Embedded Rust Workshop (Day 1)

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Rust tools

1. rustup : The Rust Toolchain Installer. This installs all the required Rust tools.
2. cargo : The official package manager of Rust. It downloads your dependencies, compiles your packages , makes distributable binaries and also uploads them to crates.io, the official Rust package registry.
3. rustc : The Rust compiler.

Creating a new project in Rust

To create a new Rust project we use the below command

```
cargo new <project_name>

#OR

cargo new --bin <project_name>
```

Here --bin makes sure that the new project created is a program and not a library.

The project directory structure - 1

Once you have run the command `cargo new`, you will get a project directory with the following structure :

```
.
├── Cargo.lock
├── Cargo.toml
└── src
    └── main.rs
```

Cargo.toml

This is the file containing all the metadata of the project. It contains stuff like the Project Name, Rust version used, Project Dependencies etc. Here is a barebones `Cargo.toml`

```toml
[package]
name = "project_name"   # The name of your crate/project
version = "0.1.0"       # The current version of your project (semver
format)
edition = "2021"        # Rust edition (2015, 2018, or 2021 are valid)

[dependencies]
# This section is where you list external crates your project depends on.
# Format: crate_name = "version"
```

The project directory structure - 2

src.main.rs

This is the main file where we write our Rust programs. cargo generates a default Hello, World program as shown below. If you are using presenterm to present this file, press CTRL + E to execute the code.

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

```
──────────────────── [finished] ────────────────────
```

```
Hello, world!
```

The project directory structure - 3

Building the code

To build the code, run the below command in your project's root directory, the executable binary (ELF for Linux and EXE for Windows) will be available in the `target/debug` directory) :

```
cargo build
```

Running the code

To run the Rust code, run the below command in your project's root directory :

```
cargo run
```

This command first builds the code and then runs it. So `cargo build` is optional.

To optimize the binary, we use the `--release` flag since by default Rust builds for debugging which increases the binary size.

```
cargo run --release
```

Hello, world! program breakdown

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

```
──────────────────── [finished] ────────────────────
```

```
Hello, world!
```

fn main() { ... }

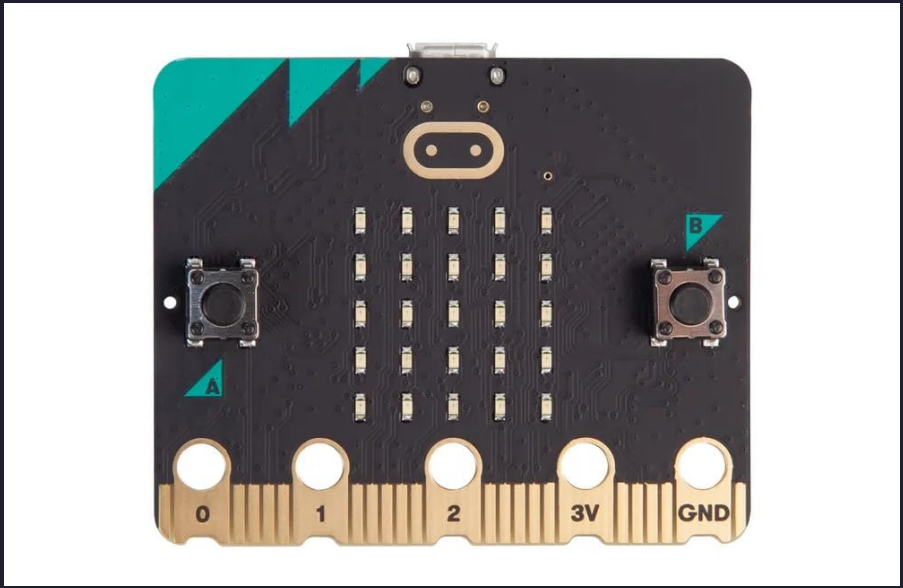
1. fn -> Keyword for defining a function in Rust
2. main -> The entry point of a Rust program. All the program's logic will be written inside the main function. This is similar to int main() in C/C++.

println!("Hello, world!);

println! is a macro which prints output to terminal with a newline \n at the end. To print the output without the newline use the print! macro instead.

Note the Semicolon (;) at the end. This indicates the end of the line.

1. BBC Microbit V2



Variables in Rust

To define a variable in Rust, we use the `let` keyword.

Immutable variables

This is the default type of variables in Rust. Here the value cannot be modified or changed.

Mutable Variables

The value of this variable can be modified or changed. To define a mutable variable, we use the `mut` keyword.

```rust
fn main() {
  let x = 45;       // Immutable variable
  let mut y = 56;  // Mutable variable
  println!("Immutable variable : {x}");
  println!("Mutable Variable : {y}");
  y *= 2;
  print!("Modified value : {y}");
}
```

```
———————————————— [finished] ————————————————
```

```
Immutable variable : 45
Mutable Variable : 56
Modified value : 112
```

Data types in Rust - 1

Integers

Integers in Rust are scalar types that represent whole numbers, available in both signed (iN) and unsigned (uN) forms with fixed bit-widths (8, 16, 32, 64, 128, or pointer-sized).

Signed integers

Type	Size
i8	8 bits
i16	16 bits
i32	32 bits
i64	64 bits
i128	128 bits
isize	Pointer-sized (Depends on architecture)

Unsigned Integers

Type	Size
u8	8 bits
u16	16 bits
u32	32 bits
u64	64 bits
u128	128 bits
usize	Pointer-sized (Depends on architecture)

Floating point

Floating point numbers are basically decimal numbers

Float types

Type	Size
f32	32 bits
f64	64 bits

Boolean (bool)

Boolean can have only 2 values true and false

Character (char)

This has a size of 4 bytes and is used to represent a single Unicode Scalar value.

Program that prints all datatypes

```rust
fn main() {
  let a: i16 = -25;     // 16-bit signed integer
  let b: u32 = 45;      // 16-bit unsigned integer
  let c: f32 = 256.32;  // 32-bit Floating point value
  let d: char = 'c';    // Character
  let e: bool = true;   //Boolean

  println!("16-bit signed Integer : {}", a);
  println!("16-bit unsigned Integer : {}", b);
  println!("32-bit Floating point value : {}", c);
  println!("Character : {}", d);
  println!("Boolean value : {}", e);
}
```

[finished]

```
16-bit signed Integer : -25
16-bit unsigned Integer : 45
32-bit Floating point value : 256.32
Character : c
Boolean value : true
```

Strings in Rust

In Rust (Or any language for that matter), a string is a collection of characters.

String types

1. `String` -> An owned, growable, heap-allocated UTF-8 string.
2. `&str` (**String Slice**) -> A borrowed view of `String`, often used for String literals.

```rust
fn main() {
    let slice: &str = "Hello";
    println!("slice: {}", slice);
    let mut owned: String = String::from("Hello");
    owned.push_str(", world!"); // we can modify it
    println!("owned: {}", owned);
    let borrowed: &str = &owned;
    println!("borrowed from String: {}", borrowed);
}
```

———————————— [finished] ————————————

```
slice: Hello
owned: Hello, world!
borrowed from String: Hello, world!
```

Specify datatype of a number

```rust
fn main() {
  let x = 3u8 - 2u8;     // Specifying datatype as u8
  let y = 4i8 - 10i8;     // Specifying datatype as i8

  println!("{x}");
  println!("{y}");
}
```

[finished]

```
1
-6
```

Type casting

This is used to change from one datatype to another.

Type casting uses the `as` keyword.

```
fn main() {
  let x = 4u32 - 3i16 as u32;

  println!("{x}");
}
```

```
———————————————— [finished] ————————————————
```

```
1
```

Control Flow in Rust

1. `if-else` -> Conditional branching based on a boolean expression
2. `if let` -> Pattern-matching shorthand for `if` with a single pattern
3. `match` -> Exhaustive branching based on patterns.
4. `loop` -> Infinite loop that runs unless explicitly broken.
5. `while` -> Loop that runs until the given condition becomes false.
6. `while let` -> Loop that run until a given pattern matches.
7. `for` -> Iterate over the elements of an iterator.
8. `break` -> Exits a loop
9. `continue` -> Skips to the next loop iteration.
10. `return` -> Exits a function and returns a value.

if-else statements

These are used to evaluate a condition and returns one of two or more values depending on whether the condition is true or false

Example

```
fn main(){
  let b = 0.5;
  if b > 0.1 {
    println!("{b} > 0.1");
  } else {
    println!("{b} < 0.1");
  }
}
```

[finished]

```
0.5 > 0.1
```

if-let statement

This statement runs a code if a value matches a single pattern.

Example

```
fn main() {
    let opt = Some(10);
    if let Some(val) = opt {
        println!("val is {}", val);
    }
}
```

```
──────────────────── [finished] ────────────────────
```

```
val is 10
```

match statement

Performs branching by matching patterns exhaustively. Similar to switch-case of C/C++.

```
fn main() {
  let num = 2;
  match num {
      1 => println!("One"),
      2 => println!("Two"),
      _ => println!("Something Else : {}", num)
  }
}
```

[finished]

```
Two
```

loop statement

Creates an infinite loop until explicitly broken.

```
fn main() {
  let mut count = 0;
  loop {
    count += 1;
    if count == 3 {
        println!("Breaking at count = {count}");
        break;
    }
  }
}
```

———————————— [finished] ————————————

```
Breaking at count = 3
```

while statement

Loops as long a given statement is true

```
fn main() {
  let mut n = 3;
  while n > 0 {
      println!("n : {n}");
      n -= 1;
  }
}
```

```
──────────────────── [finished] ────────────────────
```

```
n : 3
n : 2
n : 1
```

while let statement

Loops until the given value matches a pattern.

```
fn main() {
  let mut opt = Some(3);
  while let Some(val) = opt {
    println!("{val}");
    opt = if val > 1 {
      Some(val - 1)
    } else {
      None
    };
  }
}
```

[finished]

```
3
2
1
```

for loop

Iterates over the items in an iterator

```
fn main() {
  for i in 1..=4{   // Also includes 4 as part of the for loop
      println!("{i}");
  }
}
```

[finished]

```
1
2
3
4
```

break statement

Exits a loop immediately

```
fn main() {
  for i in 1.. {   // Iterates from 1 to infinity
    if i == 3 {
        break;
    }
    println!("{i}");
  }
}
```

[finished]

```
1
2
```

continue statement

Skips the rest of the current loop iteration

```
fn main() {
  for i in 1..5 {
    if i == 3 {
      continue;
    }
    println!("{i}");
  }
}
```

```
──────────────────── [finished] ────────────────────
```

```
1
2
4
```

return statement

Exits a function and returns a value

Two ways to return a value from a function

Using return statement

```
fn square(x: i32) -> i32 {  // Returns
i32
    return x * x;
}

fn main() {
  let n: i32 = square(4);
  println!("Square of 4 is : {n}");

}
```

[finished]

```
Square of 4 is : 16
```

Without using return statement

```
fn square(x: i32) -> i32 {
  x * x         // There is no semicolon
(;) here
}

fn main() {
  let val: i32 = square(4);
  println!("Square of 4 is : {val}");
}
```

[finished]

```
Square of 4 is : 16
```

Functions in Rust

Functions are reusable blocks of code that may or may not return a value.

```
fn ret_val(x: i32) -> f64 {   // Return f64
  x as f64     // Change i32 to f64 and return it
}

fn print_smth() {
  println!("Function call");       //This function doesn't return anything
}

fn main() {
  print_smth();
  let num: i32 = 89;
  let ret_num: f64 = ret_val(num);
  println!("Returned value : {ret_num}");
}
```

[finished]

```
Function call
Returned value : 89
```

Memory in Rust

Memory in Rust is managed through ownership, borrowing, and lifetimes, ensuring safety without a garbage collector.

Example

```rust
fn main() {
    let s1 = String::from("Hello"); // allocated on the heap
    let s2 = &s1;                   // borrowed reference (no copy)
    println!("s1: {}, s2: {}", s1, s2);
} // memory for `s1` is automatically freed here
```

[finished]

```
s1: Hello, s2: Hello
```

References vs Pointers in Rust

Feature	References (`&T`, `&mut T`)	Raw Pointers (`*const T`, `*mut T`)
Safety	Always safe	Unsafe, can cause undefined behaviour
Nullability	Cannot be NULL	Can be `NULL` (NULL Pointers)
Dereferencing	Safe, no `unsafe` block required	Requires `unsafe` block
Lifetimes	Must follow lifetime rules	No lifetime checks
Mutability	`&T` is immutable, `&mut T` is mutable	`*const T` is immutable, `*mut T` is mutable
Ownership	Enforces (No dangling, aliasing)	Not enforced (May cause dangling pointers)
Usage	Everyday Rust code (Safe borrowing)	Low level memory manipulation

References vs Pointers in Rust (Example Code)

References (Safe)

```rust
fn main() {
    let x = 42;
    let r: &i32 = &x;   // reference to x (safe)
    println!("Reference points to: {}", r);
}
```

```
———————————— [finished] ————————————
```

```
Reference points to: 42
```

Pointers (Unsafe)

```rust
fn main() {
    let x = 42;
    let p: *const i32 = &x;   // raw pointer to x

    unsafe {
        println!("Raw pointer points to: {}", *p); // dereference requires unsafe
    }
}
```

```
———————————— [finished] ————————————
```

```
Raw pointer points to: 42
```

Print memory address of a reference

The below program prints the memory address of a value's reference

```
fn main() {
  let x: i32 = 57;
  println!("Value: {x}");
  println!("Memory location: {:p}", &x);
}
```

```
──────────────────── [finished] ────────────────────
```

```
Value: 57
Memory location: 0x7ffd4aeaeb9c
```