Foreword

It wasn't always so clear, but the Rust programm
empowerment: no matter what kind of code you
to reach farther, to program with confidence in a
did before.

Take, for example, "systems-level" work that dea
management, data representation, and concurr
programming is seen as arcane, accessible only
necessary years learning to avoid its infamous p
do so with caution, lest their code be open to ex

Rust breaks down these barriers by eliminating
friendly, polished set of tools to help you along t
"dip down" into lower-level control can do so wit
customary risk of crashes or security holes, and
points of a fickle toolchain. Better yet, the langu
towards reliable code that is efficient in terms o

Programmers who are already working with low
ambitions. For example, introducing parallelism
operation: the compiler will catch the classical m
more aggressive optimizations in your code with
accidentally introduce crashes or vulnerabilities.

But Rust isn't limited to low-level systems progra
ergonomic enough to make CLI apps, web serve
quite pleasant to write — you'll find simple exam
Working with Rust allows you to build skills that
you can learn Rust by writing a web app, then ap
Raspberry Pi.

This book fully embraces the potential of Rust to
approachable text intended to help you level up
also your reach and confidence as a programme
learn—and welcome to the Rust community!

— Nicholas Matsakis and Aaron Turon

Introduction

> Note: This edition of the book is the same as
> available in print and ebook format from No

Welcome to *The Rust Programming Language*, an
Rust programming language helps you write fas
ergonomics and low-level control are often at od
Rust challenges that conflict. Through balancing
great developer experience, Rust gives you the o
(such as memory usage) without all the hassle tr
control.

Who Rust Is For

Rust is ideal for many people for a variety of rea
important groups.

Teams of Developers

Rust is proving to be a productive tool for collab
developers with varying levels of systems progra
prone to a variety of subtle bugs, which in most
through extensive testing and careful code revie
the compiler plays a gatekeeper role by refusing
bugs, including concurrency bugs. By working al
spend their time focusing on the program's logi

Rust also brings contemporary developer tools t

- Cargo, the included dependency manager
  compiling, and managing dependencies pa
  ecosystem.
- Rustfmt ensures a consistent coding style
- The Rust Language Server powers Integrat
  integration for code completion and inline

By using these and other tools in the Rust ecosy
while writing systems-level code.

Students

Rust is for students and those who are intereste
Using Rust, many people have learned about to
development. The community is very welcoming
questions. Through efforts such as this book, th
concepts more accessible to more people, espe

Companies

Hundreds of companies, large and small, use Ru
Those tasks include command line tools, web se
devices, audio and video analysis and transcodi
search engines, Internet of Things applications,
parts of the Firefox web browser.

Open Source Developers

Rust is for people who want to build the Rust pr
developer tools, and libraries. We'd love to have

People Who Value Speed and Stability

Rust is for people who crave speed and stability
speed of the programs that you can create with
you write them. The Rust compiler's checks ensu
and refactoring. This is in contrast to the brittle
these checks, which developers are often afraid
abstractions, higher-level features that compile
written manually, Rust endeavors to make safe

The Rust language hopes to support many othe
are merely some of the biggest stakeholders. O
eliminate the trade-offs that programmers have
safety *and* productivity, speed *and* ergonomics.
work for you.

Who This Book Is For

This book assumes that you've written code in a
doesn't make any assumptions about which one
broadly accessible to those from a wide variety
don't spend a lot of time talking about what pro
If you're entirely new to programming, you woul
that specifically provides an introduction to prog

How to Use This Book

In general, this book assumes that you're readin
Later chapters build on concepts in earlier chap
delve into details on a topic; we typically revisit t

You'll find two kinds of chapters in this book: co
In concept chapters, you'll learn about an aspect
build small programs together, applying what yo
and 20 are project chapters; the rest are concep

Chapter 1 explains how to install Rust, how to w
to use Cargo, Rust's package manager and build
introduction to the Rust language. Here we cove
chapters will provide additional detail. If you wa
Chapter 2 is the place for that. At first, you migh
covers Rust features similar to those of other pr
straight to Chapter 4 to learn about Rust's owne
particularly meticulous learner who prefers to le
the next, you might want to skip Chapter 2 and
Chapter 2 when you'd like to work on a project a

Chapter 5 discusses structs and methods, and C
expressions, and the `if let` control flow const
make custom types in Rust.

In Chapter 7, you'll learn about Rust's module sy
organizing your code and its public Application
8 discusses some common collection data struc
provides, such as vectors, strings, and hash map
handling philosophy and techniques.

Chapter 10 digs into generics, traits, and lifetime
code that applies to multiple types. Chapter 11 i
Rust's safety guarantees is necessary to ensure
Chapter 12, we'll build our own implementation

`grep` command line tool that searches for text
the concepts we discussed in the previous chapt

Chapter 13 explores closures and iterators: feat
functional programming languages. In Chapter
and talk about best practices for sharing your lib
discusses smart pointers that the standard libra
their functionality.

In Chapter 16, we'll walk through different mode
talk about how Rust helps you to program in mu
looks at how Rust idioms compare to object-orie
might be familiar with.

Chapter 18 is a reference on patterns and patter
of expressing ideas throughout Rust programs.
of advanced topics of interest, including unsafe
types, functions, and closures.

In Chapter 20, we'll complete a project in which
multithreaded web server!

Finally, some appendixes contain useful informa
reference-like format. Appendix A covers Rust's
operators and symbols, Appendix C covers deriv
library, and Appendix D covers macros.

There is no wrong way to read this book: if you
might have to jump back to earlier chapters if yo
whatever works for you.

An important part of the process of learning Rus
messages the compiler displays: these will guide
we'll provide many examples of code that doesn
message the compiler will show you in each situ
a random example, it may not compile! Make su
see whether the example you're trying to run is
we'll lead you to the correct version of any code

Source Code

The source files from which this book is generat

Getting Started

Let's start your Rust journey! There's a lot to lear
somewhere. In this chapter, we'll discuss:

- Installing Rust on Linux, macOS, and Windo
- Writing a program that prints `Hello, worl`
- Using `cargo`, Rust's package manager and

Installation

The first step is to install Rust. We'll download Ru
tool for managing Rust versions and associated
connection for the download.

> Note: If you prefer not to use `rustup` for som
> installation page for other options.

The following steps install the latest stable versi
stability guarantees ensure that all the example
continue to compile with newer Rust versions. T
between versions, because Rust often improves
other words, any newer, stable version of Rust y
work as expected with the content of this book.

> ### Command Line Notation
>
> In this chapter and throughout the book, we'l
> the terminal. Lines that you should enter in a
> need to type in the `$` character; it indicates t
> that don't start with `$` typically show the out
> Additionally, PowerShell-specific examples wi

Installing `rustup` on Linux or macOS

If you’re using Linux or macOS, open a terminal

```
$ curl https://sh.rustup.rs -sSf | sh
```

The command downloads a script and starts the
which installs the latest stable version of Rust. Y
password. If the install is successful, the followin

```
Rust is installed now. Great!
```

If you prefer, feel free to download the script an

The installation script automatically adds Rust to
login. If you want to start using Rust right away i
run the following command in your shell to add

```
$ source $HOME/.cargo/env
```

Alternatively, you can add the following line to y

```
$ export PATH="$HOME/.cargo/bin:$PATH"
```

Additionally, you’ll need a linker of some kind. It’
when you try to compile a Rust program and get
not execute, that means a linker isn’t installed on
install one manually. C compilers usually come w
platform’s documentation for how to install a C c
packages depend on C code and will need a C co
installing one now.

Installing `rustup` on Windows

On Windows, go to https://www.rust-lang.org/in
for installing Rust. At some point in the installati
explaining that you’ll also need the C++ build too
easiest way to acquire the build tools is to instal
The tools are in the Other Tools and Framework

The rest of this book uses commands that work
there are specific differences, we’ll explain which

Updating and Uninstalling

After you’ve installed Rust via `rustup`, updating your shell, run the following update script:

```
$ rustup update
```

To uninstall Rust and `rustup`, run the following

```
$ rustup self uninstall
```

Troubleshooting

To check whether you have Rust installed correc

```
$ rustc --version
```

You should see the version number, commit has stable version that has been released in the follo

```
rustc x.y.z (abcabcabc yyyy-mm-dd)
```

If you see this information, you have installed Ru information and you’re on Windows, check that variable. If that’s all correct and Rust still isn’t wo you can get help. The easiest is the #rust IRC cha can access through Mibbit. At that address you c nickname we call ourselves) who can help you o Users forum and Stack Overflow.

Local Documentation

The installer also includes a copy of the docume offline. Run `rustup doc` to open the local docur

Any time a type or function is provided by the st what it does or how to use it, use the applicatior documentation to find out!

Hello, World!

Now that you’ve installed Rust, let’s write your fi
learning a new language to write a little progra
to the screen, so we’ll do the same here!

> Note: This book assumes basic familiarity wit
> no specific demands about your editing or to
> you prefer to use an integrated development
> command line, feel free to use your favorite I
> degree of Rust support; check the IDE’s docu
> Rust team has been focusing on enabling gre
> been made rapidly on that front!

Creating a Project Directory

You’ll start by making a directory to store your R
where your code lives, but for the exercises and
making a *projects* directory in your home directo
there.

Open a terminal and enter the following comma
a directory for the Hello, world! project within th

For Linux and macOS, enter this:

```
$ mkdir ~/projects
$ cd ~/projects
$ mkdir hello_world
$ cd hello_world
```

For Windows CMD, enter this:

```
> mkdir "%USERPROFILE%\projects"
> cd /d "%USERPROFILE%\projects"
> mkdir hello_world
> cd hello_world
```

For Windows PowerShell, enter this:

```
> mkdir $env:USERPROFILE\projects
> cd $env:USERPROFILE\projects
> mkdir hello_world
> cd hello_world
```

Writing and Running a Rust Program

Next, make a new source file and call it *main.rs*. extension. If you're using more than one word ir separate them. For example, use *hello_world.rs* r

Now open the *main.rs* file you just created and e

Filename: main.rs

```
fn main() {
    println!("Hello, world!");
}
```

Listing 1-1: A program that prints `Hello, world`

Save the file and go back to your terminal windo following commands to compile and run the file

```
$ rustc main.rs
$ ./main
Hello, world!
```

On Windows, enter the command `.\main.exe` i

```
> rustc main.rs
> .\main.exe
Hello, world!
```

Regardless of your operating system, the string terminal. If you don't see this output, refer back Installation section for ways to get help.

If `Hello, world!` did print, congratulations! You That makes you a Rust programmer—welcome!

Anatomy of a Rust Program

Let's review in detail what just happened in your first piece of the puzzle:

```
fn main() {

}
```