RUSTikales Rust for beginners

Plan for today

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1. Recap

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1. Recap
2. Basic Types

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1. Recap
2. Basic Types
3. Variables

1. Recap

1. Recap

- Setup of tools required to start writing Rust code
  - Rust toolchain
  - IDE
  - rust-analyzer

1. Recap

- Setup of tools required to start writing Rust code
- rustc → Rust Compiler
  - The heart of the language
  - Turns your source code (e.g. main.rs) into an executable

1. Recap

- Setup of tools required to start writing Rust code
- rustc → Rust Compiler
- cargo → Package Manager
  - Manages packages (crates), like third-party libraries
  - Many utility functions such as cargo run or cargo new
  - Overkill for 99% of the things we're doing, but extremely useful in general

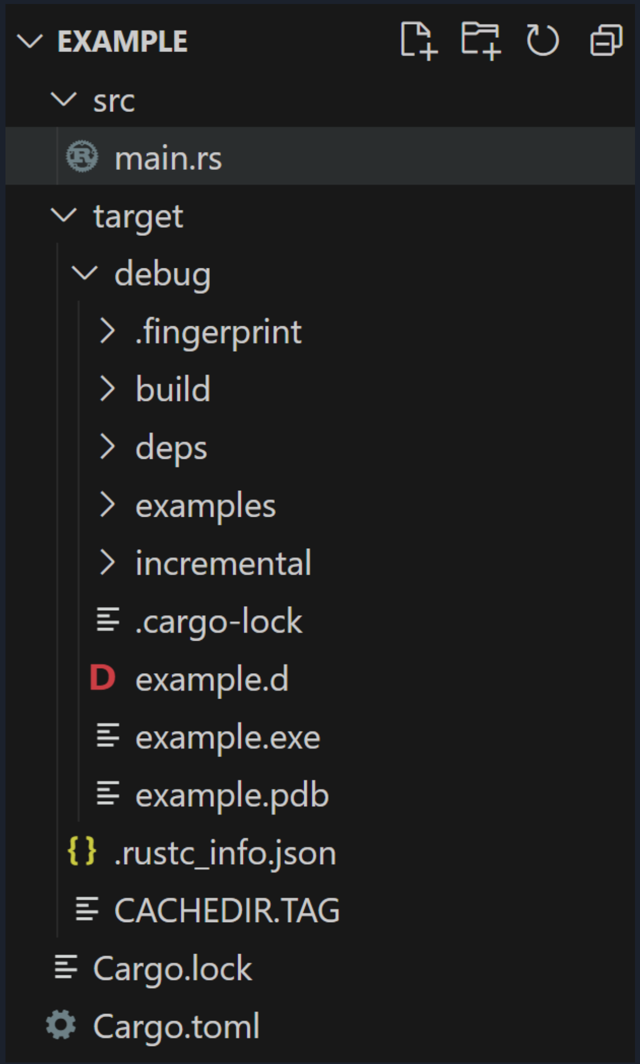
1. Recap

- Setup of tools required to start writing Rust code
- rustc → Rust Compiler
- cargo → Package Manager
- rustup → Toolchain Manager
  - Rust comes in different versions: stable, beta, nightly
  - Allows us to update the version of the Compiler, or switch to different toolchains (e.g. for cross-compilation)

1. Recap

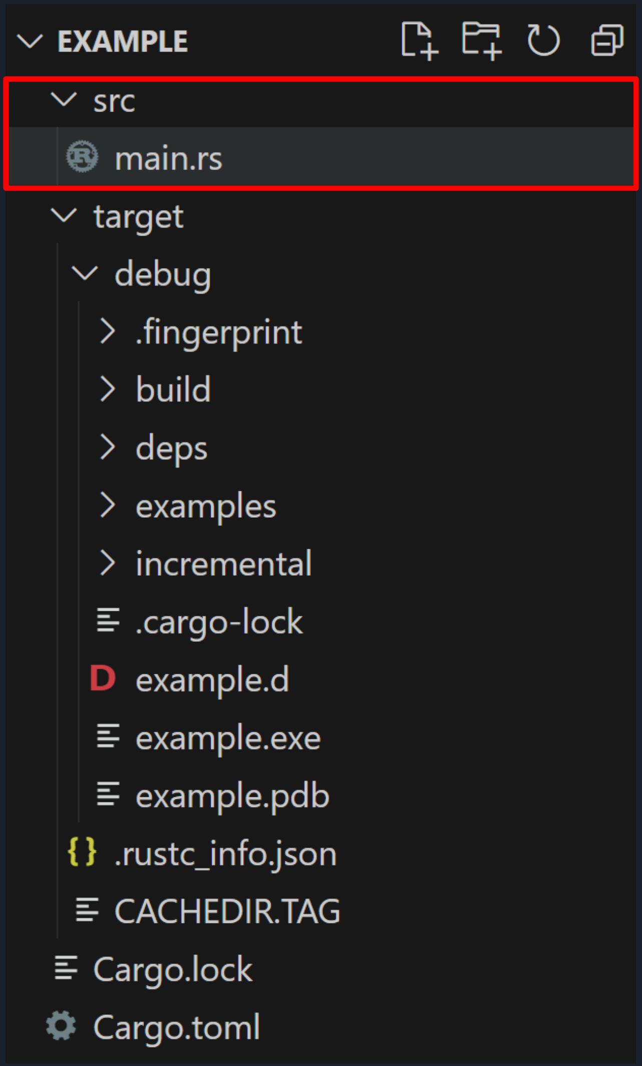
- Setup of tools required to start writing Rust code
- rustc → Rust Compiler
- cargo → Package Manager
- rustup → Toolchain Manager
- cargo new <name> creates a new package in the directory <name>
  - Unless specified otherwise, it's a binary (application) package → Executable
  - We can then open that directory in an IDE and start programming

1. Recap



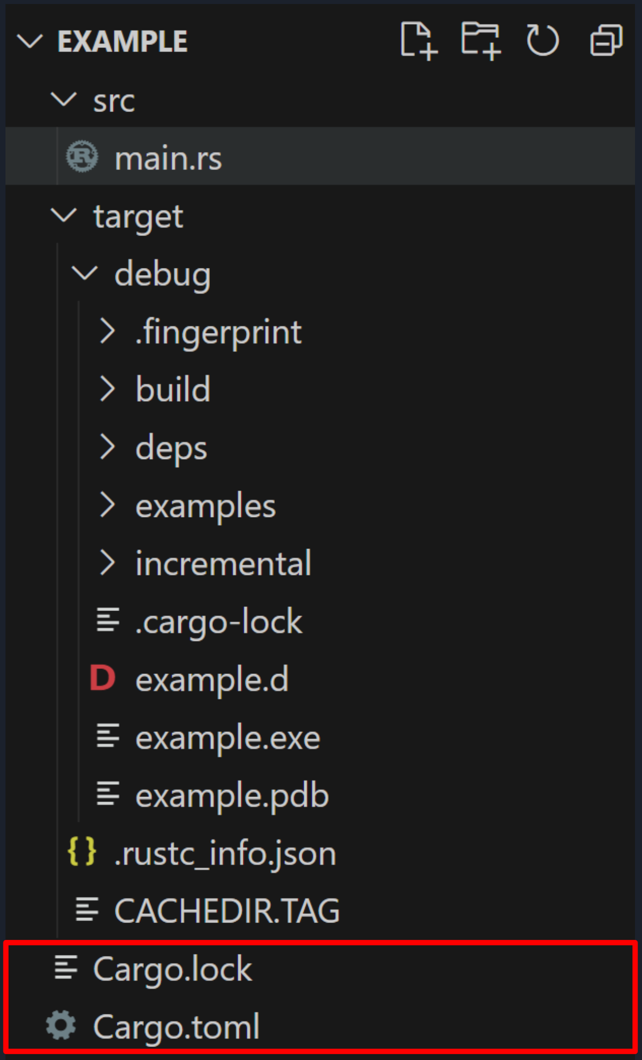
– cargo new example creates this folder structure

1. Recap



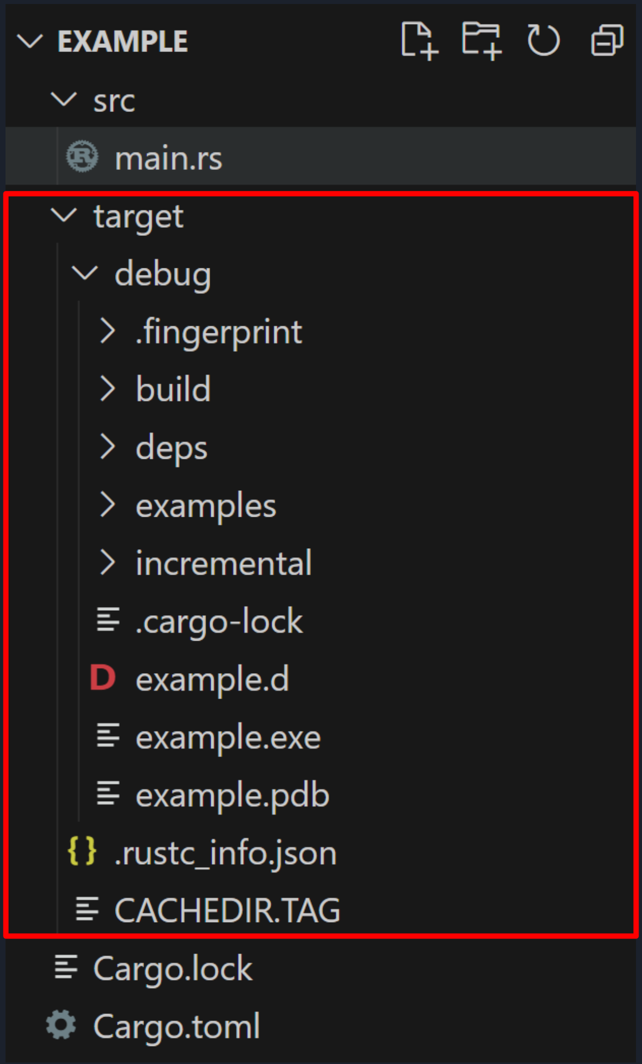
- cargo new example creates this folder structure
- We will spend most of our time in here
  - main.rs is where we write code

1. Recap



- cargo new example creates this folder structure
- main.rs is where we write code
- We can ignore Cargo.lock and Cargo.toml for now
  - Needed for package dependencies

1. Recap



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- cargo moves the output to the target directory

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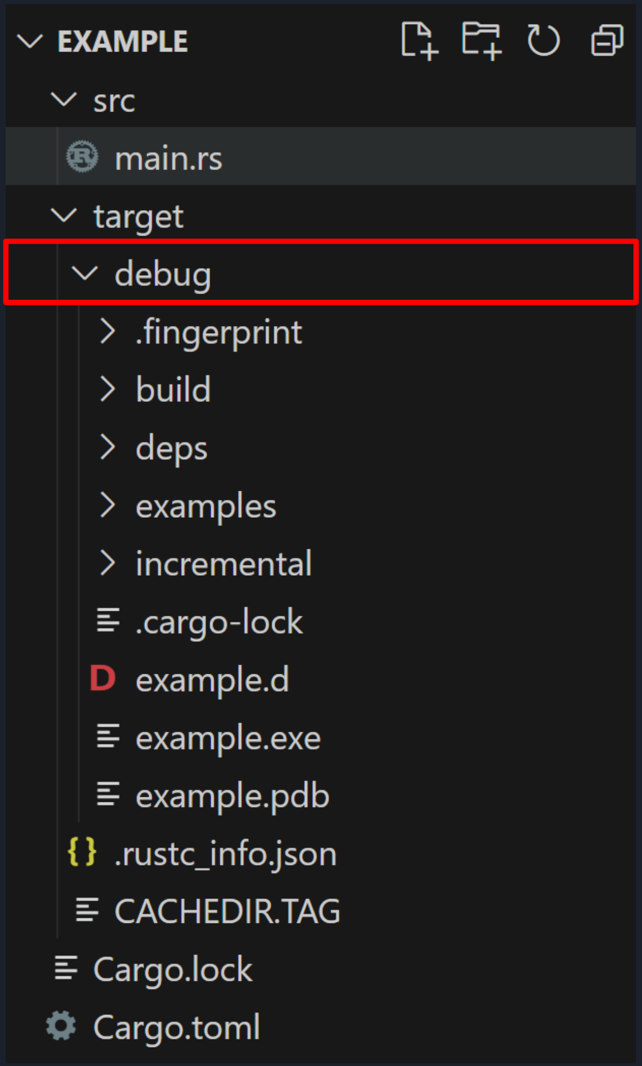
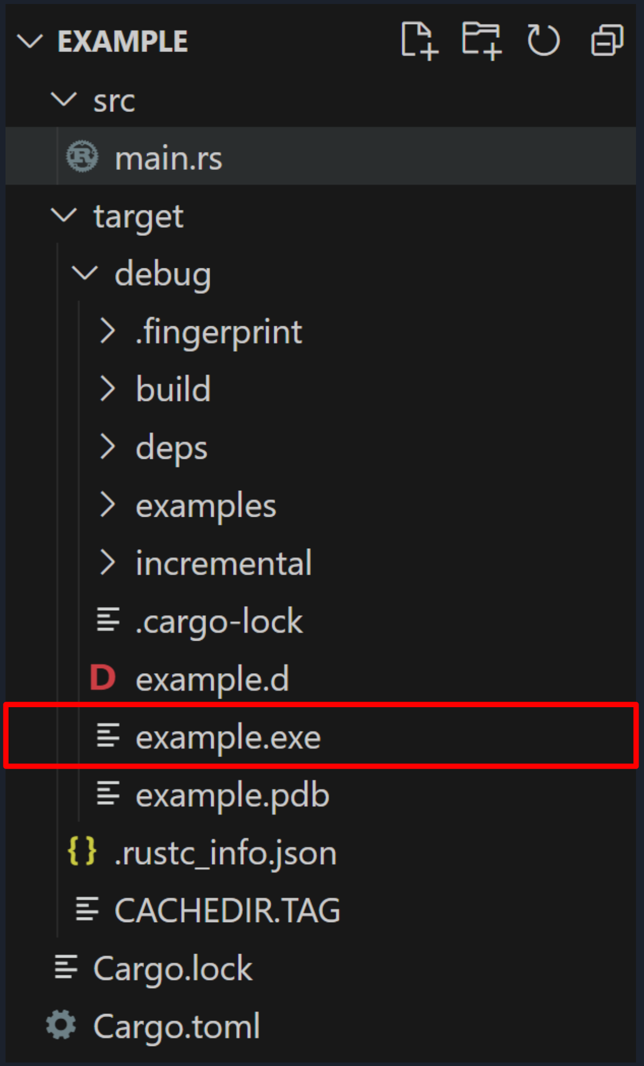


- cargo new example creates this folder structure
- main.rs is where we write code
- We can ignore Cargo.lock and Cargo.toml for now
- cargo moves the output to the target directory
- cargo build creates a debug build
- cargo build --release creates a release build
  - all optimizations enabled

1. Recap



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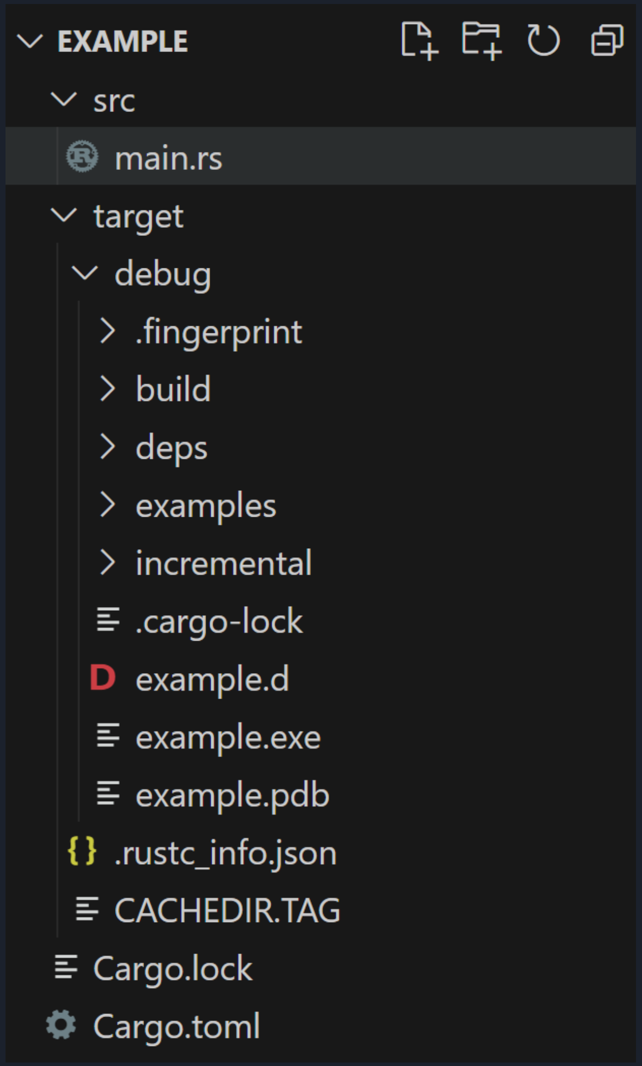
- main.rs is where we write code
- We can ignore Cargo.lock and Cargo.toml for now
- cargo moves the output to the target directory
- cargo build creates a debug build
- cargo build --release creates a release build
- you can find the executable here

1. Recap



- cargo new example creates this folder structure
- main.rs is where we write code
- We can ignore Cargo.lock and Cargo.toml for now
- cargo moves the output to the target directory
- cargo build creates a debug build
- cargo build --release creates a release build
- cargo run [--release] builds the project and runs it

2. Basic Types

2. Basic Types

- Rust is a statically typed language
  - Every variable and every value has exactly one type
  - Type must be known at compile time
  - You can’t change that type

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- The compiler statically type checks your code
  - Finds type errors such as
    - Assigning an i32 to an u64

```rust
let a: i32 = 0;
let b: u64 = a;
```

```
error[E0308]: mismatched types
 --> src\main.rs:5:18
  |
5 |     let b: u64 = a;
  |            ---   ^ expected `u64`, found `i32`
  |            |
  |            expected due to this
```

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- Rust is a statically typed language
- The compiler statically type checks your code
  - Finds type errors such as
    - Assigning an i32 to an u64
    - Passing an i32 where a u32 was expected

```rust
fn f(x: u32) {}
▶ Run | Debug
fn main() {
    let a: i32 = 0;
    f(a);
}
```

```
error[E0308]: mismatched types
 --> src\main.rs:6:7
  |
6 |     f(a);
  |     - ^ expected `u32`, found `i32`
  |     |
  |     arguments to this function are incorrect
  |
note: function defined here
 --> src\main.rs:3:4
  |
3 | fn f(x: u32) {}
  |    ^ -------
```

2. Basic Types

- Rust is a statically typed language
- The compiler statically type checks your code
  - Finds type errors such as
    - Assigning an i32 to an u64
    - Passing an i32 where a u32 was expected
    - Inserting an u8 into an array of f32

```rust
let mut a: [f32; 2] = [0.0; 2];
a[0] = 5u8;
```

```
error[E0308]: mismatched types
 --> src\main.rs:5:12
  |
5 |     a[0] = 5u8;
  |     ----   ^^^ expected `f32`, found `u8`
  |     |
  |     expected due to the type of this binding
```

2. Basic Types

- Rust is a statically typed language
- The compiler statically type checks your code
- Very useful, because we can easily reason about our code, and prevent many bugs
  - Types are always known, and not changeable
  - Contrast to variables in dynamic languages
    - Assign any value to any variable at any point
    - Hope it doesn't crash at runtime

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  - Scalar types → Represent single values

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- Rust has many different types
  - Scalar types → Represent single values
    - Integer → whole numbers, signed or unsigned
    - Floating Point → fractions, big numbers
    - boolean → either true or false
    - character → Unicode → abcäøóáßð 😊 😍

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  - Compound types → Combinations of types

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- Rust has many different types
  - Scalar types → Represent single values
  - Compound types → Combinations of types
    - array → Fixed length collection of values of the same type
    - tuple → Fixed length collection of values of (possibly) different types
    - struct → User-defined collections of values

2. Basic Types

- Rust has many different types
- Today we will only look at integers, other types will be introduced later

2. Basic Types

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- Rust has clear names for integer types
  - Letter indicates signed or unsigned
  - Number indicates size in bits
  - u8 is an unsigned 8bit integer
  - i32 is a signed 32bit integer
  - u16 is an unsigned 16bit integer

2. Basic Types

- Rust has many different types
- Rust has clear names for integer types
- The bitsize shows how big a number can be
  - More bits, bigger numbers
  - 32bits can store numbers as big as 2^32-1 = 4.294.967.295
  - Bigger numbers require more space in memory

2. Basic Types

- Rust has many different types
- Rust has clear names for integer types
- The bitsize shows how big a number can be
- signed means the number can be negative
  - one bit needed to specify the sign, so the number range is smaller
  - i32 can not represent 4.294.967.295
  - i32 can represent -420

2. Basic Types

- Rust has many different types
- Rust has clear names for integer types
- The bitsize shows how big a number can be
- signed means the number can be negative

Type	Meaning	Min Value	Max Value
i8	signed 8bit	-(2^7) = -128	2^7-1 = 127
u8	unsigned 8bit	0	2^8-1 = 255
i16	signed 16bit	-(2^15) = -32768	2^15-1 = 32767
u16	unsigned 16bit	0	2^16-1 = 65535

The pattern repeats up to i128 and u128, doubling the amount of bits every time

2. Basic Types

- Rust also has types isize and usize
  - Target machine dependent size
  - 64bit machine → 64bit wide
  - 32bit machine → 32bit wide

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- Rust also has types isize and usize
  - Target machine dependent size
  - 64bit machine → 64bit wide
  - 32bit machine → 32bit wide
  - Does anyone know why? 3/3
    - Used for indexing, sizes, offsets
    - Everything involving memory and pointer arithmetics
    - 32bit systems can't make use of 64bit memory addresses → Must be flexible

2. Basic Types

- Rust also has types isize and usize
  - Target machine dependent size
  - 64bit machine → 64bit wide
  - 32bit machine → 32bit wide
- If you want to index into an array or vector, your index needs to be of type usize

3. Variables

3. Variables

- Variables are a very fundamental part in programming
  - They allow us to store values in memory for later use

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```rust
fn main() {
    let a: i8 = -128;
    let b: u8 = 14;
    let c = 20;
    let mut d = 129;
}
```

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Declarations always follow the same rule:

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Declarations always follow the same rule:
let [mut]

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}
```

Declarations always follow the same rule:
let [mut] name

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Declarations always follow the same rule:
let [mut] name [:Type]

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Declarations always follow the same rule:
let [mut] name [:Type] = Expression;

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Declarations always follow the same rule:
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→ mut indicates the mutability of a variable

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    let c = 20;
    let mut d = 129;
}
```

Declarations always follow the same rule:
let [mut] name [:Type] = Expression;
→ mut indicates the mutability of a variable
→ Type Inference infers the type based on the context in which the variable is used

3. Variables

- Variables are a very fundamental part in programming
- Variables are declared using the keyword let

```
fn main() {
    let a: i8 = -128;
    let b: u8 = 14;
    let c = 20;
    let mut d = 129;
}
```

This code snippet creates four variables

Name	Mutable	Type	Value
a	no	i8	-128
b	no	u8	14
c	no	i32 (inferred)	20
d	yes	i32 (inferred)	129

3. Variables

- Variables are a very fundamental part in programming
- Variables are declared using the keyword let
- Using the keyword mut, we can make our variables mutable

```
fn main() {
    let a: i8 = -128;
    a = 20;
    let mut d: i32 = 129;
    d = 50;
}
```

3. Variables

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- Variables are declared using the keyword let
- Using the keyword mut, we can make our variables mutable

```rust
fn main() {
    let a: i8 = -128;
    a = 20;
    let mut d: i32 = 129;
    d = 50;
}
```

Immutable, we can't re-assign to the variable

```
error[E0384]: cannot assign twice to immutable variable `a`
 --> src\main.rs:5:5
  |
4 |     let a: i8 = -128;
  |         -
  |         |
  |         first assignment to `a`
  |         help: consider making this binding mutable: `mut a`
5 |     a = 20;
  |     ^^^^^^ cannot assign twice to immutable variable
```

3. Variables

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- Using the keyword mut, we can make our variables mutable

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fn main() {
    let a: i8 = -128;
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}
```

Mutable, we can re-assign to the variable

3. Variables

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- Using the keyword mut, we can make our variables mutable

```
fn main() {
    let a: i8 = -128;
    a = 20;
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    d = 50;
}
```

rust-analyzer shows us inferred types

3. Variables

- Variables are a very fundamental part in programming
- Variables are declared using the keyword let
- Using the keyword mut, we can make our variables mutable
  - Why does Rust have that system? What do we gain from making variables [im]mutable? 3/3

3. Variables

- Variables are a very fundamental part in programming
- Variables are declared using the keyword let
- Using the keyword mut, we can make our variables mutable
  - Why does Rust have that system? What do we gain from making variables [im]mutable? 3/3
    - Easier to reason your code, make it explicit what you’re expecting to change
    - Very useful when we get to references and the borrow checker
    - Prevents a lot of bugs and oversights
    - TLDR: More control over what is happening

3. Variables

- Variables are a very fundamental part in programming
- Variables are declared using the keyword let
- Using the keyword mut, we can make our variables mutable
- When we assign values to variables, two things can happen:
  - The value is copied
  - The value is moved
  - Will be covered when we talk about Ownership

Intermission - How a program is executed

Intermission - How a program is executed

- Understanding how a computer executes code helps with writing better programs
  - We’ll skip over all technical details, and how the source code turns into machine code

Intermission - How a program is executed

- Understanding how a computer executes code helps with writing better programs
- Computers process instructions sequentially, one after the other
  - Fetch → Decode → Execute

Intermission - How a program is executed

- Understanding how a computer executes code helps with writing better programs
- Computers process instructions sequentially, one after the other
- On a high level, we specify what these instructions should be
  - All the fancy steps in the middle just turn human-readable into machine-executable

Intermission - How a program is executed

```rust
fn main() {
    let a: i32 = 69;
    let b: i32 = 420;
    let c: i32 = a * 1000 + b;
    println!("{}", c);
}
```

Intermission - How a program is executed

```rust
fn main() {
    let a: i32 = 69;
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```

1. First, store 69 in a

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2. Then, store 420 in b

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1. First, store 69 in a
2. Then, store 420 in b
3. Read a, multiply its value by 1000

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2. Then, store 420 in b
3. Read a, multiply its value by 1000
4. Read b, add its value to the result of step 3

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    let a: i32 = 69;
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2. Then, store 420 in b
3. Read a, multiply its value by 1000
4. Read b, add its value to the result of step 3
5. Store the result of step 4 in c

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}
```

1. First, store 69 in a
2. Then, store 420 in b
3. Read a, multiply its value by 1000
4. Read b, add its value to the result of step 3
5. Store the result of step 4 in c
6. Read c, print its value to the console

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- On a high level, we specify what these instructions should be
- A memory table can help understand what the computer does

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Variable	Type	Value
a	i32	???
b	i32	???
c	i32	???
temp*	i32	???

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Variable	Type	Value
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c	i32	???
temp*	i32	69*1000=69.000

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Variable	Type	Value
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b	i32	420
c	i32	69.000+420=69.420
temp*	i32	69.000

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    let c: i32 = a * 1000 + b;
    println!("{}", c);
}
```

Variable	Type	Value
a	i32	69
b	i32	420
c	i32	69.420
temp*	i32	69.000

```
Running
69420
```

Intermission - How a program is executed

- Understanding how a computer executes code helps with writing better programs
- Computers process instructions sequentially, one after the other
- On a high level, we specify what these instructions should be
- A memory table can help understand what the computer does
  - very helpful to create one for exercises that compile
  - go step by step through the program, do you get the same output as the computer?

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- Best debugging advice:
  - Go through your program, step by step, and pretend you're the computer
  - if something doesn't make sense to you, that's usually where the bug is

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  - in theory → How computers work, how programming languages work
  - in practice → What I want my computer to do, and when, and how

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- Programming involves a lot of logic and reasoning
  - in theory → How computers work, how programming languages work
  - in practice → What I want my computer to do, and when, and how
- Better programming skills → Better logical thinking and reasoning skills, and vice versa

Intermission - Exercise

- Time for exercises!

Intermission - Exercise

1/3

```rust
fn main() {
    let a: i32 = 0;
    let b: i32 = 0;
    let c: u32 = 0;
    let d: i32 = a + b;
    let e: i32 = b + c;
    let f: u32 = (b as u32) + c;
    println!("{}", f);
}
```

Intermission - Exercise

1/3

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    println!("{}", f);
}
```

Does this code compile?
If yes, what does it print?

Intermission - Exercise

1/3

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}
```

Does this code compile?
If yes, what does it print?

Nope, you can‘t add i32 and u32 :^)

```
error[E0308]: mismatched types
 --> src\main.rs:6:22
  |
6 |     let e: i32 = b + c;
  |                      ^ expected `i32`, found `u32`

error[E0277]: cannot add `u32` to `i32`
 --> src\main.rs:6:20
  |
6 |     let e: i32 = b + c;
  |                    ^ no implementation for `i32 + u32`
  |
```

Intermission - Exercise

2/3

```rust
fn main() {
    let a = 0;
    let b: i32 = a;
    let arr: [i32; 2] = [a, b];
    let d = a as usize;
    let e = arr[d];
    println!("{}", e);
}
```

Intermission - Exercise

```rust
fn main() {
    let a = 0;
    let b: i32 = a;
    let arr: [i32; 2] = [a, b];
    let d = a as usize;
    let e = arr[d];
    println!("{}", e);
}
```

Does this code compile?
What type does a have?
What type does d have?
What type does e have?

Intermission - Exercise

2/3

```rust
fn main() {
    let a = 0;
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Does this code compile?
What type does a have?
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It does compile!
The compiler was able to figure out the types for all variables!

Intermission - Exercise

2/3

```
fn main() {
    let a: i32 = 0;
    let b: i32 = a;
    let arr: [i32; 2] = [a, b];
    let d: usize = a as usize;
    let e: i32 = arr[d];
    println!("{}", e);
}
```

Does this code compile?
What type does a have?
What type does d have?
What type does e have?

It does compile!
The compiler was able to figure out the types for all variables!
Variable a is of type i32
→ used in the context of b
Variable d is of type usize
→ Read a, take its value, interpret as usize
Variable e is of type i32
→ Arrays will be covered next time, but all elements of arr are of type i32

4. Next time

- Arrays
- Vectors