# ENGINEERING PROGRAMMING I

# Chapter 03

2017

# Topics

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# Implicit Type Conversion

- Operations are performed between operands of the same type
- If not of 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
int
unsigned short
short
char
```

- Lowest
- 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`**

```
eg) int X = 'a';
    cout << X << endl;  // prints out 97
```

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 the type of variable on left

# ASCII (American Standard Code for Information Interchange)

# ASCII TABLE

| Decimal | Hex | Char | Decimal | Hex | Char | Decimal | Hex | Char | Decimal | Hex | Char |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | [NULL] | 32 | 20 | [SPACE] | 64 | 40 | @ | 96 | 60 | ` |
| 1 | 1 | [START OF HEADING] | 33 | 21 | ! | 65 | 41 | A | 97 | 61 | a |
| 2 | 2 | [START OF TEXT] | 34 | 22 | " | 66 | 42 | B | 98 | 62 | b |
| 3 | 3 | [END OF TEXT] | 35 | 23 | # | 67 | 43 | C | 99 | 63 | c |
| 4 | 4 | [END OF TRANSMISSION] | 36 | 24 | $ | 68 | 44 | D | 100 | 64 | d |
| 5 | 5 | [ENQUIRY] | 37 | 25 | % | 69 | 45 | E | 101 | 65 | e |
| 6 | 6 | [ACKNOWLEDGE] | 38 | 26 | & | 70 | 46 | F | 102 | 66 | f |
| 7 | 7 | [BELL] | 39 | 27 | ' | 71 | 47 | G | 103 | 67 | g |
| 8 | 8 | [BACKSPACE] | 40 | 28 | ( | 72 | 48 | H | 104 | 68 | h |
| 9 | 9 | [HORIZONTAL TAB] | 41 | 29 | ) | 73 | 49 | I | 105 | 69 | i |
| 10 | A | [LINE FEED] | 42 | 2A | * | 74 | 4A | J | 106 | 6A | j |
| 11 | B | [VERTICAL TAB] | 43 | 2B | + | 75 | 4B | K | 107 | 6B | k |
| 12 | C | [FORM FEED] | 44 | 2C | , | 76 | 4C | L | 108 | 6C | l |
| 13 | D | [CARRIAGE RETURN] | 45 | 2D | - | 77 | 4D | M | 109 | 6D | m |
| 14 | E | [SHIFT OUT] | 46 | 2E | . | 78 | 4E | N | 110 | 6E | n |
| 15 | F | [SHIFT IN] | 47 | 2F | / | 79 | 4F | O | 111 | 6F | o |
| 16 | 10 | [DATA LINK ESCAPE] | 48 | 30 | 0 | 80 | 50 | P | 112 | 70 | p |
| 17 | 11 | [DEVICE CONTROL 1] | 49 | 31 | 1 | 81 | 51 | Q | 113 | 71 | q |
| 18 | 12 | [DEVICE CONTROL 2] | 50 | 32 | 2 | 82 | 52 | R | 114 | 72 | r |
| 19 | 13 | [DEVICE CONTROL 3] | 51 | 33 | 3 | 83 | 53 | S | 115 | 73 | s |
| 20 | 14 | [DEVICE CONTROL 4] | 52 | 34 | 4 | 84 | 54 | T | 116 | 74 | t |
| 21 | 15 | [NEGATIVE ACKNOWLEDGE] | 53 | 35 | 5 | 85 | 55 | U | 117 | 75 | u |
| 22 | 16 | [SYNCHRONOUS IDLE] | 54 | 36 | 6 | 86 | 56 | V | 118 | 76 | v |
| 23 | 17 | [ENG OF TRANS. BLOCK] | 55 | 37 | 7 | 87 | 57 | W | 119 | 77 | w |
| 24 | 18 | [CANCEL] | 56 | 38 | 8 | 88 | 58 | X | 120 | 78 | x |
| 25 | 19 | [END OF MEDIUM] | 57 | 39 | 9 | 89 | 59 | Y | 121 | 79 | y |
| 26 | 1A | [SUBSTITUTE] | 58 | 3A | : | 90 | 5A | Z | 122 | 7A | z |
| 27 | 1B | [ESCAPE] | 59 | 3B | ; | 91 | 5B | [ | 123 | 7B | { |
| 28 | 1C | [FILE SEPARATOR] | 60 | 3C | < | 92 | 5C | \ | 124 | 7C | \| |
| 29 | 1D | [GROUP SEPARATOR] | 61 | 3D | = | 93 | 5D | ] | 125 | 7D | } |
| 30 | 1E | [RECORD SEPARATOR] | 62 | 3E | > | 94 | 5E | ^ | 126 | 7E | ~ |
| 31 | 1F | [UNIT SEPARATOR] | 63 | 3F | ? | 95 | 5F | _ | 127 | 7F | [DEL] |

# Convert char to int

- ```
  char ch;
  cin >> ch;

  int n;
  if (ch >= '0' && ch <= '9'){
      n = ch - '0';
  }
  ```
  ```

# Explicit Type Conversion

- Also called type casting
- Used for manual data type conversion
- Format

  **static_cast<*type*>(*expression*)**

- Example:

```
cout << static_cast<char>(65); // Displays 'A'
cout << (char) 65;
cout << char(65);
```

# 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

# Overflow and Underflow

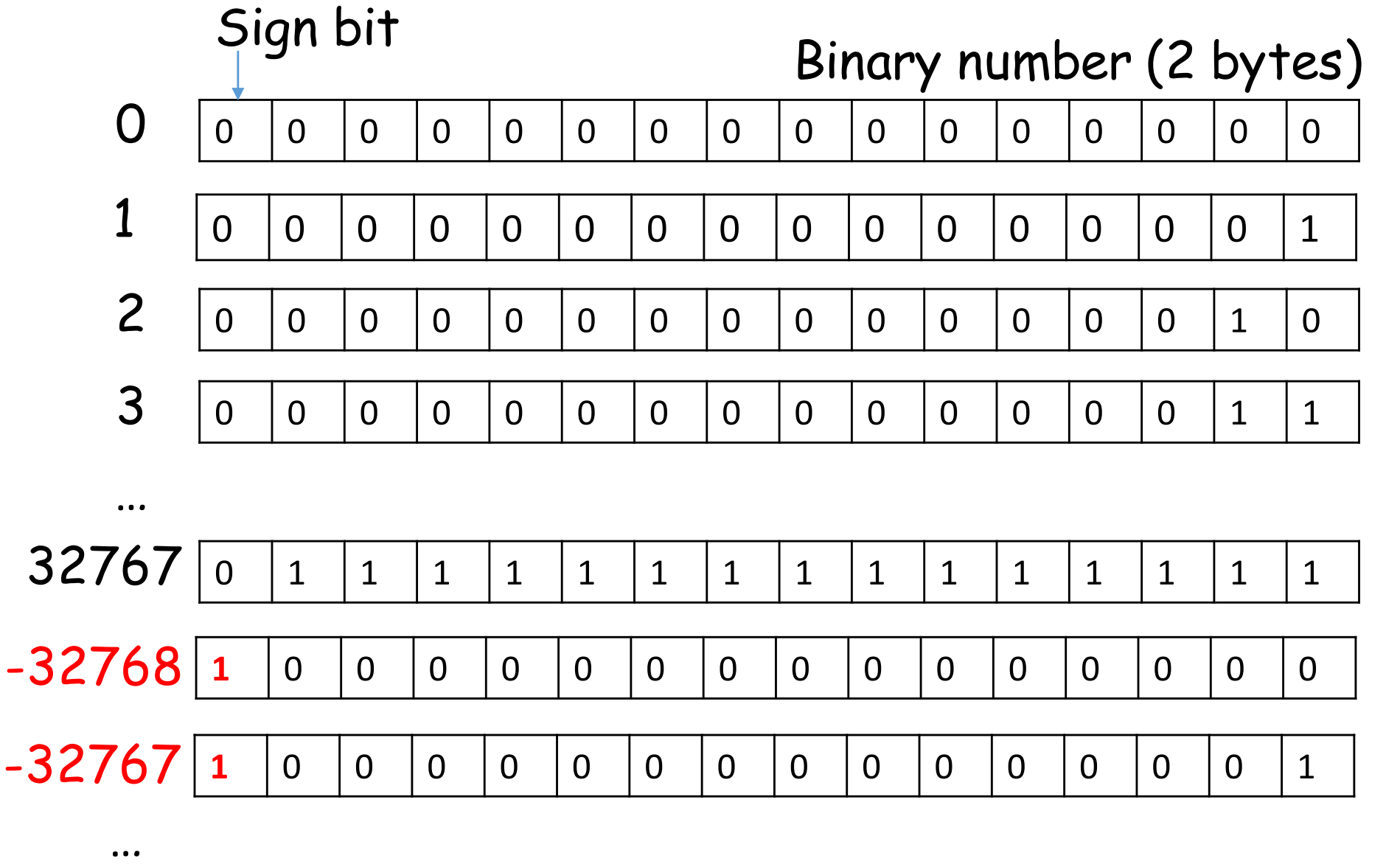
- Occurs when assigning a value that is too large (overflow) or too small (underflow) to be held in a variable
- The variable contains a value that is 'wrapped around' the set of possible values

# Overflow Example

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

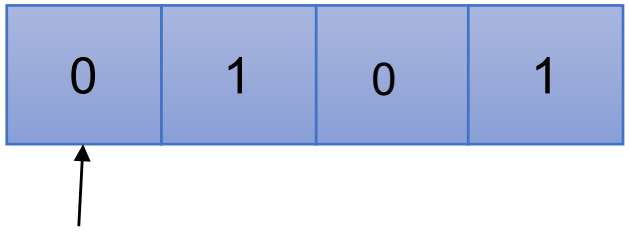
cout << num;      // Displays 32767
num = num + 1;
cout << num;      // Displays -32768
```

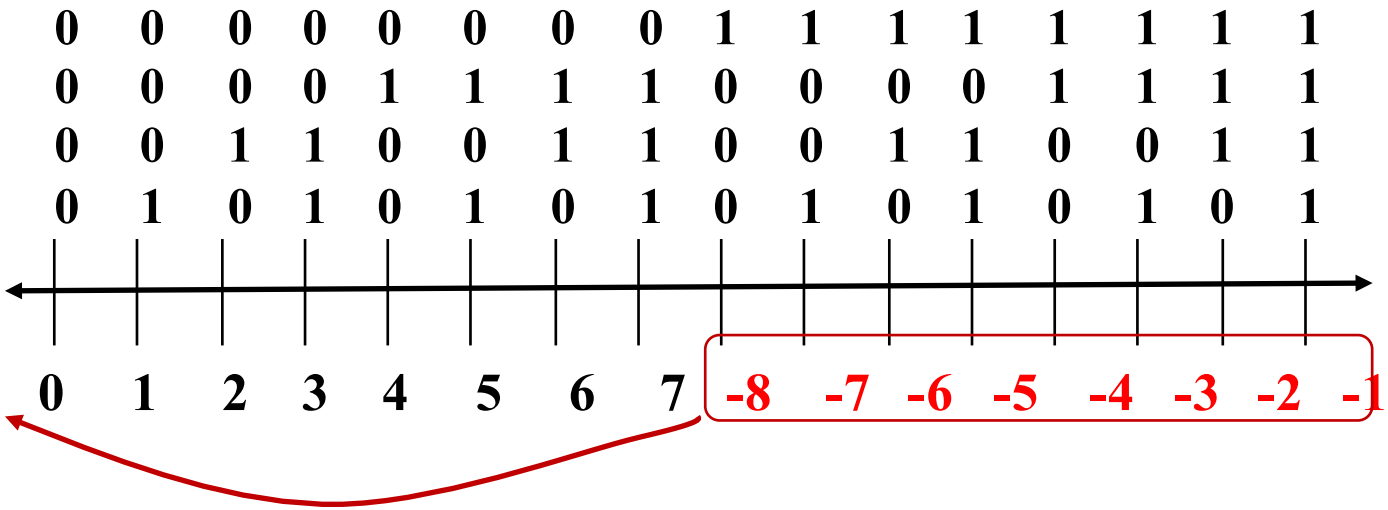
# Overflow


Sign bit
Binary number (2 bytes)
0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
1
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
2
0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0
3
0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1
...
32767
0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
-32768
1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
-32767
1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
...

# Signed Number (Two's Complement)

```
0000 = 0
0001 = 1
0010 = 2
0011 = 3
0100 = 4
0101 = 5
0110 = 6
0111 = 7
1000 = -8
1001 = -7
1010 = -6
1011 = -5
1100 = -4
1101 = -3
1110 = -2
1111 = -1
```




2's complement can be obtained by taking the 1's complement and adding one to the least significant bit.

# 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

# 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**

# Multiple and Combined Assignment

- The assignment operator (=) can be used more than 1 time 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: `+=` `-=` `*=` `/=` `%=`
- 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);
```

# 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. 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
```

# Working with Characters and String Objects

- `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

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"
```

# 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.

| H | o | t | \0 | |
|---|---|---|---|---|

# C-String and Null

- `char temp[3] = "hot"; //what is wrong?`

- A string literal contains a Null at the end

- ```
  char temp[3];
  temp[0] = 'h';
  temp[1] = 'o';
  temp[2] = 't';
  cout << temp << endl;
  ```
  ```

# 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
```

# 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 |

# Introduction to Files

- Can use a file instead of keyboard for program input
- Can use a file instead of monitor screen for program output
- Files are stored on secondary storage media, such as disk
- Files allow data to be retained between program executions

# What is Needed to Use Files

1. Include the **`fstream`** header file
2. Define a file stream object
   - **`ifstream`** for input from a file

     ```
     ifstream inFile;
     ```
   - **`ofstream`** for output to a file

     ```
     ofstream outFile;
     ```

# Open the File

3. Open the file

- Use the **open** member function

```
inFile.open("inventory.dat");
outFile.open("report.txt");
```

- Filename may include drive, path info.
- Output file will be created if necessary; existing output file will be erased first
- Input file must exist for **open** to work

# Use the File

4. Use the file

- Can use output file object and << to send data to a file

```
outFile << "Inventory report";
```

- Can use input file object and >> to copy data from file to variables

```
inFile >> partNum;
inFile >> qtyInStock >> qtyOnOrder;
```

# Close the File

5. Close the file

- Use the `close` member function

```
inFile.close();
outFile.close();
```

- Don't wait for operating system to close files at program end
  - May be limit on number of open files
  - May be buffered output data waiting to be sent to a file that could be lost

# Chapter 3: Expressions and Interactivity

Starting Out with C++
Early Objects
Seventh Edition

by Tony Gaddis, Judy Walters,
and Godfrey Muganda

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