
THE CLASSIC WORK
NEWLY UPDATED AND REVISED

The Art of Computer Programming

VOLUME 1

Fundamental Algorithms

Third Edition

DONALD E. KNUTH

This page intentionally left blank

Art of Computer Programming, The: Volume 1: Fundamental Algorithms

Table of Contents

Cover

Title Page

Copyright Page

Preface

Preface to the Third Edition

Procedure for Reading This Set of Books

Notes on the Exercises

Contents

Frontispiece

Chapter 1 Basic Concepts

1.1. Algorithms

1.2. Mathematical Preliminaries

1.2.1. Mathematical Induction

1.2.2. Numbers, Powers, and Logarithms

1.2.3. Sums and Products

1.2.4. Integer Functions and Elementary Number Theory

1.2.5. Permutations and Factorials

1.2.6. Binomial Coefficients

1.2.7. Harmonic Numbers

1.2.8. Fibonacci Numbers

1.2.9. Generating Functions

1.2.10. Analysis of an Algorithm

Table of Contents

***1.2.11. Asymptotic Representations**

***1.2.11.1. The O-notation**

***1.2.11.2. Eulers summation formula**

***1.2.11.3. Some asymptotic calculations**

1.3. MIX

1.3.1. Description of MIX

1.3.2. The MIX Assembly Language

1.3.3. Applications to Permutations

1.4. Some Fundamental Programming Techniques

1.4.1. Subroutines

1.4.2. Coroutines

1.4.3. Interpretive Routines

1.4.3.1. A MIX simulator

***1.4.3.2. Trace routines**

1.4.4. Input and Output

1.4.5. History and Bibliography

Chapter 2 Information Structures

2.1. Introduction

2.2. Linear Lists

2.2.1. Stacks, Queues, and Deques

2.2.2. Sequential Allocation

2.2.3. Linked Allocation

2.2.4. Circular Lists

2.2.5. Doubly Linked Lists

2.2.6. Arrays and Orthogonal Lists

2.3. Trees

2.3.1. Traversing Binary Trees

2.3.2. Binary Tree Representation of Trees

2.3.3. Other Representations of Trees

2.3.4. Basic Mathematical Properties of Trees

Table of Contents

2.3.4.1. Free trees

2.3.4.2. Oriented trees

*2.3.4.3. The infinity lemma

*2.3.4.4. Enumeration of trees

2.3.4.5. Path length

*2.3.4.6. History and bibliography

2.3.5. Lists and Garbage Collection

2.4. Multilinked Structures

2.5. Dynamic Storage Allocation

2.6. History and Bibliography

Answers to Exercises

Appendix A Tables of Numerical Quantities

1. Fundamental Constants (decimal)

2. Fundamental Constants (octal)

3. Harmonic Numbers, Bernoulli Numbers, Fibonacci Numbers

Appendix B Index to Notations

Appendix C Index to Algorithms and Theorems

Index and Glossary