ENGG1003 - Monday Week 12

The C programming language & version control with Git

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Lecture overview

1. Context
   - ENGG1003
   - what is C?
   - do we even need C?
2. C programming language
   - features and philosophy
   - key language details of C
3. Version control with Git
   - principles
   - practical demonstration (live demo by Brenton)

1) Context

- Recall from last week...
- $\leq$ 2020, ENGG1003 used *MATLAB* and *C*
  - **from 2021, ENGG1003 uses Python only**
  - ...yet some students will use MATLAB &/or C in later courses
- Thursday week 11: overview of MATLAB
- today's lecture: overview of C

What is C?

- C is a general-purpose, high-level programming language
  - other high-level languages: Python, MATLAB, Java, C++, FORTRAN, ...
- C has been around since early-1970s and still *very* popular
  - IEEE language ranking 2020: #1: Python **#3: C** #10: MATLAB
- C is native language of Linux, Microsoft Windows, OS X, iOS, & Android kernels
- even Python language is written in C
- **C language constructs map efficiently to computer hardware (machine instructions)**

Do we even need C?

- **C is not assessable in ENGG1003**
- BUT... C is currently used in some courses in some Engineering programs:
  - Aerospace Systems, Computer Systems, Electrical, Mechatronics and Medical Engineering
- key courses which use C language:
  - ELEC2720, ELEC3730, AERO3600, MCHA3400, MCHA3500
  - common theme of all these courses is *embedded systems*

Embedded systems

- embedded system: coupled hardware and software designed for a *specific task*
- eg: washing machine
  - inputs: buttons, water-level, water temperature
  - output: LED display, motor control
  - control unit: microprocessor & memory
- *many* other examples: smart TVs, gaming consoles, medical devices, WiFi routers, automotive ...
- **C language is well-suited to tight coupling of hardware and software in embedded systems**

2) C programming language

Quick recap of *computer language hierarchy*, week 1:

- **machine code**
  - a microprocessor can only understand machine code
  - eg: one instruction for an x86-based processor:
    0110 0110 1000 0011 1100 0000 0000 1010
  - very processor-specific!
- **assembly language**
  - human-readable abbreviations ("mnemonics")
  - eg: machine code
    0110 0110 1000 0011 1100 0000 0000 1010
  - same instruction in assembly language
    `ADD AX, 10`
  - very processor-specific

- **high-level languages** eg: C, Python, MATLAB ...
  - human-readable text-based code
  - increased complexity of each high-level instruction
  - eg: machine code
    0110 0110 1000 0011 1100 0000 0000 1010
  - same instruction in assembly language
    `ADD AX, 10`
  - same instruction in C
    `x = x + 10;`
  - *not* processor-specific (that's a good thing)
- *compilation process* converts source code (eg: C) to machine code
  - source code → pre-processor → compiler → assembler → linker → machine code ("executable")

Hello, World! ...in the C language

```
1 #include <stdio.h>
2
3 int main()
4 {
5     printf("Hello, World!\n");
6     return 0;
7 }
```

- line 1: header file `stdio.h`, like Python `import`
- line 3: function definition for `main()`, returns `int`
- line 5: formatted print, `\n` means "newline"
- line 6: returns "all good" (error-free) message
- lines 4 & 7: $\{\cdot\}$ begin/end of function `main()`

Hello, World! program in C and assembly

C source #1

```c
#include <stdio.h>

int main()
{
    printf("Hello, World!\n");

    return 0;
}
```

x86-64 gcc 11.1 (Editor #1, Compiler #1) C

```asm
.LC0:
        .string "Hello, World!"
main:
        push    rbp
        mov     rbp, rsp
        mov     edi, OFFSET FLAT:.LC0
        call    puts
        mov     eax, 0
        pop     rbp
        ret
```

- left panel: C program
- right panel: corresponding assembly language code for 64-bit Intel x86
  - x86 instructions: `push, mov, call, pop, ret`
- try it yourself at: https://godbolt.org/

The C language combines all the power of assembly language with all the ease-of-use of assembly language.

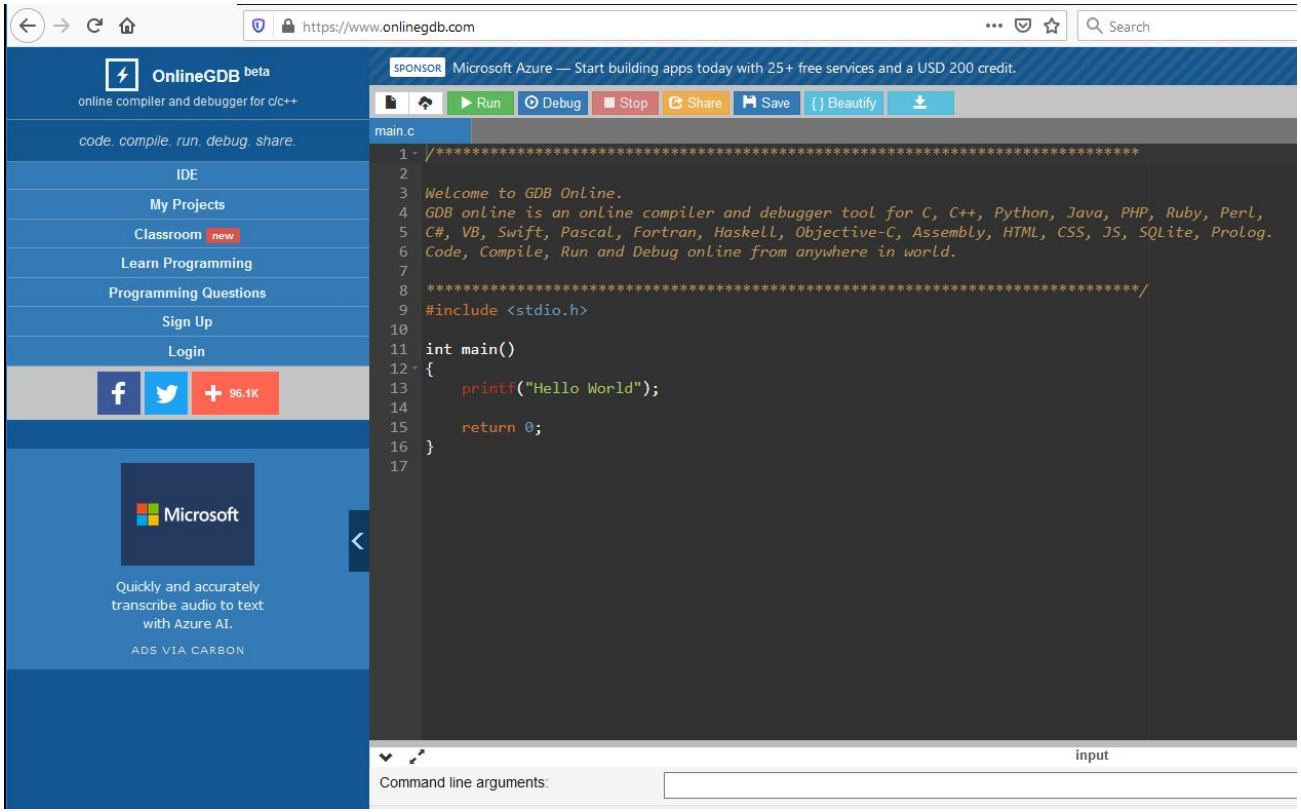
— Mark Pearce —

AZ QUOTES

Learn to think like the computer hates you, because it does.

https://learncodethehardway.org/c/

OnlineGDB: browser-based C development



edit, compile and run simple C programs with no setup!
https://www.onlinegdb.com/

C program: read and print an integer

```
1  #include <stdio.h>
2  int main() {
3      int number;
4
5      printf("Enter an integer: ");
6
7      // reads and stores input
8      scanf("%d", &number);
9
10     // displays output
11     printf("You entered: %d", number);
12
13     return 0;
14 }
```

- line 3: need to "declare" variables before use
- line 8: `scanf()` reads from keyboard, `&number` means "address of variable `number` in memory"

C program: sum of integers using a loop

```
1  #include <stdio.h>
2  int main() {
3      int n, i, sum = 0;
4
5      printf("Enter a positive integer: ");
6      scanf("%d", &n);
7
8      for (i = 1; i <= n; ++i) {
9          sum += i;
10     }
11
12     printf("Sum = %d", sum);
13     return 0;
14 }
```

- lines 8–10: iterate with `for` loop
  initialise `i` at 1; continue looping if `i` $\leq$ `n` is true;
  update `i` = `i` +1 after each iteration of loop body

C program: power of a number base^{exp}

```
1  #include <stdio.h>
2  int main() {
3      int base, exp;
4      long result = 1;
5      printf("Enter a base number: ");
6      scanf("%d", &base);
7      printf("Enter an exponent: ");
8      scanf("%d", &exp);
9
10     while (exp != 0) {
11         result *= base;
12         --exp;
13     }
14     printf("Answer = %ld", result);
15     return 0;
16 }
```

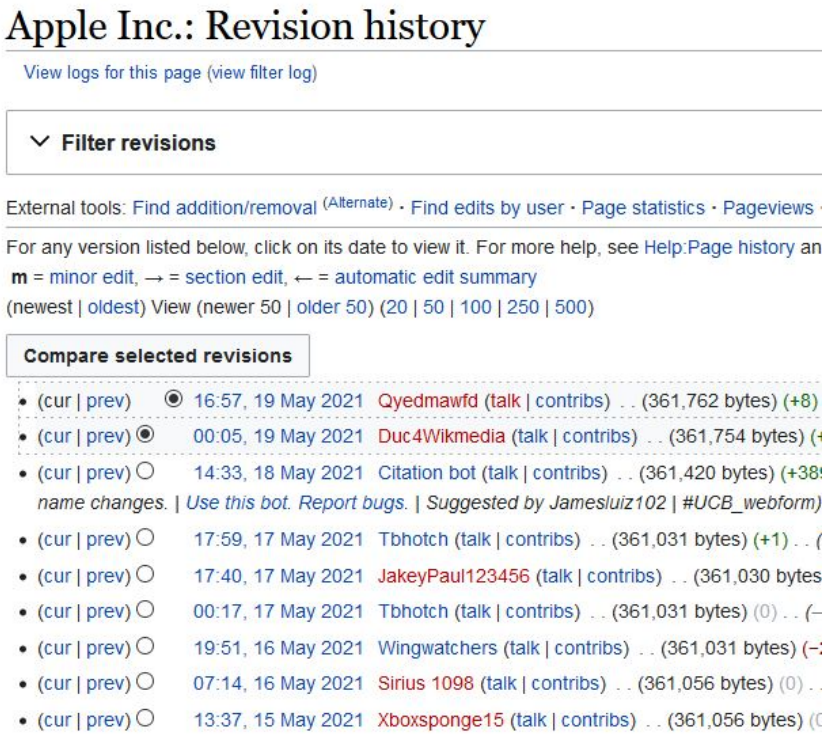
- lines 10–13: `while` loop, continues while $\texttt{exp} \neq 0$
- line 11: `result = result * base`
- line 12: decrement `exp`, ie: `exp = exp - 1`

3) Version control with Git

Programming projects often give rise to two problems:

1. programmers want to "roll back" to earlier code
   - after trying an unsuccessful idea, sometimes faster to load up working code from the past and go from there
2. multiple people contribute to the same project. How should their changes be "merged" into some kind of "master" code listing?

- *version control systems* solve both problems
- most widely used version control system is *Git*



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- Wikipedia records history of changes
- every time an edit is made, it's recorded in history, even if that change is later reverted
- possible to go back in time to look at at that page at any point in its history

Common Git terms

- **Repository (repo)**
  - store of all the different pieces of the project
  - collection of files + history of changes made to those files
- **Commit**
  - captures a snapshot of the project
- **Push**
  - upload local repository content to a remote repository
- **Pull**
  - update the local version of a repository from a remote

Practical demonstration of Git

- over to you, Brenton . . .

Next steps

C is not assessable in ENGG1003

- getting started with C, if you need it *for later courses*

- Code::Blocks integrated development environment
  - https://www.codeblocks.org/downloads/binaries/
  - runs on various platforms:
    - Windows XP / Vista / 7 / 8.x / 10
    - Linux 32- and 64-bit
    - Mac OS X