What is programming?

An example...

You've probably programmed before. When you enter 1+1 on a calculator, you are commanding it to calculate 1+1 for you.

Now, what if you want your calculator to calculate lots of equations for you over and over in the future? Well, you write those equations out on a text file and feed this text file into your calculator for it to calculate the equations in the text file for you. This way, you can re-feed this text file any time you want the calculator to perform the same calculations in the future i.e. you:

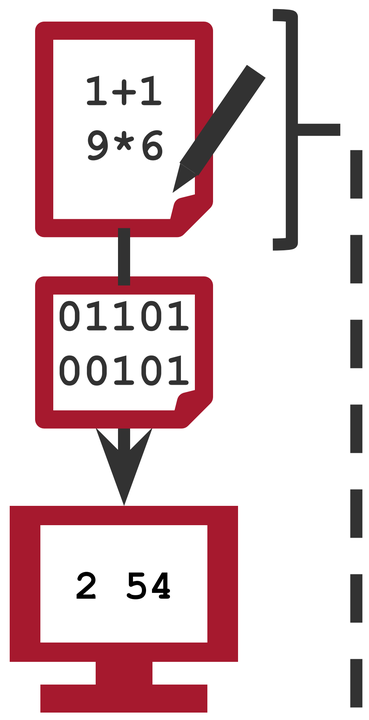
- "**programmed**" (wrote) a set of equations or instructions into a "**program**" (a text file) so that
- your "**computer**" (calculator) could "**execute**" (do the calculations requested by) your program.

of a programming workflow

A computer is just a super powerful calculator... that can only read and execute programs written in binary i.e. 0s and 1s. We call these "**binary**" program files, "machine executable" files.

Binary program code is almost impossible for us to read or write, so we came up with this workflow:

1. **program**: you write a program in a human-readable "**programming language**" to a program text file.
2. **compile**: you get a "compiler" (translator) to "compile" (translate) your program text file into a machine read-able binary file.
3. **execute**: you let the computer execute the instructions in this binary.



C++ and Python are two of the most popular **programming languages**.

C++ is more difficult to write, but it is extremely efficient and powerful.
Operating systems (OS) and lower-level software are primarily written in C++.

Python is much easier to write and is very popular, but it gives you less control.
Python is used for high-level applications such as software development and artificial intelligence.

Text editors and IDEs

Let's start with getting some tools to complete **step 1: writing a human-readable program**.

Your program code is essentially a text file, so you can edit it in any text editor.
There are two types of text editing software you can use to write your program:

Text editors are lightweight text editors that have a few additional functionalities over notepad, such as syntax (grammar) highlighting.

IDEs (integrated development environment) are heavyweight text editors plus all the other tools you will need during the programming process. These tools are usually program language-specific.

Notepad++	Sublime text	VS Code	Atom	Vim	Visual Studio	Eclipse	Code::blocks	Pycharm	Spyder
simple, fast	simple, fast	extendable	extendable	hard, flexible	generic	generic	C++	Python	Python

Set up your computer for programming with a **terminal** (C++ and Python)

Prepping your **terminal**

The easiest way to set up for programming is via a Unix terminal.

Windows: On Windows 10+, your OS comes with a Windows subsystem for Linux (WSL) which allows you to interface with your OS via a Unix terminal.

Let's **enable WSL and install a Linux distribution** if you don't have it installed already:

- open PowerShell as administrator:
  `start` > **`search`** `for "PowerShell"` > **`right-click`** `"Windows PowerShell"` and **`select`** `"Run as administrator"`.
- paste the following command into the PowerShell and press the **`enter`** key:

```
Enable-WindowsOptionalFeature
-Online -FeatureName
Microsoft-Windows-Subsystem-Linux
```

- restart your computer on prompt.
- now that you have WSL enabled, let's install the Ubuntu distribution here!
- after you've installed Ubuntu, open it up! If this is the first time you're opening it up, it should say it's installing. After that is finished, give yourself a username and password.

Now that you have a terminal (like the one you would have on Ubuntu), you will need to **install:**

- a **C++ compiler `g++`** by installing the GNU compiler tools and the GDB debugger (**`sudo`** means to run as admin, **`whereis`** verifies successful installation),

```
$ sudo apt-get update
$ sudo apt-get install
build-essential gdb
$ whereis g++
```

- and a **Python 3 interpretor**.

```
$ sudo apt update && upgrade
$ sudo apt install python3
python3-pip ipython3
```

Now you're all set up to use your terminal in Windows to work with C++ and Python :)!

Linux & macOS: Python and C++ are pre-installed and set up on your machine! It's just a matter of opening up the terminal and using them.

For Linux computers, this guide assumes you are using a Gnome-based desktop environment (e.g. Ubuntu) that interfaces between you and Linux.

Let's open up your terminal:
`application menu` / **`launchpad`** > **`search`** `for "terminal"` and `select` it.

Using your **terminal**

The terminal is an interface where you can type commands for your OS to execute. *Think of your **terminal** as a **dumbed-down Siri*** who only takes super specific typed out commands; but as long as you know what the commands are, your terminal can do almost anything! Including executing your C++ or Python program.

Navigating your files from your terminal: before programming, we need to learn how we can navigate our files. Here's a few basic commands:

- **`$ ls`**: list the contents in your current directory.
- **`$ cd [directory]`**: "change directory" i.e. go to the directory or the folder (that you saw when you `ls`-ed);
  - **`$ cd /`**: root directory on Linux & macOS.
  - **`$ cd /mnt/c`**: the C drive on Windows.
  - **`$ cd ..`**: the parent directory.
- **`$ mkdir [directory]`**: make a new directory.
- **`$ rm [file]`** / **`$ rm -rf [directory]`**: remove (delete) a file / directory.
- **`$ cp [file1] [file2]`** / **`$ cp -r [directory1] [directory2]`**: copy and paste `[file1]`/`[directory1]` as `[file2]`/`[directory2]`.
- **`$ cat [file]`**: show contents of a `[file]`.

Pro tip: press **`ctrl-c`** inside the terminal to terminate or stop any command.

1. Program Syntax

C++

Declares a **variable** `num`
- of **data type** `int` (integer),
- **value** of `0`, and
- creates a **pointer** (address) to the space in memory where C++ stores its value.

All statements end with `;`

`std::cin` takes a user input from the terminal and assigns `>>` it to `num` in replacement of its current value `0`.

`std::cout` prints to standard output `<< "You entered "` and `sqrt(number)`.

`int` is the output `return` type of `main`. In this case, it was `0`.

`return` terminates `main` and ends the program.

main.cpp

```cpp
// author: alice yue
// date: 2021-05-21
// description: does math!
```

Everything after `//` are **not ran**, they're **comments**! Use them for explanations.

```cpp
#include <iostream>
#include <cmath>
```

`#include`'s `iostream`, `cmath` which contains `cout`/`cin` and `sqrt`, which we use below.

```cpp
int main() {
    int num = 0;

    std::cout << "Enter an integer: ";
    std::cin >> num;

    std::cout << "The sqrt of " <<
        num << " is " << sqrt(num);

    return 0;
}
```

`int main() {...}` defines a special **function** called `main`.

C++ runs a program by by executing everything in the `main()` **body** `{...}`.

Put this in all your programs so that your program runs.

Python

Declares a **variable** `num`.

`input()`:
- prints to standard output `"Enter an integer: "`,
- **returns** user input, and
- **assigns** (with **operator** `=`) the input to `num`.

`print()` prints to standard output `"You entered "` and `sqrt(num)`.

main.py

```python
# author: alice yue
# date: 2021-05-21
# description: does math!
```

Everything after `#` are **not ran**, they're **comments**! Use them for explanations.

```python
import math
```

`import`'s package `math` which contains `sqrt` used below.

```python
num = input("Enter an integer: ")

print("The sqrt of ", num, " is ",
    math.sqrt(num))
```

2. Compile & 3. Execute

C++

Terminal

`g++` "compiles" **`main.cpp`** into **`program`**.

```
$ g++ -o program main.cpp
$ ./program
```

execute **`program`**

```
Enter an integer: 4
The sqrt of 4 is 2
```

Python

Terminal

`python` "interprets" (compile + execute) **`main.py`**.

```
$ python main.py

Enter an integer: 4
The sqrt of 4 is 2
```

Program Syntax

C++

Variables

A **variable** is a defined value that holds data.

```
int i = 0;
```

Each variable can be defined by its:

1. **data type (e.g. `int`)**; the data type determines how much space in memory C should allocate for your variable. You can also get the size of a variable via `sizeof(i);`. Common data types: `int` (e.g. `0`), `char` (e.g. `'a'`), `float` (e.g. `1.2`).
2. **variable name (e.g. `i`)**.
3. **value (e.g. `0`)**; the thing that is getting stored in the allocated space in your memory.
4. **pointer**; an address to the space C++ allocated for your variable value in the memory.

Array; vector

An **array** is a static (meaning it cannot change in length) list of values of the same data type; unlike variables, an array is "passed" as its pointer by default i.e. the variable name of an array is synonymous to its pointer.

The index of a list starts at `0` and can be accessed with `[...]`.

```
int ia[3] = {6,3,1};
ia[0]; // 6
ia[1]; // 3
ia[2]; // 1
```

A **vector** is an array with inbuilt functions that allow you to change its size:

```
#include <vector>
...
std::vector <int> iv(3); // declare
```

Strings are just special char arrays that you can initialize by doing:

```
std::string str = "Hello World!";
```

The notion of value vs pointer is what confuses most people, make sure you know it by heart:

Declaration	Value	Pointer
`int i`	`i`	`&i`
`int* i`	`*i`	`i`
`int ia[3]`	`*ia`	`ia`

Python

Pro tip: you can pull up documentation about a certain, e.g. function, in the Python interpreter using **`help`** in the interpretor which you can open up in your terminal:

```
$ python
>> help(str)
```

Variables

A **variable** is a defined value that holds data.

```
i = 0;
```

Each variable can be defined by its:

1. **variable name (e.g.`i`)**.
2. **value (e.g. `0`)**.

You can convert a variable to a certain data type using: `str(i)`, `int(i)`, `float(i)`, `bool(i)`.

In Python, each data type has a specific set of **methods**, functions that you can apply to variables of that data type. Methods for strings `str` include:

```
s = 'Hello World! '
s[4]                # 'o'characters
s[3:5]              # 'lo'
s.upper()           # 'HELLO WORLD! '
s.lower()           # 'hello world! '
s.count('l')        # 3
s.replace('e','p') # 'hpllo world! '
s.strip()           # 'hpllo world!'
```

List; dictionary

A **list** is a dynamic group of values not necessarily of the same data type.

The index of a list starts at `0` and can be accessed with `[...]`.

```
l1 = ['Hello', 1]
l1[0] # 'Hello'
l1[1] # 1
```

Python **dictionaries** are another way to store a list of values, but for each **value**, its index can be given a unique **key**.

```
dict = {
    "brand": "Honda",
    "colours": ["red", "blue"],
    "year": 2020
}
dict["brand"]              # "Honda"
```

Program Syntax

C++

Arithmetics

Arithmetic operators manipulate numerics:

- operators:
  - **+**, **-**, *****, **/**, **%** (modulus/remainder);
    e.g. `int i=4+5;`
- shorthands:
  - **++**, **--**; e.g. `i++;` is the same as `i=i+1;`
  - **+=**, **-=**, ***=**, **/=**; e.g. `i+=1;` is the same as `i++;`

`if` / `else` statements

if statements help add decision-making to your program; its syntax works like this: **`if`** **`(`**some statement**`)`** is true, execute the code in **`{...}`**. You can also optionally add **`else if`** and **`else`** statements if you want to embed more decision-making options.

```cpp
if (i > 2) {
    // code runs if (...) is true
} else if (i == 2) {
    // code runs if (...) is true
} else { // i < 2
    // code runs otherwise
}
```

The following are infix operators you can use in conditional statements **`(...)`** to help you with your decision making:

name	syntax
equal to	**==**
not equal to	**!=**
less than	**<**
greater than	**>**
less than or equal to	**<=**
greater than or equal to	**>=**
not	**!**

Python

Arithmetics

Arithmetic operators manipulate numerics:

- operators:
  - **+**, **-**, *****, **/**, **%** (modulus/remainder);
    e.g. `i=4+5;`
- shorthands:
  - **+=**, **-=**, ***=**, **/=**; e.g. `i+=1;`

`if` / `else` statements

if statements help add decision-making to your program; its syntax works like this: **`if`** **`(`**some statement**`)`** is true, execute the code **indented** below. You can also optionally add **`elif`** and **`else`** statements if you want to embed more decision-making options.

Hint: indentation is super important in Python, because it does not use braces!

```python
if i > 2:
    # code runs if statement is true
elif i == 2:
    # code runs if statement is true
else: # i < 2
    # code runs otherwise
```

The following are logical operators you can use in conditional statements to help you with your decision making:

name	syntax
equal to	**==**
not equal to	**!=**
less than	**<**
greater than	**>**
less than or equal to	**<=**
greater than or equal to	**>=**
not	**not**

Program Syntax

C++

Loops

If you have a list of values you want to loop through, repeating the same piece of code for each value, you can repeat that piece of code over and over again (**left**; BAD) OR use any one of the following loops (**right**).

```cpp
int i = 0;
std::cout << i;

i = 1;
std::cout << i;

i = 2;
std::cout << i;

i = 3;
std::cout << i;

i = 4;
std::cout << i;
```

while loop: `while` my condition `(...)` is true, execute the code in `{...}`.

```cpp
int i = 0;
while (i < 5) {
    std::cout << i++;
}
```

do/while loop: `do` execute `{...}`; while my condition `(...)` is true, repeat; this guarantees that `{...}` executes at least once.

```cpp
int i = 0;
do {
    std::cout << i++;
} while (i < 5);
```

for loop: `(`initialize variable `i` to `0;` for as long as `i < 5`, execute the code in `{...}` and `i++` at the end of each execution`)`.

```cpp
for (int i=0; i<5; i++) {
    std::cout << i;
}
```

Functions

When your code gets long, it's useful to **encapsulate** repeating code into a **function**:

```cpp
// function definition
int mean(int a, int b) {
    int mn = (a + b) / 2;
    return mn;
}

// calling (using) the function
void main () {
    int mn1 = mean(5, 6);
}
```

A **function definition** includes:

- a **return type**: `int`
- **function name**: `mean`
- **input arguments**: `(int a, int b)`
- **function body**: `{...}`

Python

Loops

If you have a list of values you want to loop through, repeating the same piece of code for each value, you can repeat that piece of code over and over again (**right**; BAD) OR use any one of the following loops (**left**).

```python
i = 0
print(i)

i = 1
print(i)

i = 2
print(i)

i = 3
print(i)

i = 4
print(i)
```

while loop: `while` my condition `(...)` is true, execute the code in `{...}`.

```python
i = 0;
while i < 5:
    print(i)
    i += 1
```

for loop: `for` each element in some list, run the indented code.

```python
fruits = ['apple', 'banana', 'orange']
for fruit in fruits:
    print(fruit)
```

Functions

When your code gets long, it's useful to **encapsulate** repeating code into a **function**:

```python
# function definition
def mean(a, b):
    mn = (a + b) / 2
    return mn


# calling (using) the function
mn1 = mean(5, 6)
```

A **function definition** includes:

- a keyword: `def`
- **function name**: `mean`
- **input arguments**: `(a, b)`
- the **function body** is indented `def`

SFU programming resources

Remote accessing SFU computers

If you ever need access to computers or software at SFU, you can!

1. Click here to set up **MFA** (multi-factor authentication), you will need to do this before you start remote accessing any SFU computers.

2. Click here for instructions on how to access the Burnaby or Surrey **library lab computers** and **software** from off-campus.

If you are a CMPT student, you will also have access to CSIL (computing science instructional labs).

1. Click here to set up **MFA** (multi-factor authentication), you will need to do this before you start remote accessing any SFU computers.

2. Click here for instructions on how to **access CSIL via SSH in your terminal**.

Need software?

Check out the software made available to you

- as SFU students here and
- as SFU CMPT students here!