EXPRESSIONS AND INTERACTIVITY

Chapter 3

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3.1

The `cin` Object

The `cin` Object

- Standard input object
- Like `cout`, requires `iostream` file
- Used to read input from keyboard
- Information retrieved from `cin` with >>
- Input is stored in one or more variables

Displaying a prompt

- A prompt is a message that instructs the user to enter data.
- You should always use `cout` to display a prompt before each `cin` statement.

```
cout << "How tall is the room? ";
cin >> height;
```

The `cin` Object

- `cin` converts data to the type that matches the variable:

```
int height;
cout << "How tall is the room? ";
cin >> height;
```

- It can be used to input more than one value:

```
cin >> height >> width;
```

- Multiple values from keyboard must be separated by spaces.
- **Order is important:** first value entered goes to first variable, etc.

The `cin` Object

- Can read different data types

```
1  // This program demonstrates how cin can read multiple values
2  // of different data types.
3  #include <iostream>
4  using namespace std;
5
6  int main()
7  {
8     int whole;
9     double fractional;
10    char letter;
11
12    cout << "Enter an integer, a double, and a character: ";
13    cin >> whole >> fractional >> letter;
14    cout << "Whole: " << whole << endl;
15    cout << "Fractional: " << fractional << endl;
16    cout << "Letter: " << letter << endl;
17    return 0;
18 }
```

Program Output with Example Input Shown in Bold

```
Enter an integer, a double, and a character: 4 5.7 b [Enter]
Whole: 4
Fractional: 5.7
Letter: b
```

3.2

Mathematical Expressions

Mathematical Expressions

- Can create complex expressions using multiple mathematical operators.
- An expression can be a literal, a variable, or a mathematical combination of constants and variables.
- Can be used in assignment, `cout`, other statements:

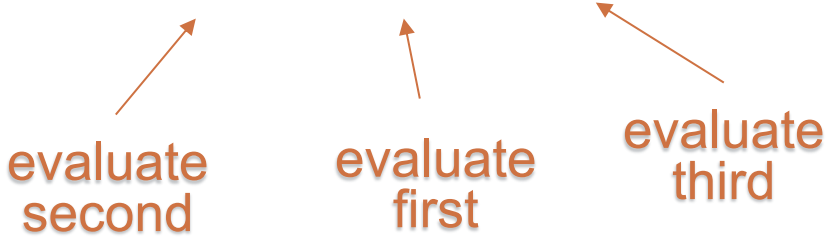
```
area = 2 * PI * radius;
cout << "border is: " << 2*(l+w);
```

Order of Operations

In an expression with more than one operator, evaluate in this order:

- `-` (unary negation), in order, left to right
- `*` `/` `%`, in order, left to right.
- `+` `-`, in order, left to right.

In the expression `2 + 2 * 2 - 2`:



Order of Operations

Expression	Value
`5 + 2 * 4`	
`10 / 2 - 3`	
`8 + 12 * 2 - 4`	
`4 + 17 % 2 - 1`	
`6 - 3 * 2 + 7 - 1`	

Associativity of Operators

- – (unary negation) associates right to left.
- `*, /, %, +, –` associate left to right.
- parentheses ( ) can be used to override the order of operations:

```
 2 + 2  *  2 - 2  = 4
(2 + 2) *  2 - 2  = 6
 2 + 2  * (2 - 2) = 2
(2 + 2) * (2 - 2) = 0
```

Grouping with Parentheses

Expression	Value
`(5 + 2) * 4`	
`10 / (5 - 3)`	
`8 + 12 * (6 - 2)`	
`(4 + 17) % 2 - 1`	
`(6 - 3) * (2 + 7) / 3`	

Algebraic Expressions

- Multiplication requires an operator:

  $Area = lw$ is written as `area = l * w;`

- There is no exponentiation operator:

  $Area = s^2$ is written as `area = pow(s, 2.0);`

- Parentheses may be needed to maintain order of operations:

$$m = \frac{y_2 - y_1}{x_2 - x_1}$$

is written as

```
m =  y2-y1 / x2-x1 ;
```

Algebraic Expressions

Algebraic Expression	Operation	C++ Equivalent
$6B$	`6 times B`	`6 * B`
$(3)(12)$	`3 times 12`	`3 * 12`
$4xy$	`4 times x times y`	`4 * x * y`

3.3

Type Conversion

Type Conversion

- Operations are performed between operands of the same type.
- If not of the same type, C++ will convert one to be the type of the other.
- This can impact the results of calculations.

Hierarchy of Types

Highest:
```
long double
double
float
unsigned long
long
unsigned int
```
Lowest:
```
int
```

Ranked by largest number they can hold.

Type Coercion

- **Type Coercion**: automatic conversion of an operand to another data type.
- **Promotion**: convert to a higher type.
- **Demotion**: convert to a lower type.

Coercion Rules

1) `char`, `short`, `unsigned short` automatically promoted to `int`.
2) When operating on values of different data types, the lower one is promoted to the type of the higher one.
3) When using the = operator, the type of expression on right will be converted to type of variable on left.

3.4

Overflow and Underflow

Overflow and Underflow

- Occurs when assigning a value that is too large (overflow) or too small (underflow) to be held in a variable.
- Variable contains value that is “wrapped around” set of possible values.
- Different systems may display a warning/error message, stop the program, or continue execution using the incorrect value.

3.5

Type Casting

Type Casting

- Used for manual data type conversion.
- Useful for floating point division using `ints`:

```
double m;
m = static_cast<double>(y2-y1)/(x2-x1);
```

- Useful to see `int` value of a `char` variable:

```
char ch = 'C';
cout << ch << " is "
     << static_cast<int>(ch);
```

Type Casting

```
1  // This program uses a type cast to avoid integer division.
2  #include <iostream>
3  using namespace std;
4
5  int main()
6  {
7     int books;         // Number of books to read
8     int months;        // Number of months spent reading
9     double perMonth;   // Average number of books per month
10
11    cout << "How many books do you plan to read? ";
12    cin >> books;
13    cout << "How many months will it take you to read them? ";
14    cin >> months;
15    perMonth = static_cast<double>(books) / months;
16    cout << "That is " << perMonth << " books per month.\n";
17    return 0;
18 }
```

Program Output with Example Input Shown in Bold

```
How many books do you plan to read? 30 [Enter]
How many months will it take you to read them? 7 [Enter]
That is 4.28571 books per month.
```

C-Style and Prestandard Type Cast Expressions

- C-Style cast:

  data type name in `()`

  ```
  cout << ch << " is " << (int)ch;
  ```

- Prestandard C++ cast:

  value in `()`

  ```
  cout << ch << " is " << int(ch);
  ```

- Both are still supported in C++, although `static_cast` is preferred.

3.6

Multiple Assignment and Combined Assignment

Multiple Assignment

- The = can be used to assign a value to multiple variables:

```
x = y = z = 5;
```

- Value of = is the value that is assigned.
- Associates right to left:

```
x = (y = (z = 5));
```

value is 5 value is 5 value is 5

Combined Assignment

- Look at the following statement:

```
sum = sum + 1;
```

This adds 1 to the variable **`sum`**.

Other Similar Statements

Assume `x = 6`:

Statement	What It Does	Value of x After the Statement
`x = x + 4;`	Adds 4 to x	10
`x = x - 3;`	Subtracts 3 from x	3
`x = x * 10;`	Multiplies x by 10	60
`x = x / 2;`	Divides x by 2	3
`x = x % 4`	Makes x the remainder of x / 4	2

Combined Assignment

- The combined assignment operators provide a shorthand for these types of statements.
- The statement

```
sum = sum + 1;
```

  is equivalent to

```
sum += 1;
```

- Combined (compound) assignment operator has lower precedence than arithmetic operators.

Combined Assignment Operators

Operator	Example Usage	Equivalent to
`+=`	`x += 5;`	`x = x + 5;`
`-=`	`y -= 2;`	`y = y - 2;`
`*=`	`z *= 10;`	`z = z * 10;`
`/=`	`a /= b;`	`a = a / b;`
`%=`	`c %= 3;`	`c = c % 3;`

3.7

Formatting Output

Formatting Output

- Can control how output displays for numeric, string data:
  - size
  - position
  - number of digits
- Requires `iomanip` header file.

Stream Manipulators

- Used to control how an output field is displayed.
- Some affect just the next value displayed:
  - `setw(x)`: print in a field at least `x` spaces wide. Use more spaces if field is not wide enough.

The `setw` Stream Manipulator

```
1  // This program displays three rows of numbers.
2  #include <iostream>
3  #include <iomanip>      // Required for setw
4  using namespace std;
5
6  int main()
7  {
8     int num1 = 2897, num2 = 5,    num3 = 837,
9         num4 = 34,   num5 = 7,    num6 = 1623,
10        num7 = 390,  num8 = 3456, num9 = 12;
11
12    // Display the first row of numbers
13    cout << setw(6) << num1 << setw(6)
14         << num2 << setw(6) << num3 << endl;
15
16    // Display the second row of numbers
17    cout << setw(6) << num4 << setw(6)
18         << num5 << setw(6) << num6 << endl;
19
20    // Display the third row of numbers
21    cout << setw(6) << num7 << setw(6)
22         << num8 << setw(6) << num9 << endl;
23    return 0;
24 }
```

```
1  // This program displays three rows of numbers.
2  #include <iostream>
3  #include <iomanip>      // Required for setw
4  using namespace std;
5
6  int main()
7  {
8     int num1 = 2897, num2 = 5,    num3 = 837,
9         num4 = 34,   num5 = 7,    num6 = 1623,
10        num7 = 390,  num8 = 3456, num9 = 12;
11
12    // Display the first row of numbers
13    cout << setw(6) << num1 << setw(6)
14         << num2 << setw(6) << num3 << endl;
15
16    // Display the second row of numbers
17    cout << setw(6) << num4 << setw(6)
18         << num5 << setw(6) << num6 << endl;
19
20    // Display the third row of numbers
21    cout << setw(6) << num7 << setw(6)
22         << num8 << setw(6) << num9 << endl;
23    return 0;
24 }
```

Program Output

```
  2897     5   837
    34     7  1623
   390  3456    12
```

Stream Manipulators

- Some affect values until changed again:
  - `fixed`: use decimal notation for floating-point values.
  - `setprecision(x)`:
    - When used with `fixed`, print floating-point value using `x` digits after the decimal.
    - Without `fixed`, print floating-point value using x significant digits.
  - `showpoint`: always print decimal for floating-point values

More Stream Manipulators

```
1  // This program asks for sales figures for 3 days. The total
2  // sales are calculated and displayed in a table.
3  #include <iostream>
4  #include <iomanip>
5  using namespace std;
6
7  int main()
8  {
9     double day1, day2, day3, total;
10
11    // Get the sales for each day.
12    cout << "Enter the sales for day 1: ";
13    cin >> day1;
14    cout << "Enter the sales for day 2: ";
15    cin >> day2;
16    cout << "Enter the sales for day 3: ";
17    cin >> day3;
18
19    // Calculate the total sales.
20    total = day1 + day2 + day3;
21
22    // Display the sales figures.
23    cout << "\nSales Figures\n";
24    cout << "-------------\n";
25    cout << setprecision(2) << fixed;
26    cout << "Day 1: " << setw(8) << day1 << endl;
27    cout << "Day 2: " << setw(8) << day2 << endl;
28    cout << "Day 3: " << setw(8) << day3 << endl;
29    cout << "Total: " << setw(8) << total << endl;
30    return 0;
31 }
```

Program Output with Example Input Shown in Bold

```
Enter the sales for day 1:   1321.87 [Enter]
Enter the sales for day 2:   1869.26 [Enter]
Enter the sales for day 3:   1403.77 [Enter]

Sales Figures
-------------
Day 1:    1321.87
Day 2:    1869.26
Day 3:    1403.77
Total:    4594.90
```

```
1  // This program asks for sales figures for 3 days. The total
2  // sales are calculated and displayed in a table.
3  #include <iostream>
4  #include <iomanip>
5  using namespace std;
6
7  int main()
8  {
9     double day1, day2, day3, total;
10
11    // Get the sales for each day.
12    cout << "Enter the sales for day 1: ";
13    cin >> day1;
14    cout << "Enter the sales for day 2: ";
15    cin >> day2;
16    cout << "Enter the sales for day 3: ";
17    cin >> day3;
18
19    // Calculate the total sales.
20    total = day1 + day2 + day3;
21
22    // Display the sales figures.
23    cout << "\nSales Figures\n";
24    cout << "-------------\n";
25    cout << setprecision(2) << fixed;
26    cout << "Day 1: " << setw(8) << day1 << endl;
27    cout << "Day 2: " << setw(8) << day2 << endl;
28    cout << "Day 3: " << setw(8) << day3 << endl;
29    cout << "Total: " << setw(8) << total << endl;
30    return 0;
31 }
```

Stream Manipulators

```
1  // This program demonstrates how setprecision rounds a
2  // floating point value.
3  #include <iostream>
4  #include <iomanip>
5  using namespace std;
6
7  int main()
8  {
9       double quotient, number1 = 132.364, number2 = 26.91;
10                132.364/26.91 = 4.91877
11      quotient = number1 / number2;
12      cout << quotient << endl;
13      cout << setprecision(5) << quotient << endl;
14      cout << setprecision(4) << quotient << endl;
15      cout << setprecision(3) << quotient << endl;
16      cout << setprecision(2) << quotient << endl;
17      cout << setprecision(1) << quotient << endl;
18      return 0;
19 }
```

Program Output

```
4.91877
4.9188
4.919
4.92
4.9
5
```

Stream Manipulators

Stream Manipulator	Description
`setw(n)`	Establishes a print field of *n* spaces.
`fixed`	Displays floating-point numbers in fixed point notation.
`showpoint`	Causes a decimal point and trailing zeroes to be displayed, even if there is no fractional part.
`setprecision(n)`	Sets the precision of floating-point numbers.
`left`	Causes subsequent output to be left justified.
`right`	Causes subsequent output to be right justified.

Stream Manipulators

Number	Manipulator	Value Displayed
28.92786	setprecision(3)	
21	setprecision(5)	
109.5	setprecision(4)	
34.28596	setprecision(2)	

Stream Manipulators

- La cantidad "default" de dígitos es 6 cifras significativas. En ausencia de formato, si el valor es mayor de 6 cifras, es cambiado a notación científica.
- `setw(x)` : ancho de la "celda" en donde se va a escribir. Si la cantidad que se entra tiene mas de `x` cifras, automáticamente se ajusta (redondea) al número de cifras entrado, dentro del límite de 6 (a menos que se use `fixed`).
- `fixed`: fuerza punto decimal (evita notación científica). Exactamente 6 cifras luego del punto si no hay ningún otro parámetro. Si el valor tiene mas de 6 cifras luego del punto, redondea.
- `setprecision(x)` : `x` es la cantidad de cifras significativas que se desplegarán. Si el valor tiene mas de `x` cifras, usa notación científica (a menos que se use `fixed`) o redondea. Cuando se usa con `fixed`, fija la cantidad de dígitos luego del punto decimal.

3.9

More Mathematical Library Functions

More Mathematical Library Functions

- Require `cmath` header file
- Take `double` as input, return a `double`
- Commonly used functions:

`sin`	Sine
`cos`	Cosine
`tan`	Tangent
`sqrt`	Square root
`log`	Natural (`e`) log
`abs`	Absolute value (takes and returns an `int`)

More Mathematical Library Functions

- These require `cstdlib` header file
- `rand()`: returns a random number (`int`) between `0` and the largest `int` the compute holds. Yields same sequence of numbers each time program is run.
- `srand(x)`: initializes random number generator with `unsigned int x.`

3.10

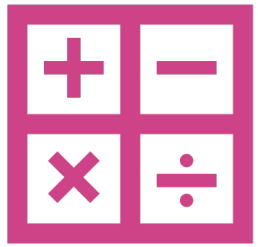
Hand Tracing a Program

Hand Tracing a Program

Hand trace a program: act as if you are the computer, executing a program:

step through and ‘execute’ each statement, one-by-one

record the contents of variables after statement execution, using a hand trace chart (table)



Useful to locate logic or mathematical errors.

Program with Hand Trace Chart

```
1  // This program asks for three numbers, then
2  // displays the average of the numbers.
3  #include <iostream>
4  using namespace std;

5  int main()

6  {

7     double num1, num2, num3, avg;

8     cout << "Enter the first number: ";

9     cin >> num1;

10    cout << "Enter the second number: ";

11    cin >> num2;

12    cout << "Enter the third number: ";

13    cin >> num3;

14    avg = num1 + num2 + num3 / 3;

15    cout << "The average is " << avg << en

16    return 0;

17 }
```

num1	num2	num3	avg
?	?	?	?
?	?	?	?
10	?	?	?
10	?	?	?
10	20	?	?
10	20	?	?
10	20	30	?
10	20	30	40
10	20	30	40

3.8

Working with Characters and `string` Objects

Working with Characters and `string` Objects

- Using `cin` with the >> operator to input strings can cause problems:
  - It passes over and ignores any leading *whitespace characters (spaces, tabs, or line breaks)*.
- To work around this problem, you can use a C++ function named `getline`.

Working with Characters and `string` Objects

```
1  // This program demonstrates using the getline function
2  // to read character data into a string object.
3  #include <iostream>
4  #include <string>
5  using namespace std;
6
7  int main()
8  {
9     string name;
10    string city;
11
12    cout << "Please enter your name: ";
13    getline(cin, name);
14    cout << "Enter the city you live in: ";
15    getline(cin, city);
16
17    cout << "Hello, " << name << endl;
18    cout << "You live in " << city << endl;
19    return 0;
20 }
```

Program Output with Example Input Shown in Bold

```
Please enter your name: Kate Smith [Enter]
Enter the city you live in: Raleigh [Enter]
Hello, Kate Smith
You live in Raleigh
```

Working with Characters and `string` Objects

- To read a single character:
  - Use `cin`:

```
char ch;
cout << "Strike any key to continue";
cin >> ch;
```

    Problem: will skip over blanks, tabs, <CR>
  - Use `cin.get()`:

```
cin.get(ch);
```

    Will read the next character entered, even whitespace

Working with Characters and `string` Objects

```
1  // This program demonstrates three ways
2  // to use cin.get() to pause a program.
3  #include <iostream>
4  using namespace std;
5
6  int main()
7  {
8     char ch;
9
10    cout << "This program has paused. Press Enter to continue.";
11    cin.get(ch);
12    cout << "It has paused a second time. Please press Enter again.";
13    ch = cin.get();
14    cout << "It has paused a third time. Please press Enter again.";
15    cin.get();
16    cout << "Thank you!";
17    return 0;
18 }
```

Program Output with Example Input Shown in Bold

```
This program has paused. Press Enter to continue. [Enter]
It has paused a second time. Please press Enter again. [Enter]
It has paused a third time. Please press Enter again. [Enter]
Thank you!
```

Working with Characters and `string` Objects

- Mixing `cin >>` and `cin.get()` in the same program can cause input errors that are hard to detect.
- To skip over unneeded characters that are still in the keyboard buffer, use `cin.ignore()`:

```
cin.ignore();          // skip next char
cin.ignore(10,'\n');   // skip the next 10 char. or
                       // until a '\n'
```

`string` Member Functions and Operators

- To find the length of a string:

```
string state = "Texas";
int size = state.length();
```

- To concatenate (join) multiple strings:

```
greeting2 = greeting1 + name1;
greeting1 = greeting1 + name2;
```

Or using the **+=** combined assignment operator:

```
greeting1 += name2;
```