## INDEX

Symbols	% (remainder operator), 39, 500
+ (addition operator), 39, 149–150, 500	; (semicolon), 6, 501
& (ampersand), 17, 500	in the array type, 42
<> (angle brackets), 502−503	to end statements, 47
for declaring lifetime	' (single quote), 502
parameters, 205	for characters, 40
for specifying type parameters,	for lifetime parameter names, 205
142, 186	for loop labels, 55
-> (arrow), 47, 500	[] (square brackets), 500
* (asterisk), 500	for array creation, 41
dereference operator, 71,	in the array type, 42
321–327, 422	for element access, 42, 143-145
glob operator, 138	_ (underscore), 502
multiplication operator, 39	as a catch-all pattern, 29, 115-116,
@ (at operator), 417–418, 501	411–413
: (colon), 501, 503	in filenames, 5
for struct fields, 86	as a visual separator in integer
for trait bounds, 197	literals, 37
{} (curly brackets), 505	(vertical pipe)
for function bodies, 6, 15	in closure definitions, 276, 502
as placeholders in the println!	in patterns, 406, 501
macro, 18	•
scope creation, 47, 74	A
/ (division operator), 39, 501	ABI (application binary interface), 427
. (dot), 500	abort, 162
for method syntax, 97-98	absolute paths, 126
for struct field access, 86-87	addition
for tuple element access, 41	of custom types, 431–433
:: (double colon), 502–503	of number types, 39
" (double quote), 40, 502	of strings, 149–150
- (hyphen)	addition operator (+), 39, 149–150, 500
for negation, 500	ahead-of-time compiled, 7
for subtraction, 39, 500	ampersand (&), 17, 500
+ (multiple trait bound syntax), 198, 500	ancestor modules, 127
! (never type), 443–444, 502	angle brackets (<>), 502–503
() (parentheses), 504	for declaring lifetime
for function parameters, 6, 15	parameters, 205
for tuples, 40–41	for specifying type parameters,
? (question mark operator), 171–175, 501	149 196
: (question mark operator), 171–173, 301	142, 186

API (application programming	buffer overread, 163
interface), 4, 300-303	byte literal syntax, 37, 78, 502
application binary interface, 427	
Arc <t> type, 370–373, 482–484</t>	C
arguments, 44	Cargo, xxvi, 7–11
arms	commands
in if expressions, 50	build, 9-10
in match expressions, 24, 111-112	check, 10
array data type, 41–43	clippy, 513
accessing elements of, 42	doc, 23, 297–299
invalid element access, 42-43	fix, 512-513
iterating over elements of, 57–58	fmt, 511-512
slices of, 83	install, 312-313
arrow (->), 47, 500	$\log in, 304$
as_bytes method, 77	new, $8-9$ , $14$ , $121$ , $124$
as keyword, 135	publish, 297-306
assert_eq! macro, 222-224	run, 10, 309
assert! macro, 219-222	test, 217–218, 230–236,
assert_ne! macro, 224	298–299, 311
associated function, 16, 101	update, 21
associated types, 430-431	yank, 306
associative array. See HashMap≺K, V> type	extending with custom
asterisk (*), 500	commands, 313
dereference operator, 71,	workspaces, 307–312
321–327, 422	Cargo.lock, 9-10, 21-22, 309-310
glob operator, 138	Cargo.toml, 8-9, 19-22, 121
multiplication operator, 39	dependencies section, 19-20
atomically reference counted, 370–373	package section, 304-305
at operator (@), 417–418, 501	profile section, 296-297
attribute-like procedural macros, 457	updating crate versions in, 21
automatic dereferencing, 99	carriage return, 465
automatic referencing, 99	cfg (configuration) attribute, 236–237
D	channels, 361–366, 480–486, 490–493
В	character data type, 40
back of house, 123	checked_* methods, 38
backtrace, 163–165	child modules, 125, 127
backward-compatibility guarantees, xxiii	client, 460
binary crate, 19, 121, 129, 241, 249	Clippy, 513
binary literal syntax, 37	clone method
binary target, 312	deep copy creation, 67
blanket implementations, 200–201	trade-offs of, 251
blocking, 357, 363, 368	Clone trait, 509–510
Boolean data type, 39	closed channel, 361
borrow checker, 202–209	closures, 274–284
borrowing, 71–77	capturing the environment with,
Box <t> type, 316–327</t>	274–276, 278–280, 287–289
break keyword, 28, 54	moving ownership into, 279-280

moving ownership out of, 280, 284	of static variables, 428
returning, 448	of type parameters, 185
running in threads, 358–361	for use paths, 133–134
type inference in, 276–278	Copy trait, 68, 509
cmd.exe, 3, 5, 7	crate, 9, 120–121
cmp method, 23–24	binary, 121–122, 129
coherence, 195	binary vs. library, 19
collections, 141–159	library, 121–122, 129
colon (:), 501, 503	license of, 305
for struct fields, 86	metadata, 304–305
for trait bounds, 197	publishing, 297–306
command line arguments, accepting,	root file of, 121–122
244–247	root module of, 124
command line notation, 2	updating versions, 21–22
comments, 49–50, 297–299, 477	using as a dependency, 19–22,
companies, xxvi	136–137
compiler-driven development, 473	yanking, 306
compile-time evaluation. See constant	crate keyword, 124
evaluation	crate root, 121–122, 124, 138
compiling	crates.io
with cargo, 9–10	publishing to, 297–306
in release mode, 11	removing from, 306
with rustc, 5-7	setting up an account on, 304
compound data types, 40–43	CRLF sequence, 465
concurrency, 353–374	CTRL-C, 27, 54
concurrent programming, 353–354	curly brackets ({}), 505
configuration (cfg) attribute, 236–237	for function bodies, 6, 15
connection, 461–462	as placeholders in the println!
cons list, 317–321	macro, 18
constant evaluation, 34	scope creation, 47, 74
constants, 33–34	custom derive procedural macros,
vs. static variables, 428	452–457
vs. variables, 33–34	
constructor, 329	D
*const T, 421-423, 500	dangling pointer, 75
consume, 284–286	dangling reference, 75–76, 201–203,
consuming adapters, 286	208–209
continue keyword, 29, 54	data race, 74, 427–428
control flow, 50–58	data types, 36–43
conventions	annotation of, 26, 36
Cargo, 11	compound, 40–43
for crate root files, 121	scalar, 36–40
naming	dbg! macro, 95–96
of constants, 34	deadlock, 355, 372–373
of files, 5	Debug trait, 94-96, 224, 508
of function and variable	decimal literal syntax, 37
names, 44	declarative macros, 449–451
*	*

deep copy, 509 Default trait, 510 default type parameters, 431–433 dependencies section in <i>Cargo.toml</i> , 9, 19–20 dependency, 7, 11, 19–22 deref coercion, 150, 325–327 dereference operator, 71, 321–327 DerefMut trait, 326–327 Deref trait, 321–327, 440 derive annotation, 94–96, 452–457, 507–510 description metadata, 305 destructor, 329 destructuring of enums, 409–410 in patterns, 407–411 of structs, 407–409, 410–411	editions, xxiii, 9, 498, 513, 515–516 else if expression, 52 else keyword, 50 empty type, 443–444, 502 encapsulation, 119, 123, 376–378 entry method, 157–158 Entry type, 157–158 enumerate method, 78, 401 enums, 103–110 defining, 103–104 destructuring, 409–410 initializer function, 447–448 instantiating, 104–105 making public, 131–132 variants of, 104 environment, 274–276, 278–280, 287–289 environment variables, 265–270
of tuples, 40–41, 411 Dickinson, Emily, 247 dictionary. See HashMap <k, v=""> type Dijkstra, Edsger W., 215 Display trait, 94, 148, 200–201, 437–439, 508 division operator (/), 39, 501 doc tests, 298–299 documentation comments, 297–299, 477</k,>	eprintln! macro, 271–272 Eq trait, 508–509 error handling, 161–180 executable file, 6–7, 9 executing code, 6–7, 9 exit status code, 255 expect method, 17–18, 26, 169 expressions, 46–47 extern functions, 426–427
offline for Rust, 4 tests, 298–299 viewing a crate's, 23 writing, 297, 299 dot (.), 500 for method syntax, 97–98 for struct field access, 86–87 for tuple element access, 41 double colon (::), 502–503 double free error, 66, 329 double quote ("), 40, 502 Doyle, Sir Arthur Conan, 293 drop function, 64, 329–330 Drop trait, 327–330, 487–493 dynamically sized type (DST), 444–446 dynamic dispatch, 384 dyn keyword, 257, 380	fearless concurrency, 354 FFI (Foreign Function Interface), 426 field init shorthand, 87–88 fields, 86 files, 247–248     naming conventions, 5     organization, 138–140 filtered-out tests, 233–235 Firefox web browser, xxvi floating-point data types, 38–39 fn keyword, 15 FnMut trait, 280–281, 447, 475 FnOnce trait, 280–283, 447, 475–476 Fn trait, 280, 447, 475 fn type, 446–448 Foreign Function Interface, 426

for keyword	guard, 367
loop, 57–58	guessing game, 13–30
patterns in, 400–401	
in trait implementations, 194	Н
format! macro, 150	hash. See HashMap <k, v=""> type</k,>
from function	hasher, 158
on the From trait, 171	hashing function, 158
on String, 63, 148	HashMap <k, v=""> type, 154−158</k,>
front of house, 123	entry method on, 157–158
fully qualified syntax, 433-437, 447	get method on, 155
functional programming, 273-274	insert method on, 154-157
function-like procedural macros, 458	iterating over, 155–156
function pointers, 446-448	new function on, 154-155
functions, 43–49	and ownership, 156
arguments to, 44	updating, 156–158
bodies, statements and expressions	hash table. See HashMap <k, v=""> type</k,>
in, 46–47	Hash trait, 510
extern, 426-427	heap
vs. macros, 449	allocating on, 60, 317
making public, 128–129	and the stack, 60-61
with multiple return values using	Hello, World! program, 4-7
a tuple, 70	Helm, Richard, 376
parameters of, 44-46	hexadecimal literal syntax, 37
patterns in, 402	Hoare, Tony, 108
returning early from, 47	HTTP (Hypertext Transfer Protocol),
with return values, 47–49	460, 464–466
	hyphen (-)
G	for negation, 500
Gallant, Andrew, 244	for subtraction, 39, 500
Gamma, Erich, 376	
garbage collector (GC), 59, 63	1
generics, 181–192, 213–214	IDE (integrated development
default types for, 431–433	environment), xxvi, 4, 514
in enum definitions, 188–189	if keyword, 50–54
in function definitions, 184–187	if let syntax, 116–117
in method definitions, 189–191	patterns in, 399–400
performance of, 191–192	ignore attribute, 235–236
in struct definitions, 187–188	immutability. See mutability
get method	impl keyword
on HashMap <k, v="">, 155</k,>	for defining associated
on Vec <t>, 143–145</t>	functions, 101
getter methods, 99, 179	for defining methods, 97–101
Git, 8, 11	for implementing traits, 194
global variables, 427–428	impl Trait syntax, 197–200
grapheme clusters, 152–154	indexing syntax, 143–145
grep, 243	indirection, 320–321
	inheritance, 378–379

input lifetimes, 210	license metadata, 305
input/output (io) library, 15	lifetimes, 201–214
installation of Rust, 1–4	annotation of, 203–209
instance, 16	elision, 209–212
integer data types, 36–38	line feed, 465
numeric operations with, 39	
type suffixes of, 37	linker, 2 lints, 513
integer overflow, 38	Linux Foundation, 305
9	Linux roundation, 505 Linux installation of Rust, 2
integrated development environment, xxvi, 4, 514	
integration tests, 236–241	"The Little Book of Rust Macros," 451 lock, 367–370
interfaces. See traits	
interfaces. <i>See</i> trans interior mutability, 334–340, 343, 372	loop keyword, 26–28, 54–56
invalidated variable, 66–67	loop labels, 55–56
	M
io (input/output) library, 15	
IpAddr type, 104–106	macOS installation of Rust, 2
irrefutable patterns, 403–405	macro_export annotation, 450
isize type	macro_rules! macros, 449–451
architecture dependent size of, 37 indexing collection with, 38	macros, 449–458
9	declarative, 449–451
iterator adapters, 286–289	vs. functions, 449
iterators, 284–294	procedural, 451
adapters for, 286–289	main function, 6, 174–175
consuming adapters for, 286	mangling, 427
creating with iter method, 77–78	map. See HashMap <k, v=""> type</k,>
enumerate method on, 78	match expression, 110–116
next method on, 285	exhaustiveness of, 114
performance of, 293–294	handling comparison results with, 24
iter method, 77–78	handling error values with, 166–167
J	handling Result values with,
	28–29, 166
Johnson, Ralph, 376	patterns in, 398–399
JoinHandle <t> type, 356-358</t>	match guard, 415–417
K	memory leak, 343, 350–351
	message passing, 361–366
Kay, Alan, 375	methods
Keep, Daniel, 451	defined on enums, 107
keywords, 32, 495–498	defined on structs, 97–102
L	disambiguating, 433–437
	getters, 99
Language Server Protocol, 514	method syntax, 97–98
last in, first out ordering, 60	minigrep project, 243–272
lazy evaluation, 284, 287	mock object, 336–340
len method, 78	mod keyword, 124
let keyword, 16	modules, 121–125
using patterns with, 401–402	cheat sheet, 121–123
library crate, 7, 19, 121, 129	file paths for, 122
license identifier value, 305	moving to other files, 138–140

1.1	0 1 .T. 100 110 114
module system, 120	Option <t> enum, 108-110, 113-114</t>
module tree, 124–125	Ordering type, 24
monomorphization, 191–192	Ord trait, 509
move keyword, 279–280, 358–361	orphan rule, 195, 439
moving ownership, 64-67	output lifetimes, 210
vs. borrowing, 71–72	overflowing_* methods, 38
with function calls, 68-69	overflow of integers, 38
with function return values, 69–70	ownership, 59–83
multiple producer, single consumer	and functions, 68–70
(mpsc), 362, 365–366	rules, 61
multiple trait bound syntax (+), 198, 500	of struct data, 90–91
multiplication, 39	of struct data, 50–51
-	P
mutability	-
of references, 73–75	package, 121
of variables, 32–33	package registry, 297–306
Mutex <t> type, 367–373, 482–484,</t>	package section in Cargo.toml, 304–305
485–487	panicking, 38
mut keyword	panic! macro, 162–165, 226–229
making a reference mutable with,	vs. Result, 175–180
73–75	parallel programming, 353–354
making a variable mutable with, 33	parameters, 44
vs. shadowing, 35–36	patterns in, 402
*mut T, 421-423, 500	parentheses (()), 504
mutual exclusion, 367	for function parameters, 6, 15
,	for tuples, 40–41
N	parent modules, 125, 127
namespace 63 101 104	parse method, 26
namespace, 63, 101, 104	
never type (!), 443–444, 502	PartialEq trait, 224, 508–509
new function	PartialOrd trait, 187, 509
on HashMap <k, v="">, 154–155</k,>	paths, 125–130
on String, 147–148	absolute, 126
on Vec <t>, 142</t>	nested, 137
new project setup, using Cargo, 14	relative, 125–126
newtype pattern, 439–440	%PATH% system variable, 3, 312
null, 108–110	patterns, 397–418
numeric operations, 39	binding to values with, 112–113
	destructuring in, 407–411
0	in for loops, 400–401
object. See HashMap <k, v=""> type</k,>	in function parameters, 402
object-oriented programming (OOP),	in if let syntax, 116–117, 399–400
375–396	ignoring values in, 411–415
octal literal syntax, 37	in let statements, 401–402
1:1 threading model, 355	in match expressions, 110–116,
open source developers, xxvii	398–399
operator overloading, 431–433	refutable vs. irrefutable, 403–405
operators, 499–501	in while let loops, 400
optimizations, 11	
optimizations, 11	.pdb file extension, 7

	11 101 100 107 177
pointer, 60, 315	recoverable errors, 161–162, 165–175
dangling, 75	recursive type, 317–321
to data on the heap, 60–61	re-export, 135–136, 300–303
raw, 421–423	RefCell <t> type, 334–351</t>
smart, 315–351	reference counting, 315, 330–334,
poisoned mutex, 485	370-373
polymorphism, 378–379	reference cycles, 343–351
PowerShell, 3-4, 6-7, 269-270	references
prelude, 15, 138	for accessing data from multiple
println! macro, 6, 18-19	places, 17
privacy, 123, 127–129	and borrowing, 71–77
procedural macros, 451	dangling, 75–76
attribute-like, 457	dereferencing, 71
custom derive, 452–457	mutability of, 73–75
function-like, 458	rules of, 77
process, 354	refutable patterns, 403–405
proc_macro crate, 452, 454	registry, 20, 297–306
profiles, 296–297	relative path, 125–126, 130
profile section in <i>Cargo.toml</i> , 296–297	release mode, 11, 38
propagating errors, 169–175	release profiles, 296–297
pub keyword, 122, 127–129	remainder operator (%), 39, 500
public, 127–129	request line, 464–465
API, 129, 300–303	request-response protocol, 460
making items, 128	Resource Acquisition Is Initialization, 64
making structs and enums, 130	Result <t, e=""> type, 17–18, 165–175</t,>
pub use, 135–136, 300–303	expect method on, 17–18, 169
push method, 142	vs. panic!, 175–180
push_str method, 63, 149	type aliases for, 442–443
Q	unwrap method on, 168
<del></del>	unwrap_or_else method on, 168
question mark operator (?), 171–175, 501	return keyword, 47
quote crate, 454–456	return values
R	of functions, 47–49
	of loops, 55
race conditions, 74, 355	multiple using a tuple, 70
RAII (Resource Acquisition Is	rev method, 58
Initialization), 64	ripgrep, 244, 312-313
rand crate, 19–23	RLS (Rust Language Server), xxvi
random number functionality, 19, 22–23	.rs file extension, 5
range syntax, 406–407	running code, 5–7, 9–10
Range type, 58	Rustaceans, 3
raw identifiers, 497–498	rust-analyzer, $514$
raw pointers, 421-423	rustc, 3, 5–7
Rc <t> type, 330–334, 342–351</t>	rustfix, 512-513
read_line method, 17–18	rustfmt, xxvi, 6, 511-512
receiver, 361–366	Rust Language Server, xxvi
	"The Rustonomicon," 145, 351, 374

rustup commands, 1–4	popping off of, 60
doc, 4	pushing onto, 60
uninstall, $4$	standard error (stderr), 270–272
${\sf update},4$	standard output (stdout), 270–272
	statements, 46-47
\$	state objects, 384–385
saturating_* methods, 38	state pattern, 384–393
scalar data types, 36–40	statically typed, 36
scope, 62, 120	static dispatch, 384
SCREAMING_SNAKE_CASE, 428	'static lifetime, 212–213, 428, 476
Self keyword, 98	static variables, 427–428
self module, 125	status line, 465
self parameter, 97	stderr (standard error), 270–272
Semantic Versioning (SemVer),	stdin function, 16-17
19–20, 306	stdout (standard output), 270-272
semicolon (;), 6, 501	&str (string slice type), 79–82
in the array type, 42	stream, 461–464
to end statements, 47	stringify! macro, 456
Send trait, 373-374, 429, 476	string literal, 62
sequence, 58	storage in the binary of, 63
server, 460	of string slice type, 81
shadowing, 34–36	string slice type (&str), 79–82
vs. mut keyword, 35-36	String type, 62-64, 147-154
shared-state concurrency, 367–373	as_bytes method on, 77
should_panic attribute, 226–229	bytes method on, 153
sibling modules, 125	chars method on, 153
single quote ('), 502	concatenation with +, 149–150
for characters, 40	from function on, 63, 148
for lifetime parameter names, 205	indexing into, 151–152
for loop labels, 55	internal structure of, 63-65,
?Sized, 445	151–152
Sized trait, 445–446, 448	iterating over, 153–154
slice type, 77–83	len method on, 78
of array, 83	new function on, 147-148
string slices, 79-82, 152-153	parse method on, 26
smart pointer, 315–351	push method on, 149
snake case, 44	push_str method on, 63, 149
Software Package Data Exchange	slicing, 152–153
(SPDX), 305	trim method on, 25-26
speed, xxvii	UTF-8 encoding of, 147–148,
square brackets ([]), 500	152–154
for array creation, 41	Stroustrup, Bjarne, 293
in the array type, 42	structs, 85-102
for element access, 42, 143-145	defining, 86
stack	destructuring, 407–411
and the heap, 60-61	field init shorthand, 87-88
last in, first out ordering, 60	fields, 86

structs (continued)	trait bounds, 197, 201, 213–214
instantiating, 86	conditionally implementing
making public, 130–131	methods with, 200-201
ownership of data, 90–91	trait objects, 379-384, 448
tuple, 89	dynamic dispatch, 384
unit-like, 89–90	traits, 192–201
update syntax, 88-89	associated types in, 430-431
students, xxvi	default implementations of, 195-197
subtraction, 39	defining, 192–193
super keyword, 125, 130	derived, 94–96
supertraits, 437–439	implementing, 193–195
symbols, 502–505	as parameters, 197–201
syn crate, 454–455	supertraits, 437–439
Sync trait, 373–374, 429	unsafe, 429
_	Transmission Control Protocol, 460
T	transmitter, 361–366
TCP (Transmission Control	trim method, 25-26
Protocol), 460	tuple data type, 40–41
teams of developers, xxvi	tuples, destructuring, 411
test attribute, 217	tuple structs, 89, 439-440
test double, 336	two's complement wrapping, 38
test-driven development (TDD), 259–265	type alias, 440–443, 484
test functions, 216–219	type annotation, 26, 36
tests, 215–241	type inference, 25
custom failure messages for, 224-226	type suffixes, 37
documentation, 298–299	
filtering, 233–235	U
ignoring, 235–236	underscore (_), 502
integration, 236–241	as a catch-all pattern, 29, 115–116,
organizing, 236–241	411–413
of private functions, 237	in filenames, 5
running, 230–236	as a visual separator in integer
unit, 236–237	literals, 37
using Result <t, e=""> in, 230</t,>	Unicode scalar value, 40, 152–154
writing, 216–230	uniform resource identifier, 465
thread pool, 472–493	uniform resource locator, 465
threads, 354–374	unions, 429
creating with spawn, 355-356,	unit-like structs, 89–90
473–486	unit tests, 236–237
joining, 356–358	unit type, 41
pausing with sleep, 356	unrecoverable errors, 161–165
running closures in, 355–356,	unrolling, 294
358–361	unsafe, 420–429
thunk, 441-442	functions, 423–427
Tom's Obvious, Minimal Language	superpowers, 420-421, 429
(TOML), 8	traits, 429
to_string method, 148, 200-201	unsized type, 444–446
ToString trait, 200-201	unwinding, 162

unwrap method, 168	iterating over, 145
unwrap or else method, 255	new function on, 142
URI (uniform resource identifier), 465	push method on, 142–143
URL (uniform resource locator), 465	storing multiple types in, 145–146
use keyword, 132–138	vertical pipe ( )
and as, 135	in closure definitions, 276, 502
and external packages, 136–137	in patterns, 406, 501
and the glob operator, 138	Visual Studio, 3
and nested paths, 137	Visual Studio Code, 514
and pub, 135–136	Vlissides, John, 376
user input, 16–17	Ü
usize type	W
architecture dependent size of, 37	warnings, 512–513
indexing collection with, 38	Weak <t> type, 348-351</t>
UTF-8 encoding, 147–148, 152–154	web server project, 459-493
	where clause, 198
V	while let loop, 400
variables, 32–36	while loop, 56-57
vs. constants, 33–34	Windows installation of Rust, 3
creating with patterns, 401-402	Wirth, Lukas, 451
global, 427–428	workspaces, 307-312
mutability, 32–33	wrapping_* methods, 38
shadowing, 34–36	
static, 427–428	Υ
storing values in, 16	yanking, 306
variants, 104	-
vec! macro, 142	Z
vector. See Vec <t> type</t>	zero-cost abstractions, 293-294
Vec <t> type, 142–147</t>	zero-overhead, 293
get method on, 143–145	
indexing into, 143–145	