Chapter 3
Developing a Program

3.1 The Program Development Cycle

Problem solving principles
- Completely understand the problem
- Devise a plan to solve it
- Carry out the plan
- Review the results

Writing a program
1) Analyze the problem
2) Design the program
3) Code the program
4) Test the program

1. Analyze the problem

Identify desired results (**output**)

Determine **input** needed to produce those results

Example: Create a program to generate 6 numbers to play the lottery
- Is 7, 7, 7, 7, 7, 7 ok?
- Is -3, 0, 8, 9, 689, 689 ok?
- Is 1, 2, 6, 47.98765, 88, 93.45 ok?
- These are all 6 numbers but we see we must be more specific
- Desired results: 6 different positive integers within the range of 1 to 40

2. Design the program

Create a detailed description of program
- Use charts, models, or ordinary language (**pseudocode**)

Identify **algorithms** needed
- Algorithm: a step-by-step method to solve a problem or complete a task

Algorithms must be:
- Well defined
- Well ordered
- Must produce some result
- Must terminate in a finite time

3. Code the program

Translate charts, models, pseudocode, or ordinary language into **program code**

Add statements to document what the code does
- Internal documenation
- External documentation

Each programming language uses its specific **syntax**

Syntax

Correct syntax for telling your friend where you put a cheese sandwich is:

"I have put it on the table."

Incorrect use of English syntax to say:

"I have it on the table put."

All the right words are there, but without proper syntax, the sentence is gibberish in English.

But translated word for word, the second sentence is correct syntax in German.

4. Test the program

In analysis phase: continually **ask questions**
- Did I interpret data correctly?
- Does program fulfill requirements?
- Are my formulas or procedures correct? Etc…

In design phase: use **desk-checking** to walk through the program

In coding phase: software will alert you to **errors in syntax** but not in the **logic** of the program

Finally, **test your program** with as many sets of test data as possible
- Use good data, bad data, data you know the answers for, etc.

Additional Steps in the Cycle

- Create an outline of the program so that it is apparent what major tasks and subtasks have to be accomplished and the relationships among these tasks
- Describe in detail how each of these tasks is to be carried out

To put a commercial program (produced by a software publishing company) you may need to:
- Create a user's guide
  - to help users can understand the intricacies of the program
- Create help files
  - installed with the software for users to get on-screen help
- Train employees to provide telephone or web-based customer support
- Duplicate disks and accompanying materials for distribution
- Advertise the program to attract buyers

Program development is a process

- Program development is a **cyclical process** that often requires returning to earlier steps and, with complex programs, may take many months
- The design process may uncover flaws in the analysis
- Coding may find problems leading to modifications or additions to the design
- Testing inevitably uncovers problems that require returning to previous phases

The Sale Price Example

A local department store wants to develop a program which, when given an item's original price and the percentage it is discounted, will compute the sale price, with sales tax.

Output required: name of item, discounted price, amount of sales tax, total price

Variables needed: `ItemName`, `SalePrice`, `Tax`, `TotalPrice`

Input required: name of item, original price, percent discounted

More variables: `OriginalPrice`, `DiscountRate`

Formulas required:

New variable needed: `AmountSaved`

```
SalePrice = OriginalPrice - AmountSaved
AmountSaved = OriginalPrice * (DiscountRate/100)
Tax = SalePrice * .065
TotalPrice = SalePrice + Tax
```


Design: Input → Processing → Output

Input	Perform Calculations (Process)	Output
Input variables:	Computations:	Display:
`ItemName`	`AmountSaved = OriginalPrice * DiscountRate/100`	`TotalPrice`
`DiscountRate`	`SalePrice = OriginalPrice - AmountSaved`	`ItemName`
`OriginalPrice`	`Tax = SalePrice * .065`	`Tax`
	`TotalPrice = SalePrice + Tax`	`SalePrice`

3.2 Program Design

Modular Programming

To begin designing a program: identify the major tasks the program must accomplish.

Each of these tasks becomes a **program module**.

- if needed, break each of these fundamental "high-level" tasks into **submodules**
- Some submodules might be divided into submodules of their own
- this process can be continued as long as necessary
- Identifying the tasks and subtasks is called **modular programming**

Using Modules and Submodules

- A module performs a single task.
- A module is self-contained and independent of other modules.
- A module is relatively short. Ideally, statements should not exceed one page.

Benefits of Modular Programming

- program is easier to read
- easier to design, code, and test the program one module at a time
- different program modules can be designed and/or coded by different programmers
- a single module may be used in more than one place in the program
- modules that perform common programming tasks can be used in more than one program

Pseudocode: uses short, English-like phrases to describe the outline of a program

Example: pseudocode for the Sale Price Program with modules:

```
Input Data module
        Prompt for ItemName, OriginalPrice, DiscountRate
        Input ItemName, OriginalPrice, DiscountRate
Perform Calculations module
        Set AmountSaved = OriginalPrice * (DiscountRate/100)
        Set SalePrice = OriginalPrice – AmountSaved
        Set Tax = SalePrice * .065
        Set TotalPrice = SalePrice + Tax
Output Results module
        Write ItemName
        Write OriginalPrice
        Write DiscountRate
        Write SalePrice
        Write Tax
        Write TotalPrice
```


Refined Pseudocode for the Sale Price Program

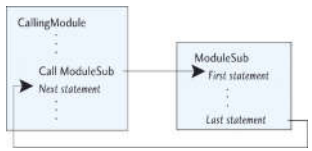
```
Input Data module
        Write "What is the item's name?"
        Input ItemName
        Write "What is its price and the percentage discounted?"
        Input OriginalPrice
        Input DiscountRate
Perform Calculations module
        Set AmountSaved = OriginalPrice * (DiscountRate/100)
        Set SalePrice = OriginalPrice – AmountSaved
        Set Tax = SalePrice * .065
        Set TotalPrice = SalePrice + Tax
Output Results module
        Write "The item is: " + ItemName
        Write "Pre-sale price was: " + OriginalPrice
        Write "Percentage discounted was: " + DiscountRate + "%"
        Write "Sale price: " + SalePrice
        Write "Sales tax: " + Tax
        Write "Total: $" + TotalPrice
```


Calling Modules

A **call statement** causes a submodule to be executed.

After a call statement, program control is transferred to the first line of the called module.

After all statements in the submodule have been executed, control returns to the line of code immediately below the call statement.



The Main Module

- The **main module** is where program execution begins and normally ends.
- The main module is not a submodule of another.
- It is the parent module of the program's highest-level modules.
- The highest-level modules are called into action by the main module.

In the Sale Price Program, we add a `Main` module to call others:

```
Main module
    Call Input Data module
    Call Perform Calculations module
    Call Output Results module
```


Format Output

- Include information about what the output means

If a program calculates the temperature converted from Fahrenheit to Celsius, the following output is confusing:

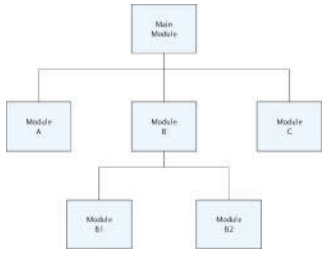
```
27
```

But the following output makes more sense:

```
81 degrees Fahrenheit is
27 degrees Celsius
```


Hierarchy Charts

- Like an organization chart
- Shows position of modules in the program
- Depicts what modules exist and how they are related
- Large programs need a "map" for documentation



3.3 Coding, Documenting, Testing

Coding

Coding is done in a specific programming language. We will use pseudocode.
This phase should only begin after a solid design exists.

Documenting

Code needs to contain documentation that describes to the reader what the code is doing
Two types of **comments** are used within the code
Internal documentation is for the programmers to read
External documentation is for the user

Comments: not processed by the computer, valued by other programmers

Header comments
- Appear at beginning of a program or a module
- Provide general information

Step comments or **in-line** comments
- Appear throughout program
- Explain purpose of specific portions of code

Often comments delineated by:
- `//`
- `/* comment goes here */`

Using comments for a program to find size of a room

```
// Program to calculate the area in square footage of a room
// Programmer: E. Drake, Santa Fe College
// Version 6.0 – January 1, 2015
// This program computes the area of a room, given its width and length
// Variables used: Width, Length, SquareFeet
// Declare the variables
    Declare Width As Float
    Declare Length As Float
    Declare SquareFeet As Float
// Get the values of the dimensions
    Write "What are the length and width of the room in inches?"
    Input Length
    Input Width
// Calculate square footage
    Set SquareFeet = Width * Length
// Output the result
    Write "Your room is " + SquareFeet + " square feet."
```


The Testing Phase

Testing
- Create **test data** that will be used to check the program's correctness.
- Use **desk checking** (or walking through a program by hand with a set of data that you know the answer to).
- Check that the program will catch errors by using test data designed to create errors.
- The more testing of various types of data you can use, the more likely you are to have a program that is free of errors.

Types of Errors: Syntax Errors

Syntax errors: a violation of the programming language's rules for creating valid statements
- May be caused by incorrect grammar or punctuation, or misspelling a keyword
- The program will not run at all with syntax errors

Types of Errors: Logic Errors

Logic errors: the program runs, but does not produce the expected results

- May be caused by using an incorrect formula, or incorrect sequence of statements, etc.
- Sometimes called **runtime errors**
- Can be detected during the desk checking phase of the programming cycle

3.4 Commercial Programs: Testing and Documenting

External documentation

Purposes:

1. Documentation in a **user's guide** or on-screen **help** system provides information about the program for the end users
2. Documentation in a **maintenance manual** provides information about how the program code accomplishes its purposes

User's Guides:

- usually written during alpha or beta test phases by a **technical writer**

Documentation for other programmers:

- Program maintenance manual
  - For programming experts
  - Used to help them fix or enhance code written by other programmers
- Design documentation
  - Written by programmer to explain rationale behind methods and code used
- Trade Study documentation
  - A research tool
  - An attempt to find the best solution

3.5 Structured Programming

- A method for designing and coding programs in a systematic, organized manner
- It combines the principles of top-down design, modularity and the use of the three accepted control structures: **sequence**, **repetition** and **selection**
- Sequence, repetition and selection can be expressed in **pseudocode**, or with **flowcharts**

Flowcharts

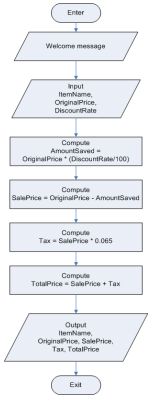
A tool for programmers to design programs

- Describes the flow of a program module's execution with diagrams
- Completely different from hierarchy charts
- Connected symbols are used to describe sequence, repetition, and selection structures
- Some prefer to use flowcharting to learn how to express algorithms, and others prefer to use pseudocode
- Many programs are designed with a combination of pseudocode and flowcharts

Basic Flowcharting Symbols

Symbol	Name	Description
	**Terminator**	Represents the start or end of a program or module
	**Process**	Represents any kind of processing function; for example, a computation
	**Input/output**	Represents an input or output operation
	**Decision**	Represents a program branch point
	**Connector**	Indicates an entry to, or exit from, a program segment


```
1   Main module
2     Declare ItemName As String
3     Declare iscountRate, SalePrice, TotalPrice As Float
4     Write "Sale Price Program"
5     Write "This program computes the total price, including tax, of an item that has
                                    been discounted a certain percentage."
6     Call Input Data module
7     Call Perform Calculations module
8     Call Output Results module
9   End Program
10  Input Data module
11    Write "What is the item's name?"
12    Input ItemName
13    Write "What is its price and the percentage discounted?"
14    Input OriginalPrice
15    Input DiscountRate
16  End Input Data Module
17  Perform Calculations module
18    Declare AmountSaved As Float
19    Set AmountSaved = OriginalPrice * (DiscountRate/100)
20    Set SalePrice = OriginalPrice - AmountSaved
21    Set Tax = SalePrice * .065
22    Set TotalPrice = SalePrice + Tax
23  End Perform Calculations Module
24  Output Results module
25    Write "The item is: " + ItemName
26    Write "Pre-sale price was: " + OriginalPrice
27    Write "Percentage discounted was: " + DiscountRate + "%"
28    Write "Sale price: " + SalePrice + "Sales tax: " + Tax
29    Write "Total: $" + TotalPrice
30  End Output Results Module
31
```



Control Structures

In the 1960s computer scientists proved there are only 3 basic **control structures** (also called **constructs**) needed to create any program or algorithm!

Sequence – execute statements in sequential order

- The simplest of control structures – start at the beginning and continue in sequential order

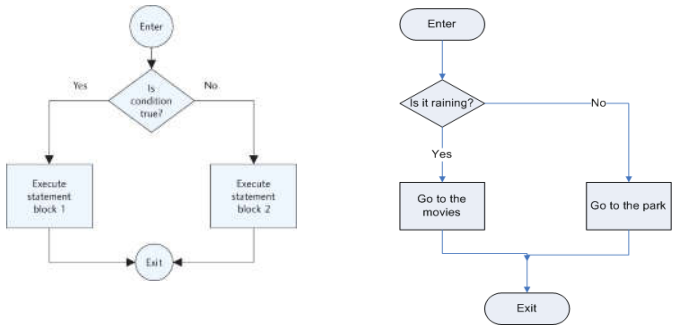
Selection – selectively execute statements

- Also called a **branch** or **decision**
- requires a **condition** to determine when to execute statements

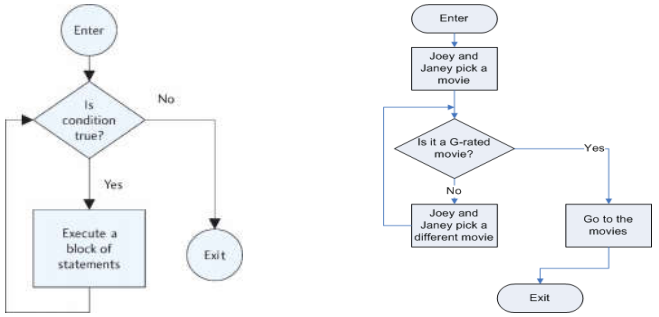
Repetition – repeat statements more than once

- Also called a **loop**
- needs a **stop condition**, i.e, the program will continue to loop until some condition is met

Flowchart for typical decision (selection) structures



Flowchart for typical repetition (loop) structures



Style Pointers

- Write modular programs
- Use descriptive variable names
- Provide a welcome message for the user
- Use a prompt before an input
- Identify program output
- Document your programs