

Contents

List of Tables	xv
Preface	xvii
PART 1 The C Language	1
1 Introduction	3
1.1 The Evolution of C	3
1.2 Which Dialect of C Should You Use?	6
1.3 An Overview of C Programming	7
1.4 Conformance	8
1.5 Syntax Notation	9
2 Lexical Elements	11
2.1 Character Set	11
2.2 Comments	18
2.3 Tokens	20
2.4 Operators and Separators	20
2.5 Identifiers	21
2.6 Keywords	23
2.7 Constants	24
2.8 C++ Compatibility	38
2.9 On Character Sets, Repertoires, and Encodings	39
2.10 Exercises	41
3 The C Preprocessor	43
3.1 Preprocessor Commands	43
3.2 Preprocessor Lexical Conventions	44
3.3 Definition and Replacement	46
3.4 File Inclusion	59
3.5 Conditional Compilation	61
3.6 Explicit Line Numbering	66
3.7 Pragma Directive	67
3.8 Error Directive	69
3.9 C++ Compatibility	70
3.10 Exercises	71

4	Declarations	73
4.1	Organization of Declarations	74
4.2	Terminology	75
4.3	Storage Class and Function Specifiers	83
4.4	Type Specifiers and Qualifiers	86
4.5	Declarators	95
4.6	Initializers	103
4.7	Implicit Declarations	113
4.8	External Names	113
4.9	C++ Compatibility	116
4.10	Exercises	119
5	Types	123
5.1	Integer Types	124
5.2	Floating-Point Types	132
5.3	Pointer Types	136
5.4	Array Types	140
5.5	Enumerated Types	145
5.6	Structure Types	148
5.7	Union Types	160
5.8	Function Types	165
5.9	The Void Type	168
5.10	Typedef Names	168
5.11	Type Compatibility	172
5.12	Type Names and Abstract Declarators	176
5.13	C++ Compatibility	178
5.14	Exercises	179
6	Conversions and Representations	181
6.1	Representations	181
6.2	Conversions	188
6.3	The Usual Conversions	194
6.4	C++ Compatibility	200
6.5	Exercises	201
7	Expressions	203
7.1	Objects, Lvalues, and Designators	203
7.2	Expressions and Precedence	204
7.3	Primary Expressions	207
7.4	Postfix Expressions	210
7.5	Unary Expressions	219
7.6	Binary Operator Expressions	227
7.7	Logical Operator Expressions	242
7.8	Conditional Expressions	244
7.9	Assignment Expressions	246
7.10	Sequential Expressions	249

7.11	Constant Expressions	250
7.12	Order of Evaluation	253
7.13	Discarded Values	255
7.14	Optimization of Memory Accesses	256
7.15	C++ Compatibility	257
7.16	Exercises	258
8	Statements	259
8.1	General Syntactic Rules for Statements	260
8.2	Expression Statements	260
8.3	Labeled Statements	261
8.4	Compound Statements	262
8.5	Conditional Statements	264
8.6	Iterative Statements	266
8.7	Switch Statements	274
8.8	Break and Continue Statements	277
8.9	Return Statements	279
8.10	Goto Statements	280
8.11	Null Statements	281
8.12	C++ Compatibility	282
8.13	Exercises	282
9	Functions	285
9.1	Function Definitions	286
9.2	Function Prototypes	289
9.3	Formal Parameter Declarations	295
9.4	Adjustments to Parameter Types	298
9.5	Parameter-Passing Conventions	299
9.6	Agreement of Parameters	300
9.7	Function Return Types	301
9.8	Agreement of Return Types	302
9.9	The Main Program	303
9.10	Inline Functions	304
9.11	C++ Compatibility	306
9.12	Exercises	307
PART 2	The C Libraries	309
10	Introduction to the Libraries	311
10.1	Standard C Facilities	312
10.2	C++ Compatibility	313
10.3	Library Headers and Names	316
11	Standard Language Additions	325
11.1	NULL, ptrdiff_t, size_t, offsetof	325
11.2	EDOM, ERANGE, EILSEQ, errno, strerror, perror	327
11.3	bool, false, true	329

- 11.4 `va_list`, `va_start`, `va_arg`, `va_end` 329
- 11.5 Standard C Operator Macros 333

12 Character Processing **335**

- 12.1 `isalnum`, `isalpha`, `iscentrl`, `iswalnum`, `iswalpha`, `iswcentrl` 336
- 12.2 `iscsym`, `iscsymf` 338
- 12.3 `isdigit`, `isodigit`, `isxdigit`, `iswdigit`, `iswxdigit` 338
- 12.4 `isgraph`, `isprint`, `ispunct`, `iswgraph`, `iswprint`, `iswpunct` 339
- 12.5 `islower`, `isupper`, `iswlower`, `iswupper` 340
- 12.6 `isblank`, `isspace`, `iswhite`, `iswspace` 341
- 12.7 `toascii` 341
- 12.8 `toint` 342
- 12.9 `tolower`, `toupper`, `tolower`, `toupper` 342
- 12.10 `wctype_t`, `wctype`, `iswctype` 343
- 12.11 `wctrans_t`, `wctrans` 344

13 String Processing **347**

- 13.1 `strcat`, `strncat`, `wscat`, `wcsncat` 348
- 13.2 `strcmp`, `strncmp`, `wscmp`, `wcsncmp` 349
- 13.3 `strcpy`, `strncpy`, `wscpy`, `wcsncpy` 350
- 13.4 `strlen`, `wcslen` 351
- 13.5 `strchr`, `strchr`, `wcschr`, `wcschr` 351
- 13.6 `strspn`, `strcspn`, `strpbrk`, `strpbrk`, `wcsspn`, `wcscspn`, `wcsprbrk` 352
- 13.7 `strstr`, `strtok`, `wcsstr`, `wcstok` 354
- 13.8 `strtod`, `strtof`, `strtold`, `strtoul`, `strtoll`, `strtoul`, `strtoull` 355
- 13.9 `atof`, `atoi`, `atol`, `atoll` 356
- 13.10 `strcoll`, `strxfrm`, `wscoll`, `wcsxfrm` 356

14 Memory Functions **359**

- 14.1 `memchr`, `wmemchr` 359
- 14.2 `memcmp`, `wmemcmp` 360
- 14.3 `memcpy`, `memccpy`, `memmove`, `wmemcpy`, `wmemmove` 361
- 14.4 `memset`, `wmemset` 362

15 Input/Output Facilities **363**

- 15.1 `FILE`, `EOF`, `wchar_t`, `wint_t`, `WEOF` 365
- 15.2 `fopen`, `fclose`, `fflush`, `freopen`, `fwide` 366
- 15.3 `setbuf`, `setvbuf` 370
- 15.4 `stdin`, `stdout`, `stderr` 371
- 15.5 `fseek`, `ftell`, `rewind`, `fgetpos`, `fsetpos` 372
- 15.6 `fgetc`, `fgetwc`, `getc`, `getwc`, `getchar`, `getwchar`, `ungetc`, `ungetwc` 374
- 15.7 `fgets`, `fgetws`, `gets` 376
- 15.8 `fscanf`, `fwscanf`, `scanf`, `wscanf`, `sscanf`, `swscanf` 377
- 15.9 `fputc`, `fputwc`, `putc`, `putwc`, `putchar`, `putwchar` 385
- 15.10 `fputs`, `fputws`, `puts` 386
- 15.11 `fprintf`, `printf`, `sprintf`, `snprintf`, `fwprintf`, `wprintf`, `swprintf` 387

- 15.12 `vfprintf, vfwprintf, vprintf, vwprintf, vsprintf, vswprintf, vfscanf, vfwscanf, vscanf, vswscanf, vsscanf, vswscanf` 401
- 15.13 `fread, fwrite` 402
- 15.14 `feof, ferror, clearerr` 404
- 15.15 `remove, rename` 404
- 15.16 `tmpfile, tmpnam, mktemp` 405

16 General Utilities

407

- 16.1 `malloc, calloc, malloc, calloc, free, cfree` 407
- 16.2 `rand, srand, RAND_MAX` 410
- 16.3 `atof, atoi, atol, atoll` 411
- 16.4 `strtod, strtod, strtold, strtol, strtoll, strtoul, strtoull` 412
- 16.5 `abort, atexit, exit, _Exit, EXIT_FAILURE, EXIT_SUCCESS` 414
- 16.6 `getenv` 415
- 16.7 `system` 416
- 16.8 `bsearch, qsort` 417
- 16.9 `abs, labs, llabs, div, ldiv, lldiv` 419
- 16.10 `mblen, mbtowc, wctomb` 420
- 16.11 `mbstowcs, wcstombs` 422

17 Mathematical Functions

425

- 17.1 `abs, labs, llabs, div, ldiv, lldiv` 426
- 17.2 `fabs` 426
- 17.3 `ceil, floor, lrint, llrint, lround, llround, nearbyint, round, rint, trunc` 427
- 17.4 `fmod, remainder, remquo` 428
- 17.5 `frexp, ldexp, modf, scalbn` 429
- 17.6 `exp, exp2, expm1, ilogb, log, log10, log1p, log2, logb` 430
- 17.7 `cbrt, fma, hypot, pow, sqrt` 432
- 17.8 `rand, srand, RAND_MAX` 432
- 17.9 `cos, sin, tan, cosh, sinh, tanh` 433
- 17.10 `acos, asin, atan, atan2, acosh, asinh, atanh` 434
- 17.11 `fdim, fmax, fmin` 435
- 17.12 `Type-Generic Macros` 435
- 17.13 `erf, erfc, lgamma, tgamma` 439
- 17.14 `fpclassify, isfinite, isinf, isnan, isnormal, signbit` 440
- 17.15 `copysign, nan, nextafter, nexttoward` 441
- 17.16 `isgreater, isgreaterequal, isless, islessequal, islessgreater, isunordered` 442

18 Time and Date Functions

443

- 18.1 `clock, clock_t, CLOCKS_PER_SEC, times` 443
- 18.2 `time, time_t` 445
- 18.3 `asctime, ctime` 445
- 18.4 `gmtime, localtime, mktime` 446
- 18.5 `difftime` 447

18.6	strftime, wcsftime	448
19	Control Functions	453
19.1	assert, NDEBUG	453
19.2	system, exec	454
19.3	exit, abort	454
19.4	setjmp, longjmp, jmp_buf	454
19.5	atexit	456
19.6	signal, raise, gsignal, ssignal, psignal	456
19.7	sleep, alarm	458
20	Locale	461
20.1	setlocale	461
20.2	localeconv	463
21	Extended Integer Types	467
21.1	General Rules	467
21.2	Exact-Size Integer Types	470
21.3	Least-Size Types of a Minimum Width	471
21.4	Fast Types of a Minimum Width	472
21.5	Pointer-Size and Maximum-Size Integer Types	473
21.6	Ranges of ptrdiff_t, size_t, wchar_t, wint_t, and sig_atomic_t	474
21.7	imaxabs, imaxdiv, imaxdiv_t	474
21.8	strtoimax, strtouimax	475
21.9	wcstoimax, wcstouimax	475
22	Floating-Point Environment	477
22.1	Overview	477
22.2	Floating-Point Environment	478
22.3	Floating-Point Exceptions	479
22.4	Floating-Point Rounding Modes	481
23	Complex Arithmetic	483
23.1	Complex Library Conventions	483
23.2	complex, _Complex_I, imaginary, _Imaginary_I, I	484
23.3	CX_LIMITED_RANGE	484
23.4	cacos, casin, catan, ccosh, csin, ctan	485
23.5	cacosh, casinh, catanh, ccosh, csinh, ctanh	486
23.6	cexp, clog, cabs, cpow, csqrt	487
23.7	carg, cimag, creal, conj, cproj	488
24	Wide and Multibyte Facilities	489
24.1	Basic Types and Macros	489
24.2	Conversions Between Wide and Multibyte Characters	490
24.3	Conversions Between Wide and Multibyte Strings	491
24.4	Conversions to Arithmetic Types	493
24.5	Input and Output Functions	493

24.6	String Functions	493	
24.7	Date and Time Conversions	494	
24.8	Wide-Character Classification and Mapping Functions	494	
A	The ASCII Character Set		497
B	Syntax		499
C	Answers to the Exercises		513
	Index		521

List of Tables

Table 2–1	Graphic characters	12
Table 2–2	ISO trigraphs	15
Table 2–3	Operators and separators	21
Table 2–4	Keywords in C99	23
Table 2–5	Types of integer constants	27
Table 2–6	Assignment of types to integer constants	28
Table 2–7	Character escape codes	36
Table 2–8	Additional C++ keywords	39
Table 3–1	Preprocessor commands	44
Table 3–2	Predefined macros	52
Table 4–1	Identifier scopes	75
Table 4–2	Overloading classes	78
Table 4–3	Storage class specifiers	83
Table 4–4	Default storage class specifiers	84
Table 4–5	Function declarators	101
Table 4–6	Form of initializers	104
Table 4–7	Interpretation of top-level declarations	115
Table 5–1	C types and categories	124
Table 5–2	Values defined in <code>limits.h</code>	127
Table 5–3	Values defined in <code>float.h</code>	134
Table 5–4	IEEE floating-point characteristics	135
Table 6–1	Memory models on early PCs	186
Table 6–2	Permitted casting conversions	194
Table 6–3	Allowable assignment conversions	195
Table 6–4	Conversion rank	196
Table 6–5	Usual unary conversions (choose first that applies)	197
Table 6–6	Usual binary conversions (choose first that applies)	199
Table 7–1	Nonarray expressions that can be lvalues	204
Table 7–2	Operators requiring lvalue operands	204
Table 7–3	C operators in order of precedence	205
Table 7–4	Binary operator expressions	227
Table 7–5	Conditional expression 2nd and 3rd operands (pre-Standard)	245
Table 7–6	Conditional expression 2nd and 3rd operands (Standard C)	245
Table 7–7	Assignment operands	247

Table 7–8	Operand types for compound assignment expressions	249
Table 12–1	Property names for wctype	344
Table 15–1	Type specifications for fopen and freopen	368
Table 15–2	Properties of fopen modes	368
Table 15–3	Input conversions (scanf , fscanf , sscanf)	380
Table 15–4	Input conversions of the c specifier	382
Table 15–5	Input conversions of the s specifier	383
Table 15–6	Output conversion specifications	393
Table 15–7	Examples of the d conversion	394
Table 15–8	Examples of the u conversion	394
Table 15–9	Examples of the o conversion	395
Table 15–10	Examples of the x and X conversions	395
Table 15–11	Conversions of the c specifier	396
Table 15–12	Examples of the c conversion	396
Table 15–13	Conversions of the s specifier	397
Table 15–14	Examples of the s conversion	397
Table 15–15	Examples of the f conversion	398
Table 15–16	Examples of e and E conversions	399
Table 17–1	Type-generic macros	437
Table 18–1	Fields in struct tm type	447
Table 18–2	Formatting codes for strftime	449
Table 19–1	Standard signals	458
Table 20–1	Predefined setlocale categories	462
Table 20–2	lconv structure components	465
Table 20–3	Examples of formatted monetary quantities	465
Table 20–4	Examples of lconv structure contents	466
Table 21–1	Format control string macros for integer types (N = width of type in bits)	469
Table 23–1	Domain and range of complex trigonometric functions	485
Table 23–2	Domain and range of complex hyperbolic functions	486
Table 23–3	Domain and range of complex exponential and power	487
Table 23–4	Domain and range of miscellaneous complex functions	488
Table 24–1	Wide input/output functions	494
Table 24–2	Wide-string functions	495
Table 24–3	Wide-character functions	495