Introduction

Programming Language Theory

Contacts

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  - E-mail: jindae.kim@seoultech.ac.kr
  - Post your questions in e-class, so that other classmates can discuss together.

Syllabus

- Programming Language Theory
- Pre-requisites
  - Good understanding of at least one programming language.
  - Basic understanding of C++ and Java, maybe Python too.

Syllabus

- Contents
  - Programming Language Design Principles
  - Programming Language Concepts
  - Programming Language Paradigm
  - A few programming languages in different paradigms.

Textbooks

- No official textbooks.
    - If you want to study further, we may check the following books as references.
    - Michael L. Scott, Programming Language Pragmatics, 4th Edition, Morgan Kaufmann
    - Maurizio Gabbrielli and Simone Martini, Programming Languages: Principles and Paradigms, Springer-Verlag London
    - Robert W. Sebesta, Concepts of Programming Languages, 11th edition, Pearson
- Please, don’t buy the books unless you’re really into it.
- We will use many other materials related to PL during the semester.

Course Organization

- We will first look at programming language design principles and concepts for the first half of the semester.
    - How can we design and implement PLs?
- For the next half, we will study various programming language paradigms with selected specific languages.
    - What kinds of programming languages are there?

Course Organization

- Every week consists of **two online lectures + online real-time practice**.
- **Lectures will be posted on e-class**.
  - It might be changed based on the university policy after the mid-term exam.
- **One practice session on Friday**: simple tasks related to the same week's lectures.
  - It means that ***you have to watch the lecture videos before the practice session***.

Evaluation

- Evaluation
  - Mid-term Exam 40%
  - Final Exam 40%
  - Assignments 20%

Assignments

- Basically assignments are to verify that you're finishing your tasks in practice sessions.
- You can submit your results to e-class during practice sessions.
  - i.e., an assignment will be posted at the beginning of each practice session, and its deadline will be around the end of the session.

Practice Sessions

- You need to attend practice sessions via Zoom.
- Every Friday 10:00AM~11:50AM (~2 hours). 😔
  - Schedule could be adjusted within the course schedule.
- Doing simple assignments - you can ask questions and discuss with your friends.
- If you finish your tasks and submit your results, you can leave early. 😏
- Assignments can only be submitted ***during practice sessions***.

Introduction to Programming Language Theory

Programming Language Theory

- So far, you're mostly 'using' programming languages for software development.
- How about 'making' programming languages?
- Programming Language (PL) theory is about **how to design good programming languages**, and build a basis for programming language development.

Scope of This Course

- The aim of this course is to ***understand PL concepts and paradigms***, and use that knowledge ***to help learning new programming languages***.
- Normally PL courses cover very serious theoretical stuff from the foundation.
- However, not everyone is interested in programming language development.
- Apologies to students who want to create their own programming languages; this course doesn't cover that much.

Scope of This Course

- Still, this is actually a theory course.
- We cannot avoid studies on theoretical foundation of programming languages.
- This will help you have more deep understanding in programming languages.
- Also, many of these contents will make you look very professional!

Why PL Theory?

- There have been so many different programming languages.
- Useful common concepts among these languages have been studied, evolved, and reflected on new programming languages.
- How can we include useful concepts in a new programming language?
    - While minimize accompanying drawbacks?

PL Concepts and Paradigms

- Many programming languages are different implementations of the similar concepts following the similar paradigms.
- For example, consider a sorting program.
- You may write many sorting programs in different languages implementing different algorithms.
- Still, they’re sorting programs which place something in order.

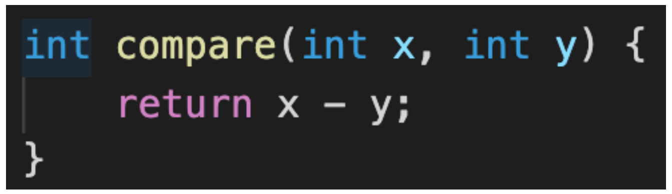
PL Concepts and Paradigms

- **PL concepts**: more like individual features.
- e.g.) data types, control flow, expression, statements, variables, functions, etc.
- **PL Paradigms**: principles and strategies which a PL follows.
- e.g.) Procedural, Imperative, Object oriented, Functional, Logic, etc.

PL Concepts and Paradigms

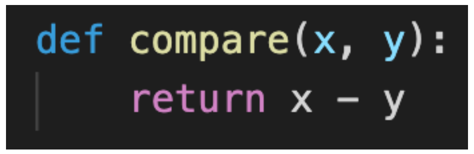
- PLs share common concepts and paradigms.
- Once you understand those concepts and paradigms, learning a PL is now learning how the PL implements them (e.g., syntax).

C/C++



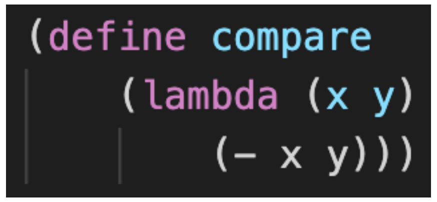
```
int compare(int x, int y) {
    return x - y;
}
```

Python



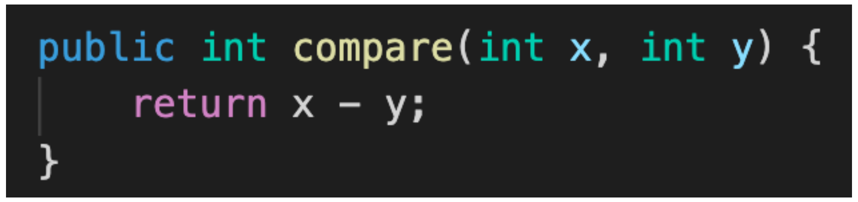
```
def compare(x, y):
    return x - y
```

Scheme



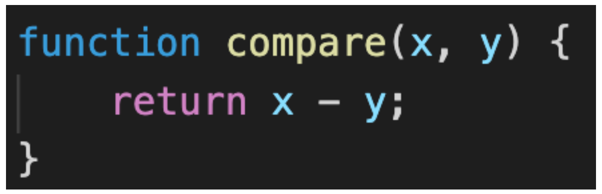
```
(define compare
    (lambda (x y)
        (- x y)))
```

Java



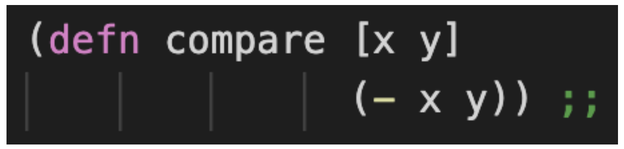
```
public int compare(int x, int y) {
    return x - y;
}
```

JavaScript



```
function compare(x, y) {
    return x - y;
}
```

Clojure



```
(defn compare [x y]
            (- x y)) ;;
```

For Practices

- We will write some code in different languages.
- Hence you may need to install compilers and interpreters for several languages.
- Also, you need to setup your own software development environment.
- In this course, practices will be explained mainly with VSCode.
- However, you can use any tools which you're familiar with.

Why We Setup Development Environment?

- This is the very first step for successful software development.
- Programming does not mean simply writing code.
- It also includes various tasks such as software design, verification and debugging.
- You cannot perform these tasks without good development environment.

How to Setup Development Environment?

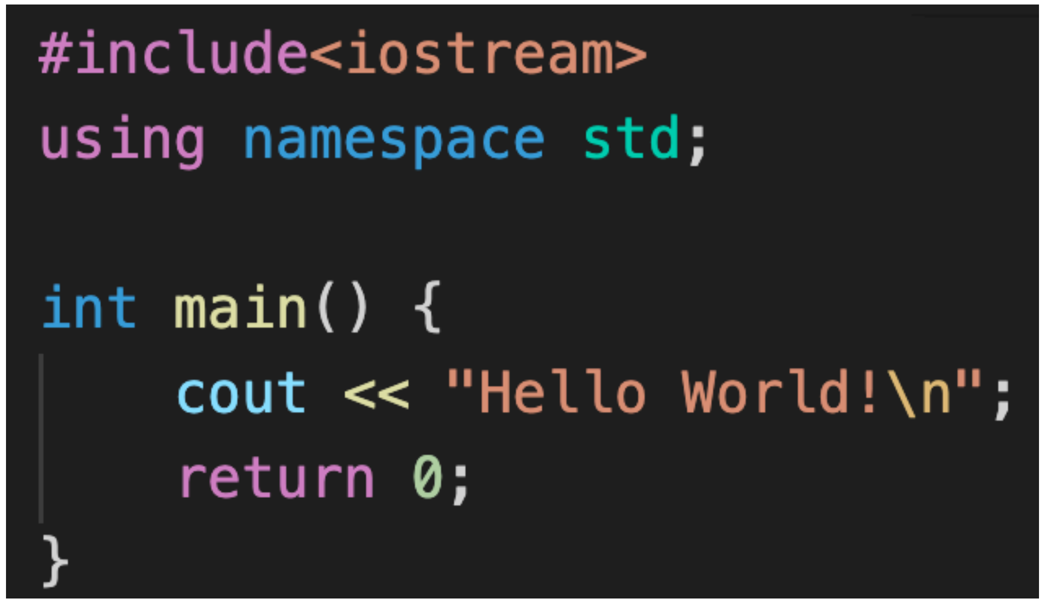
- Usually, it is setting up the environment to *write* and *build* code for your program, and also *execute* and *verify* the program.
- Mostly, it is done by installing compilers (or interpreters), and installing IDE and configuring it.
- There are other tasks such as source code management, issue tracking, documentations which you might need to consider.

Integrated Development Environment

- IDE: a program supports various software development tasks (e.g., VSCode, Eclipse, IntelliJ, PyCharm, etc.).
- Major Features
  - Syntax Highlight
  - Auto Completion
  - Build
  - Debugging Support
  - Automatic Code Formatting
  - Refactoring
  - Version Control

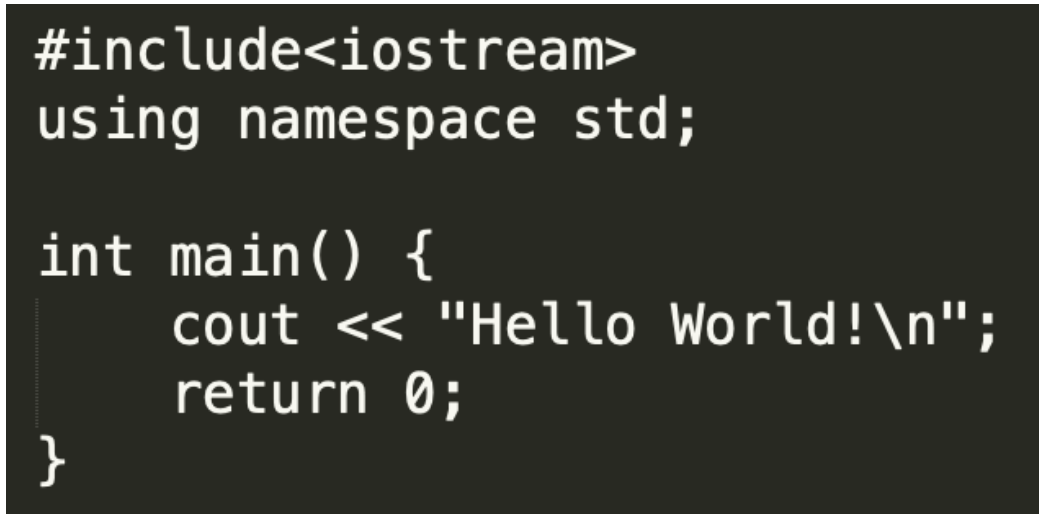
Syntax Highlight

- Highlight words in different syntactical positions.
- Readability of code is greatly increased, hence the productivity is increased too.
- Checking syntactic errors in pre-compile time in Code Editor.



```cpp
#include<iostream>
using namespace std;

int main() {
    cout << "Hello World!\n";
    return 0;
}
```

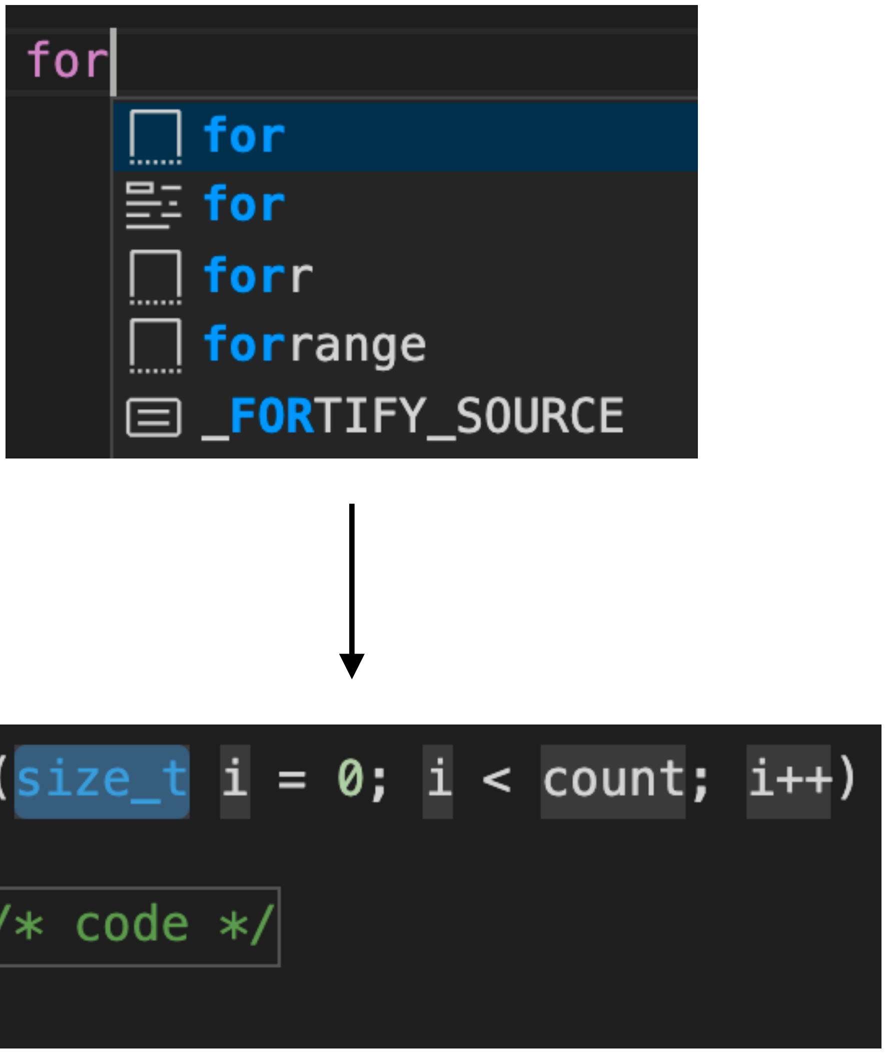


```cpp
#include<iostream>
using namespace std;

int main() {
    cout << "Hello World!\n";
    return 0;
}
```

Auto Completion

- Automatically recommend or complete code after typing a few characters.
- One of the most great features of IDE.
- Significant influence on developers' productivity.
- So many research on more efficient, effective auto-completion.



```
for
```

```
for (size_t i = 0; i < count; i++)
{
        /* code */
}
```

Build

- Automatically compile necessary files to make an executable program.
- Dependency management, Packaging.
- Complex programs may have code on many files and complicated dependencies.
- Considering all these would be painful if you need to do that repeatedly.
- With IDE, you can simply build your program (or a project) by clicking a button.

Program Execution

- You can also execute your program and check the output in IDE’s console.
- When you modify your code, you can directly execute the program and verify the influence of modification.
- If your program requires complex inputs or configuration for execution, you can configure such requirements once, and use them repeatedly.

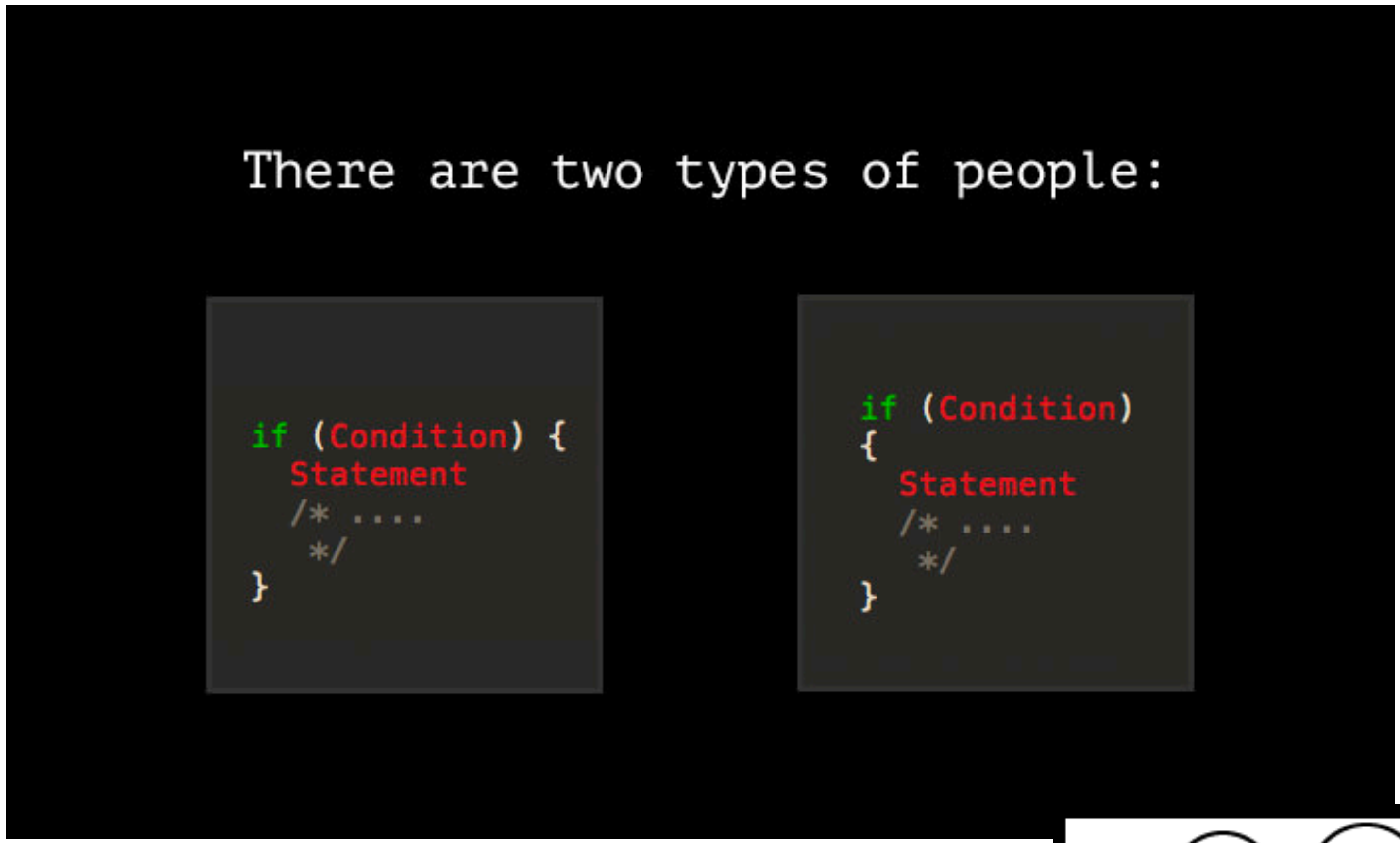
Debugging Support

- You can execute your code line by line, and check how values in memory are changed.
- For instance, you can set a break point at line 10, then run your program in debug mode.
- The execution just stops at line 10, and waiting for your command.
- You can see the status of your variables and verify that they are as expected.
- Also, you can execute your program further from that point, to observe your program's execution in more details.

Automatic Code Formatting

- It’s very important to follow code style guidelines when many people working together.
- Consistent code style → Better Readability.
- Crude code style → Bad Handwriting.
- IDE provides various configurations to keep your code in appropriate style.

Unresolved Debates

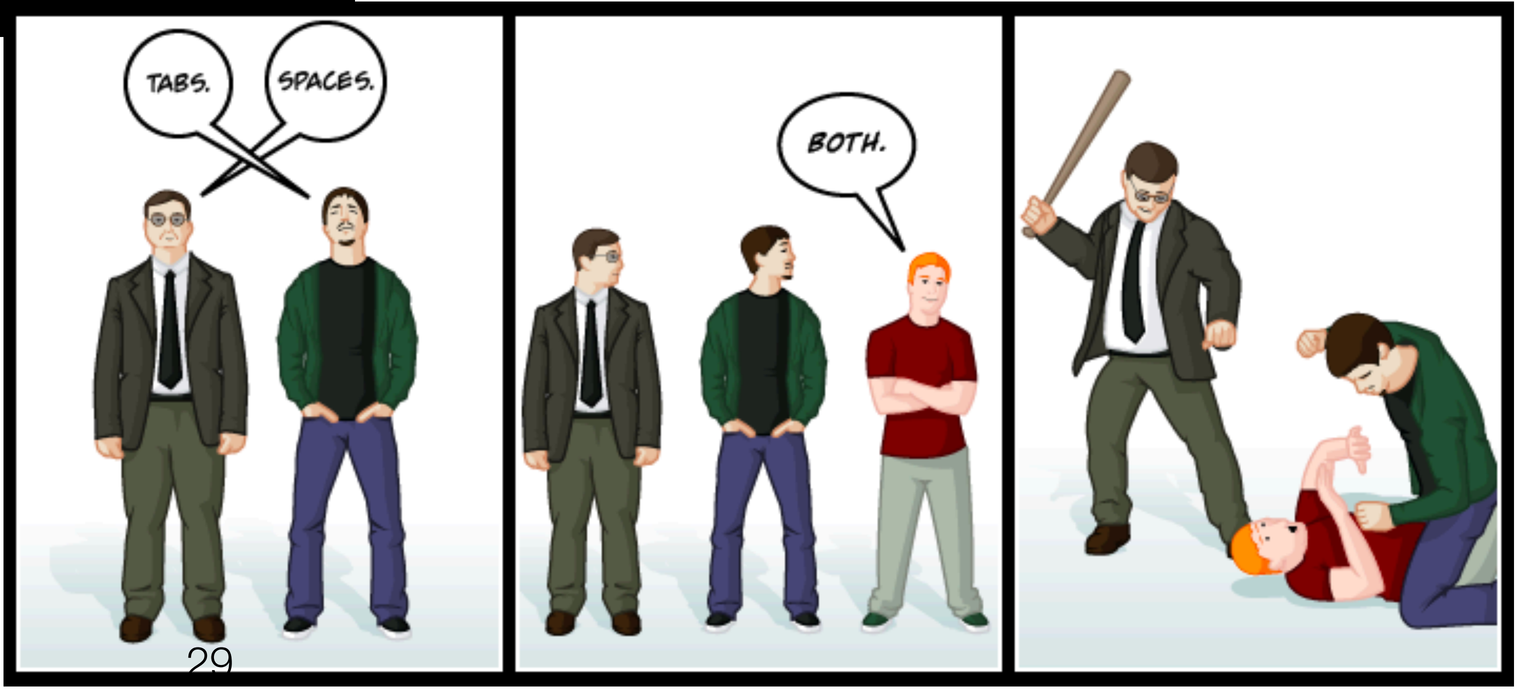


There are two types of people:

```
if (Condition) {
  Statement
  /* ....
   */
}
```

```
if (Condition)
{
  Statement
  /* ....
   */
}
```

Curly Brackets:
Are you the left or the right?



Tabs vs. Spaces:
Are you a tab guy or a space guy?

Refactoring

- Refactoring is a task to improve the quality of code.
- It maintains the same functionalities of code, while modifying the structures of code.
- Often expect to improve Readability, Maintainability, and Reusability.
- IDE provides commands to automatically perform refactoring on your code.

Version Control

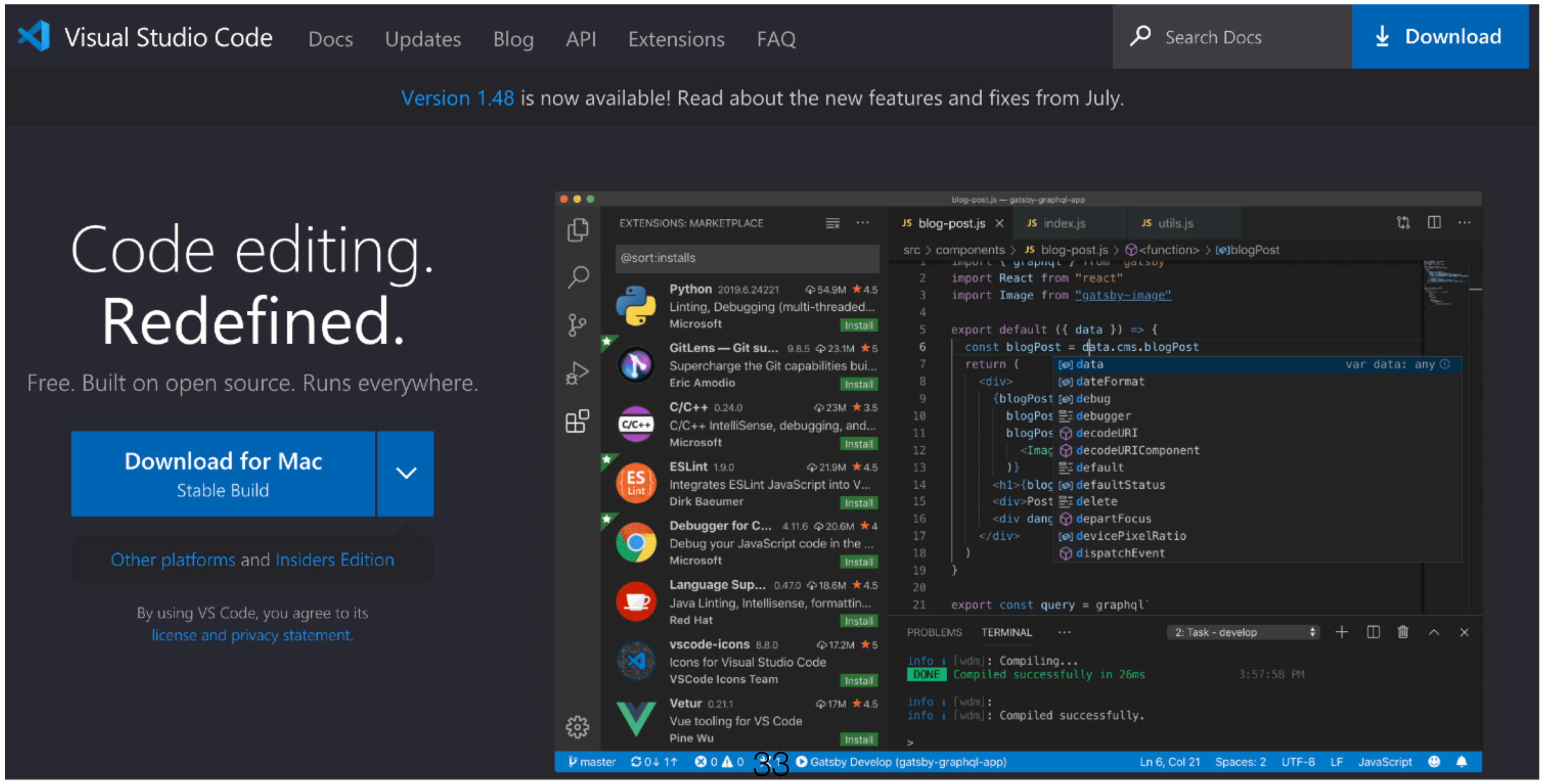
- Keep tracking modifications in code.
- When more than one people are involved in development, you can synchronize with the others and prevent conflicts.
- IDEs are often integrated with version control system.
- You can easily commit your changes to software repositories, resolve conflicts with IDE.

Many Others

- Toggle Comment
- File Comparison
- Advanced Code Navigation
  - Go to Definition, Declaration, File, and Line.
- Advanced Code Search
  - Find all references of a variable.
- Fancy Fonts

VSCode

- Visual Studio Code: Free IDE developed by Microsoft.
- Support various OS - Windows, Mac, Linux
- Using Extensions to support various programming languages.


Visual Studio Code
Docs
Updates
Blog
API
Extensions
FAQ
Search Docs
Download
Download for Mac
Stable Build
Other platforms and Insiders Edition
EXTENSIONS: MARKETPLACE
@sort:installs
Python 2019.6.24221 54.9M 4.5
Linting, Debugging (multi-threaded...
Microsoft
GitLens — Git su... 9.8.5 23.1M 5
Supercharge the Git capabilities bui...
Eric Amodio
C/C++ 0.24.0 23M 3.5
C/C++ IntelliSense, debugging, and...
Microsoft
ESLint 1.9.0 21.9M 4.5
Integrates ESLint JavaScript into V...
Dirk Baeumer
Debugger for C... 4.11.6 20.6M 4
Debug your JavaScript code in the ...
Microsoft
Language Sup... 0.47.0 18.6M 4.5
Java Linting, Intellisense, formattin...
Red Hat
vscode-icons 8.8.0 17.2M 5
Icons for Visual Studio Code
VSCode Icons Team
Vetur 0.21.1 17M 4.5
Vue tooling for VS Code
Pine Wu
Install
blog-post.js — gatsby-graphql-app
blog-post.js
index.js
utils.js
src > components > blog-post.js > <function> > blogPost
data
dateFormat
debug
debugger
decodeURI
decodeURIComponent
default
defaultStatus
delete
departFocus
devicePixelRatio
dispatchEvent
var data: any
PROBLEMS
TERMINAL
2: Task - develop
master
Gatsby Develop (gatsby-graphql-app)
Ln 6, Col 21
Spaces: 2
UTF-8
LF
JavaScript

Version 1.48 is now available! Read about the new features and fixes from July.

Code editing.
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```
import { graphql } from "gatsby"
import React from "react"
import Image from "gatsby-image"

export default ({ data }) => {
  const blogPost = data.cms.blogPost
  return (
    <div>
      {blogPost
        blogPos
        blogPos
          <Imag
        )}
      <h1>{blog
      <div>Post
      <div dang
    </div>
  )
}

export const query = graphql`
```

```
info ℹ ｢wdm｣: Compiling...
 DONE  Compiled successfully in 26ms                    3:57:58 PM

info ℹ ｢wdm｣:
info ℹ ｢wdm｣: Compiled successfully.

>
```

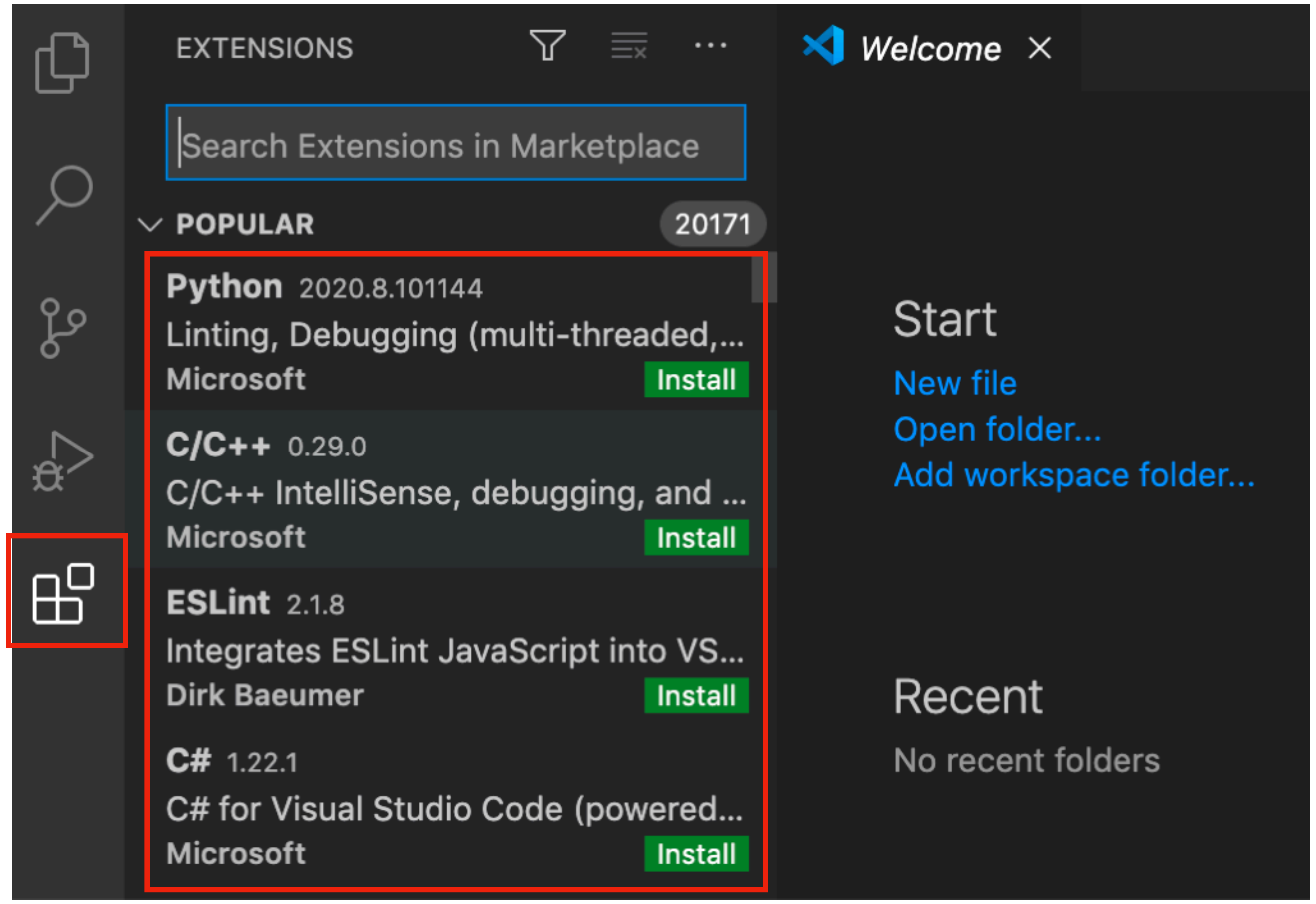
Extensions

- Support for various programming languages via Extensions.

- To setup development environment for a new programming language,

    1. Install a compiler or an interpreter for the language.

    2. Install Extension and setup according to 1.



Python 2020.8.101144
Linting, Debugging (multi-threaded,...
Microsoft Install

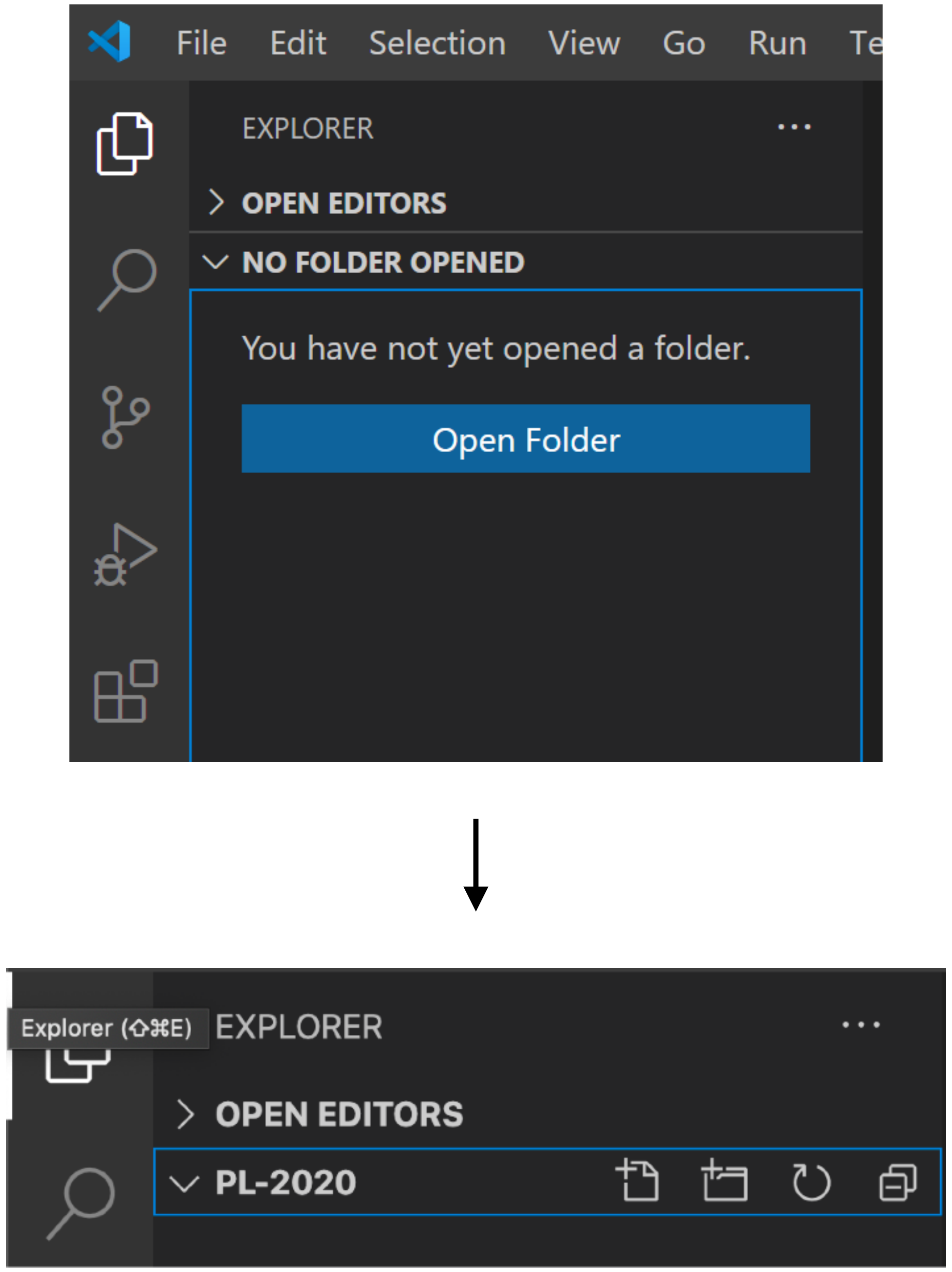
C/C++ 0.29.0
C/C++ IntelliSense, debugging, and ...
Microsoft Install

ESLint 2.1.8
Integrates ESLint JavaScript into VS...
Dirk Baeumer Install

C# 1.22.1
C# for Visual Studio Code (powered...
Microsoft Install

Workspace

- Workspace for software development.
- Collection of all stuff for your program.
- Different configurations for different workspace.
- You can switch between workspaces when you need to work on different projects.

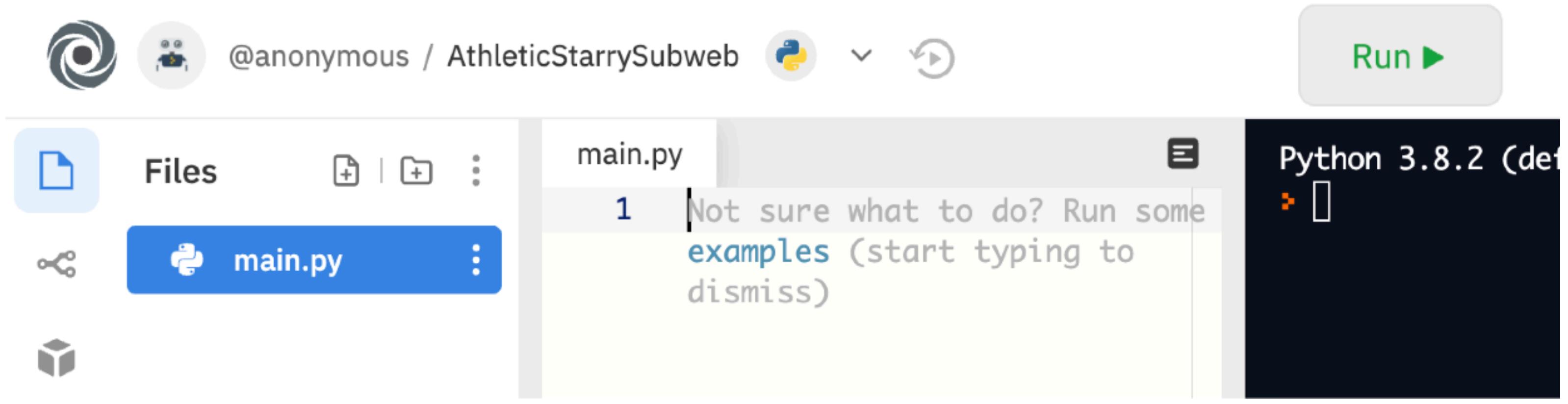


You have not yet opened a folder.

Possible Scenario

- You’re working on an assignment XXX class.
- You’re getting tired of the assignment, and decide to fiddle with interesting PL course stuff.
- Then you just need to switch from XXX workspace to PL workspace.
- All the files and configurations will be switched and you can continue on what you’re doing.
- Once you’re prepared to go back to the boring stuff, you can switch back again to the previous workspace.

Repl.it



```
Not sure what to do? Run some examples (start typing to dismiss)
```

```
Python 3.8.2 (def
```

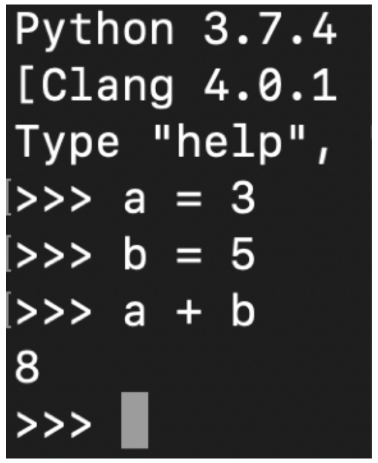
- Online IDE supports many languages (https://repl.it/).

- **Pros**: Don’t need to care about how to install and configure compilers and interpreters for various languages / Good practice for online coding exams or interviews.

- **Cons**: Lose an opportunity to learn how to setup development environment for various languages.

REPL

- **Read-Eval-Print Loop**: or language shell.
- Read user input, Evaluate the input, and Print the result.
  - e.g.) Python
- Similar to Scripting languages.
- Do not require the whole compilable program.



```
Python 3.7.4
[Clang 4.0.1
Type "help",
>>> a = 3
>>> b = 5
>>> a + b
8
>>>
```

Summary

- Syllabus
- Course Organization
- PL Concepts and Paradigms
- Using IDEs and REPL