



Contents

<i>Preface</i>	<i>vii</i>
<i>Contents in Brief</i>	<i>ix</i>
CHAPTER 1 Introducing Computers and Hardware	1
1.1 The Computer Boom	1
1.2 Computer Basics	2
1.3 The Background	4
1.3.1 Napier, Pascal and Leibniz: The Early Pioneers	4
1.3.2 The Programmable Computer	4
1.3.3 The Programmable Electronic Computer	5
1.4 Computer Generations	6
1.4.1 Vacuum Tubes: The First Generation	6
1.4.2 Transistors: The Second Generation	6
1.4.3 Integrated Circuits: The Third Generation	7
1.4.4 The Microprocessor: The Fourth Generation	7
1.4.5 Artificial Intelligence: The Fifth Generation	8
1.5 Computer Types	8
1.5.1 Supercomputers	9
1.5.2 Mainframes	9
1.5.3 Minicomputers	9
1.5.4 Microcomputers	10
1.5.5 Smartphones and Embedded Computers	10
1.6 Bits, Bytes and Words	11
1.7 Inside the Computer	12
1.8 The Central Processing Unit (CPU)	13
1.9 Primary Memory	14
1.9.1 Random Access Memory (RAM)	14
1.9.2 Read Only Memory (ROM)	15
1.9.3 Cache Memory	16
1.9.4 Registers	16
1.10 Secondary Memory	17
1.10.1 The Hard Disk	17
1.10.2 Magnetic Tape	19

1.10.3	Optical Disks: The CD-ROM, DVD-ROM and Blu-Ray Disk	19
1.10.4	Flash Memory	20
1.10.5	Floppy Diskette	21
1.11	Ports and Connectors	21
1.12	Input Devices	23
1.12.1	The Keyboard	23
1.12.2	Pointing Devices	23
1.12.3	The Scanner	24
1.13	Output Devices	25
1.13.1	The Monitor	25
1.13.2	Impact Printers	26
1.13.3	Non-Impact Printers	27
1.13.4	Plotters	27
1.14	Computers in a Network	28
1.14.1	Network Topology	28
1.14.2	Network Types	29
1.14.3	The Internet and internet	30
1.15	Network Hardware	30
1.15.1	Network Interface Card	30
1.15.2	Hub and Switch	31
1.15.3	Bridge and Router	31

CHAPTER 2 Computer Software**36**

2.1	Why Computers Need Software	36
2.2	Software Basics	37
2.3	Software Types	38
2.3.1	System Software	38
2.3.2	Application Software	39
2.4	Basic Input Output System (BIOS)	40
2.5	The Operating System (OS)	41
2.5.1	How Users Interact with an Operating System	42
2.5.2	Classification of Operating Systems	43
2.5.3	The Current Operating Systems	45
2.6	Device Drivers	45
2.7	MSDOS: A CUI Operating System	47
2.7.1	Files and the File System	47
2.7.2	Internal and External Commands	48
2.7.3	Working with Files and Directories	49
2.7.4	Using Wild-Cards with Files	50
2.7.5	The Utilities	50
2.8	Windows: A GUI Operating System	51
2.8.1	The Display and Mouse	51
2.8.2	File Explorer: Manipulating Files and Directories	52
2.8.3	Utilities and Administrative Tools	54

2.9	UNIX/Linux: A Programmer's Operating System	55
2.9.1	The UNIX File System	56
2.9.2	Basic Directory and File Handling Commands	56
2.9.3	File Ownership and Permissions	57
2.9.4	grep and find : The UNIX Search Commands	58
2.9.5	Other Utilities	59
2.10	Microsoft Word	60
2.10.1	Creating and Saving a Document	61
2.10.2	Handling Text	62
2.10.3	Font Handling	64
2.10.4	Inserting Tables	64
2.10.5	Inserting Graphics	65
2.10.6	Other Useful Utilities	66
2.11	Microsoft Excel	66
2.11.1	Creating, Saving and Printing a Spreadsheet	67
2.11.2	Formatting Cells	68
2.11.3	Computing and Using Formulas	69
2.11.4	Handling Data	70
2.11.5	Creating Charts	73
2.12	Microsoft Powerpoint	74
2.13	Understanding a TCP/IP Network	75
2.13.1	Hostnames and IP Addresses	75
2.13.2	The TCP/IP Model—The Four Layers	76
2.13.3	DNS: Resolving Domain Names on the Internet	77
2.14	Internet Applications	77
2.14.1	Electronic Mail	77
2.14.2	Telnet: Remote Login	78
2.14.3	Ftp: Transferring Files	79
2.14.4	The Secure Shell	79
2.14.5	The World Wide Web	79

CHAPTER 3 Computing and Programming Concepts

85

3.1	Numbering Systems	85
3.2	The Binary Numbering System	87
3.2.1	Converting from Binary to Decimal	87
3.2.2	Converting from Decimal to Binary	88
3.2.3	Binary Coded Decimal (BCD)	88
3.3	Negative Binary Numbers	89
3.3.1	Sign-and-Magnitude Representation	89
3.3.2	One's Complement	89
3.3.3	Two's Complement	90
3.4	Binary Arithmetic	91
3.4.1	Binary Addition	91

Contents

3.4.2	Binary Subtraction (Regular Method)	92
3.4.3	Binary Subtraction Using Two's Complement	92
3.4.4	Binary Multiplication	93
3.4.5	Binary Division	94
3.5	The Octal Numbering System (Base-8)	95
3.5.1	Converting from Octal to Decimal	95
3.5.2	Converting from Decimal to Octal	95
3.5.3	Converting from Octal to Binary	96
3.5.4	Converting from Binary to Octal	96
3.6	The Hexadecimal Numbering System (Base-16)	96
3.6.1	Converting from Hexadecimal to Decimal	97
3.6.2	Converting from Decimal to Hexadecimal	97
3.6.3	Converting between Hexadecimal and Octal Systems	98
3.6.4	Converting between Hexadecimal and Binary Systems	98
3.7	Numbers with a Fractional Component	99
3.7.1	Converting Binary, Octal and Hexadecimal Fractions to Decimal	99
3.7.2	Converting a Decimal Fraction to Binary, Octal and Hexadecimal	100
3.7.3	Converting between Binary, Octal and Hexadecimal Fractions	101
3.8	ASCII Codes	103
3.9	Logic Gates	103
3.9.1	The AND, OR and XOR Gates	104
3.9.2	The NOT Gate	105
3.9.3	The NAND, NOR and XNOR Gates	105
3.10	Programming Methodologies	106
3.10.1	Top-Down Programming	107
3.10.2	Bottom-Up Programming	107
3.10.3	Object-Oriented Programming	108
3.11	Structured Programming	108
3.12	Algorithms	109
3.12.1	Sequencing	109
3.12.2	Decision Making	110
3.12.3	Repetition	110
3.13	Flowcharts	111
3.13.1	Sequencing	111
3.13.2	Decision Making	112
3.13.3	Repetition	112
3.14	Classification of Programming Languages	114
3.14.1	Assembly Language (2GL)	114
3.14.2	High-Level Languages (3GL)	115
3.14.3	4GL Languages	116
3.15	Compilers, Linkers and Loaders	116
3.16	Compiled vs Interpreted Languages	117

CHAPTER 4 A Taste of C**121**

-
- 4.1 The C Language 121
 - 4.2 The Life Cycle of a C Program 122
 - 4.2.1 Header Files and Functions 122
 - 4.2.2 Editing the Program 124
 - 4.2.3 The Three-Phase Compilation Process 124
 - 4.2.4 Executing the Program 125
 - 4.3 Know Your C Compiling Software 125
 - 4.3.1 GCC (Linux) 126
 - 4.3.2 Microsoft Visual Studio (Windows) 126
 - 4.4 **first_prog.c:** Understanding Our First C Program 127
 - 4.4.1 Program Comments 128
 - 4.4.2 Preprocessor Section 128
 - 4.4.3 Variables and Computation 128
 - 4.4.4 Encounter with a Function: **printf** 129
 - 4.4.5 The **return** Statement 129
 - 4.5 Editing, Compiling and Executing **first_prog.c** 130
 - 4.5.1 Using **gcc** (Linux) 130
 - 4.5.2 Using Visual Studio (Windows) 131
 - 4.6 Handling Errors and Warnings 132
 - 4.7 **second_prog.c:** An Interactive and Decision-Making Program 133
 - 4.8 Two Functions: **printf** and **scanf** 135
 - 4.8.1 **printf:** Printing to the Terminal 135
 - 4.8.2 **scanf:** Input from the Keyboard 136
 - 4.9 **third_prog.c:** An Interactive Program Featuring Repetition 137
 - 4.10 Functions 138
 - 4.11 **fourth_prog.c:** A Program Containing a User-Defined Function 139
 - 4.12 Features of C 141
 - 4.13 Some Programming Tips 142
 - 4.14 C89 and C99: The C Standards 143

CHAPTER 5 Data—Variables and Constants**148**

-
- 5.1 Program Data 148
 - 5.1.1 Variables and Constants 148
 - 5.1.2 Data Types 149
 - 5.1.3 Data Sources 149
 - 5.2 Variables 149
 - 5.2.1 Naming Variables 149
 - 5.2.2 Declaring Variables 150
 - 5.2.3 Assigning Variables 151
 - 5.3 **intro2variables.c:** Declaring, Assigning and Printing Variables 151
 - 5.4 Data Classification 152
 - 5.4.1 The Fundamental Types 153
 - 5.4.2 Type Sizes: The **sizeof** Operator 153

5.5	sizeof.c: Determining the Size of the Fundamental Data Types	154
5.6	The Integer Types	154
5.6.1	The ANSI Stipulation for Integers	156
5.6.2	Signed and Unsigned Integers	156
5.6.3	The Specific Integer Types	157
5.6.4	Octal and Hexadecimal Integers	158
5.7	all_about_int.c: Understanding Integers	158
5.8	The Floating Point Types	160
5.9	The Specific Floating Point Types	161
5.10	all_about_real.c: Understanding Floating Point Numbers	162
5.11	char: The Character Type	163
5.11.1	char as Integer and Character	164
5.11.2	Computation with char	165
5.11.3	char as Escape Sequence	165
5.12	all_about_char.c: Understanding the char Data Type	166
5.13	Data Types of Constants	168
5.13.1	Constants of the Fundamental Types	168
5.13.2	Variables as Constants: The const Qualifier	169
5.13.3	Symbolic Constants: Constants with Names	169
5.14	sizeof_constants.c: Program to Evaluate Size of Constants	170
5.15	Arrays and Strings: An Introduction	171
5.16	intro2arrays.c: Getting Familiar with Arrays	172

CHAPTER 6 Operators and Expressions**178**

6.1	Expressions	178
6.2	Operators	179
6.3	expressions.c: Evaluating Expressions	180
6.4	Arithmetic Operators	181
6.4.1	The +, -, * and /: The Basic Four Operators	182
6.4.2	The %: The Modulus Operator	182
6.5	computation.c: Making Simple Calculations	182
6.6	Automatic or Implicit Type Conversion	184
6.7	implicit_conversion.c: Program to Demonstrate Implicit Conversion	185
6.8	Explicit Type Conversion—The Type Cast	186
6.9	casts.c: Program to Demonstrate Attributes of a Cast	187
6.10	Order of Evaluation	188
6.10.1	Operator Precedence	188
6.10.2	Using Parentheses to Change Default Order	189
6.10.3	Operator Associativity	189
6.11	order_of_evaluation.c: Precedence and Associativity	190
6.12	Assignment Operators	192
6.12.1	The =: The Simple Assignment Operator	192
6.12.2	The Other Assignment Operators	192

6.13	++ and --: Increment and Decrement Operators	193
6.13.1	Side Effect of ++ and --	193
6.13.2	When Things Can Go Wrong	194
6.14	computation2.c: Using the Assignment and ++/-- Operators	194
6.15	Relational Operators and Expressions	196
6.15.1	Using the Operators	196
6.15.2	Precedence and Associativity	197
6.16	The Logical Operators	198
6.16.1	The && & Operators	198
6.16.2	The ! Operator	199
6.17	The Conditional Operator	199
6.18	binary_outcomes.c: Relational, Logical and Conditional Operators at Work	200
6.19	Other Operators	200
6.19.1	The Comma (,) Operator	200
6.19.2	The sizeof Operator	202

CHAPTER 7 Control Structures—Decision Making**207**

7.1	Decision-Making Concepts	207
7.2	Decision Making in C	208
7.2.1	The Control Expression	208
7.2.2	Compound Statement or Block	209
7.3	The if Statement	209
7.4	average_integers.c: Average Calculating Program	210
7.5	if-else: Two-Way Branching	212
7.6	leap_year_check.c: Program to Check Leap Year	212
7.7	Multi-Way Branching with if-else-if ...	214
7.8	irctc_refund.c: Computes Train Ticket Cancellation Charges	216
7.9	atm_operation.c: Checks PIN Before Delivery of Cash	216
7.10	Multi-Way Branching with Nested if (if-if-else)	218
7.11	right_angle_check.c: Program to Check Pythagoras' Theorem	219
7.12	Pairing Issues with if-if-else Nested Constructs	219
7.13	leap_year_check2.c: Program Using the if-if-else Structure	221
7.14	The Conditional Expression (?:)	223
7.15	The switch Statement	224
7.16	calculator.c: A Basic Calculator Program Using switch	226
7.17	mobile_tariffs.c: Program to Compute Charges for 4G Services	227
7.18	date_validation.c: A Program to Validate a Date	229
7.19	The “Infinitely Abusable” goto Statement	230

CHAPTER 8 Control Structures—Loops**236**

8.1	Looping Basics	236
8.2	The while Loop	238
8.2.1	while_intro.c: An Introductory Program	238

8.2.2	The Control Expression	238
8.2.3	Updating the Key Variable in the Control Expression	239
8.3	Three Programs Using while	240
8.3.1	factorial.c : Determining the Factorial of a Number	240
8.3.2	extract_digits.c : Program to Reverse Digits of an Integer	241
8.3.3	fibonacci_ite.c : Printing and Summing the Fibonacci Numbers	242
8.4	Loading the Control Expression	243
8.4.1	Merging Entire Loop Body with the Control Expression	243
8.4.2	When You Actually Need a Null Body	244
8.5	Nested while Loops	244
8.5.1	nested_while.c : Printing a Multiplication Table	245
8.5.2	half_pyramid.c : Printing a Half-Pyramid with Digits	246
8.5.3	power.c : Computing Power of a Number	247
8.6	Using while with break and continue	248
8.7	prime_number_check.c : More of break and continue	249
8.8	The do-while Loop	251
8.9	decimal2binary.c : Collecting Remainders from Repeated Division	252
8.10	The for Loop	253
8.10.1	ascii_letters.c : A Portable ASCII Code Generator	255
8.10.2	print_terms.c : Completing a Series of Mathematical Expressions	256
8.11	for : The Three Expressions (<i>exp1, exp2, exp3</i>)	257
8.11.1	Moving All Initialization to <i>exp1</i>	257
8.11.2	Moving Expression Statements in Body to <i>exp3</i>	257
8.11.3	Dropping One or More Expressions	258
8.11.4	The Infinite Loop	258
8.12	decimal2binary2.c : Converting a Decimal Number to Binary	259
8.13	Nested for Loops	260
8.14	Using for with break and continue	261
8.15	all_prime_numbers.c : Using break and continue	261

CHAPTER 9 Terminal Input/Output Functions**266**

9.1	I/O Function Basics	266
9.2	Character Input with getchar	267
9.3	Character Output with putchar	269
9.4	retrieve_from_buffer.c : A Buffer-Related Issue	269
9.5	The Standard Files	270
9.6	unix2dos.c : Program to Convert a UNIX File to MSDOS Format	271
9.7	Other Character-I/O Functions	272
9.7.1	The fgetc and fputc Functions	272
9.7.2	The getc and putc Macros	272
9.7.3	The ungetc Function	273
9.8	Formatted Input: The scanf Function	274

- 9.9 **scanf**: The Matching Rules 277
9.9.1 Mismatches and Return Value 277
9.9.2 **scanf_retval.c**: Program to Extract Numbers from a String 278
- 9.10 **scanf**: The Major Format Specifiers 279
9.10.1 Handling Numeric Data (%d and %f) 280
9.10.2 Handling Character Data (%c) 280
9.10.3 Handling String Data (%s) 281
- 9.10.4 **scanf_char_string.c**: Characters and Strings as Input 281
- 9.11 **scanf**: Other Features 281
9.11.1 The Scan Set Specifier 281
9.11.2 The * Flag 284
9.11.3 The %p, %n and %% Specifiers 284
- 9.12 Formatted Output: The **printf** Function 285
9.12.1 **printf** and **scanf** Compared 286
9.12.2 Printing Plain Text 286
9.12.3 **printf_special.c**: A Second Look at the Data Types 287
- 9.13 **printf**: Using Field Width and the * Flag 288
- 9.14 **printf**: Using Precision 289
9.14.1 Precision with Floating Point Numbers 289
9.14.2 Precision with Integers 290
9.14.3 Precision with Character Strings 290
- 9.15 **printf**: Using Flags 291
- 9.16 **printf_flags.c**: Using the Flags 292

CHAPTER 10 Arrays

298

- 10.1 Array Basics 298
- 10.2 Declaring and Initializing an Array 299
10.2.1 Initializing During Declaration 300
10.2.2 Initializing After Declaration 300
- 10.3 **array_init.c**: Initializing and Printing Arrays 301
- 10.4 **scanf_with_array.c**: Populating an Array with **scanf** 302
- 10.5 Basic Operations on Arrays 302
10.5.1 **insert_element.c**: Inserting an Element in an Array 303
10.5.2 **delete_element.c**: Deleting an Element from an Array 304
- 10.6 Reversing an Array 305
10.6.1 Reversing with Two Arrays 305
10.6.2 Reversing with a Single Array 306
- 10.7 Two Programs Revisited 306
10.7.1 **extract_digits2.c**: Saving Digits of an Integer 306
10.7.2 **decimal2anybase.c**: Converting from Decimal to Any Base 307
- 10.8 Sorting an Array (Selection) 309
- 10.9 **array_search.c**: Program to Sequentially Search an Array 311

- 10.10 Binary Search 311
 - 10.10.1 The Binary Search Algorithm 313
 - 10.10.2 **binary_search.c**: Implementation of the Algorithm 313
- 10.11 **count_chars.c**: Frequency Count of Data Items 315
- 10.12 Two-Dimensional (2D) Arrays 316
 - 10.12.1 Full Initialization During Declaration 317
 - 10.12.2 Partial Initialization During Declaration 318
 - 10.12.3 Assignment After Declaration 318
 - 10.12.4 Assignment and Printing Using a Nested Loop 319
- 10.13 **count_numbers.c**: Using a 2D Array as a Counter 320
- 10.14 Multi-Dimensional Arrays 321
- 10.15 Using Arrays as Matrices 322
 - 10.15.1 **matrix_transpose.c**: Transposing a Matrix 322
 - 10.15.2 **matrix_add_subtract.c**: Adding and Subtracting Two Matrices 323
 - 10.15.3 **matrix_multiply.c**: Multiplying Two Matrices 324
- 10.16 Variable Length Arrays (C99) 326

CHAPTER 11 Functions**331**

- 11.1 Function Basics 331
- 11.2 **first_func.c**: No Arguments, No Return Value 332
- 11.3 The Anatomy of a Function 334
 - 11.3.1 Declaration, Prototype or Signature 334
 - 11.3.2 Definition or Implementation 335
 - 11.3.3 Invocation or Call 335
- 11.4 **c2f.c**: One Argument and Return Value 336
- 11.5 Arguments, Parameters and Local Variables 337
 - 11.5.1 Parameter Passing: Arguments and Parameters 338
 - 11.5.2 Passing by Value vs Passing by Reference 338
 - 11.5.3 Local Variables 339
 - 11.5.4 **swap_failure.c**: The “Problem” with Local Variables 340
- 11.6 The Return Value and Side Effect 341
- 11.7 **prime_number_check2.c**: Revised Program to Check Prime Numbers 342
- 11.8 Using Arrays in Functions 343
 - 11.8.1 **input2array.c**: Passing an Array as an Argument 345
 - 11.8.2 The **static** keyword: Keeping an Array Alive 346
- 11.9 **merge_arrays.c**: Merging Two Sorted Arrays 346
- 11.10 Passing a Two-Dimensional Array as Argument 348
- 11.11 Calling a Function from Another Function 350
 - 11.11.1 **time_diff.c**: Program to Compute Difference Between Two Times 350
 - 11.11.2 **power_func.c**: Computing the Sum of a Power Series 351
- 11.12 **sort_bubble.c**: Ordering an Array Using Bubble Sort 353
- 11.13 Recursive Functions 355
 - 11.13.1 **factorial_rec.c**: Using a Recursive Function to Compute Factorial 356
 - 11.13.2 Recursion vs Iteration 357

- 11.14 Thinking in Recursive Terms 359
 - 11.14.1 Adding Array Elements Recursively 359
 - 11.14.2 Computing the Power of a Number Recursively 360
 - 11.14.3 Using Recursion To Compute Fibonacci Numbers 360
- 11.15 The **main** Function 361
- 11.16 Variable Scope and Lifetime 362
 - 11.16.1 Local and Global Variables 362
 - 11.16.2 Variables in a Block 362
 - 11.16.3 Variable Hiding 363
- 11.17 The Storage Classes 364
 - 11.17.1 Automatic Variables (**auto**) 364
 - 11.17.2 Static Variables (**static**) 364
 - 11.17.3 External Variables (**extern**) 365
 - 11.17.4 **extern.c**: Using **extern** to Control Variable Visibility 366
 - 11.17.5 Register Variables (**register**) 368

CHAPTER 12 Pointers

373

- 12.1 Memory Access and the Pointer 373
- 12.2 Pointer Basics 374
- 12.3 **intro2pointers.c**: A Simple Demonstration of Pointers 375
- 12.4 Declaring, Initializing and Dereferencing a Pointer 375
- 12.5 **pointers.c**: Using Two Pointers 377
- 12.6 Important Attributes of Pointers 379
- 12.7 Pointers and Functions 382
 - 12.7.1 **swap_success.c**: Making the **swap** Function Work 383
 - 12.7.2 Using Pointers to Return Multiple Values 384
 - 12.7.3 **sphere_calc.c**: Function “Returning” Multiple Values 385
 - 12.7.4 Returning a Pointer 386
- 12.8 Pointers and Arrays 387
 - 12.8.1 Using a Pointer for Browsing an Array 387
 - 12.8.2 Dereferencing the Array Pointer 388
 - 12.8.3 Treating a Pointer as an Array 389
 - 12.8.4 Array vs Pointer Which Points to an Array 389
 - 12.8.5 **pointer_array.c**: Treating an Array as a Pointer 390
- 12.9 Operations on Pointers 391
 - 12.9.1 Assignment 391
 - 12.9.2 Pointer Arithmetic Using + and - 391
 - 12.9.3 Pointer Arithmetic Using ++ and -- 392
 - 12.9.4 Comparing Two Pointers 393
- 12.10 **max_min.c**: Using **scanf** and **printf** with Pointer Notation 393
- 12.11 NULL and the Null Pointer 393
- 12.12 Pointers, Arrays and Functions Revisited 395
 - 12.12.1 Pointers in Lieu of Array as Function Argument 395

12.12.2 Using const to Protect an Array from a Function	397
12.12.3 Returning a Pointer to an Array	397
12.13 Array of Pointers	398
12.14 sort_selection2.c : Sorted View of Array Using Array of Pointers	398
12.15 Pointer to a Pointer	399
12.16 Pointers and Two-Dimensional Arrays	402
12.17 The Generic or Void Pointer	404
12.18 Using the const Qualifier with Pointers	406

CHAPTER 13 Strings**412**

13.1 String Basics	412
13.2 Declaring and Initializing a String	413
13.2.1 Using an Array to Declare a String	413
13.2.2 When an Array is Declared But Not Initialized	413
13.2.3 Using a Pointer to Declare a String	414
13.2.4 When an Array of Characters Is Not a String	415
13.3 intro2strings.c : Declaring and Initializing Strings	415
13.4 Handling Lines as Strings	417
13.4.1 Using gets/puts : The Unsafe Way	417
13.4.2 gets_puts.c : A Program Using gets and puts	417
13.4.3 Using fgets/fputs : The Safe Way	418
13.4.4 fgets_fputs.c : A Program Using fgets and fputs	419
13.5 The sscanf and sprintf Functions	420
13.5.1 sscanf : Formatted Input from a String	420
13.5.2 sprintf : Formatted Output to a String	421
13.5.3 validate_pan.c : Using sscanf and sprintf to Validate Data	421
13.6 Using Pointers for String Manipulation	422
13.7 Common String-Handling Programs	423
13.7.1 string_palindrome.c : Program to Check a Palindrome	423
13.7.2 count_words.c : Counting Number of Words in a String	424
13.7.3 sort_characters.c : Sorting Characters in a String	425
13.8 Developing String-Handling Functions	426
13.8.1 my_strlen : Function to Evaluate Length of a String	426
13.8.2 reverse_string : Function to Reverse a String	427
13.8.3 my_strcpy : Function to Copy a String	427
13.8.4 my_strcat : Function to Concatenate Two Strings	427
13.8.5 string_manipulation.c : Invoking All Four Functions from main	428
13.8.6 substr.c : Program Using a Function to Extract a Substring	429
13.9 Standard String-Handling Functions	430
13.9.1 The strlen Function	430
13.9.2 The strcpy Function	430
13.9.3 The strcat Function	431
13.9.4 The strcmp Function	431

13.9.5	The strchr and strrchr Functions	432
13.9.6	The strstr Function	432
13.10	The Character-Oriented Functions	433
13.11	password_check.c : Using the Character-Handling Functions	434
13.12	Two-Dimensional Array of Strings	435
13.13	Array of Pointers to Strings	435
13.14	sort_strings.c : Sorting a 2D Array of Strings	437
13.15	string_swap.c : Swapping Two Strings	438
13.16	The main Function Revisited	439

CHAPTER 14 User-Defined Data Types**445**

14.1	Structure Basics	445
14.2	Declaring and Defining a Structure	446
14.2.1	Accessing Members of a Structure	447
14.2.2	Combining Declaration, Definition and Initialization	448
14.2.3	Declaring without Structure Tag	448
14.3	intro2structures.c : An Introductory Program	449
14.4	Important Attributes of Structures	450
14.4.1	structure_attributes.c : Copying and Comparing Structures	451
14.4.2	Abbreviating a Data Type: The typedef Feature	452
14.4.3	structure_typedef.c : Simplifying Use of Structures	453
14.5	Nested Structures	454
14.5.1	Initializing a Nested Structure	455
14.5.2	Accessing Members	456
14.5.3	structure_nested.c : Program Using a Nested Structure	456
14.6	Arrays as Structure Members	457
14.7	Arrays of Structures	458
14.7.1	array_of_structures.c : Program for Displaying Batting Averages	459
14.7.2	structure_sort.c : Sorting an Array of Structures	460
14.8	Structures in Functions	462
14.8.1	structure_in_func.c : An Introductory Program	463
14.8.2	time_difference.c : Using a Function that Returns a Structure	464
14.8.3	swap_success2.c : Swapping Variables Revisited	465
14.9	Pointers to Structures	466
14.9.1	pointer_to_structure.c : Accessing Structure Members	467
14.9.2	update_pay.c : Using a Pointer as a Function Argument	468
14.9.3	time_addition.c : Using Pointers as Function Arguments	469
14.10	student_management.c : A Project	470
14.11	Unions	473
14.11.1	Unique Attributes of Unions	473
14.11.2	intro2unions : An Introductory Program	474
14.12	Bit Fields	475
14.13	The Enumerated Type	476

CHAPTER 15 File Handling**484**

15.1	A Programmer's View of the File	484
15.2	File-Handling Basics	485
15.3	Opening and Closing Files	486
15.3.1	fopen : Opening a File	486
15.3.2	File Opening Modes	486
15.3.3	The Filename	487
15.3.4	Error Handling	488
15.3.5	fclose : Closing a File	489
15.3.6	fopen_fclose.c : An Introductory Program	489
15.4	The File Pointer and File Buffer	490
15.5	The File Read/Write Functions	491
15.5.1	mixing_functions.c : Manipulating the File Offset Pointer	491
15.5.2	The fgetc and fputc Functions Revisited	492
15.5.3	file_copy.c : A File Copying Program	493
15.5.4	file_append.c : A File Appending Program	494
15.6	The fgets and fputs Functions Revisited	495
15.6.1	fgets_fputs2.c : Using fgets and fputs with a Disk File	496
15.6.2	save_student_data.c : Writing Data Stored in Array to a File	497
15.7	fscanf and fprintf : The Formatted Functions	498
15.8	fscanf_fprintf.c : Writing and Reading Lines Containing Fields	498
15.9	Filenames from Command-Line Arguments	500
15.9.1	file_copy2.c : File Copying Using Command-Line Arguments	500
15.9.2	validate_records.c : Detecting Lines Having Wrong Number of Fields	501
15.10	perror and errno : Handling Function Errors	503
15.11	feof , ferror and clearerr : EOF and Error Handling	504
15.12	Text and Binary Files	505
15.13	fread and fwrite : Reading and Writing Binary Files	506
15.13.1	The fread Function	506
15.13.2	The fwrite Function	507
15.13.3	fread_fwrite.c : Using the Primitive and Derived Data Types	507
15.13.4	save_structure.c : Saving and Retrieving a Structure	508
15.14	Manipulating the File Position Indicator	510
15.14.1	fseek : Positioning the Offset Pointer	510
15.14.2	The ftell and rewind Functions	510
15.14.3	reverse_read.c : Reading a File in Reverse	511
15.15	update_structure.c : Updating a Structure Stored on Disk	512
15.16	The Other File-Handling Functions	514
15.16.1	The remove Function	514
15.16.2	The rename Function	514
15.16.3	The tmpfile Function	515

CHAPTER 16 Dynamic Memory Allocation and Linked Lists**520**

- 16.1 Memory Allocation Basics 520
16.2 The Functions for Dynamic Memory Allocation 521
 16.2.1 The Generic Pointer 522
 16.2.2 Error Handling 522
16.3 **malloc**: Specifying Memory Requirement in Bytes 523
 16.3.1 **malloc.c**: An Introductory Program 524
 16.3.2 Error-Checking in **malloc** 524
 16.3.3 Using **malloc** to Store an Array 525
 16.3.4 **malloc_array.c**: An Array-Handling Program Using **malloc** 525
16.4 **free**: Freeing Memory Allocated by **malloc** 526
16.5 Memory Mismanagement 527
 16.5.1 The Dangling Pointer 527
 16.5.2 Memory Leaks 528
16.6 **malloc_2Darray.c**: Simulating a 2D Array 529
16.7 **malloc_strings.c**: Storing Multiple Strings 531
16.8 **calloc**: Allocating Memory for Arrays and Structures 532
16.9 **realloc**: Changing Size of Allocated Memory Block 534
16.10 The Linked List 536
 16.10.1 Creating a Linked List with Variables 538
 16.10.2 **create_list.c**: Creating a Linked List Using **malloc** 539
 16.10.3 Operations on Linked Lists 540
16.11 Adding a Node 541
 16.11.1 Adding a Node at Beginning 541
 16.11.2 Adding a Node at End 542
16.12 Deleting a Node at Beginning and End 543
16.13 **head_tail_operations.c**: Adding and Deleting a Single Node 543
16.14 **list_manipulation.c**: A List Handling Program 545
 16.14.1 The **add_node** Function 547
 16.14.2 The **count_nodes** Function 548
 16.14.3 The **find_node** Function 548
 16.14.4 The **insert_after** Function 549
 16.14.5 The **delete_node** Function 549
16.15 Types of Linked Lists 550
16.16 Abstract Data Types (ADTs) 550
 16.16.1 The Stack 551
 16.16.2 The Queue 551
 16.16.3 The Tree 552

CHAPTER 17 The Preprocessor and Other Features**558**

- 17.1 The Preprocessor 558
17.2 **#define**: Macros without Arguments 560
 17.2.1 Using Numbers and Expressions 561

17.2.2	Why Not Use a Variable?	562
17.2.3	Abbreviating Text	562
17.3	#define: Macros with Arguments	563
17.3.1	When Parentheses Are Required	564
17.3.2	Useful Macros	564
17.3.3	swap_with_macro.c: Swapping Two Numbers Using a Macro	565
17.3.4	Functions vs Macros	566
17.4	Macros and Strings	567
17.4.1	The # Operator	567
17.4.2	The ## Operator	568
17.4.3	tokens.c: Using the # and ## Operators	568
17.5	The #undef Directive	569
17.6	The #include Directive	570
17.7	Conditional Compilation	571
17.7.1	The #ifdef and #ifndef Directives	572
17.7.2	The #if and #elif Directives	573
17.8	Using #ifdef for Debugging Programs	574
17.9	The Bitwise Operators	575
17.9.1	The & Operator: Bitwise AND	576
17.9.2	Using a Mask with &	577
17.9.3	The Operator: Bitwise OR	578
17.9.4	The ^ Operator: Bitwise Exclusive OR (XOR)	578
17.9.5	The ~ Operator: One's Complement (NOT)	579
17.9.6	The << Operator: Bitwise Left-Shift	579
17.9.7	The >> Operator: Bitwise Right-Shift	580
17.10	bitwise_operations.c: Using the Bitwise Operators	580
17.11	Pointers to Functions	582
17.11.1	Function Pointer for Functions Using Arguments	583
17.11.2	func_pointer.c: Using Function Pointers	584
17.11.3	Callback Functions	585
17.12	Functions with Variable Arguments	587
17.13	Multi-Source Program Files	589
17.13.1	A Multi-Source Application	590
17.13.2	Compiling and Linking the Application	592
Appendix A	Selective C Reference	599
Appendix B	The ASCII Character Set	606
Appendix C	Glossary	610
Appendix D	Answers to Objective Questions	628
Appendix E	Bibliography	635
Index		637