagram of single bus architecture of a computer, and the process of performing arithmetic operations.
2. Comprehend the 8086 microprocessor architecture.
3. Design assembly language programs using 8086 instruction set.
4. Analyze memory transfer operations and performance enhancement using pipelining,
5. Interpret the working of memory system and Large computer systems.

Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes:

PO/PSO / CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	2	1	-	1	-	-	-	-	-	2	1	-	-	-	-
CO2	2	1	1	2	3	-	-	-	3	1	2	-	-	-	-
CO3	1	2	-	1	-	-	-	-	-	2	-	1	-	-	1
CO4	-	2	2	1	-	-	-	-	3	1	-	1	1	-	2
CO5	-	3	2	1	1	-	-	-	-	1	-	1	-	-	2

UNIT - I

Basic Structure of Computers: Computer Types, Functional Units, Basic Operational Concepts, Bus Structures, Software, Performance, Multiprocessors and Multi-computers.

Arithmetic: Addition and Subtraction of Signed numbers, Design of fast adders, Multiplication of positive numbers, Signed-Operand Multiplication, Integer Division.

UNIT - II

Basic Processing Unit: Fundamental concepts, Execution of a complete instruction, Multiple-Bus organization, Hardwired control, Microprogrammed control.

8086 Architecture: CPU Architecture, Internal operation, Machine language instructions, Addressing modes.

UNIT- III

Assembly Language Programming: Instruction format, Instruction execution timing. Data transfer instructions, Arithmetic instructions.

Branch instructions, Loop instructions, NOP and HLT, Flag manipulation instructions, Logical instructions, Shift and Rotate instructions, Directives and Operators. Procedures, Interrupts and Interrupt routines, Macros .

UNIT - IV

Peripheral devices and their characteristics: Input-output subsystems, I/O deviceinterface,I/Otransfers– ProgramControlled,Interrupt Driven and DMA, privileged and non-privileged instructions, software interrupts and exceptions. Programs and processes – role of interrupts in process state transitions, I/O device interfaces– SCSI,USB.

Pipelining: Basic concepts, Data hazards, Instruction hazards, Structural hazard. Influence on instruction sets, Data path and control considerations.

UNIT – V

The Memory System: Memory hierarchy, Semiconductor RAM Memories, Cache Memories, Performance considerations, Virtual Memories, Memory Management requirements, Secondary Storage.

Large Computer Systems: Forms of Parallel Processing, Array Processors, Structure of general-purpose multiprocessors, Program parallelism and shared variables.

Text Books:

1. Carl Hamacher, ZvonkoVranesic, SafwatZaky, "Computer Organization",5thEdition, McGraw HillEducation Edition2011.
2. Yu-chengLiu, Glenn A.Gibson, "Microcomputer Systems: The 8086/ 8088 Family", 2nd Edition, PHILearning 2011.

Suggested Reading:

1. M. M. Mano, "Computer System Architecture", 3rd edition, Prentice Hall,1994.
2. William Stallings, "Computer Organisation and Architecture, Design for Performance", Pearson, 9th Edition, 2013.
3. Douglas Hall. "Microprocessor and Interfacing programming and Hardware", Tata McGraw Hill, Revised2nd Edition, 2007.
4. Brey B. Brey, "The Intel Microprocessor, 8086/8088, 80186/80188, 80286, 80386, 80486, Pentium and PentiumPro-Processors-Architecture, Programming and Interfacing", 4thEdition, Prentice Hall.

22AMC02

PRINCIPLES OF ARTIFICIAL INTELLIGENCE

Instruction	3 Hours per week
Duration of End Examination	3 Hours
Semester End Examination	60 Marks
Continuous Internal Evaluation	40 Marks
Credits	3

Pre-requisites: Data structures, Discrete Mathematics, Probability Theory.

Course Objectives: The objectives of this course are
1. To list the significance of AI.
2. To discuss the various components that is involved in solving an AI problem.
3. To analyze the various knowledge representation schemes, reasoning and learning techniques of AI.

Course Outcomes: Upon completion of this course, students will be able to
1. Explain the role of agents and interaction with the environment to establish goals.
2. Identify and formulate search strategies to solve problems by applying suitable search strategy.
3. Compare and contrast the various knowledge representation schemes of AI.
4. Appraise probabilistic reasoning and model building
5. Apply Markov decision Process to solve real world Problems.

Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes:

PO/PSO / CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO3
CO 1	2	3	2	2	2	2	1	1	1	1	1	3	3	1	3
CO 2	3	3	2	2	2	2	2	2	1	2	1	3	3	1	3
CO 3	3	3	2	1	2	2	1	-	1	1	-	3	2	3	2
CO 4	3	3	3	3	2	2	2	2	2	2	2	3	3	2	3
CO 5	3	3	3	3	2	3	1	1	1	2	2	3	3	2	3

UNIT - I

Introduction: Foundations of AI, History, State of the Art, Risks and Benefits.
Intelligent agents: Agents and Environment, The Concept of Rationality, Structure of an Agent.
Solving problems by Search- Problem-Solving Agents, State space representation, Search graph and Search tree Searching for Solutions,

UNIT - II

Uninformed Search Strategies: Uniform cost search, Iterative deepening Depth-first search, Bidirectional search**.**
Informed (Heuristic) Search Strategies: Heuristic Functions, Hill- climbing, Greedy best-first search, A* search, Simulated Annealing search.

UNIT – III

Adversarial Search: Game Theory, Alpha–Beta Pruning, Constraint Satisfaction Problems.
Logic Concepts and Logic Programming: Introduction, Propositional Calculus Propositional Logic, Natural Deduction System, Axiomatic System, Semantic Tableau, Predicate Logic, Resolution Refutation in Propositional Logic and Predicate Logic

UNIT - IV

Knowledge Representation: Introduction, approaches to knowledge Representation, Knowledge Representation using Semantic Network, Knowledge Representationusing Frames.
Probabilistic Reasoning: Probability, inference using full joint distributions, Bayes rule, Bayesian networks-representation, construction, exact and approximate inference, temporal model, hidden Markov model.

UNIT – V

Markov Decision process: MDP formulation, utility theory, multi attribute utility functions, decision networks, sequential decision problems value iteration, policy iteration partially observable MDP.

Textbooks:

1. Russell, Norvig, "Artificial Intelligence: A Modern Approach", Pearson Education, 4th Edition, 2020.
2. Saroj Kaushik, "Artificial Intelligence", Cengage Learning India, First Edition, 2011.

Suggested Reading:

1. Rich, Knight, Nair, "Artificial Intelligence", Tata McGraw Hill, 3rd Edition 2009.
2. Trivedi. M.C., "A classical approach to Artificial Intelligence", Khanna Publishing House, Delhi.

Online Resources:

1. http://nptel.ac.in/courses/106106126/
2. http://nptel.ac.in/courses/106105077/

22AMC03

INTRODUCTION TO MACHINE LEARNING

Instruction	3 Hours per week
Duration of End Examination	3 Hours
Semester End Examination	60 Marks
Continuous Internal Evaluation	40 Marks
Credits	3

Course Objectives: The objectives of this course are,

1. To understand the Concepts of Machine Learning.
2. To study various machine learning techniques.
3. To design solutions for real world problems using machine learning techniques.

Course Outcomes: Upon completion of this course student will be able to,

1. Define the basic concepts related to Machine Learning.
2. Describe the Feature Engineering Methods and Regression techniques.
3. Comparison between Supervised and Unsupervised Learning.
4. Classification of algorithms.
5. Applying Machine Learning techniques to real world problems.

Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes:

PO/PSO / CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	1	-	-	-	-	1	1	-	1	-	-	1	-	-	1
CO 2	1	1	-	-	1	-	-	-	1	-	-	1	-	-	1
CO 3	2	1	1	-	-	-	1	-	1	1	-	1	-	-	2
CO 4	1	1	2	1	-	-	1	-	1	1	1	1	-	1	2
CO 5	1	1	1	1	-	-	-	1	1	1	-	-	1	1	2

UNIT-I

Introduction to Machine Learning: Introduction, Well-Posed Learning Problems, Types of Learning, Perspectives and Issues in Machine Learning.

Concept Learning: Concept Learning Task, Concept learning as Search: General –to – Specific Ordering of Hypothesis, Find-S: Finding Maximally Specific Hypothesis, Candidate Elimination Algorithm.

UNIT-II

Feature Engineering: Introductionto Features and need of Feature Engineering, Feature Extraction and Selection.

Regression: Linear Regression, Multivariate Regression, Regression Types: Ridge, Lasso, Elastic Net.

UNIT-III

Naïve Bayes and Discriminant Analysis: Naïve Bayes Classifiers, Discriminant Analysis.

Ensemble Learning: Introduction to Ensemble Learning-Random Forests, AdaBoost, Gradient Tree Boosting ,Voting classifier.

Instance-based Learning: Logically Weighted Regressions, Radial Basis functions, Linear SVM, K-means, Evaluation methods, DBSCAN.

UNIT-IV

Unsupervised Learning: Clustering, types of clustering, K-Means clustering,Hierarchical clustering,Birch Algorithm, CURE Algorithm, Principal Component Analysis (PCA), Principal Component Regression (PCR).

Classification Algorithms: KNN, Linear Classification, Logistic Classification.

Reinforcement Learning: Introduction, Q-Learning.

UNIT-V

Neural Network: Neural network –gradient descent, Activation functions, Parameter initialization, convolutional neural networks, recurrent neural networks, Introduction to Recommender System.

Text Books:

1. Abhishek Vijavargia "Machine Learning using Python", BPB Publications, 1st Edition, 2018.
2. Giuseppe Bonaccorso, "Machine Learning Algorithms", 2nd Edition, Packt, 2018.
3. Tom Mitchel "Machine Learning", Tata McGraw Hill, 2017.

Suggested Reading:

1. Abhishek Vijavargia "Machine Learning using Python", BPB Publications, 1st Edition, 2018.
2. Marsland, S."Machine Learning: An Algorithmic Perspective" 1st Edition, Chapman and Hall/CRC, 2009.https://doi.org/10.1201/9781420067194.
3. Reema Thareja "Python Programming", Oxford Press, 2017.
4. Yuxi Liu, "Python Machine Learning by Example", 2nd Edition, PACT, 2017.

Online Resource:

1. https://www.guru99.com/machine-learning-tutorial.htm
2. https://www.tutorialspoint.com/machine_learning_with_python/index.htm
3. https://www.tutorialspoint.com/python/
4. https://docs.python.org/3/tutorial/
5. https://www.geeksforgeeks.org/machine-learning/

22AMC08

AGILE SOFTWARE DEVELOPMENT

Instruction	3 Hours per week
Duration of End Examination	3 Hours
Semester End Examination	60 Marks
Continuous Internal Evaluation	40 Marks
Credits	3

Pre-requisites: Data structures, Design Thinking

Course Objectives:

This course aims to:

1. Demonstrate the ability to participate effectively in Agile Process for Software Development.
2. Explain the Purpose behind common Agile practices.
3. Apply Agile Principles and Values to a given real time problem.

Course Outcomes:

Upon completion of this course, students will be able to:

1. Interpret the concept of agile software engineering and its advantages in software development.
2. Analyze the core practices behind several specific agile methodologies.
3. Identify the roles and responsibilities in agile projects and their difference from projects following traditional methodologies.
4. Access implications of functional testing, unit testing, and continuous integration.
5. Determine the role of design principles in agile software design.

Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes:

PO/PSO / CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	2	2	2	1	-	2	2	2	1	1	2	2	2	2	2
CO 2	2	2	2	2	-	2	2	2	1	1	2	2	2	2	2
CO 3	2	1	2	1	-	2	2	2	2	2	2	2	1	1	2
CO 4	2	2	1	1	-	2	1	2	2	2	2	2	1	1	2
CO 5	2	1	3	1	-	2	2	2	2	2	2	2	2	1	2

Unit I

Introduction: Need of Agile software development, agile context– Manifesto, Principles, Methods, Values, Roles, Artifacts, Stakeholders, and challenges. Business benefits of software agility.

Unit II

Project Planning: Recognizing the structure of an agile team– Programmers, Managers, Customers. User stories– Definition, Characteristics and content. Estimation– Planning poker, Prioritizing, and selecting user stories with the customer, projecting team velocity for releases and iterations.

Unit III

Project Design: Fundamentals, Design principles–Single responsibility, Open-closed, Liskov substitution, Dependency-inversion, Interface-segregation.

Unit IV

Design Methodologies: Need of scrum, Scrum practices –Working of scrum, Project velocity, Burn down chart, Sprint backlog, Sprint planning and retrospective, Daily scrum, Scrum roles– Product Owner, Scrum Master, Scrum Team. Extreme Programming- Core principles, values and practices. Kanban, Feature-driven development, Lean software development.

Unit V

Testing: The Agile lifecycle and its impact on testing, Test driven development– Acceptance tests and verifying stories, writing a user acceptance test, Developing effective test suites, Continuous integration, Code

refactoring. Risk based testing, Regression tests, Test automation.

Text Books:

1. Ken Schawber, Mike Beedle, “Agile Software Development with Scrum”, International Edition, Pearson.
2. Robert C. Martin, “Agile Software Development, Principles, Patterns and Practices”, First International Edition, Prentice Hall.
3. Pedro M. Santos, Marco Consolaro, and Alessandro Di Gioia, “Agile Technical Practices Distilled: A learning journey in technical practices and principles of software design”, First edition, Packt Publisher.

Reference Books:

1. Lisa Crispin, Janet Gregory, “Agile Testing: A Practical Guide for Testers and Agile Teams”, International edition, Addison Wesley.
2. Alistair Cockburn, “Agile Software Development: The Cooperative Game”, 2nd Edition, Addison-Wesley

E-Books and Online learning material:

1. “The Complete Guide to Agile Software Development” https://clearbridgemobile.com/complete-guide- agile-software-development/
2. “Agile Fundamentals Ebook: A Complete Guide for Beginners”, https://agileken.com/agile-fundamentals-ebook/

Online Courses and Video lectures:

1. “Agile Software Development”, https://www.edx.org/course/agile-software-development Accessed on August 27, 2021.
2. “Agile Software Development”, https://www.coursera.org/learn/agile-software-development Accessed on August 27, 2021.

22CSC15

OPERATING SYSTEMS

Instruction	3 Hours per week
Duration of End Examination	3 Hours
Semester End Examination	60 Marks
Continuous Internal Evaluation	40 Marks
Credits	3

Pre-requisites: Computer Architecture and Programming Fundamentals.

Course Objectives:
This course aims to:
1. Understand the basic concepts and design of an operating system.
2. Interpret the structure and organization of the file system
3. Learn Inter Process Communication mechanisms and memory management approaches.
4. Explore cloud infrastructures and technologies.

Course Outcomes:
Upon completion of this course, students will be able to:
1. Understand the basics of Operating systems and its major components.
2. Illustrate the concepts related to process management.
3. Distinguish various memory management techniques.
4. Apply concepts of process synchronization and deadlocks to a given situation.
5. Evaluate various file allocation methods and Apply security as well as recovery features in the design Operating system.

Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes:

PO/PSO CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	2	1	1	-	-	-	-	-	-	-	-	-		1	1
CO 2	3	3	-	3	1	-	-	-	-	-	-	-	1	1	1
CO 3	3	3	2	1	1	-	-	-	-	-	-	-	1	2	1
CO 4	3	3	1	3	-	-	-	-	-	-	-	-	1	1	1
CO 5	3	3	2	3	1	-	-	-	-	-	-	-	1	1	1

UNIT – I
Introduction to Operating Systems: Computer System overview, Components of a computer system, functions of OS, Examples, different types of OS (RTOS vs. desktop vs. mobile etc.), OS distributions and versions.
OS architectures: Micro-kernel, Layered, Kernel Approaches and examples.

UNIT – II
Process management: Program vs. process, process states, Process Control Block (PCB), OS services and system calls (fork, wait, exec, getpid, getppid etc.), system calls vs. System programs, Process scheduling- Process context switching, Scheduling algorithms, scheduling criteria.
Inter Process Communication: Linux IPC Mechanisms, RPC, RPC exception handling, Security issues.

UNIT – III
Memory Management: Memory view of a process, Process memory usage requirements, virtual and physical memory related system calls (mmap, munmap, sbrk, mprotect). Address translation mechanisms --- static mapping, segmentation, paging, page faults, page replacement algorithms, page sharing, read/write permissions, swapping.
Secondary Memory Management: Disk structure, disk scheduling, disk management, buffering, swap space management, RAID levels.

UNIT – IV

Concurrency and Synchronization: Introduction to threads, benefits, types and thread APIs, Synchronization, issues, hardware and software solutions for synchronization, Classical problems of synchronization.

Deadlocks: Introduction, necessary conditions for deadlock occurrence, RAG, deadlock handling mechanisms - prevention, avoidance and recovery.

UNIT - V

File Systems: File concepts, file types, allocation and organization methods, file handling system calls, File system metadata, directory structure, caching optimizations File Systems case study.

OS Security: Types of threats in OS, basic security mechanisms, malware taxonomy, viruses, worms, and rootkits; Defense: overview, logging, auditing, and recovery, OS-level memory protection.

Text Books:

1. Galvin, Silberschatz, "Operating system Concepts", 10th Edition, John Wiley & Sons, 2018.
2. Maurice J. Bach, "Design of the UNIX Operating System", Pearson Education India; 1st Edition, 2015.
3. Ekta Walia Khanna ,"Operating System Concepts", Publishing House; 2nd Edition,2019.
4. Dhananjay Dhamdhare, "Operating Systems-A Concept Based Approach", 3rd Edition, McGraw Hill Education, 2017.

Suggested Reading:

1. W. Richard Stevens, Stephen A. Rago, "Advanced Programming in the UNIX® Environment" Pearson Education India; 3rd Edition, 2013.

Online Resources:

1. Remzi H. Arpaci-Dusseau and Andrea C. , "Three Easy Pieces", Arpaci-Dusseau Arpaci-Dusseau Books, LLC https://pages.cs.wisc.edu/~remzi/OSTEP/ (online version)
2. Frans Kaashoek, Robert Morris, and Russ Cox, Xv6, a simple Unix-like teaching operating system [T4-R] https://github.com/mit-pdos/xv6-riscv (RISC-V version) [T4-X] https://github.com/mit-pdos/xv6-public (x86 version)

22MTC13

Mathematical Foundation for Data Science & Security

Instruction	3 Hours per week
Duration of End Examination	3 Hours
Semester End Examination	60 Marks
Continuous Internal Evaluation	40 Marks
Credits	3

Course Objectives:

1. Able to learn and Analyzing data in Linear and Non-Linear form.
2. Able to fit the hypothetical data using probability distribution.
3. To know the characteristic of various continuous probability distributions
4. To discuss the testing of hypothesis of sample data.
5. To know the security issues of Cryptography

Course outcomes: Upon completion of this course the students shall be able to

1. Analyze the coefficient of skewness and fitting of the data by various methods
2. Apply properties of Mathematical Expectations and analyse the various distributions.
3. Evaluate areas of curves by using various distributions
4. Apply various tests for testing the significance of sample data.
5. Apply RSA –PKC for solving security issues.

Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes:

PO/PSO CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	3	3	3	-	-	-	-	-	-	-	2	1	1	-
CO 2	3	3	2	3	-	-	-	-	-	-	-	2	1	1	-
CO 3	3	3	2	3	-	-	-	-	-	-	-	2	1	1	-
CO 4	3	3	3	3	-	-	-	-	-	-	-	2	1	1	-
CO 5	3	3	2	3	-	-	-	-	-	-	-	2	1	1	-

UNIT-I: Basic Statistics

Measures of Central Tendency, Measures of Dispersion, Moments (Moments about the mean and moments about a point). Skewness, Karl Pearson's coefficient of skewness and Bowley's coefficient of skewness for frequency distribution, Kurtosis. Correlation, coefficient of correlation, limits of correlation coefficient. Linear Regression, Regression coefficients, Properties of Regression Coefficients. Curve fitting by the Method of Least Squares, Fitting
of Straight lines and Exponential curve.

UNIT-II: Mathematical Expectation and Discrete Probability Distribution

Conditional Probability, Baye's theorem. Random variable, discrete random variable, Probability Mass Function, continuous random variable, probability density function. Mathematical expectation, properties of Expectation, properties of variance and co-variance. Poisson distribution, MGF and Cumulates of the Poisson distribution, Recurrence formula for the probabilities of Poisson distribution (Fitting of Poisson distribution)

UNIT-III: Continuous Probability Distributions

Normal distribution, Characteristics of normal distribution and Normal probability Curve, MGF and CGF of Normal distribution, Areas under normal curve. Uniform distribution, moment generating function, mean and variance of uniform distribution. Exponential distribution, MGF, CGF, Mean and Variance of Exponential distribution.

UNIT-IV: Testing of Hypotheses

Test of significance, null and alternative hypotheses, Errors in sampling, level of significance. Large sample test: Test of significance for single proportion, difference of proportions, single mean and difference of means. Small Sample Tests: T-Test for single mean, differences of Means. F- test for equality of two population variances. Chi-Square test of Goodness of fit.

UNIT-V: Number Theory & CRYPTOGRAPHY (RSA – PKC)

Division Algorithm, Greatest Common Divisor, Euclidean Algorithm, Wilson's Theorem, Euler's Phi-Function,

Euler's Theorem, Some Properties of the Phi-Function.The RSA public key cryptosystem, Implementation and security issues, Pollard's p−1 factorization algorithm, Quadratic Residues and quadratic reciprocity

Text books:

1. S.C.Gupta, V.K.Kapoor, "Fundamentals of Mathematical Statistics", Sultan Chand and Sons, 2014.
2. Burton, David M. (2007) Elementary Number Theory (7^{th}edu.). Tata McGraw Hill Edition, Indian Reprint
3. Mathematical Cryptography by Jeffrey Hoffstein, Jill Pipher, Joseph H. Silverman Springer Science+ Business Media LLC.

Suggested Reading:

1 .W. Feller, "An Introduction to Probability Theory and its Applications", Vol. 1, 3rd Ed., Wiley, 1968.
2. Sheldon Ross, "A First Course in Probability", 9th Edition, Pearson publications, 2014.
3. Koshy, T.Elementary Number Theory with Applications, Elsevier Publications, New Delhi, 2002.
4. G.A.Jones & J.M.Jones "Elementary Number Theory", Springer UTM, 2007

22AMC04

PRINCIPLES OF ARTIFICIAL INTELLIGENCE LAB

Instruction	3 Hours per week
Duration of End Examination	3 Hours
Semester End Examination	50 Marks
Continuous Internal Evaluation	50 Marks
Credits	1.5

Pre-requisites: Programming Basics, Probability and Statistics.

Course Objectives: The objectives of this course are,

1. To design and analyze various computing algorithms and techniques using Python.
2. To apply different learning algorithms to solve real time problems.
3. To recognize the underlying mathematical models and logics behind various AI techniques.

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

1. Understand the basic components of library environment and installations.
2. Analyze the design heuristics and apply various techniques to solve real world problems.
3. Apply variety of algorithms to solve problems.
4. Identify how to use GitHub and submit back genuine contributions.
5. Implement problems using game search algorithms.

Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes:

PO/PSO / CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	2	2	2	2	3	-	-	2	2	2	1	3	3	2	2
CO 2	3	3	3	3	3	1	2	2	2	2	1	3	3	3	3
CO 3	3	3	3	3	3	2	1	2	2	2	1	3	3	3	3
CO 4	3	2	3	3	3	2	1	2	1	2	1	3	3	3	1
CO 5	3	3	2	3	3	3	1	2	2	2	1	3	3	3	3

Lab Experiments:

1. Design/construct the workflow of a general AI project using draw.io
2. Implement Water Jug Problem using A* search
3. Implement an 8-puzzle solver using Heuristic search technique.
4. Implement the Constraint Satisfaction problem using backtracking.
5. Implement a program for game search.
6. Implement a Bayesian network from a given data and infer the data from that Bayesian network.
7. Implement a MDP to run value and policy iteration in any environment.
8. Build a bot to build any game using easy AI libraries
9. Understanding of GitHub and Anaconda environments.
10. Use the GitHub packages and libraries to frame a standard project and commit back to GitHub.

Text Books:

1. Stuart Russell and Peter Norvig, "Artificial Intelligence: A Modern Approach", 3rd Edition, Prentice Hall,2010.
2. Saroj Kaushik, "Artificial Intelligence", Cengage Learning India, 2011.

Suggested Reading:

1. Trivedi, M.C., "A Classical Approach to Artificial Intelligence", Khanna Publishing House, Delhi, 2018.
2. Elaine Rich and Kevin Knight, "Artificial Intelligence", Tata McGraw Hill, 3rd Edition, 2017.

Online Resources:

1. https://nptel.ac.in/courses/106105077
2. https://nptel.ac.in/courses/106106126
3. https://aima.cs.berkeley.edu
4. https://ai.berkeley,edu/project_overview.html

22AMC05

INTRODUCTION TO MACHINE LEARNING LAB

Instruction	3 Hours per week
Duration of End Examination	3 Hours
Semester End Examination	50 Marks
Continuous Internal Evaluation	50 Marks
Credits	1.5

Course Objectives: The main objectives of this course are,

1. To make use of Data sets in implementing the machine learning algorithms.
2. To implement the machine learning concepts and algorithms.
3. To use real world data and implement machine learning models.

Course Outcomes: Upon completion of this course, student will be able to,

1. Identify the fundamental issues and challenges of machine learning: data, model selection, model complexity, etc.
2. Identify and utilize modern tools that are useful for data analysis.
3. Recognize and implement various ways of selecting suitable model parameters for different machine learning techniques.
4. Implement and evaluate various Machine Learning approaches on real world problems.
5. Apply Keras and Tensorflow to implement ML techniques.

Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes:

PO/PSO / CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	1	1	-	-	1	-	-	-	1	-	-	1	-	-	-
CO 2	-	1	1	1	1	-	-	-	1	-	-	-	-	-	1
CO 3	-	2	1	-	-	-	-	-	1	-	1	1	-	-	1
CO 4	-	-	1	1	1	-	-	-	1	-	-	2	-	1	1
CO 5	-	-	-	1	1	-	-	-	1	-	-	-	1	1	-

List of Experiments:

1. Identification and Installation of python environment towards the machine learning, installing python modules/Packages Import scikitlearn, keras and tensorflows etc.
2. Build linear regression model using gradient descent, least squares, polynomial, LASSO and RIDGE approaches also compare all the algorithms and draw a table for all the metrics.
3. Demonstration of decision tree based ID3 algorithm. Use an appropriate data set for building the decision tree and apply this knowledge to classify a new sample.
4. Build the decision tree classifier compare its performance with ensemble techniques like random forest,bagging, boosting and voting Demonstrate it with different decision trees.
5. Build FIND-S and Candidate-Elimination algorithm on a different data set.
6. Demonstration of Logistic Regression for a sample training data set stored as a .CSV file. Calculate the accuracy, precision, and recall for your dataset.
7. Demonstration of Naïve Bayesian classifier for a sample training data set stored as a .CSV file.
8. Implementation of Gradient Descent Algorithm using Tensorflow.
9. Case study on supervised learning algorithms.
10. Demonstration of clustering algorithms- k-Means, Agglomerative and DBSCAN to classify for the standard datasets.

Text Books:

1. Giuseppe Bonaccorso, “Machine Learning Algorithms”, Packt Publishing, 2017.

Online Resources:

1. http://www.cs.cmu.edu/~tom/
2. http://www.holehouse.org/mlclass/

22AMC09

PRINCIPLES OF OPERATING SYSTEMS LAB

Instruction	2 Hours per week
Duration of End Examination	2 Hours
Semester End Examination	50 Marks
Continuous Internal Evaluation	50 Marks
Credits	1

Pre-requisites: Programming for problem solving.

Course Objectives: The objectives of this course are,

1. To explore Unix/Linux operating system.
2. To analyze various system calls available in Linux/Unix.

Course Outcomes: Upon completion of this course, student will be able to,

1. Understand Linux/Unix environment.
2. Understand and implement shell programming.
3. Simulate memory management and file allocation techniques.
4. Analyze process and file management system calls by creating and/or modifying concurrent programs.
5. Build network-oriented applications using system calls.

Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes:

PO/PSO / CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	2	1	-	1	-	-	-	-	-	-	-	-	1	1	1
CO 2	2	-	-	-	2	-	-	-	-	-	-	-	1	1	1
CO 3	2	-	2	-	-	-	-	-	-	-	-	-	1	2	1
CO 4	2	2	2	1	-	-	-	-	-	-	-	-	1	1	1
CO 5	2	1	1	1	-	-	-	-	-	-	-	-	1	1	1

List of Experiments:

1. Shell programming.
2. Demonstration and Performance Evaluation of CPU scheduling algorithms
3. Implementation of memory management techniques like paging and segmentation.
4. Implementation of Linked, Indexed and Contiguous file allocation methods.
5. Demonstration of Linux/Unix file related system calls: mkdir, link, unlink, mount, unmount, users+, chown, chmod, open, close, read, write, lseek, stat, sync.
6. Implementation of producer-consumer, readers- writers and dining philosophers problem using semaphores
7. Demonstration of Bankers Algorithm for Deadlock Avoidance.
8. Development of applications using Linux/Unix system calls: signal, socket, accept, snd, recv, connect.

Text Books:

1. Galvin, Silberschatz, “Operating System Concepts”, 10th Edition, John Wiley & Sons, 2018.
2. Dhananjay Dhamdhare, “Operating Systems-A Concept Based Approach”, 3rd Edition, McGraw Hill
3. Education, 2017.

Suggested Reading:

1. Ekta Walia, “Operating System Concepts”, Khanna Book Publishing, 2020.
2. William Stallings, “Operating Systems Internals and Design Principles”, Pearson Ed., 2012.
3. Charles Crowley, “Operating Systems –A Design Oriented Approach”, McGraw Hill Education, 2017.
4. Andrew S. Tanenbaum, Albert S Woodhull, “Operating systems Design and Implementation”, Pearson
5. Ed., 2009.

22MTC14

Mathematical Foundation for Data Science & Security (Lab)
R- Programming

Instruction	2 Hours per week
Duration of End Examination	3 Hours
Semester End Examination	50 Marks
Continuous Internal Evaluation	50 Marks
Credits	1

Course Objectives:

1. To know the graphical visualizations for the data.
2. To learn the measures of central tendency and dispersion.
3. To learn and analyze data in linear and non-linear form.
4. To learn the probabilities of various distributions.
5. To know the various cryptographic schemes for the encryption and decryption.

Course outcomes: Upon completion of this course the students shall be able to

1. Create graphs and charts for the statistical data.
2. Analyze the data set using measures of central tendency and dispersion.
3. Develop the linear and non-linear regression models for the statistical data.
4. Evaluate the probabilities of various discrete and continuous distributions.
5. Demonstrate RSA – PKC technique of number theory for solving security issues.

Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes:

PO/PSO CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	2	2	1	1	-	-	-	-	-	-	-	2	-	1	-
CO 2	2	2	1	1	-	-	-	-	-	-	-	2	-	1	-
CO 3	2	2	1	1	-	-	-	-	-	-	-	2	-	1	-
CO 4	2	2	1	1	-	-	-	-	-	-	-	2	-	1	-
CO 5	2	2	1	1	-	-	-	-	-	-	-	2	-	1	-

List of Programs

1. Write a Program to create Graphs and Charts.
2. Write a Program to calculate the measures of Central Tendency for the data.
3. Write a Program to compute measures of disposition for the data.
4. Write a Program for Correlation and Covariance using Pearson method.
5. Write a Program for simple linear Regression and Logistic regression.
6. Write a Program to compute probabilities using Binomial Distribution.
7. Write a Program to compute probabilities using Poisson Distribution.
8. Write a Program to compute probabilities using Normal Distribution.
9. Write a program for hypothesis testing
10. Write a Program to compute gcd of any two positive integers using Euclidian algorithm.
11. Write a Program to encrypt the given data, using RSA algorithm.
12. Write a Program to decrypt the given data, using RSA algorithm

Text Books:

1. S.R.Mani Sekhar, Dr. T.V. Suresh Kumar, “Programming with R” CENGAGE Publishers, 2017.
2. K.G.Srinivasa, G.M.Siddesh, “Statistical Programming in R”, Oxford University Press, 2017.
3. Jared P Lander, “R for Everyone” Pearson.2018.
4. **http://www.cyclismo.org/tutorial/R/**