Object-Oriented Programming

Key Concepts

Procedural Programming

- Procedural programming is a form of structured programming:
  - Generally oriented around *procedures* (also known as *functions*, *routines*, or *subroutines*) which accept data, usually as parameters
  - These process this data according to their internal programming logic, using basic statements or by calling other procedures
  - In the end, they produce a result and return it to where they were called from
  - Typically, a main procedure drives the program by executing statements and procedure calls in sequence until completion

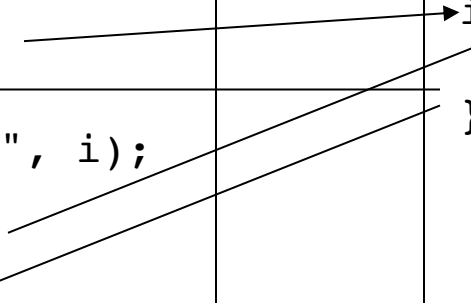
Procedural Programming

- Procedural programming is also sometimes referred to as imperative programming
  - That said, procedural programming uses blocks and scoping rules that non-structured imperative languages do not
- Examples of procedural languages
  - Basic, Fortran, Pascal, C
  - Go is a more modern example
  - Python can be, but Python can also be other things, including object-oriented

Procedural Programming

```
void main() {
  int i = 0;
  int j = 0;

  i = sum(j, 10);

  printf("i is %d\n", i);

  j = sum(i, 20);

  printf("j is %d\n", j);

}
```

```
int sum(int a1, int a2) {
  return (a1+a2);
}
```



- Procedures are called for performing an operation (in this case summing two numbers).
- After a procedure completes its operation, the control of the program returns to a point right after the calling point.

Object-Oriented Programming

- Object-Oriented programming
  - Structured around *objects*
  - Objects are instances of *classes*
  - Objects accept *messages* from other objects; these messages essentially *call methods* in the receiving object in order to perform an action (that is the programming logic of the invoked method)
  - You may think of methods as procedures that are encapsulated inside a class
- Examples of object-oriented languages
  - Java, Objective-C, Swift, C#, and of course C++

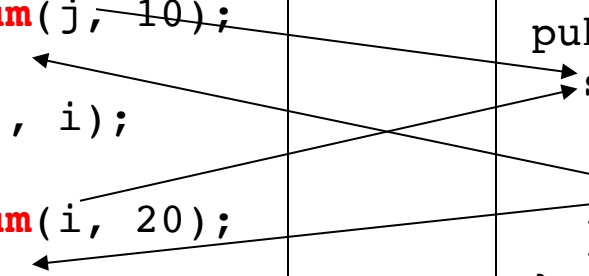
Object-Oriented Programming

- Objects
  - They combine (i.e. encapsulate) in one unit both *data* and *functionality*
  - The data encapsulated in an object are called *data members* of the object
  - The functionality is provided by functions called *methods*; the methods encapsulated in an object are also referred as *member functions* of the object
  - Usually methods of an object provide the only way for an external piece of code (i.e. another object) to access its data members
  - Objects are instances of corresponding types that are called *classes*
  - There is a direct link between the concept of a class and that of a traditional Abstract Data Type

Object-Oriented Programming

```
int main() {
  int i = 0;
  int j = 0;

  i = Calculator::sum(j, 10);

  printf("i is %d\n", i);

  j = Calculator::sum(i, 20);

  printf("j is %d\n", j);

}
```

```
class Calculator {
public:
  static int sum(int a1,
                 int a2) {
    return (a1+a2);
  }
};
```



- Methods are called in a very similar fashion as procedures were called earlier.
- Notice that methods can also be attached to a class and not just an instance of the class.
- Please note there are several things wrong with what we are doing. As we go through the course, you will see why!

Procedural vs. Object-Oriented Programming

- There is a very similar control flow between procedure and object-oriented programming
  - Very similar call-and-return mechanisms, in one case using procedures and in the other using methods on classes and objects
- The key distinction is that procedural languages organize by procedures with data and functionality separate (though sometimes loosely collected into *modules*), whereas object-oriented languages organize by classes and objects, with data and functionality effectively bundled together

Benefits of Object-Oriented Programming

- Better modeling of elements of the real world
- Better application and use of Software Engineering principles
  - Information/data hiding
  - Encapsulation
  - Abstraction
  - Modularization
- Better integration with other programs and libraries through agreed upon and standardized interfaces

Benefits of Object-Oriented Programming

- Information hiding:
  - Refers to shielding and “hiding” the underlying design and implementation details of a subsystem (or a class) from the rest of the program
  - Instead of needing to know the details, the rest of the program simply interacts with the subsystem through a published interface
  - For example, if the subsystem is a class, then information hiding is shielding and hiding from the rest of the program (i.e. other classes) how data members and member functions (i.e. methods) are implemented; instead they only need to know how to invoke the relevant methods

Benefits of Object-Oriented Programming

- Encapsulation:
  - Refers to the bundling of data and functionality together into a single package that is accessed through a well defined interface, as opposed to having things spread around a program or otherwise only loosely associated
  - Not only does this promote information hiding, but this also effectively restricts direct access to at least some of the package's data and functions

Benefits of Object-Oriented Programming

- Abstraction:
  - Refers to modeling an entity (e.g. program, method, algorithm, data) in a way so that only the important characteristics are presented, while the non important ones are omitted
  - “The essence of abstractions is preserving information that is relevant in a given context, and forgetting information that is irrelevant in that context.”
    – John V. Guttag

Benefits of Object-Oriented Programming

- Modularization:
  - Refers to the design approach where a software application is implemented as a collection of independent units (subsystems) that communicate by exchanging only the absolutely necessary information (data) that is required to perform an operation
  - In other words, they have low coupling
  - Furthermore, each unit (subsystem) performs a specific operation or a collection of very closely related operations
  - In other words, they have high cohesion
  - Usually, a collection of related classes constitutes a subsystem

Some Caveats

- Object orientation is not the solution to every programming need
  - Data base applications → SQL, 4GLs
  - Embedded systems → Assembly, …..
- While object-oriented programming has numerous benefits in theory, achieving those benefits in practice can be difficult and developers often fall short of achieving these goals
  - Remember the old adage:

    “In theory, theory and practice are the same. In practice, they’re not.”

Some Caveats

- Most importantly, this has been a fairly superficial coverage of object-oriented programming, and many details have been glossed over or left out for now

- As we progress through the course and explore C++ as a language, we will come back and delve deeper into things accordingly …