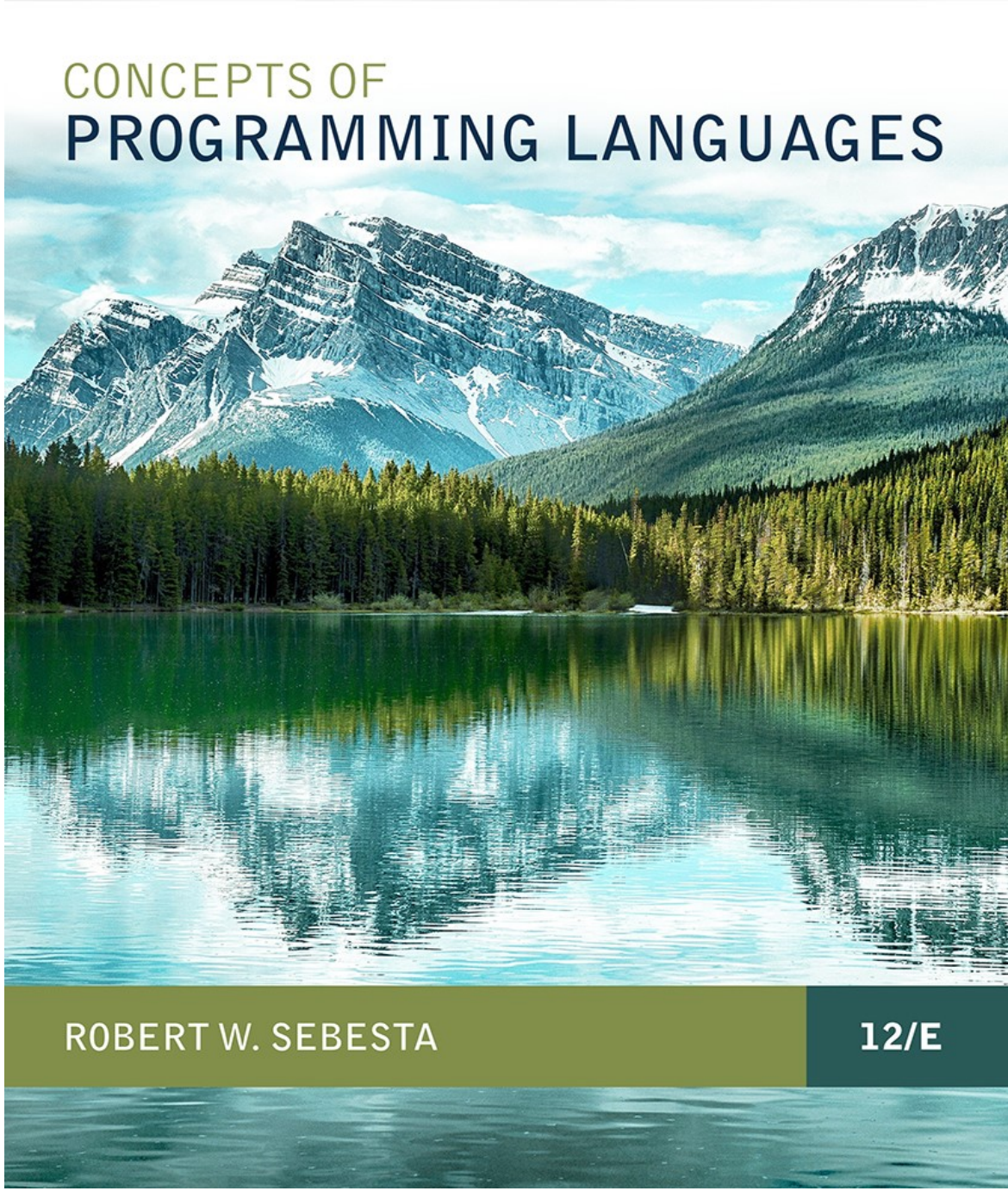
Chapter 5

Names, Bindings, and Scopes



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Chapter 5 Topics

- Introduction
- Names
- Variables
- The Concept of Binding
- Scope
- Scope and Lifetime
- Referencing Environments
- Named Constants

Today's topics

```
count = count + 5;
Count  = count +5
int CoUnT = 5;
float if = 1;
```

- Names
- Variables
- Binding

Introduction

- Imperative languages are abstractions of von Neumann architecture
  - Memory
  - Processor
- Variables are characterized by attributes
  - To design a type, must consider scope, lifetime, type checking, initialization, and type compatibility

Names

- Design issues for names:
  - Are names case sensitive?
  - Are special words reserved words or keywords?

Names (continued)

- Length
  - If too short, they cannot be connotative
  - Language examples:
    - C99: no limit but only the first 63 are significant; also, external names are limited to a maximum of 31
    - C# and Java: no limit, and all are significant
    - C++: no limit, but implementers often impose one

Names (continued)

- Special characters
  - PHP: all variable names must begin with dollar signs
  - Perl: all variable names begin with special characters, which specify the variable's type
  - Ruby: variable names that begin with `@` are instance variables; those that begin with `@@` are class variables

Names (continued)

- Case sensitivity
  - Disadvantage: readability (names that look alike are different)
    - Names in the C-based languages are case sensitive
    - Names in others are not
    - Worse in C++, Java, and C# because predefined names are mixed case (e.g. `IndexOutOfBoundsException`)

Names (continued)

- Special words
  - An aid to readability; used to delimit or separate statement clauses
  - A *keyword* is a word that is special only in certain contexts
  - A *reserved word* is a special word that cannot be used as a user-defined name
  - Potential problem with reserved words: If there are too many, many collisions occur (e.g., COBOL has 300 reserved words!)
    - `LENGTH`, `BOTTOM`, `DESTINATION`, and `COUNT`

Variables

- A variable is an abstraction of a memory cell
- Variables can be characterized as a sextuple of attributes:
  - Name
  - Address
  - Value
  - Type
  - Lifetime
  - Scope

Variables Attributes

- Name – not all variables have them
- Address – the memory address with which it is associated
  - A variable may have different addresses at different times during execution
  - A variable may have different addresses at different places in a program
  - If two variable names can be used to access the same memory location, they are called aliases
  - Aliases are created via pointers, reference variables, C and C++ unions
  - Aliases are harmful to readability (program readers must remember all of them)

Variables Attributes (continued)

- *Type* – determines the range of values of variables and the set of operations that are defined for values of that type; in the case of floating point, type also determines the precision
- *Value* – the contents of the location with which the variable is associated
  - The l-value of a variable is its address
  - The r-value of a variable is its value
- *Abstract memory cell* – the physical cell or collection of cells associated with a variable

The Concept of Binding

A *binding* is an association between an entity and an attribute, such as between a variable and its type or value, or between an operation and a symbol

- *Binding time* is the time at which a binding takes place.

Possible Binding Times

- Language design time -- bind operator symbols to operations
- Language implementation time-- bind floating point type to a representation
- Compile time -- bind a variable to a type in C or Java
- Load time -- bind a C or C++ `static` variable to a memory cell)
- Runtime -- bind a nonstatic local variable to a memory cell

Static and Dynamic Binding

- A binding is *static* if it first occurs before run time and remains unchanged throughout program execution.
- A binding is *dynamic* if it first occurs during execution or can change during execution of the program

Type Binding

How is a type specified?

When does the binding take place?

If static, the type may be specified by either an explicit or an implicit declaration

- `count = count + 5;`
- Section 5.4

Explicit/Implicit Declaration

- An *explicit declaration* is a program statement used for declaring the types of variables
- An *implicit declaration* is a default mechanism for specifying types of variables through default conventions, rather than declaration statements
- Basic, Perl, Ruby, JavaScript, and PHP provide implicit declarations
  - Advantage: writability (a minor convenience)
  - Disadvantage: reliability (less trouble with Perl)

Explicit/Implicit Declaration (continued)

- Some languages use type inferencing to determine types of variables (context)
  - C# – a variable can be declared with **`var`** and an initial value. The initial value sets the type
  - Visual Basic 9.0+, ML, Haskell, and F# use type inferencing. The context of the appearance of a variable determines its type

Dynamic Type Binding

- Dynamic Type Binding (JavaScript, Python, Ruby, PHP, and C# (limited))
- Specified through an assignment statement e.g., JavaScript

```
list = [2, 4.33, 6, 8];
list = 17.3;
```

  - Advantage: flexibility (generic program units)
  - Disadvantages:
    - High cost (dynamic type checking and interpretation)
    - Type error detection by the compiler is difficult