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.
#include <eecs230.h>

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

    string first_name;
    cin >> first_name;

    cout << "Hello, " << first_name << 'n';
}
Header files

#include <eecs230.h>

Includes our course header file, which provides an interface to libraries, into your program
Input and type

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

- We *declare* 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”)
int main()
{
    cout << "Please enter your first and second names:\n";
    string first;
    string second;
    cin >> first >> second;
    string name = first + ' ' + second;
    cout << "Hello, " << first << ' ' << second << '\n';
}

Fine print: left out the include, since every program will have that from now on
Syntax of `cin`

```
cin >> a >> b;
```

means the same thing as

```
cin >> a;
cin >> b;
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- *i.e.*, operator `>>` is *left associative*
Syntax of cin

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IS THIS MAGIC? No, because

- `cin >> a` returns a reference to `cin`
- `cin >> a >> b` means `(cin >> a) >> b`
- *i.e.*, `operator>>` is *left associative*
- (same deal for `cout` and `operator<<`)
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';
}

### Integers and numbers

| string \( s \) | int \( x \) or double \( x \) |
Integers and numbers

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<th>int x or double x</th>
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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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Names, a/k/a identifiers

A legal name in C++

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Names, a/k/a identifiers

A legal name in C++

- starts with a letter,
- contains only letters, digits, and underscores, and

Illegal names:
- `purple line` (space not allowed)
- `number_of_bees`
- `jflsiejslf_`
- `else` (keyword)
- `time$to$market` (bad punctuation)
- `Fourier_transform`
- `12x` (starts with a digit)
- `y2`
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Which of these names are illegal? Why?

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- **number_of_bees**
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- **else** (keyword)
- **time$to$market** (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
Choose meaningful names

- Abbreviations and acronyms can be confusing: myw, bamf, TLA
Choose meaningful names

- Abbreviations and acronyms can be confusing: `myw`, `bamf`, `TLA`
- Very short names are meaningful only when there's a convention:
  - `x` is a local variable
  - `n` is an `int`
  - `i` is a loop index

The length of a name should be proportional to its scope

Don't use overly long names
- Good: `partial_sum`, `element_count`
- Bad: `the_number_of_elements`, `remaining_free_slots_in_the_symbol_table`
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  - Good:
    - partial_sum
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  - Bad:
    - the_number_of_elements
    - remaining_free_slots_in_the_symbol_table
int main()
{
    cout << "Please enter a floating-point number: ";
    double f;
    cin >> f;
    cout << "f == " << f << endl;
    cout << "f + 1 == " << f + 1 << endl;
    cout << "\n2f == " << 2 * f << endl;
    cout << "\n3f == " << 3 * f << endl;
    cout << "\nf² == " << f * f << endl;
    cout << "\n√f == " << sqrt(f) << endl;
}
A simple computation

```cpp
int main()
{
    double r;
    cout << "Please enter the radius: ";
    cin >> r;
    double c = 2 * M_PI * r;
    cout << "Circumference is " << c << '\n';
}
```
## Types and literals

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† stored as 8 bits
‡ actually has type const char[], but converts automatically to string
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C++ provides built-in types:

- bool
- (unsigned or signed) char
- (unsigned) short
- (unsigned) int
- (unsigned) long
- float
- double
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  - called “user-defined 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

- An *object* is some memory that can hold a value (of some particular type)
Objects

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Objects

- An *object* is some memory that can hold a value (of some particular type)
- A *variable* is a named object
- A *declaration* names an object
- A *initialization* fills in the initial value of a variable
int a;

int a;

a: -2340024

int b = 9;
b: 9

auto c = 'z';
c: 'z'

double x = 6.7;
x: 6.7

string s = "hello!";
s: "hello!

t: ""
int a; a: -2340024

int b = 9; b: 9

auto c = 'z'; // c is a char
c: 'z'

double x = 6.7; x: 6.7

string s = "hello!"; s: 6 "hello!"

string t; t: 0 ""
Declaration and initialization

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int b = 9;
```

```c
int a;
a: -2340024
int b = 9;
b: 9
```
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string s = "hello!";
string t;
Language rule: Type safety

Definition: In a *type safe* language, objects are used only according to their types.
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- Only operations defined for an object will be applied to it
- A variable will be used only after it has been initialized
- Every operation defined for a variable leaves the variable with a valid value
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Ideal: Static type safety

- A program that violates type safety will not compile
- The compiler reports every violation
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Ideal: Static type safety

- A program that violates type safety will not compile
- The compiler reports every violation

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.

int a = 7;
Assignment and increment

The value of a variable may change.

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

a: 7

```
a + a = 2;
```
Assignment and increment

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int a = 7;
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```
a = a + a;
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Assignment and increment

The value of a variable may change.

```plaintext
int a = 7;

a = 9;

a = a + a;
```

a: 7

9

20
Assignment and increment

The value of a variable may change.

```
int a = 7;
7
a = 9;
a = a + a;
18
```
Assignment and increment

The value of a variable may change.

```
int a = 7;
a = 9;
a = a + a;
a += 2;
```

a: 7 9 18
Assignment and increment

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```
int a = 7;
a = 9;
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The value of a variable may change.

```plaintext
int a = 7;
a = 9;
a = a + a;
a += 2;
++a;
```

a:

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```
int a = 7;
a = 9;
a = a + a;
a += 2;
++a;
```

```
a: 7 9 18 20 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)

```cpp
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)

```cpp
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:
    cout << " x: " << x << " c: " << c << " d: " << d << "\n";
}
```
A type-safety violation: uninitialized variables

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    // prints garbage:
    cout << " x: " << x << " c: " << c << " d: " << d << 'n';
}
```

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) \texttt{01100001} is the \texttt{int 97} and also \texttt{char 'a'}
- (bits/binary) \texttt{01000001} is the \texttt{int 65} and also \texttt{char 'A'}
- (bits/binary) \texttt{00110000} is the \texttt{int 48} and also \texttt{char '0'}

\begin{verbatim}
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
\end{verbatim}
A word on efficiency

For now, don’t worry about “efficiency”

- Concentrate on correctness and simplicity of code
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C++ is derived from C, low-level programming language

- C++’s built-in types map directly to computer main memory
  - 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