Chapter 3: Expressions and Interactivity

Starting Out with C++
Early Objects
Eighth Edition

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Topics

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3.2 Mathematical Expressions

3.3 Data Type Conversion and Type Casting

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Topics (continued)

3.6 Multiple and Combined Assignment

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3.8 Working with Characters and Strings

3.9 Using C-Strings

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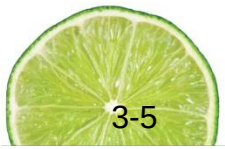
3.1 The `cin` Object

- Standard input object
- Like **`cout`**, requires **`iostream`** file
- Used to read input from keyboard
- Often used with **`cout`** to display a user prompt first
- Data is retrieved from **`cin`** with **`>>`**
- Input data is stored in one or more variables

The `cin` Object

- User input goes from keyboard to the input buffer, where it is stored as characters
- **`cin`** converts the data to the type that matches the variable

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

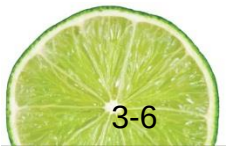


The `cin` Object

- Can be used to input multiple values

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

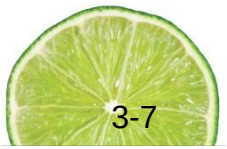
- Multiple values from keyboard must be separated by spaces or [Enter]
- Must press [Enter] after typing last value
- Multiple values need not all be of the same type
- Order is important; first value entered is stored in first variable, etc.



3.2 Mathematical Expressions

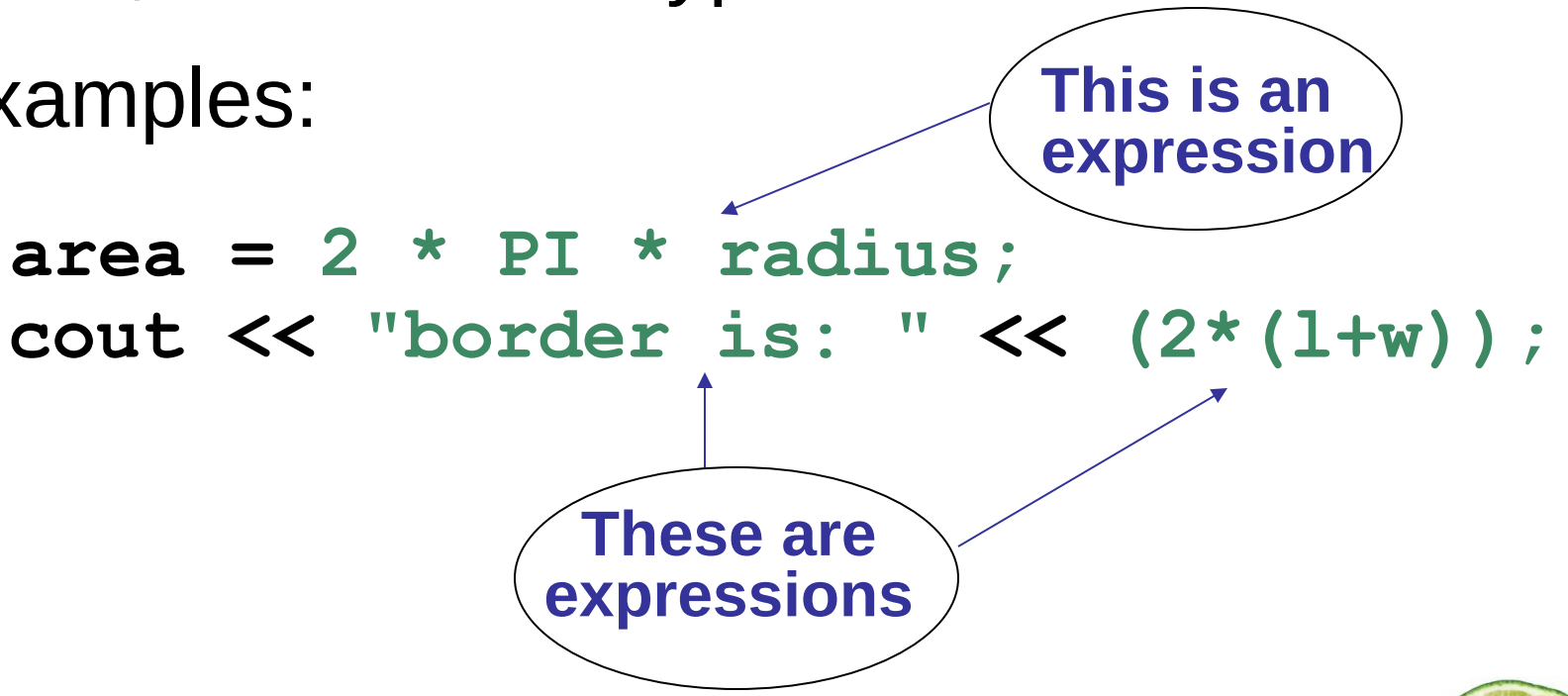
- An expression can be a constant, a variable, or a combination of constants and variables combined with operators
- Can create complex expressions using multiple mathematical operators
- Examples of mathematical expressions:

```
   2
height
a + b / c
```

Using Mathematical Expressions

- Can be used in assignment statements, with **`cout`**, and in other types of statements
- Examples:



Order of Operations

- In an expression with > 1 operator, evaluate in this order

Do first: ( ) expressions in parentheses

Do next: - (unary negation) in order, left to right

Do next: * / % in order, left to right

Do last: + - in order, left to right

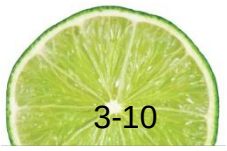
- In the expression `2 + 2 * 2 - 2 ,`

Evaluate 2nd **Evaluate 1st** **Evaluate 3rd**

Associativity of Operators

- `-` (unary negation) associates right to left
- `*  /  %  +  -` all 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
```



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);`

  (note: **`pow`** requires the **`cmath`** header file)

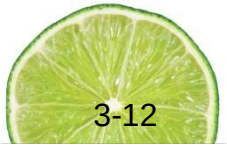
- Parentheses may be needed to maintain order of operations

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

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

3.3 Data Type Conversion and Type Casting

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



Hierarchy of Data Types

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

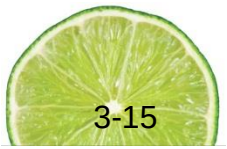
- Ranked by largest number they can hold

Type Coercion

- Coercion: automatic conversion of an operand to another data type
- Promotion: converts to a higher type
- Demotion: converts to a lower type

Coercion Rules

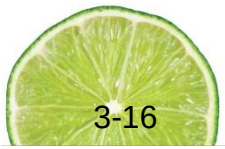
1) **`char`**, **`short`**, **`unsigned short`** are automatically promoted to **`int`**
2) When operating on values of different data types, the lower-ranked one is promoted to the type of the higher one.
3) When using the **`=`** operator, the type of expression on right will be converted to the type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



Coercion Rules – Important Notes

1) If demotion is required to use the = operator,
   - the stored result may be incorrect if there is not enough space available in the receiving variable
   - floating-point values are truncated when assigned to integer variables

2) Coercion affects the value used in a calculation. It does not change the type associated with a variable.



Type Casting

- Used for manual data type conversion
- Format

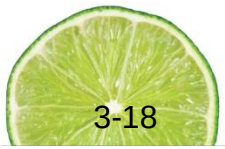
```
static_cast<Data Type>(Value)
```

- Example:

```
cout << static_cast<int>(4.2);
                        // Displays 4
```

More Type Casting Examples

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

gallons = static_cast<int>(area/500);

avg = static_cast<double>(sum)/count;
```



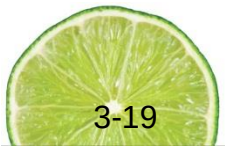
Older Type Cast Styles

```
double Volume = 21.58;
int intVol1, intVol2;
intVol1 = (int) Volume; // C-style
                        // cast
intVol2 = int (Volume); //Prestandard
                        // C++ style
                        // cast
```

C-style cast uses prefix notation

Prestandard C++ cast uses functional notation

`static_cast` is the current standard

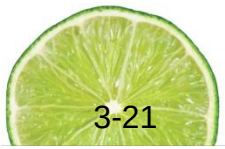


3.4 Overflow and Underflow

- Occurs when assigning a value that is too large (overflow) or too small (underflow) to be held in a variable
- The variable contains a value that is ‘wrapped around’ the set of possible values

Overflow Example

```
// Create a short int initialized to
// the largest value it can hold
short int num = 32767;

cout << num;      // Displays 32767
num = num + 1;
cout << num;      // Displays -32768
```



Handling Overflow and Underflow

Different systems handle the problem differently. They may

- display a warning / error message, or display a dialog box and ask what to do
- stop the program
- continue execution with the incorrect value

3.5 Named Constants

- Also called constant variables
- Variables whose content cannot be changed during program execution
- Used for representing constant values with descriptive names

```
const double TAX_RATE = 0.0675;
const int NUM_STATES = 50;
```

- Often named in uppercase letters

Benefits of Named Constants

- Makes program code more readable by documenting the purpose of the constant in the name:

```
const double TAX_RATE = 0.0675;

…

salesTax = purchasePrice * TAX_RATE;
```

- Simplifies program maintenance:

```
const double TAX_RATE = 0.0725;
```

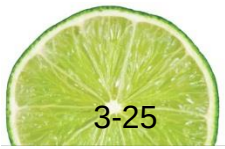
`const` vs. `#define`

`#define`

- C-style of naming constants

  ```
  #define NUM_STATES 50
  ```

- Interpreted by pre-processor rather than compiler
- Does not occupy a memory location like a constant variable defined with **`const`**
- Instead, causes a text substitution to occur. In above example, every occurrence in program of `NUM_STATES` will be replaced by `50`



3.6 Multiple and Combined Assignment

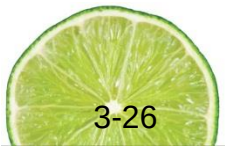
- The assignment operator (=) can be used multiple times in an expression

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

- Associates right to left

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

Done 3rd — Done 2nd — Done 1st



Combined Assignment

- Applies an arithmetic operation to a variable and assigns the result as the new value of that variable
- Operators: `+=` `-=` `*=` `/=` `%=`
- Also called compound operators or arithmetic assignment operators
- Example:

```
sum += amt;
```
is short for
```
sum = sum + amt;
```

More Examples

```
x += 5;   means   x = x + 5;
x -= 5;   means   x = x - 5;
x *= 5;   means   x = x * 5;
x /= 5;   means   x = x / 5;
x %= 5;   means   x = x % 5;
```

The right hand side is evaluated before the combined assignment operation is done.

```
x *= a + b;   means   x = x * (a + b);
```

3.7 Formatting Output

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

Stream Manipulators

- Used to control features of an output field
- Some affect just the next value displayed
  - `setw(x)`: Print in a field at least `x` spaces wide. It will use more spaces if specified field width is not big enough.

Stream Manipulators

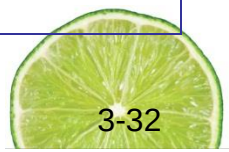
- Some affect values until changed again
  - **`fixed`**: Use decimal notation (not E-notation) for floating-point values.
  - **`setprecision(x)`**:
    - When used with **`fixed`**, print floating-point value using **`x`** digits after the decimal.
    - Without **`fixed`**, print floating-point value using **`x`** significant digits.
  - **`showpoint`**: Always print decimal for floating-point values.
  - **`left, right`**: left-, right justification of value

Manipulator Examples

```
const float e = 2.718;
float price = 18.0;
cout << setw(8) << e << endl;
cout << left << setw(8) << e
     << endl;
cout << setprecision(2);
cout << e << endl;
cout << fixed << e << endl;
cout << setw(6) << price;
```

Displays

```
^^^2.718

2.718^^^

2.7
2.72
^18.00
```



3.8 Working with Characters and Strings

- **`char`**: holds a single character
- **`string`**: holds a sequence of characters
- Both can be used in assignment statements
- Both can be displayed with **`cout`** and **`<<`**

String Input

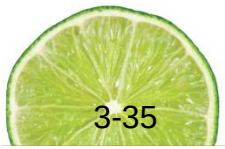
Reading in a string object

```
string str;

cin >> str;                  // Reads in a string
                             // with no blanks

getline(cin, str);           // Reads in a string
                             // that may contain
                             // blanks
```

Character Input

Reading in a character:

```
char ch;
cin >> ch;      // Reads in any non-blank char
cin.get(ch);    // Reads in any char
ch = cin.get;   // Reads in any char
cin.ignore();   // Skips over next char in
                // the input buffer
```

String Operators

= Assigns a value to a string

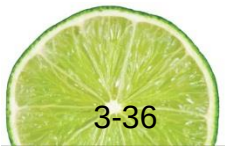
```
string words;
words = "Tasty ";
```

+ Joins two strings together

```
string s1 = "hot", s2 = "dog";
string food = s1 + s2; // food = "hotdog"
```

+= Concatenates a string onto the end of another one

```
words += food; // words now = "Tasty hotdog"
```

string Member Functions

- **`length()`** – the number of characters in a string

```
string firstPrez="George Washington";
int size=firstPrez.length(); // size is 17
```

- assign() – put repeated characters in a string. Can be used for formatting output.

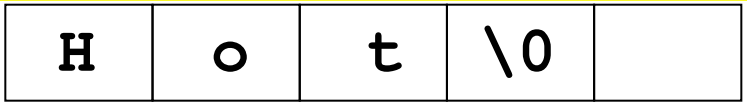
```
string equals;
equals.assign(80,'=');
…
cout << equals << endl;
cout << "Total: " << total << endl;
```

3.9 Using C-Strings

- C-string is stored as an array of characters
- Programmer must indicate maximum number of characters at definition

```
const int SIZE = 5;
char temp[SIZE] = "Hot";
```

- NULL character (`\0`) is placed after final character to mark the end of the string



Programmer must make sure array is big enough for desired use; `temp` can hold up to 4 characters plus the `\0`.

C-String Input

- Reading in a C-string

```
const int SIZE = 10;
char Cstr[SIZE];
cin >> Cstr;     // Reads in a C-string with no
                 // blanks. Will write past the
                 // end of the array if input string
                 // is too long.
cin.getline(Cstr, 10);
                 // Reads in a C-string that may
                 // contain blanks. Ensures that <= 9
                 // chars are read in.
```

- Can also use **`setw()`** and **`width()`** to control input field widths

C-String Initialization vs. Assignment

- A C-string can be initialized at the time of its creation, just like a string object

```
const int SIZE = 10;

char month[SIZE] = "April";
```

- However, a C-string cannot later be assigned a value using the = operator; you must use the **`strcpy()`** function

```
char month[SIZE];
month = "August"              // wrong!
strcpy(month, "August"); //correct
```

C-String and Keyboard Input

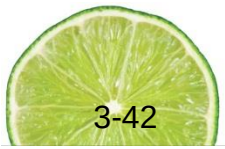
- Must use **`cin.getline()`** to put keyboard input into a C-string
- Note that **`cin.getline() ≠ getline()`**
- Must indicate the target C-string and maximum number of characters to read:

```
const int SIZE = 25;
char name[SIZE];
cout << "What's your name? ";
cin.getline(name, SIZE);
```

3.10 More Mathematical Library Functions

- These require **`cmath`** header file
- Take **`double`** arguments and return a **`double`**
- Commonly used functions

`abs`	Absolute value
`sin`	Sine
`cos`	Cosine
`tan`	Tangent
`sqrt`	Square root
`log`	Natural (e) log
`pow`	Raise to a power



More Mathematical Library Functions

These require **`cstdlib`** header file

- **`rand`**
  - Returns a random number between **`0`** and the largest **`int`** the computer holds
  - Will yield the same sequence of numbers each time the program is run
- **`srand(x)`**
  - Initializes random number generator with **`unsigned int x`**. **`x`** is the "seed value".
  - Should be called at most once in a program

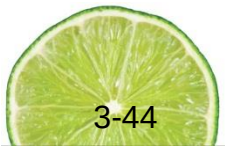
More on Random Numbers

- Use **`time()`** to generate different seed values each time that a program runs:

```
#include <ctime> //needed for time()
…
unsigned seed = time(0);
srand(seed);
```

- Random numbers can be scaled to a range:

```
int max=6;
int num;
num = rand() % max + 1;
```



Chapter 3: Expressions and Interactivity

The End!!!