IS 0020
Program Design and Software Tools

Introduction to C++ Programming

Lecture 1
Jan 6, 2004

Course Information

- Lecture:
  - James B D Joshi
  - Tuesdays: 6:00-8.50 PM
    - One (two) 15 (10) minutes break(s)
  - Office Hours: Wed 3:00-5:00PM/Appointment
- Pre-requisite
  - IS 0015 Data Structures and Programming Techniques
- Textbook
  - ***C++ How to Program*** - Fourth Edition, by H. M. Deitel, P. J. Deitel, Prentice Hall, New Jersey, 2003, ISBN: 0-13-038474.

Course Information

- Course Description
  - An introduction to the development of programs using C++.
  - Emphasis is given to the development of program modules that can function independently.
    - Object-oriented design
  - The theory of data structures and programming language design is continued.

Grading

- Quiz 10% (in the beginning of the class; on previous lecture)
- Homework/Programming Assignments 40% (typically every week)
- Midterm 25%
- Comprehensive Final 25%

Course Policy

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- Your work MUST be your own
  - Zero tolerance for cheating
  - You get an F for the course if you cheat in anything however small – NO DISCUSSION
- Homework
  - There will be penalty for late assignments (15% each day)
  - Ensure clarity in your answers – no credit will be given for vague answers
  - Homework is primarily the GSA's responsibility
- Check webpage for everything!
  - You are responsible for checking the webpage for updates

Course Policy

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  - Solutions/theory will be posted on the web
- Check webpage for everything!
  - You are responsible for checking the webpage for updates

Computer Languages

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- Machine language
  - Only language computer directly understands
  - Defined by hardware design
    - Machine-dependent
  - Generally consist of strings of numbers
    - Ultimately 0s and 1s
  - Instruct computers to perform elementary operations
    - One at a time
  - Cumbersome for humans
  - Example:

```
+1300042774
+1400593419
+1200274027
```


Computer Languages

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- Assembly language
  - English-like abbreviations representing elementary computer operations
  - Clearer to humans
  - Incomprehensible to computers
    - Translator programs (assemblers)
      - Convert to machine language
  - Example:

```
LOAD   BASEPAY
ADD    OVERPAY
STORE  GROSSPAY
```

Computer Languages

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- High-level languages
  - Similar to everyday English, use common mathematical notations
  - Single statements accomplish substantial tasks
    - Assembly language requires many instructions to accomplish simple tasks
  - Translator programs (compilers)
    - Convert to machine language
  - Interpreter programs
    - Directly execute high-level language programs
  - Example:

```
grossPay = basePay + overTimePay
```


History of C and C++

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- History of C
  - Evolved from two other programming languages
    - BCPL and B
      - "Typeless" languages
  - Dennis Ritchie (Bell Laboratories)
    - Added data typing, other features
  - Development language of UNIX
  - Hardware independent
    - Portable programs
  - 1989: ANSI standard
  - 1990: ANSI and ISO standard published
    - ANSI/ISO 9899: 1990

History of C and C++

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- History of C++
  - Extension of C
  - Early 1980s: Bjarne Stroustrup (Bell Laboratories)
  - Provides capabilities for object-oriented programming
    - Objects: reusable software components
      - Model items in real world
    - Object-oriented programs
      - Easy to understand, correct and modify
  - Hybrid language
    - C-like style
    - Object-oriented style
    - Both

C++ Standard Library

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- C++ programs
  - Built from pieces called classes and functions
- C++ standard library
  - Rich collections of existing classes and functions
- "Building block approach" to creating programs
  - "Software reuse"

Java

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- Java
  - 1991: Sun Microsystems
    - Green project
  - 1995: Sun Microsystems
    - Formally announced Java at trade show
  - Web pages with dynamic and interactive content
  - Develop large-scale enterprise applications
  - Enhance functionality of web servers
  - Provide applications for consumer devices
    - Cell phones, pagers, personal digital assistants, …

Structured Programming

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- Structured programming (1960s)
  - Disciplined approach to writing programs
  - Clear, easy to test and debug, and easy to modify
- Pascal
  - 1971: Niklaus Wirth
- Ada
  - 1970s - early 1980s: US Department of Defense (DoD)
  - Multitasking
    - Programmer can specify many activities to run in parallel

The Key Software Trend: Object Technology

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- Objects
  - Reusable software components that model real world items
  - Meaningful software units
    - Date objects, time objects, paycheck objects, invoice objects, audio objects, video objects, file objects, record objects, etc.
    - Any noun can be represented as an object
  - More understandable, better organized and easier to maintain than procedural programming
  - Favor modularity
    - Software reuse
      - Libraries
        - MFC (Microsoft Foundation Classes)
        - Rogue Wave

Basics of a Typical C++ Environment

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- C++ systems
  - Program-development environment
  - Language
  - C++ Standard Library
- C++ program names extensions
  - .cpp
  - .cxx
  - .cc
  - .C

Basics of a Typical C++ Environment

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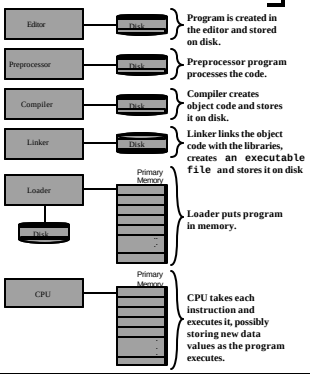
Phases of C++ Programs:

1. Edit
2. Preprocess
3. Compile
4. Link
5. Load
6. Execute



Basics of a Typical C++ Environment

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- Common Input/output functions
  - **cin**
    - Standard input stream
    - Normally keyboard
  - **cout**
    - Standard output stream
    - Normally computer screen
  - **cerr**
    - Standard error stream
    - Display error messages

A Simple Program: Printing a Line of Text

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- Before writing the programs
  - Comments
    - Document programs
    - Improve program readability
    - Ignored by compiler
    - Single-line comment
      - Use C's comment /* .. */ OR Begin with **// or**
  - Preprocessor directives
    - Processed by preprocessor before compiling
    - Begin with **#**

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Outline

fig01_02.cpp

fig01_02.cpp
output (1 of 1)

```
1  // Fig. 1.2: fig01_02.cpp
2  // A first program
3  #include <iostream>
4
5  // function main b
6  int main()
7  {
8     std::cout << "Welcome to
9
10    return 0; // in
11
12 } // end function main
Welcome to C++!
```

Single-line comments.

Function **main** returns an

Left brace **{** begins function body.

directive to

exactly once in every C++ program..

Statements end with a semicolon **;**.

Corresponding right brace **}** ends function body.

Name

Stream insertion operator.

namespace **std**.

Keyword **return** is one of several means to exit function; value **0** indicates program terminated successfully.

A Simple Program: Printing a Line of Text

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- Standard output stream object
  - **`std::cout`**
  - "Connected" to screen
  - **`<<`**
    - Stream insertion operator
    - Value to right (right operand) inserted into output stream
- Namespace
  - **`std::`** specifies using name that belongs to "namespace" **`std`**
  - **`std::`** removed through use of **`using`** statements
- Escape characters
  - \
  - Indicates "special" character output

A Simple Program: Printing a Line of Text

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Escape Sequence	Description
`\n`	Newline. Position the screen cursor to the beginning of the next line.
`\t`	Horizontal tab. Move the screen cursor to the next tab stop.
`\r`	Carriage return. Position the screen cursor to the beginning of the current line; do not advance to the next line.
`\a`	Alert. Sound the system bell.
`\\`	Backslash. Used to print a backslash character.
`\"`	Double quote. Used to print a double quote character.

Another Simple Program: Adding Two Integers

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- Variables
  - Location in memory where value can be stored
  - Common data types
    - **`int`** - integer numbers
    - **`char`** - characters
    - **`double`** - floating point numbers
  - Declare variables with name and data type before use

```
int integer1;
int integer2;
int sum;
```

  - Can declare several variables of same type in one declaration
    - Comma-separated list

```
int integer1, integer2, sum;
```


Another Simple Program: Adding Two Integers

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- Input stream object
  - **`>>`** (stream extraction operator)
    - Used with **`std::cin`**
    - Waits for user to input value, then press *Enter* (Return) key
    - Stores value in variable to right of operator
      - Converts value to variable data type
- **`=`** (assignment operator)
  - Assigns value to variable
  - Binary operator (two operands)
  - Example:

```
sum = variable1 + variable2;
```

Outline

fig01_06.cpp
(1 of 1)

```
1  // Fig. 1.6: fig01_06.cpp
2  // Addition program.
3  #include <iostream>
4
5  // function main begins program execution
6  int main()
7  {
8     int integer1;  // first number to be input by user
9     int integer2;  // second nu
10    int sum;       // variable
11
12    std::cout << "Enter first
13    std::cin >> integer1;                  // read an integer
14
15    std::cout << "Enter second integer\n"; // prompt
16    std::cin >> integer2;
17
18    sum = integer1 + integer2;
19
20    std::cout << "Sum is " << sum << std::endl; // print su
21
22    return 0;   // indicate that program ended successfully
23
24 } // end function main
```

Declare integer variables.

Use stream extraction operator with standard input stream to obtain user input.

Calculations can be performed in output statements: alternative for lines 18 and 20:

```
std::cout << "Sum is " << integer1 + integer2 << std::endl;
```

Concatenating, chaining or cascading stream insertion operations.

Memory Concepts

- Variable names
  - Correspond to actual locations in computer's memory
  - Every variable has name, type, size and value
  - When new value placed into variable, overwrites previous value

- std::cin >> integer1;
- Assume user entered 45

integer1	45

- std::cin >> integer2;
- Assume user entered 72

integer1	45
integer2	72

- sum = integer1 + integer2;

integer1	45
integer2	72
sum	117

Arithmetic

- Arithmetic calculations
  - **`*`** : Multiplication
  - **`/`** : Division
    - Integer division truncates remainder
      - **`7 / 5`** evaluates to 1
  - **`%`** : Modulus operator returns remainder
    - **`7 % 5`** evaluates to 2

Operator(s)	Operation(s)	Order of evaluation (precedence)
`()`	Parentheses	Evaluated first. If the parentheses are nested, the expression in the innermost pair is evaluated first. If there are several pairs of parentheses "on the same level" (i.e., not nes ted), they are evaluated left to right.
`*`, `/`, or `%`	Multiplication Division Modulus	Evaluated second. If there are several, they re evaluated left to right.
`+` or `-`	Addition Subtraction	Evaluated last. If there are several, they are evaluated left to right.

Decision Making: Equality and Relational Operators

- **`if`** structure
  - Make decision based on truth or falsity of condition
    - If condition met, body executed
    - Else, body not executed
- Equality and relational operators
  - Equality operators
    - Same level of precedence
  - Relational operators
    - Same level of precedence
  - Associate left to right
- **`using`** statements
  - Eliminate use of **`std::`** prefix
  - Write **`cout`** instead of **`std::cout`**

Decision Making: Equality and Relational Operators

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Standard algebraic equality operator or relational operator	C++ equality or relational operator	Example of C++ condition	Meaning of C++ condition
Relational operators			
>	`>`	`x > y`	`x` is greater than `y`
<	`<`	`x < y`	`x` is less than `y`
≥	`>=`	`x >= y`	`x` is greater than or equal to `y`
≤	`<=`	`x <= y`	`x` is less than or equal to `y`
Equality operators			
=	`==`	`x == y`	`x` is equal to `y`
≠	`!=`	`x != y`	`x` is not equal to `y`

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Outline

fig01_14.cpp (1 of 2)

```
1  // Fig. 1.14: fig01_14.cpp
2  // Using if statements, relational
3  // operators, and equality operators.
4  #include <iostream>
5
6  using std::cout;  // program uses cout
7  using std::cin;   // program uses cin
8  using std::endl;  // program uses endl
9
10 // function main begins program execution
11 int main()
12 {
13    int num1;  // first number to be read from user
14    int num2;  // second number to be read from user
15
16    cout << "Enter two integers, and I will tell you\n"
17         << "the relationships they satisfy: ";
18    cin >> num1 >> num2;  // read two integers
19
20    if ( num1 == num2 )
21       cout << num1 << " is equal to " << num2 << endl;
22
23    if ( num1 != num2 )
24       cout << num1 << " is not equal to " << num2 << endl;
25
```

`using` statements eliminate need for `std::` prefix.

Declare variables.

Can write `cout` and `cin` without `std::` prefix.

`if` structure compares values of `num1` and `num2` to test for equality. If condition is true (i.e., values are equal), execute this statement.

`if` structure compares values of `num1` and `num2` to test for inequality. If condition is true (i.e., values are not equal), execute this statement.

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Outline

fig01_14.cpp output (1 of 2)

```
26    if ( num1 < num2 )
27       cout << num1 << " is less than " << num2 << endl;
28
29    if ( num1 > num2 )
30       cout << num1 << " is greater than " << num2 << endl;
31
32    if ( num1 <= num2 )
33       cout << num1 << " is less than or equal to "
34            << num2 << endl;
35
36    if ( num1 >= num2 )
37       cout << num1 << " is greater than or equal to "
38            << num2 << endl;
39
40    return 0;   // indicate that program ended successfully
41
42 } // end function main
```

```
Enter two integers, and I will tell you
the relationships they satisfy: 22 12
22 is not equal to 12
22 is greater than 12
22 is greater than or equal to 12
```

Statements may be split over several lines.

Algorithms

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- Computing problems
  - Solved by executing a series of actions in a specific order
- Algorithm a procedure determining
  - Actions to be executed
  - Order to be executed
  - Example: recipe
- Program control
  - Specifies the order in which statements are executed

Pseudocode

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- Pseudocode
  - Artificial, informal language used to develop algorithms
  - Similar to everyday English
- Not executed on computers
  - Used to think out program before coding
    - Easy to convert into C++ program
  - Only executable statements
    - No need to declare variables

Control Structures

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- Sequential execution
  - Statements executed in order
- Transfer of control
  - Next statement executed *not* next one in sequence
  - Structured programming – "goto"-less programming
- 3 control structures to build any program
  - Sequence structure
    - Programs executed sequentially by default
  - Selection structures
    - **`if`**, **`if/else`**, **`switch`**
  - Repetition structures
    - **`while`**, **`do/while`**, **`for`**

Keywords

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- C++ keywords
  - Cannot be used as identifiers or variable names

C++ Keywords

Keywords common to the C and C++ programming languages

`auto`	`break`	`case`	`char`	`const`
`continue`	`default`	`do`	`double`	`else`
`enum`	`extern`	`float`	`for`	`goto`
`if`	`int`	`long`	`register`	`return`
`short`	`signed`	`sizeof`	`static`	`struct`
`switch`	`typedef`	`union`	`unsigned`	`void`
`volatile`	`while`			

C++ only keywords

`asm`	`bool`	`catch`	`class`	`const_cast`
`delete`	`dynamic_cast`	`explicit`	`false`	`friend`
`inline`	`mutable`	`namespace`	`new`	`operator`
`private`	`protected`	`public`	`reinterpret_cast`	
`static_cast`	`template`	`this`	`throw`	`true`
`try`	`typeid`	`typename`	`using`	`virtual`
`wchar_t`				

Control Structures

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- Flowchart
  - Graphical representation of an algorithm
  - Special-purpose symbols connected by arrows (flowlines)
  - Rectangle symbol (action symbol)
    - Any type of action
  - Oval symbol
    - Beginning or end of a program, or a section of code (circles)
- Single-entry/single-exit control structures
  - Connect exit point of one to entry point of the next
  - Control structure stacking

if Selection Structure

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- Selection structure
  - Choose among alternative courses of action
  - Pseudocode example:
    If student's grade is greater than or equal to 60
    Print "Passed"
  - If the condition is **`true`**
    - Print statement executed, program continues to next statement
  - If the condition is **`false`**
    - Print statement ignored, program continues
  - Indenting makes programs easier to read
    - C++ ignores whitespace characters (tabs, spaces, etc.)

if Selection Structure

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- Translation into C++
  If student's grade is greater than or equal to 60
  Print "Passed"

```
if ( grade >= 60 )
   cout << "Passed";
```

- Diamond symbol (decision symbol)
  - Indicates decision is to be made
  - Contains an expression that can be true or false
    - Test condition, follow path
- **`if`** structure
  - Single-entry/single-exit

if Selection Structure

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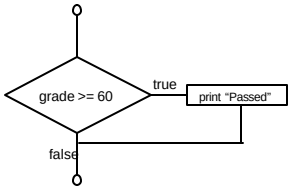
- Flowchart of pseudocode statement



A decision can be made on any expression.

zero - **`false`**

nonzero - **`true`**

Example:

`3 - 4` is **`true`**

`if/else` Selection Structure

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- **`if`**
  - Performs action if condition true
- **`if/else`**
  - Different actions if conditions true or false
- Pseudocode
  if student's grade is greater than or equal to 60
  print "Passed"
  else
  print "Failed"
- C++ code

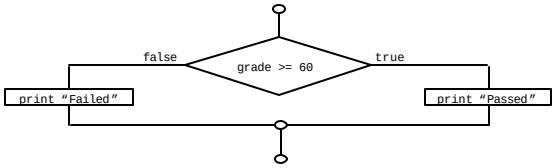
```
if ( grade >= 60 )
   cout << "Passed";
else
   cout << "Failed";
```

41 `if/else` Selection Structure

- Ternary conditional operator (`?:`)
  - Three arguments (condition, value if `true`, value if `false`)
- Code could be written:

```
cout << ( grade >= 60 ? "Passed" : "Failed" );
```

Condition — Value if true — Value if false



42 `if/else` Selection Structure

- Nested `if/else` structures
  - One inside another, test for multiple cases
  - Once condition met, other statements skipped

```
if student's grade is greater than or equal to 90
      Print "A"
else
      if student's grade is greater than or equal to 80
        Print "B"
      else
        if student's grade is greater than or equal to 70
          Print "C"
        else
          if student's grade is greater than or equal to 60
            Print "D"
          else
                Print "F"
```


43 `if/else` Selection Structure

- Example

```
if ( grade >= 90 )       // 90 and above
   cout << "A";
else if ( grade >= 80 )  // 80-89
   cout << "B";
else if ( grade >= 70 )  // 70-79
   cout << "C";
else if ( grade >= 60 )  // 60-69
   cout << "D";
else                     // less than 60
   cout << "F";
```


44 `if/else` Selection Structure

- Compound statement
  - Set of statements within a pair of braces

```
if ( grade >= 60 )
   cout << "Passed.\n";
else {
   cout << "Failed.\n";
   cout << "You must take this course again.\n";
}
```

  - Without braces,

```
cout << "You must take this course again.\n";
```

  always executed
- Block
  - Set of statements within braces

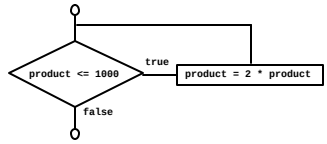
while Repetition Structure

- Repetition structure
  - Action repeated while some condition remains true
  - Psuedocode
    while there are more items on my shopping list
    Purchase next item and cross it off my list
  - **while** loop repeated until condition becomes false
- Example

```
int product = 2;
while ( product <= 1000 )
   product = 2 * product;
```


while Repetition Structure

- Flowchart of **while** loop



Counter-Controlled Repetition

- Counter-controlled repetition
  - Loop repeated until counter reaches certain value
- Definite repetition
  - Number of repetitions known
- Example

A class of ten students took a quiz. The grades (integers in the range 0 to 100) for this quiz are available to you. Determine the class average on the quiz.

Outline

fig02_07.cpp
(1 of 2)

```
1  // Fig. 2.7: fig02_07.cpp
2  // Class average program with counter-controlled repetition.
3  #include <iostream>
4
5  using std::cout;
6  using std::cin;
7  using std::endl;
8
9  // function main begins program execution
10 int main()
11 {
12    int total;        // sum of grades input by user
13    int gradeCounter; // number of grade to be entered next
14    int grade;        // grade value
15    int average;      // average of grades
16
17    // initialization phase
18    total = 0;          // initialize total
19    gradeCounter = 1;   // initialize loop counter
20
```

```
21    // processing phase
22    while ( gradeCounter <= 10 ) {       // loop 10 times
23       cout << "Enter grade: ";          // prompt for input
24       cin >> grade;                     // read grade from user
25       total = total + grade;            // add grade to total
26       gradeCounter = gradeCounter + 1;  // increment counter
27    }
28
29    // termination phase
30    average = total / 10;                // integer division
31
32    // display result
33    cout << "Class average is
34
35    return 0;   // indicate p
36
37 } // end function main
```

The counter gets incremented each time the loop executes. Eventually, the counter causes the loop to end.

```
Enter grade: 98
Enter grade: 76
Enter grade: 71
Enter grade: 87
Enter grade: 83
Enter grade: 90
Enter grade: 57
Enter grade: 79
Enter grade: 82
Enter grade: 94
Class average is 81
```


Outline

fig02_07.cpp
(2 of 2)

fig02_07.cpp
output (1 of 1)

Sentinel-Controlled Repetition

- Suppose problem becomes:
  Develop a class-averaging program that will process an arbitrary number of grades each time the program is run
  - Unknown number of students
  - How will program know when to end?
- Sentinel value
  - Indicates "end of data entry"
  - Loop ends when sentinel input
  - Sentinel chosen so it cannot be confused with regular input
    - -1 in this case


```
1  // Fig. 2.9: fig02_09.cpp
2  // Class average program with sentinel-controlled repetition.
3  #include <iostream>
4
5  using std::cout;
6  using std::cin;
7  using std::endl;
8  using std::fixed;
9
10 #include <iomanip>        // parameterized stream manipulators
11
12 using std::setprecision;  // sets numeric output precision
13
14 // function main begins program execution
15 int main()
16 {
17    int total;         // sum of grades
18    int gradeCounter;  // number of grades entered
19    int grade;         // grade value
20
21    double average;    // number with decimal point for average
22
23    // initialization phase
24    total = 0;         // initialize total
25    gradeCounter = 0;  // initialize loop counter
```

Data type **double** used to represent decimal numbers.

Outline

fig02_09.cpp
(1 of 3)


```
26
27    // processing phase
28    // get first grade from user
29    cout << "Enter grade, -1 to end: ";  // prompt for input
30    cin >> grade;                        // read grade from user
31
32    // loop until sentinel value read from user
33    while ( grade != -1
34       total = total + g
35       gradeCounter = gr
36
37       cout << "Enter gr
38       cin >> grade;
39
40    } // end while
41
42    // termination phase
43    // if user entered at least one grade ...
44    if ( gradeCounter != 0 ) {
45
46       // calculate average of all grades entered
47       average = static_cast< double >( total ) / gradeCounter;
48
```

static_cast<double>() treats **total** as a **double** temporarily (casting).

Required because dividing two integers truncates the remainder.

gradeCounter is an **int**, but it gets *promoted* to **double**.

Outline

fig02_09.cpp
(2 of 3)

```
49       // display average with two digits of precision
50       cout << "Class average is " << setprecision( 2 )
51            << fixed << average << endl;
52
53    } // end if part of if/else
54
55    else // if no grades were entered, output appropriate message
56       cout << "No grades were entered" << endl;
57
58    return 0;   // indicate program ended successfully
59
60 } // end function main
```

```
Enter grade, -1 to end: 75
Enter grade, -1 to end: 94
Enter grade, -1 to end: 97
Enter grade, -1 to end: 88
Enter grade, -1 to end: 70
Enter grade, -1 to end: 64
Enter grade, -1 to end: 83
Enter grade, -1 to end: 89
Enter grade, -1 to end: -1
Class average is 82.50
```

Outline

fig02_09.cpp (3 of 3)

fig02_09.cpp output (1 of 1)

setprecision(2) prints two digits past decimal point (rounded to fit precision).

Programs that use this must include **<iomanip>**

fixed forces output to print in fixed point format (not scientific notation). Also, forces trailing zeros and decimal point to print.

Include **<iostream>**

switch Multiple-Selection Structure

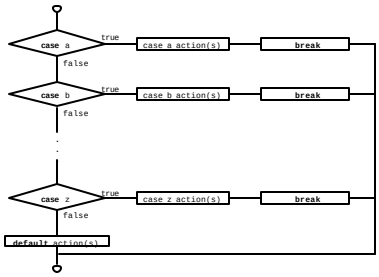
- **switch**
  - Test variable for multiple values
  - Series of **case** labels and optional **default** case

```
switch ( variable ) {
     case value1:      // taken if variable == value1
            statements
            break;     // necessary to exit switch

     case value2:
     case value3:      // taken if variable == value2 or == value3
            statements
            break;

     default:          // taken if none matches
            statements
            break;
}
```


switch Multiple-Selection Structure



switch Multiple-Selection Structure

- Example upcoming
  - Program to read grades (A-F)
  - Display number of each grade entered
- Details about characters
  - Single characters typically stored in a **char** data type
    - **char** a 1-byte integer, so **char**s can be stored as **int**s
  - Can treat character as **int** or **char**
    - 97 is the numerical representation of lowercase 'a' (ASCII)
    - Use *single quotes* to get numerical representation of character

```
cout << "The character (" << 'a' << ") has the value "
       << static_cast< int > ( 'a' ) << endl;
```

Prints

```
The character (a) has the value 97
```

Outline

fig02_22.cpp
(1 of 4)

```
1  // Fig. 2.22: fig02_22.cpp
2  // Counting letter grades.
3  #include <iostream>
4
5  using std::cout;
6  using std::cin;
7  using std::endl;
8
9  // function main begins program execution
10 int main()
11 {
12    int grade;       // one grade
13    int aCount = 0;  // number of As
14    int bCount = 0;  // number of Bs
15    int cCount = 0;  // number of Cs
16    int dCount = 0;  // number of Ds
17    int fCount = 0;  // number of Fs
18
19    cout << "Enter the letter grades." << endl
20         << "Enter the EOF character to end input." << endl;
21
```


Outline

fig02_22.cpp
(2 of 4)

```
22    // loop until user types end-of-file key sequence
23    while ( ( grade = cin.get() ) != EOF ) {
24
25       // determine which grade was input
26       switch ( grade ) {  // switch structure
27
28          case 'A':       // grade was uppercase A
29          case 'a':       // or lowercase a
30             ++aCount;    // increment aCount
31             break;       //
32
33          case 'B':       //
34          case 'b':       //
35             ++bCount;    //
36             break;       //
37
38          case 'C':       //
39          case 'c':       //
40             ++cCount;    //
41             break;       //
42
```

break causes **switch** to end and the program continues with the first statement after the **switch** structure.

cin.get() uses dot notation (explained chapter 6). This function gets 1 character from the keyboard (after *Enter* pressed), and it is assigned to **grade**.

cin.get() returns EOF (end-of-file) after the EOF character is input, to indicate the end of data. EOF may be ctrl-d or ctrl-z, depending on your OS.

Compares **grade** (an **int**) to the numerical representations of **A** and **a**.

Assignment statements have a value, which is the same as the variable on the left of the **=**. The value of this statement is the same as the value returned by **cin.get()**.

This can also be used to initialize multiple variables:
a = b = c = 0;

Outline

fig02_22.cpp
(3 of 4)

```
43          case 'D':       // grade was uppercase D
44          case 'd':       // or lowercase d
45             ++dCount;    // increment dCount
46             break;       // exit switch
47
48          case 'F':       // grade was
49          case 'f':       // or lowerc
50             ++fCount;    // increment
51             break;       // exit swit
52
53          case '\n':      // ignore ne
54          case '\t':      // tabs,
55          case ' ':       // and spac
56             break;       // exit sw
57
58          default:        // catch all other characters
59             cout << "Incorrect letter grade entered."
60                  << " Enter a new grade." << endl;
61             break;       // optional; will exit switch anyway
62
63       } // end switch
64
65    } // end while
66
```

This test is necessary because *Enter* is pressed after each letter grade is input. This adds a newline character that must be removed. Likewise, we want to ignore any whitespace.

Notice the **default** statement, which catches all other cases.

Outline

fig02_22.cpp
(4 of 4)

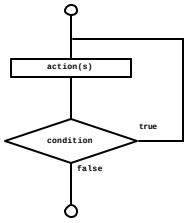
```
67    // output summary of results
68    cout << "\n\nTotals for each letter grade are:"
69         << "\nA: " << aCount   // display number of A grades
70         << "\nB: " << bCount   // display number of B grades
71         << "\nC: " << cCount   // display number of C grades
72         << "\nD: " << dCount   // display number of D grades
73         << "\nF: " << fCount   // display number of F grades
74         << endl;
75
76    return 0;  // indicate successful termination
77
78 } // end function main
```

61

do/while Repetition Structure

- Similar to **`while`** structure
  - Makes loop continuation test at end, not beginning
  - Loop body executes at least once
- Format

```
do {
   statement
} while ( condition );
```



62

Outline

fig02_24.cpp
(1 of 1)

fig02_24.cpp
output (1 of 1)

```
1  // Fig. 2.24: fig02_24.cpp
2  // Using the do/while repetition structure.
3  #include <iostream>
4
5  using std::cout;
6  using std::endl;
7
8  // function main begins program execution
9  int main()
10 {
11    int counter = 1;
12
13    do {
14       cout << counter << "  ";   // display counter
15    } while ( ++counter <= 10 );  // end do/while
16
17    cout << endl;
18
19    return 0;   // indicate successful termination
20
21 } // end function main
```

Notice the preincrement in loop -continuation test.

```
1  2  3  4  5  6  7  8  9  10
```


63

break and **continue** Statements

- **`break`** statement
  - Immediate exit from **`while`**, **`for`**, **`do/while`**, **`switch`**
  - Program continues with first statement after structure
- Common uses
  - Escape early from a loop
  - Skip the remainder of **`switch`**

64

Outline

fig02_26.cpp
(1 of 2)

```
1  // Fig. 2.26: fig02_26.cpp
2  // Using the break statement in a for structure.
3  #include <iostream>
4
5  using std::cout;
6  using std::endl;
7
8  // function main begins program execution
9  int main()
10 {
11
12    int x;  // x declared here so it can be used after the loop
13
14    // loop 10 times
15    for ( x = 1; x <= 10; x++ ) {
16
17       // if x is 5, terminate loop
18       if ( x == 5 )
19          break;           // break loop only if x is 5
20
21       cout << x << " ";   // display value of x
22
23    } // end for
24
25    cout << "\nBroke out of loop when x became " << x << endl;
```

Exits **`for`** structure when **`break`** executed.

Logical Operators

65

- Used as conditions in loops, **if** statements
- **&&** (logical **AND**)
  - **true** if both conditions are **true**

```
if ( gender == 1 && age >= 65 )
   ++seniorFemales;
```

- **||** (logical **OR**)
  - **true** if either of condition is **true**

```
if ( semesterAverage >= 90 || finalExam >= 90 )
   cout << "Student grade is A" << endl;
```


Logical Operators

66

- **!** (logical **NOT**, logical negation)
  - Returns **true** when its condition is **false**, & vice versa

```
if ( !( grade == sentinelValue ) )
   cout << "The next grade is " << grade << endl;
```

Alternative:

```
if ( grade != sentinelValue )
   cout << "The next grade is " << grade << endl;
```


Confusing Equality (==) and Assignment (=) Operators

67

- Common error
  - Does not typically cause syntax errors
- Aspects of problem
  - Expressions that have a value can be used for decision
    - Zero = false, nonzero = true
  - Assignment statements produce a value (the value to be assigned)

Confusing Equality (==) and Assignment (=) Operators

68

- Example

```
if ( payCode == 4 )
   cout << "You get a bonus!" << endl;
```

  - If paycode is 4, bonus given

- If **==** was replaced with **=**

```
if ( payCode = 4 )
   cout << "You get a bonus!" << endl;
```

  - Paycode set to 4 (no matter what it was before)
  - Statement is true (since 4 is non-zero)
  - Bonus given in every case

Confusing Equality (==) and Assignment (=) Operators

69

- Lvalues
  - Expressions that can appear on left side of equation
  - Can be changed (I.e., variables)
    `x = 4;`
- Rvalues
  - Only appear on right side of equation
  - Constants, such as numbers (i.e. cannot write **`4 = x;`**)
- Lvalues can be used as rvalues, but not vice versa

Structured-Programming Summary

70

- Structured programming
  - Programs easier to understand, test, debug and modify
- Rules for structured programming
  - Only use single-entry/single-exit control structures
  - Rules
    1) Begin with the "simplest flowchart"
    2) Any rectangle (action) can be replaced by two rectangles (actions) in sequence
    3) Any rectangle (action) can be replaced by any control structure (sequence, if, if/else, switch, while, do/while or for)
    4) Rules 2 and 3 can be applied in any order and multiple times

Structured-Programming Summary

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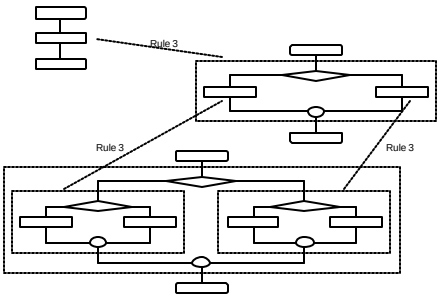
Representation of Rule 3 (replacing any rectangle with a control structure)



Structured-Programming Summary

72

- All programs broken down into
  - Sequence
  - Selection
    - **`if`**, **`if/else`**, or **`switch`**
    - Any selection can be rewritten as an **`if`** statement
  - Repetition
    - **`while`**, **`do/while`** or **`for`**
    - Any repetition structure can be rewritten as a **`while`** statement