

# CONTENTS IN DETAIL

<b>FOREWORD TO THE SECOND EDITION</b>	<b>xvii</b>
---------------------------------------	-------------

<b>FOREWORD TO THE FIRST EDITION</b>	<b>xix</b>
--------------------------------------	------------

<b>ACKNOWLEDGMENTS</b>	<b>xxi</b>
------------------------	------------

<b>INTRODUCTION</b>	<b>xxiii</b>
---------------------	--------------

A Brief History of C . . . . .	xxiv
The C Standard . . . . .	xxv
The CERT C Coding Standard . . . . .	xxvi
Common Weakness Enumeration . . . . .	xxvi
Who This Book Is For . . . . .	xxvi
What's in This Book . . . . .	xxvii

<b>1</b>	
<b>GETTING STARTED WITH C</b>	<b>1</b>

Developing Your First C Program . . . . .	1
Compiling and Running a Program . . . . .	3
Function Return Values . . . . .	4
Formatted Output . . . . .	5
Editors and Integrated Development Environments . . . . .	6
Compilers . . . . .	7
GNU Compiler Collection . . . . .	8
Clang . . . . .	8
Microsoft Visual Studio . . . . .	8
Portability . . . . .	9
Implementation-Defined Behavior . . . . .	9
Unspecified Behavior . . . . .	10
Undefined Behavior . . . . .	10
Locale-Specific Behavior and Common Extensions . . . . .	11
Summary . . . . .	11

<b>2</b>	
<b>OBJECTS, FUNCTIONS, AND TYPES</b>	<b>13</b>

Entities . . . . .	13
Declaring Variables . . . . .	14
Swapping Values, First Attempt . . . . .	15
Swapping Values, Second Attempt . . . . .	16
Object Types . . . . .	18
Boolean . . . . .	18
Character . . . . .	19
Arithmetic . . . . .	19
void . . . . .	22

Derived Types . . . . .	22
Function . . . . .	22
Pointer . . . . .	23
Array . . . . .	25
Structure . . . . .	27
Union . . . . .	28
Tags . . . . .	29
Type Qualifiers . . . . .	31
const . . . . .	32
volatile . . . . .	32
restrict . . . . .	33
Scope . . . . .	34
Storage Duration . . . . .	35
Storage Class . . . . .	36
static . . . . .	36
extern . . . . .	37
thread_local . . . . .	37
constexpr . . . . .	37
register . . . . .	38
typedef . . . . .	38
auto . . . . .	38
typeof Operators . . . . .	39
Alignment . . . . .	41
Variably Modified Types . . . . .	42
Attributes . . . . .	44
Summary . . . . .	45

### **3 ARITHMETIC TYPES 47**

Integers . . . . .	48
Padding, Width, and Precision . . . . .	48
Integer Ranges . . . . .	48
Integer Declarations . . . . .	49
Unsigned Integers . . . . .	49
Signed Integers . . . . .	52
Bit-Precise Integer Types . . . . .	56
Integer Constants . . . . .	57
Floating-Point Representation . . . . .	59
Floating Types and Encodings . . . . .	59
C Floating-Point Model . . . . .	60
Floating-Point Arithmetic . . . . .	62
Floating-Point Values . . . . .	62
Floating Constants . . . . .	64
Arithmetic Conversion . . . . .	64
Integer Conversion Rank . . . . .	65
Integer Promotions . . . . .	66
Usual Arithmetic Conversions . . . . .	67
An Example of Implicit Conversion . . . . .	69
Safe Conversions . . . . .	70
Summary . . . . .	72

## **4 EXPRESSIONS AND OPERATORS 73**

Simple Assignment . . . . .	74
Evaluations . . . . .	75
Function Invocation . . . . .	76
Increment and Decrement Operators . . . . .	77
Operator Precedence and Associativity . . . . .	78
Order of Evaluation . . . . .	80
Unsequenced and Indeterminately Sequenced Evaluations . . . . .	81
Sequence Points . . . . .	81
sizeof Operator . . . . .	82
Arithmetic Operators . . . . .	83
Unary + and - . . . . .	83
Logical Negation . . . . .	83
Additive . . . . .	83
Multiplicative . . . . .	84
Bitwise Operators . . . . .	85
Complement . . . . .	85
Shift . . . . .	86
Bitwise AND . . . . .	87
Bitwise Exclusive OR . . . . .	88
Bitwise Inclusive OR . . . . .	88
Logical Operators . . . . .	89
Cast Operators . . . . .	90
Conditional Operator . . . . .	91
alignof Operator . . . . .	92
Relational Operators . . . . .	93
Compound Assignment Operators . . . . .	93
Comma Operator . . . . .	94
Pointer Arithmetic . . . . .	94
Summary . . . . .	96

## **5 CONTROL FLOW 97**

Expression Statements . . . . .	97
Compound Statements . . . . .	98
Selection Statements . . . . .	99
if . . . . .	99
switch . . . . .	102
Iteration Statements . . . . .	105
while . . . . .	105
do...while . . . . .	106
for . . . . .	107
Jump Statements . . . . .	109
goto . . . . .	109
continue . . . . .	111
break . . . . .	111
return . . . . .	112
Summary . . . . .	113

## **6 DYNAMICALLY ALLOCATED MEMORY 115**

Storage Duration . . . . .	116
The Heap and Memory Managers . . . . .	116
When to Use Dynamically Allocated Memory . . . . .	117
Memory Management . . . . .	117
malloc . . . . .	118
aligned_alloc . . . . .	120
calloc . . . . .	120
realloc . . . . .	121
reallocarray . . . . .	123
free . . . . .	123
free_sized . . . . .	124
free_aligned_sized . . . . .	124
Memory States . . . . .	126
Flexible Array Members . . . . .	127
Other Dynamically Allocated Storage . . . . .	128
alloca . . . . .	128
Variable-Length Arrays . . . . .	129
Debugging Allocated Storage Problems . . . . .	132
dmalloc . . . . .	132
Safety-Critical Systems . . . . .	134
Summary . . . . .	135

## **7 CHARACTERS AND STRINGS 137**

Characters . . . . .	138
ASCII . . . . .	138
Unicode . . . . .	138
Source and Execution Character Sets . . . . .	140
Data Types . . . . .	140
Character Constants . . . . .	142
Escape Sequences . . . . .	143
Linux . . . . .	144
Windows . . . . .	145
Character Conversion . . . . .	146
Strings . . . . .	149
String Literals . . . . .	150
String-Handling Functions . . . . .	152
<string.h> and <wchar.h> . . . . .	152
Annex K Bounds-Checking Interfaces . . . . .	161
POSIX . . . . .	164
Microsoft . . . . .	165
Summary . . . . .	165

## **8 INPUT/OUTPUT 167**

Standard I/O Streams . . . . .	168
Error and End-of-File Indicators . . . . .	168
Stream Buffering . . . . .	169

Predefined Streams . . . . .	170
Stream Orientation . . . . .	171
Text and Binary Streams. . . . .	172
Opening and Creating Files . . . . .	172
fopen. . . . .	172
open . . . . .	174
Closing Files . . . . .	176
fclose. . . . .	176
close . . . . .	177
Reading and Writing Characters and Lines . . . . .	177
Stream Flushing . . . . .	180
Setting the Position in a File. . . . .	180
Removing and Renaming Files . . . . .	183
Using Temporary Files. . . . .	184
Reading Formatted Text Streams. . . . .	184
Reading from and Writing to Binary Streams. . . . .	188
Endian . . . . .	191
Summary . . . . .	192

**9**  
**PREPROCESSOR** **195**

The Compilation Process . . . . .	196
File Inclusion . . . . .	197
Conditional Inclusion . . . . .	198
Generating Diagnostics . . . . .	200
Using Header Guards . . . . .	201
Macro Definitions. . . . .	202
Macro Replacement . . . . .	205
Type-Generic Macros. . . . .	207
Embedded Binary Resources. . . . .	209
Predefined Macros . . . . .	210
Summary . . . . .	211

**10**  
**PROGRAM STRUCTURE** **213**

Principles of Componentization . . . . .	213
Coupling and Cohesion. . . . .	214
Code Reuse . . . . .	215
Data Abstractions . . . . .	215
Opaque Types . . . . .	217
Executables. . . . .	218
Linkage. . . . .	219
Structuring a Simple Program . . . . .	221
Building the Code . . . . .	225
Summary . . . . .	227

**11**  
**DEBUGGING, TESTING, AND ANALYSIS** **229**

Assertions . . . . .	230
Static Assertions . . . . .	230
Runtime Assertions . . . . .	232

