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Second Year Engineering

Semester – III

Computer Engineering

According to New Revised Credit System Syllabus of Savitribai Phule Pune University, Pune.

EFFECTIVE FROM ACADEMIC YEAR JUNE 2016

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Igniting Minds

Data Structures and Algorithms

Second Year Engineering (Semester – I)

Computer Engineering

Dr. Kamini Shirsath-Nalavade, Dr. Sharmistha Desai, Dr. Dipti D. Patil

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Preface

This Book Data Structures and Algorithms is intended to be a textbook for students of Second Year Engineering In most sciences, one generation years down what another has built and what one has established another undoes. In Data Structures and Algorithms, each generation adds a new story to the old structure. Keeping this in mind, this book is written to have a better introduction of the Data Structures and Algorithms. This book is presented with simple but exact explanation of subject matter, application of each topic to real life, engineering problems, large number of illustrative examples followed by well graded exercise. We have tried to be rigorous and precise in presenting the concepts in very simple manner. We hope that the students will not only learn some powerful concepts, but also will develop their ability to understand the concept and apply it properly to solve engineering problems. We feel that faculty member will also enjoy reading this book which is enriched with application of each topic.

Acknowledgment

The authors acknowledge the help of colleagues and friends for the warm relationship which provides a source of energy in our endeavours.

We are grateful to our family members for the encouragement and constant cooperation and assistance in creation of this book.

We are certainly thankful to the students of engineering who are a constant source of our enthusiasm and encouragement in our endeavours.

We are also thankful to **Gigatech Publishing House TEAM** for their continuous support, hard work and patience in preparing this book.

SYLLABUS

Unit - I : Introduction to Algorithms and Data Structures (09 Hrs.)

Algorithms : Problem Solving, Introduction to Algorithms, Characteristics of Algorithms, Algorithm Design Tools: Pseudo Code and Flowchart, Analysis of Algorithms, Complexity of Algorithms-Space Complexity, Time Complexity, Asymptotic notation-Big O, Theta and Omega , standard measures of efficiency.

Data Structures : Data Structure, Abstract Data Types(ADT), Concept of Linear and Non-Linear, static and dynamic, persistent and ephemeral data structures and relationship among data, data structure and algorithm, from Problem to Program.

Algorithmic Strategies : Introduction to algorithm design strategies - Divide and Conquer, and Greedy Strategy.

Recurrence Relation : Recurrence Relation, Linear Recurrence Relations, With constant coefficients, Homogeneous Solutions, Solving recurrence relations.

Unit - II : Linear Data Structures Using Sequential Organization (09 Hrs.)

Sequential Organization, Linear Data Structure Using Sequential Organization, Array as an Abstract Data Type, Memory Representation and Address Calculation, Inserting an element into an array, Deleting an element, Multidimensional Arrays, Two-dimensional arrays, n- dimensional arrays, Concept of Ordered List, Single Variable Polynomial, Representation using arrays, Polynomial as array of structure, Polynomial addition, Polynomial multiplication, Sparse Matrix, Sparse matrix representation, Sparse matrix addition, Transpose of sparse matrix, String Manipulation Using Array.

Case Study : Use of sparse matrix in Social Networks and Maps.

Unit – III : Linked Lists (09 Hrs.)

Concept, Comparison of sequential and linked organizations, Primitive operations, Realization of Linked Lists, Realization of linked list using arrays, Dynamic Memory Management, Linked list using dynamic memory management, Linked List Abstract Data Type, Linked list operations, Head pointer and header node,

Types of linked list : Linear and circular linked lists, Doubly Linked List and operations, Circular Linked List, Singly circular linked list, Doubly circular linked list,

Polynomial Manipulations : Polynomial addition, Multiplication of two polynomials using linked list. **Generalized Linked List (GLL)** concept, representation of polynomial and sets using GLL.

Case Study : Garbage Collection

Unit- IV : Stacks (09 Hrs.)

Stacks : Concept, Primitive operations, Stack Abstract Data Type, Representation of Stacks Using Sequential Organization, stack operations, Multiple Stacks, Applications of Stack- Expression Evaluation and Conversion, Polish notation and expression conversion, Need for prefix and postfix expressions, Postfix expression evaluation, Linked Stack and Operations.

Recursion : Concept, variants of recursion- direct, indirect, tail and tree, Backtracking algorithmic strategy, use of stack in backtracking.

Case Study : 4 queens problem, Android- multiple tasks/multiple activities and back stack.

Unit - V : Queues (09 Hrs.)

Concept, Queue as Abstract Data Type, Realization of Queues Using Arrays , Circular Queue, Advantages of using circular queues, Multi-queues, Deque, Priority Queue, Array implementation of priority queue, Linked Queue and operations.

Case study : Priority queue in bandwidth management

Unit - VI : Sorting and Searching (09 Hrs.)

Searching : Search Techniques, Sequential search, variant of sequential search- sentinel search, Binary search, Fibonacci search.

Case Study : Use of Fibonacci search in non-uniform access memory storage and in Optimization of Unimodal Functions.

Sorting : Types of sorting-Internal and external sorting, General sort concepts-sort order, stability, efficiency, number of passes, Sorting methods- Bubble sort, Insertion sort, Selection sort, Quick sort, Heap sort, Shell sort, Bucket sort, Radix sort, Comparison of All Sorting Methods.

Case Study : Timsort as a hybrid stable sorting algorithm.

Recommended by SPPU Text Books and Reference Books

Text Books :

1. Brassard & Bratley, ―Fundamentals of Algorithmics‖, Prentice Hall India/Pearson Education, ISBN 13-9788120311312.
2. Horowitz and Sahani, ―Fundamentals of Data Structures in C++‖, University Press, ISBN 10: 0716782928 ISBN 13: 9780716782926.
3. Goodrich, Tamassia, Goldwasser, ―Data Structures and Algorithms in C++‖, Wiley publication, ISBN-978-81-265-1260-7

Reference Books :

1. R. Gillberg, B. Forouzn, ―Data Structures: A Pseudo code approach with C‖, Cenage Learning, ISBN 9788131503140.
2. Horowitz, Sahani and Rajshekaran, ―Fundamentals of Computer Algorithms‖, University Press, ISBN-13, 9788175152571.
3. Yedidyah Langsam, Moshe J Augenstein, Aron M Tenenbaum, ―Data Structures using C and C++‖, Pearson Education, ISBN 81-317-0328-2.
4. A Michael Berman, ―Data Structures via C++: Objects by Evolution‖, Oxford University Press, ISBN:0-19-510843-4.
5. M. Weiss, ―Data Structures and Algorithm Analysis in C++‖, 2nd edition, Pearson Education, 2002, ISBN-81-7808-670-0.

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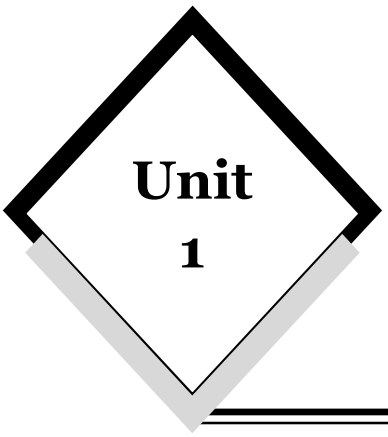
CONTENTS



Introduction to Algorithms and Data Structures

Syllabus :

Algorithms : Problem Solving, Introduction to Algorithms, Characteristics of Algorithms, Algorithm Design Tools: Pseudo Code and Flowchart, Analysis of Algorithms, Complexity of Algorithms-Space Complexity, Time Complexity, Asymptotic notation-Big O, Theta and Omega , standard measures of efficiency.

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1.1 Algorithms :

Dec 2009, Dec 2010

Problem solving is the main goal of engineering. Computer science aims to design solutions to various problems and write programs for them. Before programming, steps for solution of problem are designed. It is very important step in programming.

1.1.1 Definition :

An algorithm is a set of steps required to solve any problem. Algorithm can be defined as a step-by-step set of instructions for solving a problem in a limited number of steps. Generally algorithms are written for each module and then combined to form complete solution. An algorithm is used for data processing, calculation and other related computer and mathematical operations. The steps must be performed in a sequence. Each step of algorithm is labelled.

1.1.2 Characteristics of Algorithms :

There are five important characteristics of an algorithm that should be considered while designing any algorithm for any problem.

1. **Inputs:** An algorithm must have zero or more inputs but must be finite number.
2. **Output:** An algorithm must have at-least one desirable outcome, i.e., output.
3. **Finiteness:** An algorithm should terminate in finite number of steps and each step must terminate after finite amount of time.
4. **Effectiveness:** An algorithm should be effective. Effective means that each step should be very basic so that it can be easily converted into a program and should be executing in finite time.
5. **Definiteness (No Ambiguity):** Each step of algorithm should be clear and precisely defined and there should not be any ambiguity.

Example: Write an algorithm to add two numbers

Step 1 : Read two positive integers and store them in A and B.

Step 2 : Add A with B and store result in A.

Step 3 : Print A.

Step 4 : Stop

1.2 Algorithm Design Tools :

Dec 2009, Dec 2010

An algorithm can be represented in many ways. A language like English can be used to describe algorithm is called as pseudocode. A flowchart is another way of describing algorithm with the help graphical symbols.

1.2.1 Pseudo Code :

Pseudocode is a method of describing computer algorithms using a combination of natural language like structured English and programming language. It is essentially an intermediate step towards the development of the actual program. It allows the programmer to formulate their logic on the organization and sequence of algorithm before generating code of the program.

The pseudocode describes the entire logic of the algorithm so that translating line by line into source code becomes easy. Although pseudocode is frequently used there are no set of rules for its exact implementation. The usual Fortran symbols are used for arithmetic operations (+, -, *, / , **). Symbolic names are used to indicate the quantities being processed. Fortran keywords can be used, such as PRINT, WRITE, READ, etc. Indentation should be used to indicate branches and loops of instruction.

Example :

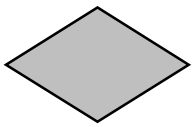
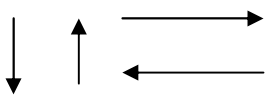
Pseudo code Algorithm for Student Registrations System

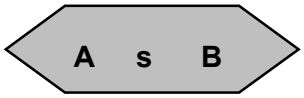
Input : Integer values for age, Character value for Name and Gender.
Output: Boolean value
1. Repeat
2. Read Student Name, Age, Gender
3. Read Course and Branch.
4. Read Year
5 Check Availability of seat
6. If seat is available, calculate Fees
7. Print Receipt
8. If seat is not available, print seat unavailable message
9. Else print seat is available.
10. End

1.2.2 Flowchart :

Flowchart is a graphical or pictorial representation of algorithm using different symbols. **Flowcharts** are written with program flow from the top of a page to the bottom. Each command is placed in a box of the appropriate shape, and arrows are used to direct program flow. It is used to showcase basic operations of algorithms.

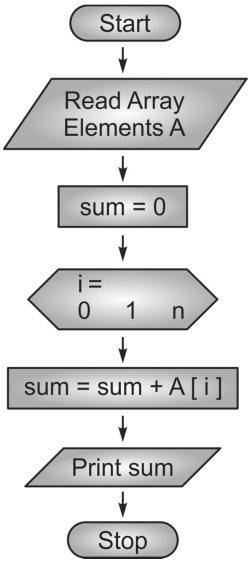
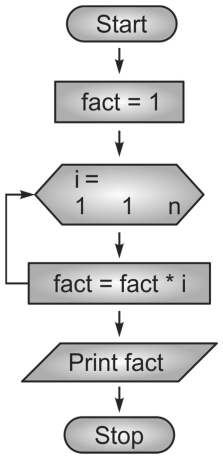
The following shapes are often used in flowcharts:

Flowchart Symbol	Explanation
 Start/Stop/End	An ellipse uses the name of the module at the start. The end is indicated by the word end or stop.
	Processing block such as calculations, opening and closing files.
	Input to or output from the computer
	Decision symbol. one entrance and two and only two exits
	Flow lines are indicated by straight lines with optional arrows to show direction of data flow.

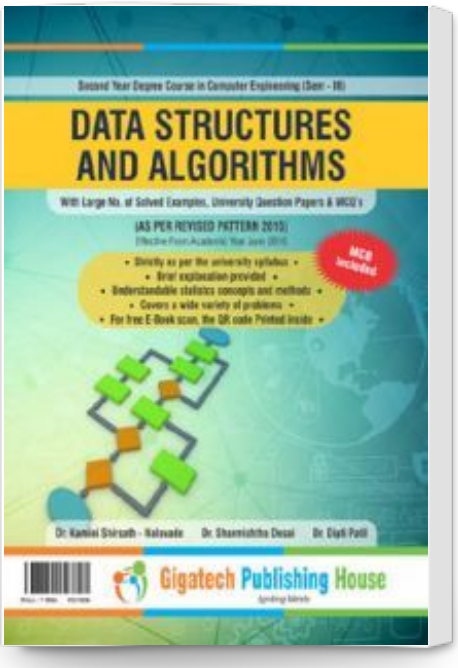
	Loop within counter. The counter starts with A and incremented by s until the counter is greater than B.
	On-page connector. Connects sections on same page

Flowchart makes it easier to understand the logic of the program. Flowcharts help to find out errors and bugs in the logic of program and set of data can be easily tested. This will help programmers to write correct programs.

Example :

Algorithm	Flowchart
Flowchart for Calculating Average of Array Elements *1. Start* *2. Read Elements of Array A* *3. Integer sum = 0, i = 0* *4. for each value of i from 0 to n* *5. sum = sum+ Array element A[i]* *6. Print sum* 7. *Stop*	
Flowchart for Calculating Factorial of number *1. Start* *2. integer fact=1;* *3. for each value of i from 1 to n* *4. fact=fact * i* *5. Print fact* 6. *Stop*	

Data Structures And Algorithms



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