

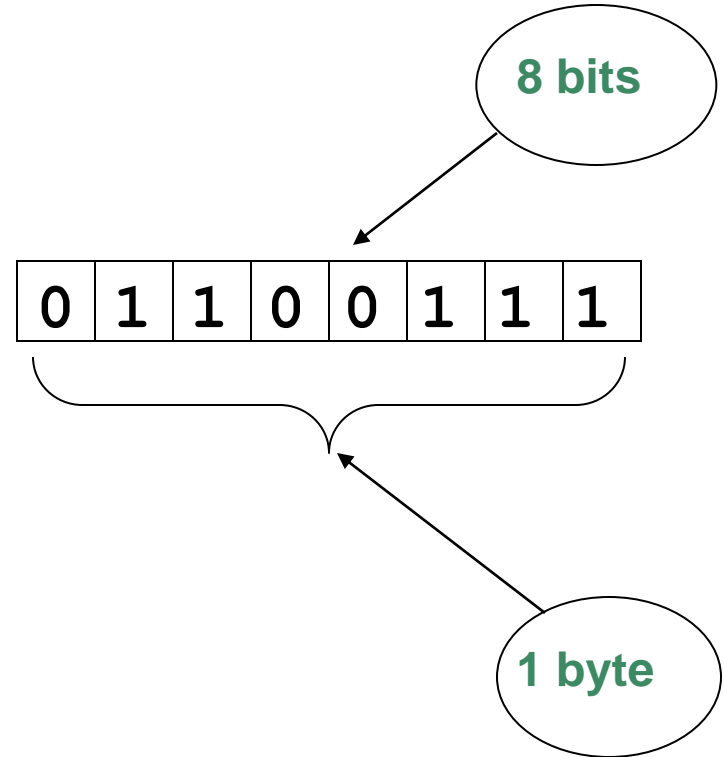
# Exercise: Using Numbers

- Problem: You are a spy going into an evil party to find the super-secret code phrase (made up of letters and spaces), which you will immediately send via text message to your team to prevent, oh, let's say a volcano from destroying the Earth. Unfortunately, you're a poor spy and your phone can only type digits (0-9). It can't even type spaces!

Quickly! Before you are sent in, figure out what you can tell your team that will allow you to get the code phrase out to them.

# Main Memory Organization

- **Bit**
  - Smallest piece of memory
  - Stands for binary digit
  - Has values 0 (off) or 1 (on)
- **Byte**
  - Is 8 consecutive bits
- **Word**
  - Usually 4 consecutive bytes
  - Has an address



# Data Storage

- All data is stored in binary bits in main memory
- The meaning of a set of bits depends on the *encoding*
  - Encoding determines the length of a meaningful chunk
  - We use bytes (8-bits) as our most common unit
  - Encoding also determines how those bits should be read

8-bit Binary	8-bit Integer	8-bit Character (ASCII)
0100 0001	65	'A'
0100 0010	66	'B'
0100 0011	67	'C'

# Data Types and Conversion

- The data type assigned to a literal or variable tells the computer how it is encoded
  - That is, how to interpret it
- You can also tell the computer to treat a literal or variable with a different encoding
  - This is called *type casting* or *type coercion*

```
static_cast<dataTypeName>( expression )
```

# Simple Data Types

- Three categories of simple data
  - Integral: integers (numbers without a decimal)
  - Floating-point: decimal numbers
  - Enumeration type: user-defined data type

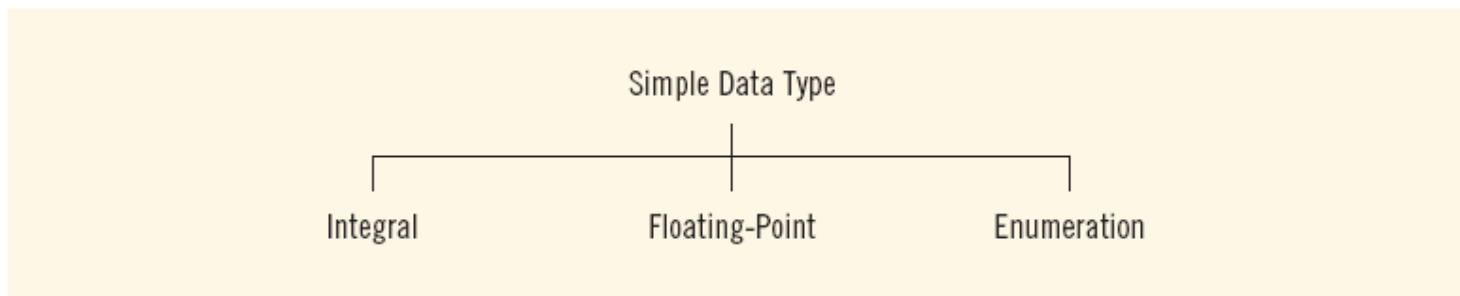


FIGURE 2-2 Simple data types

# Simple Data Types (continued)

- Integral data types are further classified into nine categories:

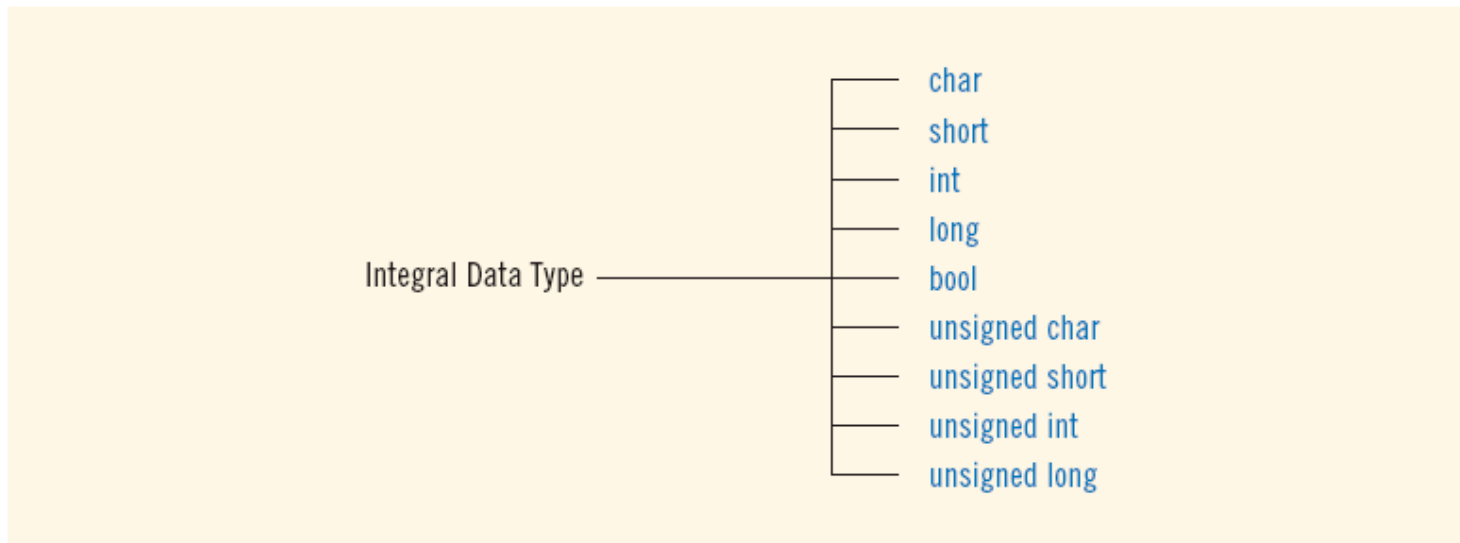


FIGURE 2-3 Integral data types

# int Data Type

- Examples:

-6728

0

78

+763

- Positive integers do not need a + sign
- No commas are used within an integer
  - Commas are used for separating items in a list

# char Data Type

- The smallest integral data type
- Used for characters: letters, digits, and special symbols
- Each character is enclosed in single quotes
  - 'A', 'a', '0', '\*', '+', '\$', '&', ' '
- A blank space is a character

# bool Data Type

- `bool` type
  - Two values: `true` and `false`
  - Manipulate logical (Boolean) expressions
- `true` and `false` are called logical values
- `bool`, `true`, and `false` are reserved words

# Simple Data Types

TABLE 2-2 Values and Memory Allocation for Three Simple Data Types

Data Type	Values	Storage (in bytes)
<code>int</code>	-2147483648 to 2147483647	4
<code>bool</code>	<code>true</code> and <code>false</code>	1
<code>char</code>	-128 to 127	1

- Different compilers may allow different ranges of values

# 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' 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
  - display a dialog box and ask what to do
  - stop the program
  - continue execution with the incorrect value

# Floating-Point Data Types

- C++ uses scientific notation to represent real numbers (floating-point notation)

TABLE 2-3 Examples of Real Numbers Printed in C++ Floating-Point Notation

Real Number	C++ Floating-Point Notation
75.924	7.592400E1
0.18	1.800000E-1
0.0000453	4.530000E-5
-1.482	-1.482000E0
7800.0	7.800000E3

# Floating-Point Data Types (continued)

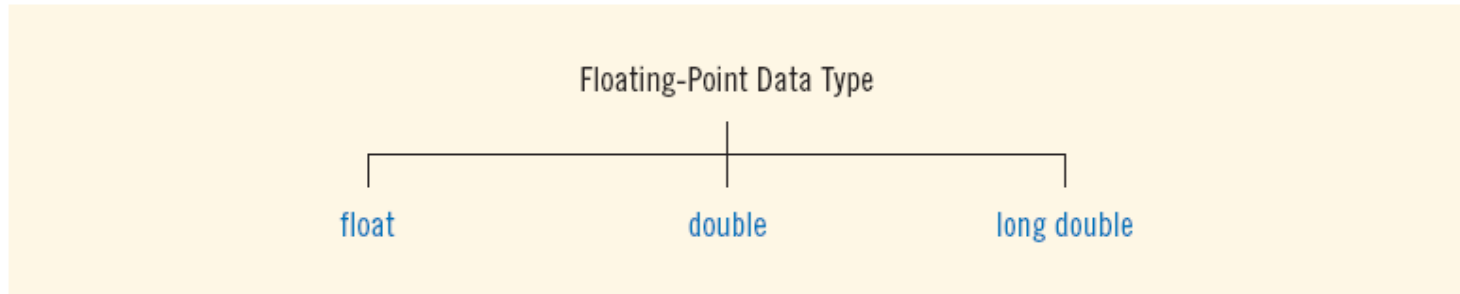


FIGURE 2-4 Floating-point data types

- `float`: represents any real number
  - Range:  $-3.4\text{E}+38$  to  $3.4\text{E}+38$  (four bytes)
- `double`: represents any real number
  - Range:  $-1.7\text{E}+308$  to  $1.7\text{E}+308$  (eight bytes)
- On most newer compilers, data types `double` and `long double` are same

# Floating-Point Data Types (continued)

- Maximum number of significant digits (decimal places) for float values is 6 or 7
- Maximum number of significant digits for double is 15
- Precision: maximum number of significant digits
  - Float values are called single precision
  - Double values are called double precision