NINTH EDITION

Problem Solving with C++

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Chapter 1

Introduction to Computers and C++ Programming

Overview

1.1 Computer Systems

1.2 Programming and Problem Solving

1.3 Introduction to C++

1.4 Testing and Debugging

1.1

Computer Systems

Computer Systems

- A computer program is…
  - A set of instructions for a computer to follow

- Computer software is …
  - The collection of programs used by a computer
    - Includes:
      - Editors
      - Translators
      - System Managers

Hardware

- Three main classes of computers
  - PCs (Personal Computer)
    - Relatively small used by one person at a time
  - Workstation
    - Larger and more powerful than a PC
  - Mainframe
    - Still larger
    - Requires support staff
    - Shared by multiple users

Networks

- A number of computers connected to share resources
  - Share printers and other devices
  - Share information

Computer Organization

- Five main components
  - Input devices
    - Allows communication to the computer
  - Output devices
    - Allows communication to the user
  - Processor (CPU)
  - Main memory
    - Memory locations containing the running program
  - Secondary memory
    - Permanent record of data often on a disk

Display 1.1

Computer Memory

- Main Memory
  - Long list of memory locations
    - Each contains zeros and ones
    - Can change during program execution
  - Binary Digit or Bit
    - A digit that can only be zero or one
  - Byte
    - Each memory location has eight bits
  - Address
    - Number that identifies a memory location

Larger Data Items

- Some data is too large for a single byte
  - Most integers and real numbers are too large
  - Address refers to the first byte
  - Next few consecutive bytes can store the additional
    bits for larger data

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Data or Code?

- ‘A’ may look like 01000001
- 65 may look like 01000001
- An instruction may look like 01000001

- How does the computer know the meaning of 01000001?
  - Interpretation depends on the current instruction

- Programmers rarely need to be concerned with this problem.
  - Reason as if memory locations contain letters and numbers rather than zeroes and ones

Secondary Memory

- Main memory stores instructions and data while a program is running.
- Secondary memory
  - Stores instructions and data between sessions
  - A file stores data or instructions in secondary memory

Secondary Memory Media

- A computer might have any of these types of secondary memory
  - Hard disk
    - Fast
    - Fixed in the computer and not normally removed
  - Floppy disk
    - Slow
    - Easily shared with other computers
  - Compact disk
    - Slower than hard disks
    - Easily shared with other computers
    - Can be read only or re-writable

Memory Access

- Random Access
  - Usually called RAM
    - Computer can directly access any memory location
- Sequential Access
  - Data is generally found by searching through other items first
    - More common in secondary memory

The Processor

- Typically called the CPU
  - Central Processing Unit
  - Follows program instructions
  - Typical capabilities of CPU include:

    add
    subtract
    multiply
    divide
    move data from location to location

Computer Software

- The operating system
  - Allows us to communicate with the computer
  - Is a program
  - Allocates the computer's resources
  - Responds to user requests to run other programs

- Common operating systems include…
  - UNIX Linux DOS
    Windows Macintosh VMS

Computer Input

- Computer input consists of
  - A program
  - Some data

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High-level Languages

- Common programming languages include …

  C C++ Java Pascal Visual Basic FORTRAN Perl
  PHP Lisp Scheme Ada C# Python

- These high – level languages
  - Resemble human languages
  - Are designed to be easy to read and write
  - Use more complicated instructions than the CPU can follow
  - Must be translated to zeros and ones for the CPU to execute a program

Low-level Languages

- An assembly language command such as

  ADD X Y Z

  might mean add the values found at x and y in memory, and store the result in location z.

- Assembly language must be translated to machine language (zeros and ones)

  0110 1001 1010 1011

- The CPU can follow machine language

Compilers

- Translate high-level language to machine language
  - Source code
    - The original program in a high level language
  - Object code
    - The translated version in machine language

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Linkers

- Some programs we use are already compiled
  - Their object code is available for us to use
  - For example: Input and output routines

- A Linker combines
  - The object code for the programs we write
    and
  - The object code for the pre-compiled routines
    into
  - The machine language program the CPU can run

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History Note

- First programmable computer
  - Designed by Charles Babbage
  - Began work in 1822
  - Not completed in Babbage's life time
- First programmer
  - Ada Augusta, Countess of Lovelace
    - Colleague of Babbage

Section 1.1 Conclusion

- Can you…
  - List the five main components of a computer?
  - List the data for a program that adds two numbers?
  - Describe the work of a compiler?
  - Define source code? Define object code?
  - Describe the purpose of the operating system?

1.2

Programming and Problem-Solving

Algorithms

- Algorithm
  - A sequence of precise instructions that leads to a solution
- Program
  - An algorithm expressed in a language the computer can understand

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Program Design

- Programming is a creative process
  - No complete set of rules for creating a program

- Program Design Process
  - Problem Solving Phase
    - Result is an algorithm that solves the problem
  - Implementation Phase
    - Result is the algorithm translated into a programming language

Problem Solving Phase

- Be certain the task is completely specified
  - What is the input?
  - What information is in the output?
  - How is the output organized?

- Develop the algorithm before implementation
  - Experience shows this saves time in getting your program to run.
  - Test the algorithm for correctness

Implementation Phase

- Translate the algorithm into a programming language
  - Easier as you gain experience with the language
- Compile the source code
  - Locates errors in using the programming language
- Run the program on sample data
  - Verify correctness of results
- Results may require modification of the algorithm and program

Display 1.7

Object Oriented Programming

- Abbreviated OOP
- Used for many modern programs
- Program is viewed as interacting objects
  - Each object contains algorithms to describe its behavior
  - Program design phase involves designing objects and their algorithms

OOP Characteristics

- Encapsulation
  - Information hiding
  - Objects contain their own data and algorithms
- Inheritance
  - Writing reusable code
  - Objects can inherit characteristics from other objects
- Polymorphism
  - A single name can have multiple meanings depending on its context

Software Life Cycle

- Analysis and specification of the task (problem definition)
- Design of the software (object and algorithm design)
- Implementation (coding)
- Maintenance and evolution of the system
- Obsolescence

Section 1.2 Conclusion

- Can you…
  - Describe the first step to take when creating a program?
  - List the two main phases of the program design process?
  - Explain the importance of the problem-solving phase?
  - List the steps in the software life cycle?

1.3

Introduction to C++

Introduction to C++

- Where did C++ come from?
  - Derived from the C language
  - C was derived from the B language
  - B was derived from the BCPL language
- Why the ‘++’?
  - ++ is an operator in C++ and results in a cute pun

C++ History

- C developed by Dennis Ritchie at AT&T Bell Labs in the 1970s.
  - Used to maintain UNIX systems
  - Many commercial applications written in c
- C++ developed by Bjarne Stroustrup at AT&T Bell Labs in the 1980s.
  - Overcame several shortcomings of C
  - Incorporated object oriented programming
  - C remains a subset of C++

A Sample C++ Program

- A simple C++ program begins this way

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

int main()
{
```

- And ends this way

```
        return 0;
}
```

Display 1.8

Explanation of code (1/5)

- Variable declaration line

  int number_of_pods, peas_per_pod, total_peas;

  - Identifies names of three variables to name numbers
  - int means that the variables represent integers

Explanation of code (2/5)

- Program statement

  cout << “Press return after entering a number.\n”;

  - cout (see-out) used for output to the monitor
  - “<<“ inserts “Press…a number.\n” in the data bound for the monitor
  - Think of cout as a name for the monitor
    - “<<“ points to where the data is to end up
  - ‘\n’ causes a new line to be started on the monitor

Explanation of code (3/5)

- Program statement

  cin >> number_of_pods;

  - cin (see-in) used for input from the keyboard
  - “>>” extracts data from the keyboard
  - Think of cin as a name for the keyboard
    - “>>” points from the keyboard to a variable where the data is stored

Explanation of code (4/5)

- Program statement

```
total_peas = number_of_pods * peas_per_pod;
```

  - Performs a computation
  - ‘*’ is used for multiplication
  - ‘=‘ causes total_peas to get a new value based on the calculation shown on the right of the equal sign

Explanation of code (5/5)

- Program statement

```
cout << number_of_pods;
```

  - Sends the value of variable number_of_pods to the monitor

Program Layout (1/3)

- Compiler accepts almost any pattern of line breaks and indentation
- Programmers format programs so they are easy to read
  - Place opening brace ‘{‘ and closing brace ‘}’ on a line by themselves
  - Indent statements
  - Use only one statement per line

Program Layout (2/3)

- Variables are declared before they are used
  - Typically variables are declared at the beginning of the program
  - Statements (not always lines) end with a semi-colon

- Include Directives
  #include <iostream>
  - Tells compiler where to find information about items used in the program
  - iostream is a library containing definitions of cin and cout

Program Layout (3/3)

- using namespace std;
  - Tells the compiler to use names in iostream in a “standard” way

- To begin the main function of the program

```
int main()
{
```

- To end the main function

```
        return 0;
}
```

  - Main function ends with a return statement

Running a C++ Program

- C++ source code is written with a text editor
- The compiler on your system converts source code to object code.
- The linker combines all the object code into an executable program.

C++11

- C++11 (formerly known as C++0x) is the most recent version of the standard of the C++ programming language.
  - Approved on August 12, 2011 by the International Organization for Standardization.
- C++11 language features are not supported by older compilers
- Check the documentation with your compiler to determine if special steps are needed to compile C++11 programs
  - e.g. with g++, use extra flags of –std=c++11

Run a Program

- Obtain code in Display 1.10

Display 1.10

- Compile the code
- Fix any errors the compiler indicates and re-compile the code
- Run the program
- Now you know how to run a program on your system

Section 1.3 Conclusion

- Can you…
  - Describe the output of this line?

    cout << “C++ is easy to understand.”;

  - Explain what this line does?

    cin >> peas_per_pod;

  - Explain this? #include <iostream>

1.4

Testing and Debugging

Testing and Debugging

- Bug
  - A mistake in a program
- Debugging
  - Eliminating mistakes in programs
  - Term used when a moth caused a failed relay on the Harvard Mark 1 computer. Grace Hopper and other programmers taped the moth in logbook stating:

    “First actual case of a bug being found.”

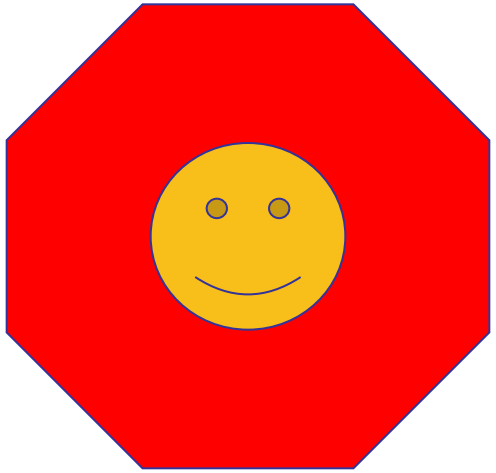
Program Errors

- Syntax errors
  - Violation of the grammar rules of the language
  - Discovered by the compiler
    - Error messages may not always show correct location of errors
- Run-time errors
  - Error conditions detected by the computer at run-time
- Logic errors
  - Errors in the program's algorithm
  - Most difficult to diagnose
  - Computer does not recognize an error

Section 1-4 Conclusion

- Can you…
  - Describe the three kinds of program errors?
  - Tell what kind of errors the compiler catches?
  - What kind of error is produced if you forget a punctuation symbol such as a semi-colon?
  - Tell what type of error is produced when a program runs but produces incorrect results?

Chapter 1 -- End



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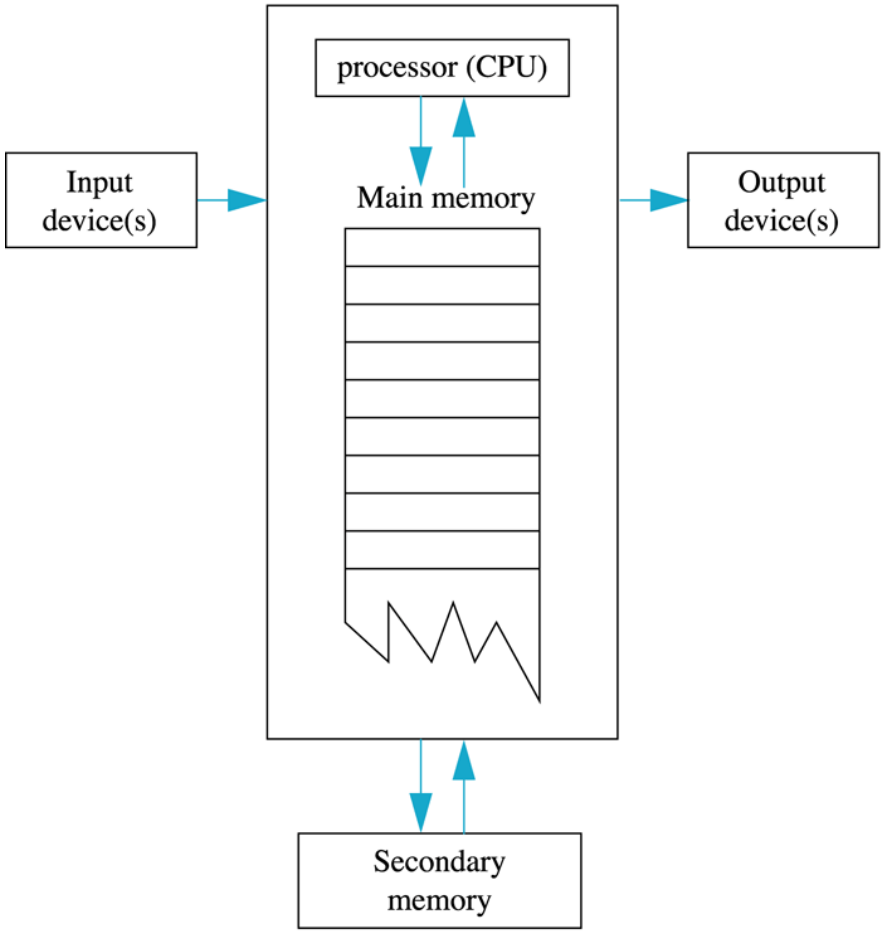
Main Components of a Computer



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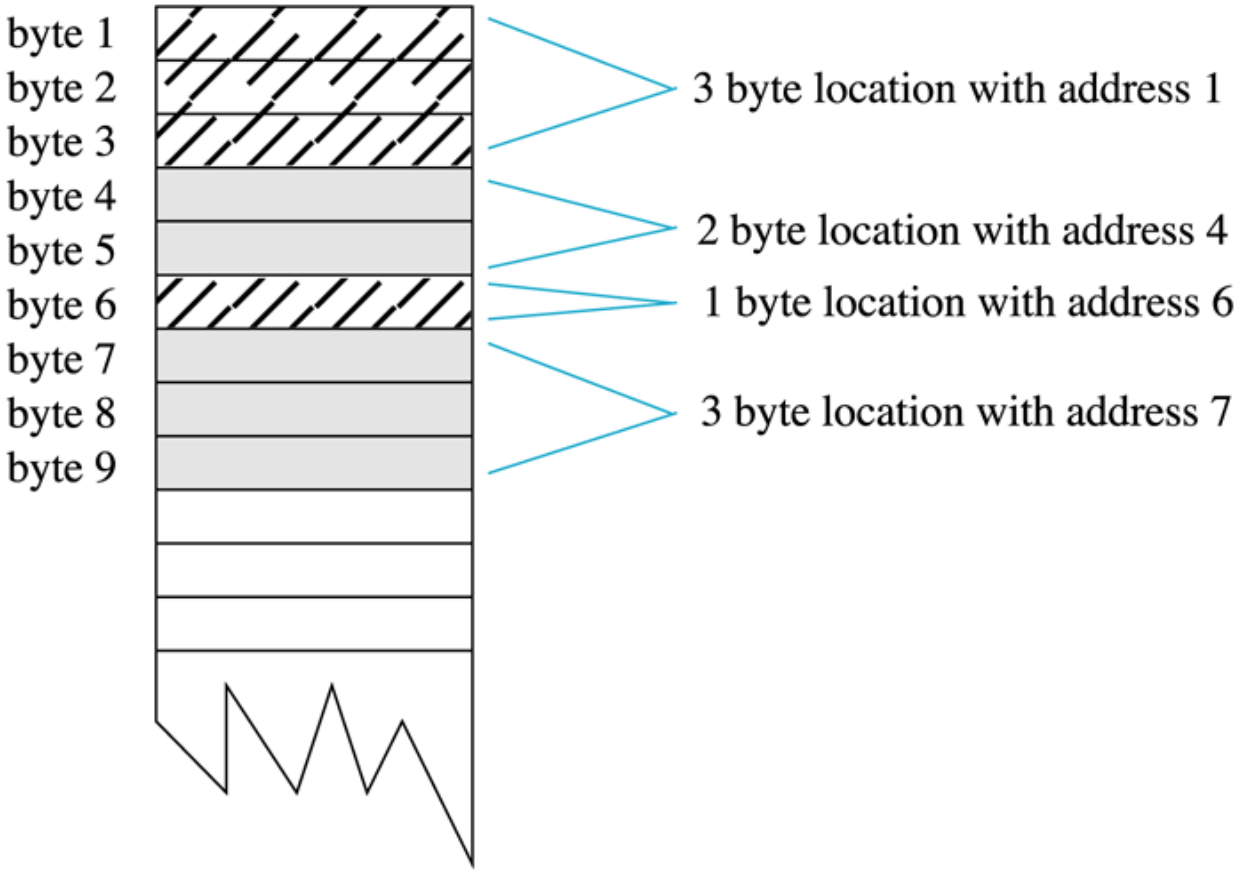
Memory Locations and Bytes



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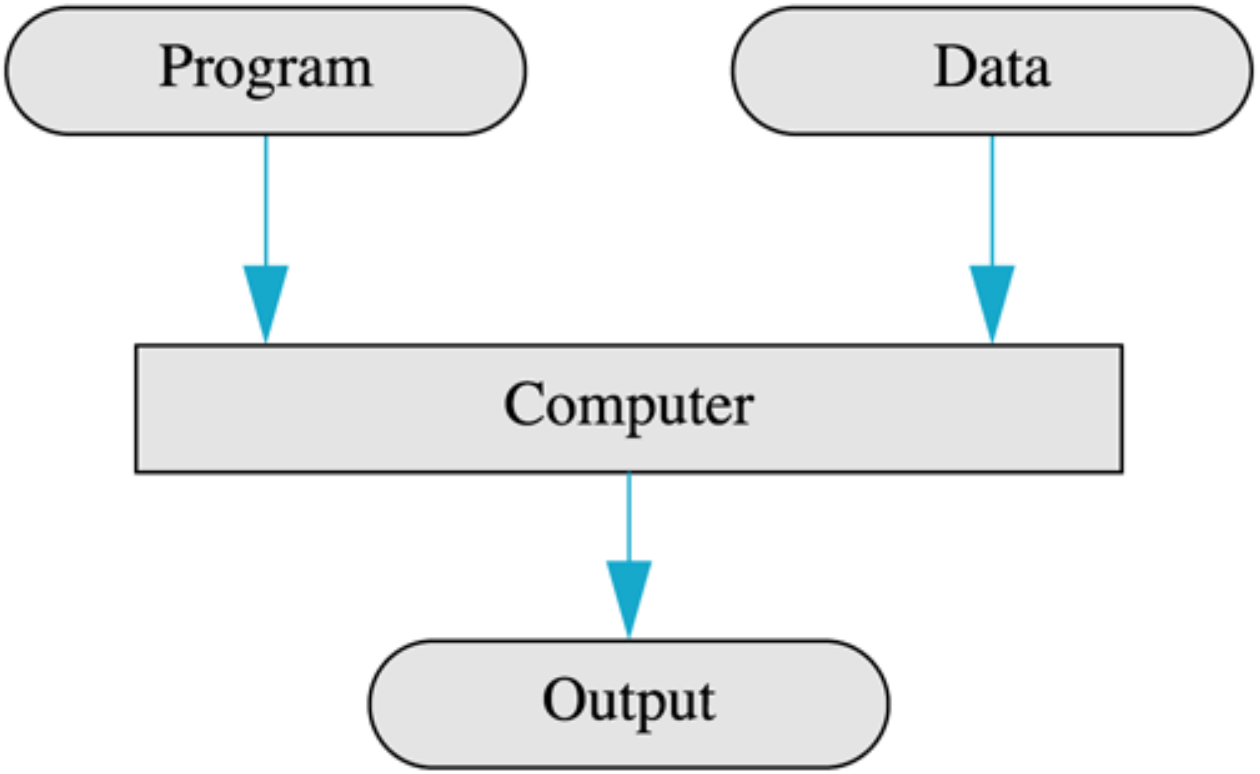
Simple View of Running a Program



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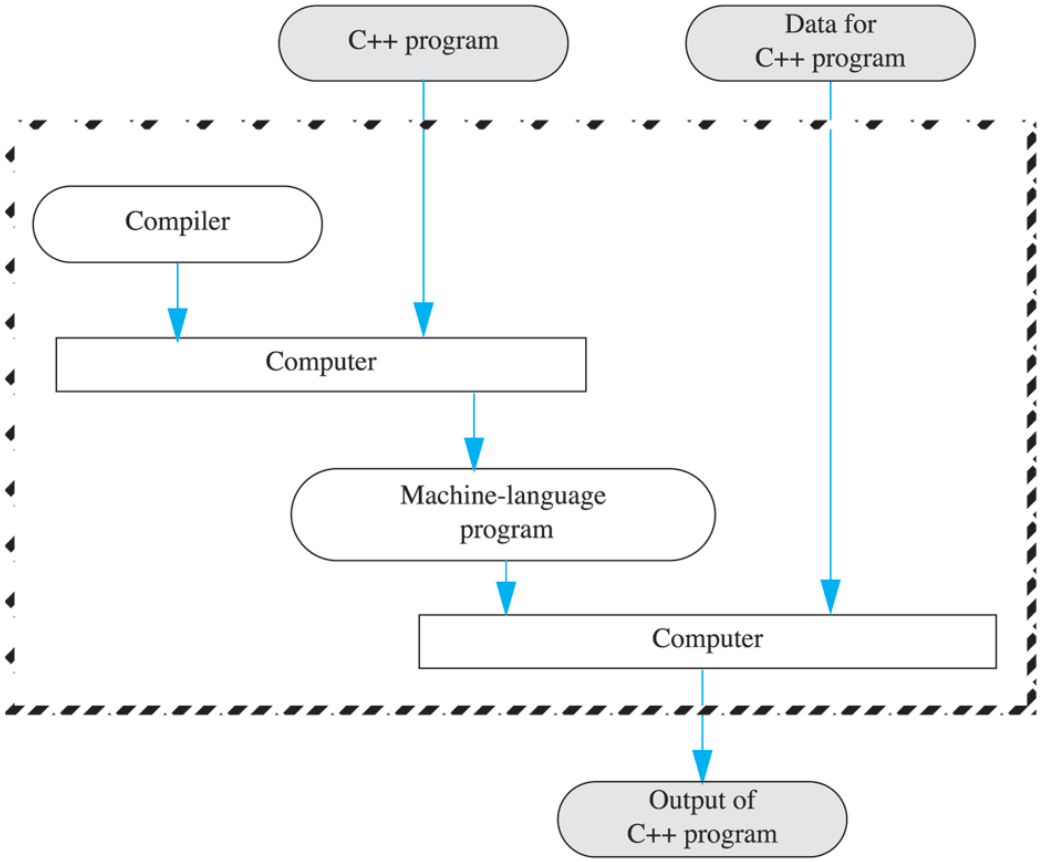
Compiling and Running a C++ Program (Basic Outline)



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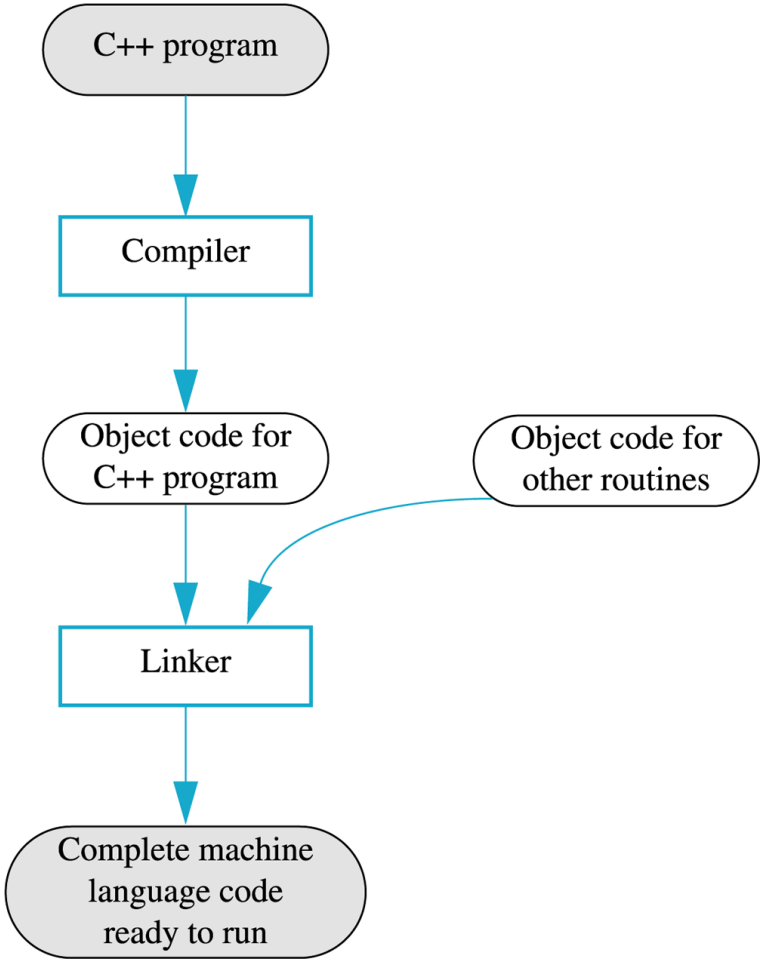
Preparing a C++ Program for Running



Display 1.6

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An Algorithm

Algorithm that determines how many times a name occurs in a list of names:

1. Get the list of names.
2. Get the name being checked.
3. Set a counter to zero.
4. Do the following for each name on the list:
   Compare the name on the list to the name being checked, and if the names are the same, then add one to the counter.
5. Announce that the answer is the number indicated by the counter.

Display 1.7

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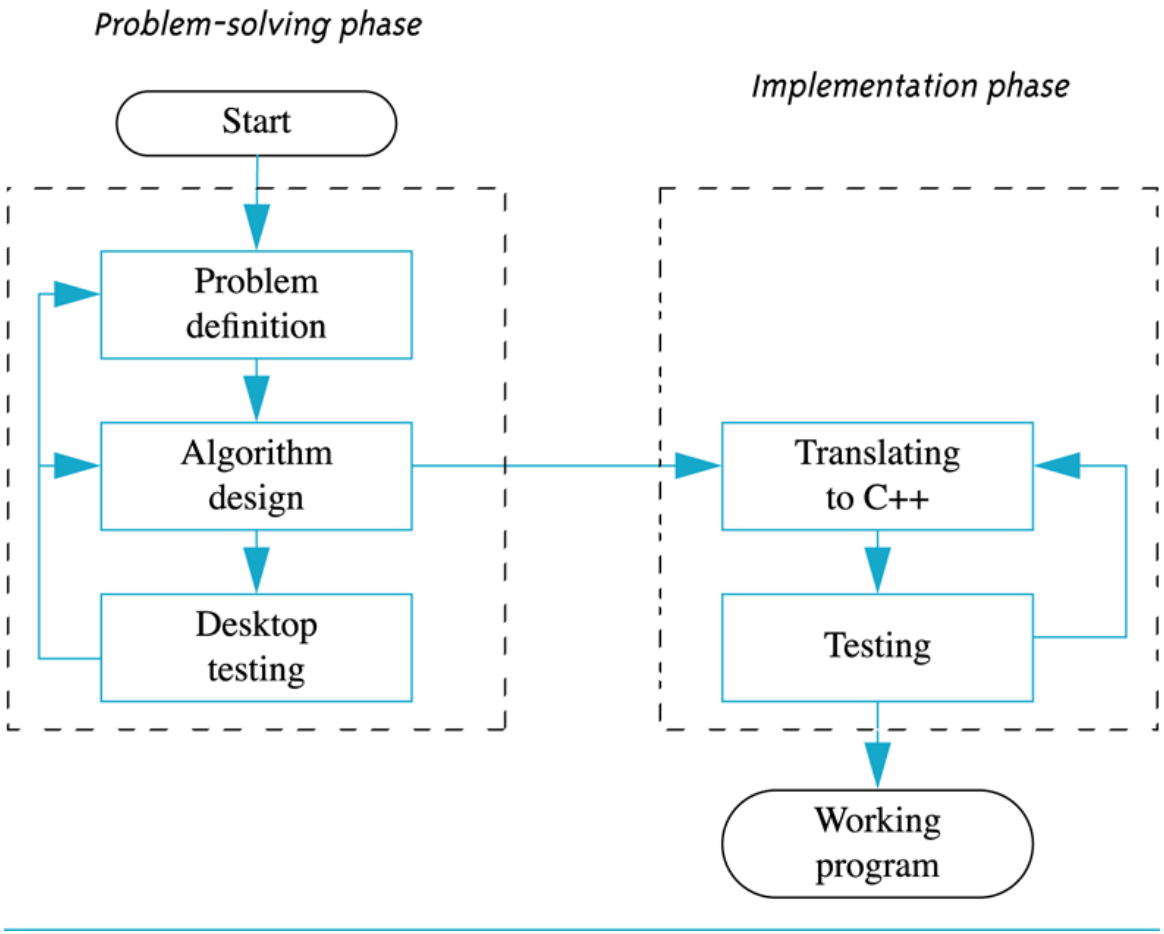
Program Design Process



Display 1.8

A Sample C++ Program

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

int main( )
{
    int number_of_pods, peas_per_pod, total_peas;

    cout << "Press return after entering a number.\n";
    cout << "Enter the number of pods:\n";
    cin >> number_of_pods;
    cout << "Enter the number of peas in a pod:\n";
    cin >> peas_per_pod;

    total_peas = number_of_pods * peas_per_pod;

    cout << "If you have ";
    cout << number_of_pods;
    cout << " pea pods\n";
    cout << "and ";
    cout << peas_per_pod;
    cout << " peas in each pod, then\n";
    cout << "you have ";
    cout << total_peas;
    cout << " peas in all the pods.\n";

    return 0;
}
```

Sample Dialogue

```
Press return after entering a number.
Enter the number of pods:
10
Enter the number of peas in a pod:
9
If you have 10 pea pods
and 9 peas in each pod, then
you have 90 peas in all the pods.
```

Display 1.9

Layout of a Simple C++ Program

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

int main( )
{
    Variable_Declarations

    Statement_1
    Statement_2
      ...
    Statement_Last

    return 0;
}
```

Display 1.10

Testing Your C++ Setup

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

int main( )
{
    cout << "Testing 1, 2, 3\n";
    return 0;
}
```

If you cannot compile and run this program, then see the programming tip entitled "Getting Your Program to Run." It suggests some things you might do to get your C++ programs to run on your particular computer setup.

Sample Dialogue

```
Testing 1, 2, 3
```