Types and Structs

Types make things better…and sometimes harder…but still better >:(

Recap

C++: Basic Syntax + the STL

Basic syntax

- Semicolons at EOL
- Primitive types (ints, doubles etc)
- Basic grammar rules

The STL

- Tons of general functionality
- Built in classes like maps, sets, vectors
- Accessed through the namespace std::

Standard C++: Basic Syntax + std library

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- Prim
  doub
- Basi

The STL

- Tons of general functionality
- Built in classes like maps, sets, vectors
- Accessed through the namespace std::
- Extremely powerful and well-maintained

Namespaces

- MANY things are in the `std::` namespace
  - e.g. **std::cout**, **std::cin**, **std::lower_bound**
- CS 106B always uses the `using namespace std;` declaration, which automatically adds **std::** for you
- We won't (most of the time)
  - it's not good style!

Today

- **Types**
- Intro to structs
- Sneak peek at streams!

C++ Fundamental Types

```
int val = 5; //32 bits
char ch = 'F'; //8 bits (usually)
float decimalVal1 = 5.0;  //32 bits (usually)
double decimalVal2 = 5.0;  //64 bits (usually)
bool bVal = true;  //1 bit
```

C++ Fundamental Types++

```
#include <string>
int val = 5; //32 bits
char ch = 'F'; //8 bits (usually)
float decimalVal1 = 5.0;  //32 bits (usually)
double decimalVal2 = 5.0;  //64 bits (usually)
bool bVal = true;  //1 bit
std::string str = "Frankie";
```

🧠 Fill in the types!

```
______ a = "test";
______ b = 3.2 * 5 - 1;
______ c = 5 / 2;

______ d(int foo) { return foo / 2; }
______ e(double foo) { return foo / 2; }
______ f(double foo) { return int(foo / 2); }

______ g(double c) {
    std::cout << c << std::endl;
}
```

Fill in the types!

```
string a = "test";
double b = 3.2 * 5 - 1;
int    c = 5 / 2;          // int/int → int, what's the value?

______ d(int foo) { return foo / 2; }
______ e(double foo) { return foo / 2; }
______ f(double foo) { return int(foo / 2); }

______ g(double c) {
   std::cout << c << std::endl;
}
```

🧠 Fill in the types!

```
string a = "test";
double b = 3.2 * 5 - 1;
int    c = 5 / 2;          // int/int → int, what's the value?

int d(int foo) { return foo / 2; }
double e(double foo) { return foo / 2; }
int f(double foo) { return int(foo / 2); }

______ g(double c) {
    std::cout << c << std::endl;
}
```

🧠 Fill in the types!

```
string a = “test”;
double b = 3.2 * 5 - 1;
int    c = 5 / 2;          // int/int → int, what’s the value?

int d(int foo) { return foo / 2; }
double e(double foo) { return foo / 2; }
int f(double foo) { return int(foo / 2); }

void g(double c) {
    std::cout << c << std::endl;
}
```

C++ is a statically typed language

Definition

statically typed: everything with a name (variables, functions, etc) is given a type **before runtime**

C++ Types in Action

```
int a = 3;
string b = "test";

char func(string c) {
    // do something
}

b = "test two";

func(b);

// don't need to declare type after initialization
```

Dynamic vs Static typing: Python vs C++

Python

```python
a = 3
b = "test"

def func(c):
    # do something
```

C++

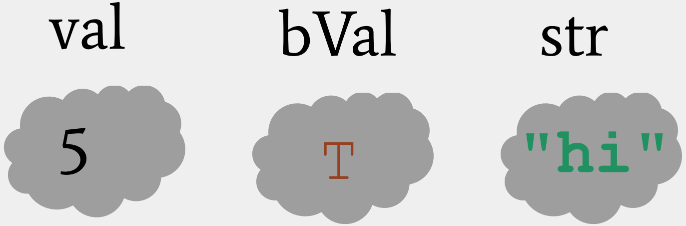
```cpp
int a = 3;
string b = "test";

char func(string c) {
    // do something
}
```

Dynamic vs Static typing: Python vs C++

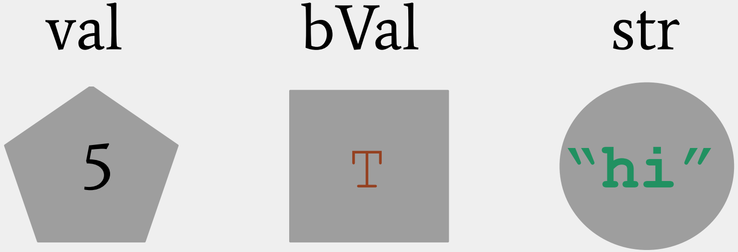
Python

```
val = 5;
bVal = true;
str = "hi";
```



C++

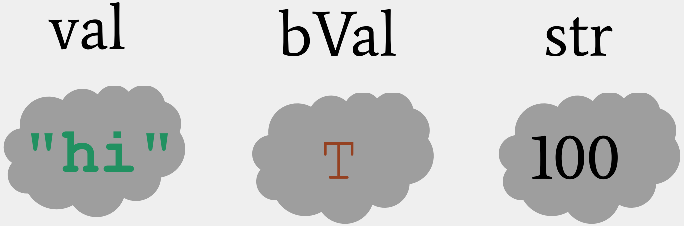
```
int val = 5;
bool bVal = true;
string str = "hi";
```



Dynamic vs Static typing: Python vs C++

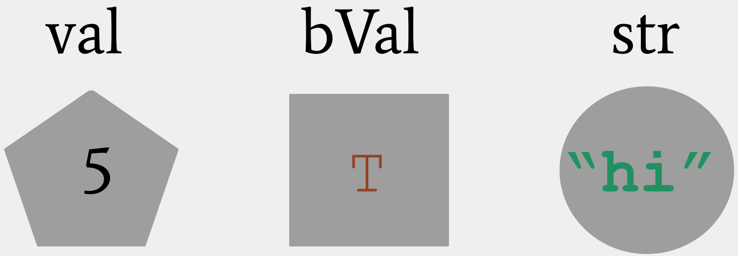
Python

```python
val = 5
bVal = true
str = "hi"
val = "hi"
str = 100
```



C++

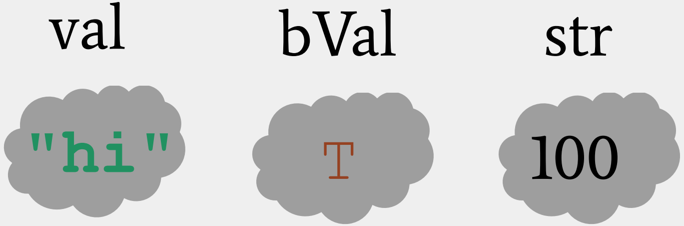
```cpp
int val = 5;
bool bVal = true;
string str = "hi";
```



Dynamic vs Static typing: Python vs C++

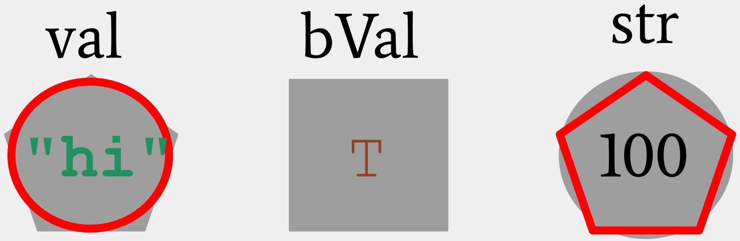
Python

```
val = 5
bVal = true
str = "hi"
val = "hi"
str = 100
```



C++

```
int val = 5;
bool bVal = true;
string str = "hi";
val = "hi";
str = 100;
```



Dynamic vs Static typing: Python vs C++

Python

```
def div_3(x):
   return x / 3
div_3("hello")
```

C++

```
int div_3(int x){
   return x / 3;
}
div_3("hello")
```

Dynamic vs Static typing: Python vs C++

Python

```
def div_3(x):
    return x / 3
div_3("hello")
```

//CRASH during runtime, can't divide a string

C++

```
int div_3(int x){
    return x / 3;
}
div_3("hello")
```

Dynamic vs Static typing: Python vs C++

Python

```
def div_3(x):
    return x / 3
div_3("hello")
```

//CRASH during runtime, can't divide a string

C++

```
int div_3(int x){
    return x / 3;
}
 div_3("hello")
```

//Compile error: this code will never run

Dynamic vs Static typing: Python vs C++

Python

```python
def mul_3(x):
    return x * 3
mul_3("10")
```

C++

```cpp
int mul_3(int x){
    return x * 3;
}
mul_3("10");
```

Dynamic vs Static typing: Python vs C++

Python

```
def mul_3(x):
    return x * 3
mul_3("10")


//returns “101010”
```

C++

```
int mul_3(int x){
    return x * 3;
}
mul_3("10");
```

Dynamic vs Static typing: Python vs C++

Python

```
def add_3(x):
    return x + 3
add_3("10")
```

//returns "103"

C++

```
int add_3(int x){
    return x + 3;
}
add_3("10");
```

//Compile error: "10" is a string! This code wont run static typing helps us to prevent errors **before our code runs**

Static Types + Functions

Python

```
def div_3(x)
```

div_3: __ -> ??

C++

```
int div_3(int x)
```

div_3: int -> int

C++ to Python, probably

Static Types + Functions

What are the "types" of the following functions?

```
int add(int a, int b);
    int, int -> int
string echo(string phrase);

______________________
string helloworld();

______________________
double divide(int a, int b);

______________________
```

Static Types + Functions

What are the “types” of the following functions?

```
int add(int a, int b);
    int, int -> int
string echo(string phrase);
    string -> string
string helloworld();

______________________
double divide(int a, int b);

______________________
```

Static Types + Functions

What are the “types” of the following functions?

```
int add(int a, int b);
   int, int -> int
string echo(string phrase);
   string -> string
string helloworld();
   void -> string
double divide(int a, int b);

_______________________
```

Static Types + Functions

What are the “types” of the following functions?

```
int add(int a, int b);
   int, int -> int
string echo(string phrase);
   string -> string
string helloworld();
   void -> string
double divide(int a, int b);
   int, int -> double
```

Questions?

Overloading

- What if we want two versions of a function for two different types?
- Example: int division vs double division

Overloading

Define two functions with the same name but different types

```
int half(int x) {
    std::cout << “1” << endl;      // (1)
    return x / 2;
}

double half(double x) {
    cout << “2” << endl;    // (2)
    return x / 2;
}
half(3)            // uses version (1), returns ?
half(3.0)      // uses version (2), returns ?
```

Overloading

Define two functions with the same name but different types

```
int half(int x, int divisor = 2) {      // (1)
    return x / divisor;
}
double half(double x) {    // (2)
    return x / 2;
}
half(3)// uses version (1), returns 1
half(3, 3)// uses version (1), returns 1

half(3.0)     // uses version (2), returns 1.5
```

Questions?

Today

- ~~Types~~
- **Intro to structs**
- Sneak peek at streams!

Definition

struct: a group of named variables *each with their own type*. A way to bundle different types together

Structs in Code

```
struct Student {
   string name; // these are called fields
   string state; // separate these by semicolons
   int age;
};

Student s;
s.name = "Frankie";
s.state = "MN";
s.age = 21; // use . to access fields
```

Use structs to pass around grouped information

```
Student s;
s.name = "Frankie";
s.state = "MN";
s.age = 21; // use . to access fields

void printStudentInfo(Student student) {
  cout << s.name << " from " << s.state;
  cout << " (" << s.age ")" << endl;
}
```

Use structs to return grouped information

```
Student randomStudentFrom(std::string state) {
  Student s;
  s.name = "Frankie";//random = always Frankie
  s.state = state;
  s.age = std::randint(0, 100);
  return s;
}

Student foundStudent = randomStudentFrom("MN");
cout << foundStudent.name << endl; // Frankie
```

Abbreviated Syntax to Initialize a struct

```
Student s;
s.name = "Frankie";
s.state = "MN";
s.age = 21;

//is the same as ...
```

Abbreviated Syntax to Initialize a struct

```
Student s;
s.name = "Frankie";
s.state = "MN";
s.age = 21;

//is the same as ...
Student s = {"Frankie", "MN", 21};
```

Questions?

Definition

`std::pair`: An STL built-in struct with two fields *of any type*

`std::pair`

- **`std::pair`** is a ***template:*** You specify the types of the fields inside <> for each pair object you make
- The fields in **`std::pair`**s are named **`first`** and **`second`**

```
std::pair<int, string> numSuffix = {1,"st"};

cout << numSuffix.first << numSuffix.second;
//prints 1st
```

`std::pair`

- `std::pair` is a ***template:*** You specify the types of the fields inside <> for each pair object you make
- The fields in `std::pair`s are named **`first`** and **`second`**

```
struct Pair {
  fill_in_type first;
  fill_in_type second;
};
```

Use `std::pair` to return success + result

```
std::pair<bool, Student> lookupStudent(string name) {
 Student blank;
 if (found(name)) return std::make_pair(false, blank);
 Student result = getStudentWithName(name);
 return std::make_pair(true, result);
}
std::pair<bool, Student> output = lookupStudent("Keith");
```

Use `std::pair` to return success + result

```
std::pair<bool, Student> lookupStudent(string name) {
 Student blank;
 if (notFound(name)) return std::make_pair(false, blank);
 Student result = getStudentWithName(name);
 return std::make_pair(true, result);
}
 std::pair<bool, Student> output = lookupStudent("Keith");
```

To avoid specifying the types of a pair, use **`std::make_pair(field1, field2)`**

Questions?

Aside: Type Deduction with `auto`

Definition

`auto`: Keyword used in lieu of type when declaring a variable, tells the compiler to deduce the type.

Type Deduction using `auto`

```
// What types are these?
auto a = 3;
auto b = 4.3;
auto c = 'X';
auto d = "Hello";
auto e = std::make_pair(3, "Hello");
```

📝 `auto` **does not mean that the variable doesn't have a type.**
It means that the type is **deduced** by the compiler.

Type Deduction using `auto`

```
// What types are these?
auto a = 3;
auto b = 4.3;
auto c = ‘x’;
auto d = “Hello”;
auto e = std::make_pair(3, “Hello”);
```

Answers: int, double, char, char* (a C string), std::pair<int, char*>

📝 `auto` **does not mean that the variable doesn’t have a type.**

It means that the type is **deduced** by the compiler.

‼️ `auto` **does not mean that the variable doesn't have a type.**

It means that the type is **deduced** by the compiler.

Code Demo!

Recap

- Everything with a name in your program has a **type**
- **Strong type systems** prevent errors before your code runs!
- **Structs** are a way to bundle a bunch of variables of many types
- **std::pair** is a type of struct that had been defined for you and is in the STL
- So you access it through the **std:: namespace** (std::pair)
- **auto** is a keyword that tells the compiler to deduce the type of a variable, it should be used when the type is obvious or very cumbersome to write out

Today

- ~~Types~~
- ~~Intro to structs~~
- Sneak peek at streams!

Definition

stream: an abstraction for input/output. Streams convert between *data* and the *string representation of data.*

A stream you've used: cout

```
std::cout << 5 << std::endl; // prints 5
// use a stream to print any primitive type!
std::cout << "Frankie" << std::endl;
```

A stream you've used: cout

```
std::cout << 5 << std::endl; // prints 5
// use a stream to print any primitive type!
std::cout << "Frankie" << std::endl;
// Mix types!
std::cout << "Frankie is " << 21 << std::endl;
```

A stream you've used: cout

```
std::cout << 5 << std::endl; // prints 5
// use a stream to print any primitive type!
std::cout << "Frankie" << std::endl;
// Mix types!
std::cout << "Frankie is " << 21 << std::endl;
// structs?
Student s = {"Frankie", "MN", 21};
std::cout << s << std::endl;
```

A stream you've used: cout

```
std::cout << 5 << std::endl; // prints 5
// use a stream to print any primitive type!
std::cout << "Frankie" << std::endl;
// Mix types!
std::cout << "Frankie is " << 21 << std::endl;
// structs?
Student s = {"Frankie", "MN", 21};
std::cout << s << std::endl;
```

A stream you've used: cout

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std::cout << 5 << std::endl; // prints 5
// use a stream to print any primitive type!
std::cout << "Frankie" << std::endl;
// Mix types!
std::cout << "Frankie is " << 21 << std::endl;
// structs?
Student s = {"Frankie", "MN", 21};
std::cout << s.name << s.age << std::endl;
```

A stream you've used: cout

```
std::cout << 5 << std::endl; // prints 5
// use a stream to print any primitive type!
std::cout << "Frankie" << std::endl;
// Mix types!
std::cout << "Frankie is " << 21 << std::endl;
// Any primitive type + most from the STL work!
// For other types, you will have to write the
            << operator yourself!
```