Types, Values, Variables & Assignment

EECS 211

Winter 2017

Road map

- Strings and string I/O
- Integers and integer I/O
- Types and objects *
- Type safety

* Not as in object orientation—we'll get to that much later.

Input and output

```
#include <iostream>
#include <string>

using namespace std;

int main()
{
    cout << "Please enter your name: ";

    string first_name;
    cin >> first_name;

    cout << "Hello, " << first_name << '\n';
}
```

Using libraries

```
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#include <string>
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Includes the I/O stream library header, which lets us refer to cin and cout to do I/O, and the string library header, which lets us use strings.

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```
using namespace std;
```

Tells C++ to let us refer to things in the **st**andar**d** library without prefixing them with std::. Otherwise we'd have to write std::cin.

Main function

```
int main()
{

    ⋮

}
```

Wraps the *main function* of every program.

Input and type

```
string first_name;
cin >> first_name;
```

- We *define* a variable first_name to have type string
  - This means that first_name can hold textual data
  - The type of the variable determines what we can do with it
- Here, cin>>first_name; reads characters until it sees whitespace (“a word”)

Reading multiple words

```
int main()
{
        cout << ”Please enter your first and second names:\n”;

        string first;
        string second;
        cin >> first >> second;
        string name = first + ' ' + second;

        cout << "Hello, " << name << '\n';
}
```

Fine print: left out the includes and using, since every program will have those from now on

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means the same thing as

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- *i.e.,* operator>> is *left associative*
- (same deal for cout and operator<<)

Reading integers

```
int main()
{
	cout << ”Please enter your first name and age:\n”;

	string first_name;
	int age;
	cin >> first_name >> age;

	cout << "Hello, " << first_name << ", age "
		<< age << '\n';
}
```

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The type of a variable determines

- what operations are valid
- and what they mean for that type

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Which of these names are illegal? Why?

- purple line
- number_of_bees
- jflsiejslf_
- else
- timetomarket
- Fourier_transform
- 12x
- y2

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- contains only letters, digits, and underscores, and
- isn't a language keyword (*e.g.,* if).

Which of these names are illegal? Why?

- purple line (space not allowed)
- number_of_bees
- jflsiejslf_
- else (keyword)
- timetomarket (bad punctuation)
- Fourier_transform
- 12x (starts with a digit)
- y2

Also, don’t start a name with an underscore

The compiler might allow it, but technically such names are reserved for the system

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    - partial_sum
    - element_count
  - Bad:
    - the_number_of_elements
    - remaining_free_slots_in_the_symbol_table

Simple arithmetic

```
#include <cmath> // For sqrt
⋮
int main()
{
    cout << "Please enter a floating-point number: ";

    double f;
    cin >> f;

    cout <<   "f      == " << f
         << "\nf + 1 == " << f + 1
         << "\n2f     == " << 2 * f
         << "\n3f     == " << 3 * f
         << "\nf²     == " << f * f
         << "\n√f     == " << sqrt(f) << '\n';
}
```

A simple computation

```
#include <cmath>
#include <iostream>

using namespace std;

int main()
{
    double r;

    cout << "Please enter the radius: ";
    cin >> r;

    double c = 2 * M_PI * r;
    cout << "Circumference is " << c << '\n';
}
```

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string	varies	`"Hello, world!"` ‡

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‡ actually has type const char[], but converts automatically to string

Types

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  - (unsigned or signed) char
  - (unsigned) short
  - (unsigned) int
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- C++ programmers can define new types
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- The C++ standard library (STL) provides types
  - *e.g.,* string, vector, complex
  - technically these are user-defined, but they come with C++

Objects

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- A *variable* is a named object
- A *definition* names and creates an object
- A *initialization* fills in the initial value of a variable

Definition and initialization

```
int a;
```

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```
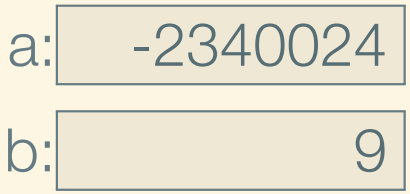

a: -2340024

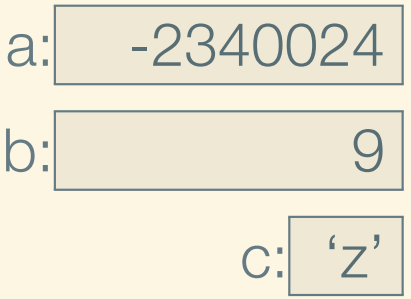
Definition and initialization

```
int a;
int b = 9;
```



Definition and initialization

```
int a;
int b = 9;
auto c = 'z';    // c is a char
```



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int a;
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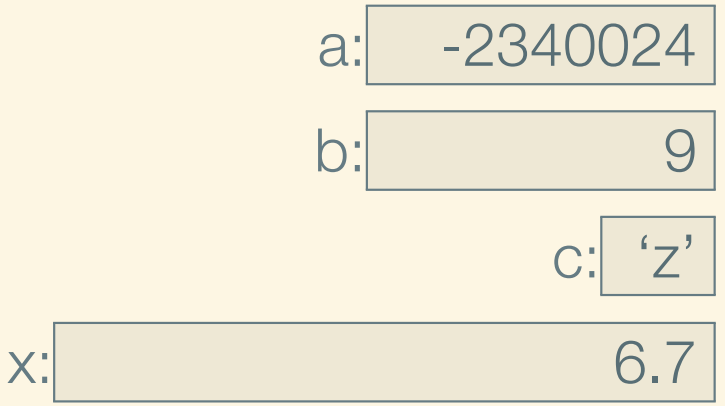
auto c = 'z';    // c is a char
double x = 6.7;
```



Definition and initialization

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string s = "hello!";
```

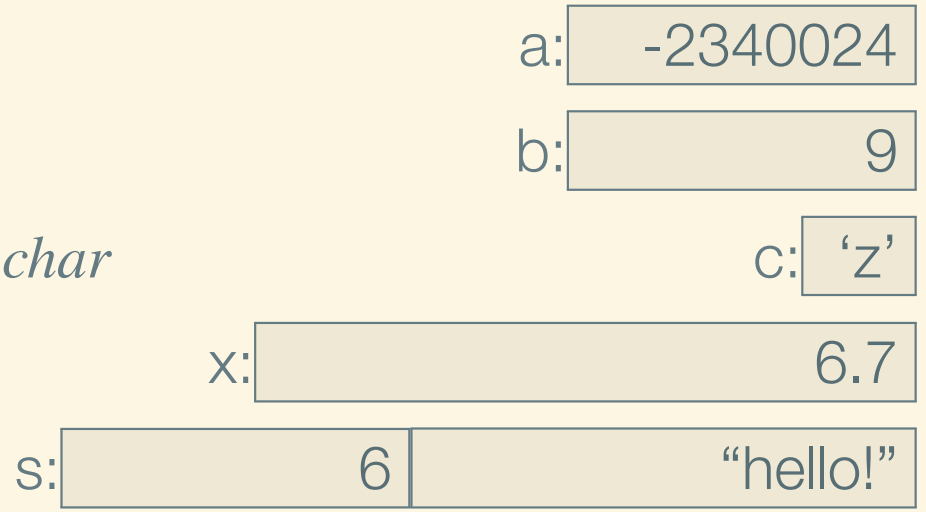

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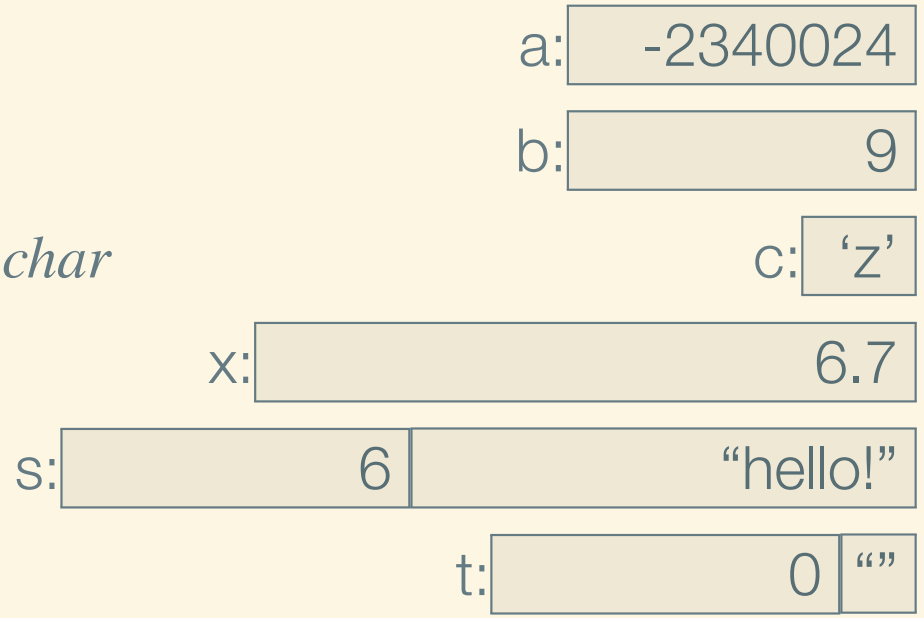

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Ideal: Dynamic type safety

- An operation that violates type safety will not be run
- The program or run-time system catches every potential violation

Assignment and increment

The value of a variable may change.

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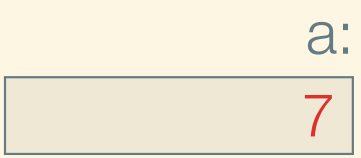
int a = 7;
```



Assignment and increment

The value of a variable may change.

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int a = 7;
a = 9;
```

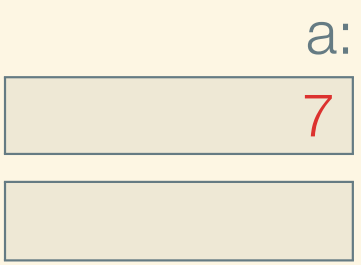

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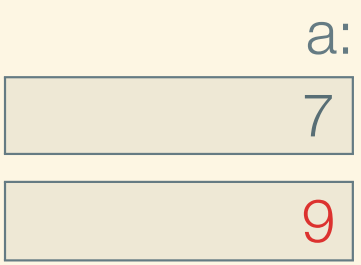

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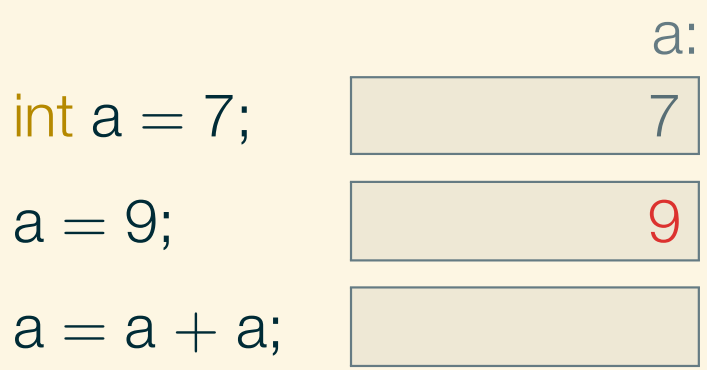

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`int a = 7;`	7
`a = 9;`	9
`a = a + a;`	18

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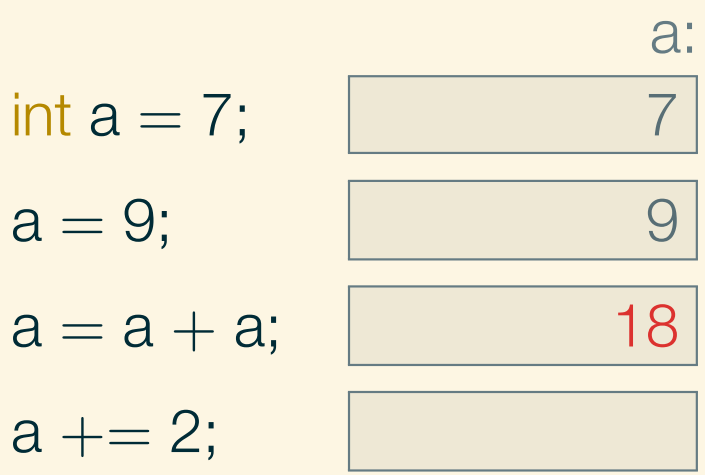

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`++a;`	21

A type safety violation: implicit narrowing

Beware! C++ does not prevent you from putting a large value into a small variable (though a compiler may warn)

```
int main()
{
        int a = 20000;
        char c = a;
        int b = c;

        if (a != b)        // != means "not equal"
                cout << "oops!: " << a << " != " << b << '\n';
        else
                cout << "Wow! We have large characters\n";
}
```

Try it to see what value b gets on your machine

A type-safety violation: uninitialized variables

Beware! C++ does not prevent you from trying to use a variable before you have initialized it (though a compiler typically warns)

```
int main()
{
        int x;          // x gets a "random" initial value
        char c;         // c gets a "random" initial value
        double d;       // d gets a "random" initial value

        // not every bit pattern is a valid floating-point value, and on some
        // implementations copying an invalid float/double is an error:
        double dd = d; // potential error: some implementations

        // prints garbage (if you're lucky):
        cout << " x: " << x << " c: " << c << " d: " << d << '\n';
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```

Always initialize your variables. Watch out: The debugger may initialize variables that don't get initialized when running normally

A technical detail

In memory, everything is just bits; type is what gives meaning to the bits:

- (bits/binary) 01100001 is the int `97` *and also* char `'a'`
- (bits/binary) 01000001 is the int `65` *and also* char `'A'`
- (bits/binary) 00110000 is the int `48` *and also* char `'0'`

```
char c = 'a';
cout << c;   // print the value of character c, which is 'a'
int i = c;
cout << i;   // print the integer value of the character c, which is 97
```

A word on efficiency

For now, don’t worry about “efficiency”

- Concentrate on correctness and simplicity of code

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  - a char is stored in a byte
  - an int is stored in a word
  - a double fits in a floating-point register
- C++'s built-in ops. map directly to machine instructions
  - $+$ on ints is implemented by an integer add operation
  - $=$ on ints is implemented by a simple copy operation
  - C++ provides direct access to most of facilities provided by modern hardware

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A bit of philosophy

- One of the ways that programming resembles other kinds of engineering is that it involves tradeoffs.
- You must have ideals, but they often conflict, so you must decide what really matters for a given program.
  - Type safety
  - Run-time performance
  - Ability to run on a given platform
  - Ability to run on multiple platforms with same results
  - Compatibility with other code and systems
  - Ease of construction
  - Ease of maintenance
- Don’t skimp on correctness or testing
- By default, aim for type safety and portability