12.010 Computational Methods of Scientific Programming
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Lecturers

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Summary

- Today we finish up C and start C++
- Final C topics
  - Structures: A method for grouping like variables together
  - Memory management
- Start of C++
  - History
  - Ideas of classes and objects
  - Examples to demonstrate concepts

Structures and Types

- Struct alone is still unclear - typedef

```
typedef struct { double cx;
                 double cy;
                 double cz; } t_point;

main() {
    t_point point;
 point.cx = 3.; point.cy=3.; point.cz=2.;
 plot(point);
 }
```

Structures and Types

- Derived types just like basic types
  - e.g. can use arrays
- typedef struct { double cx;
  double cy;
  double cz; } t_point;

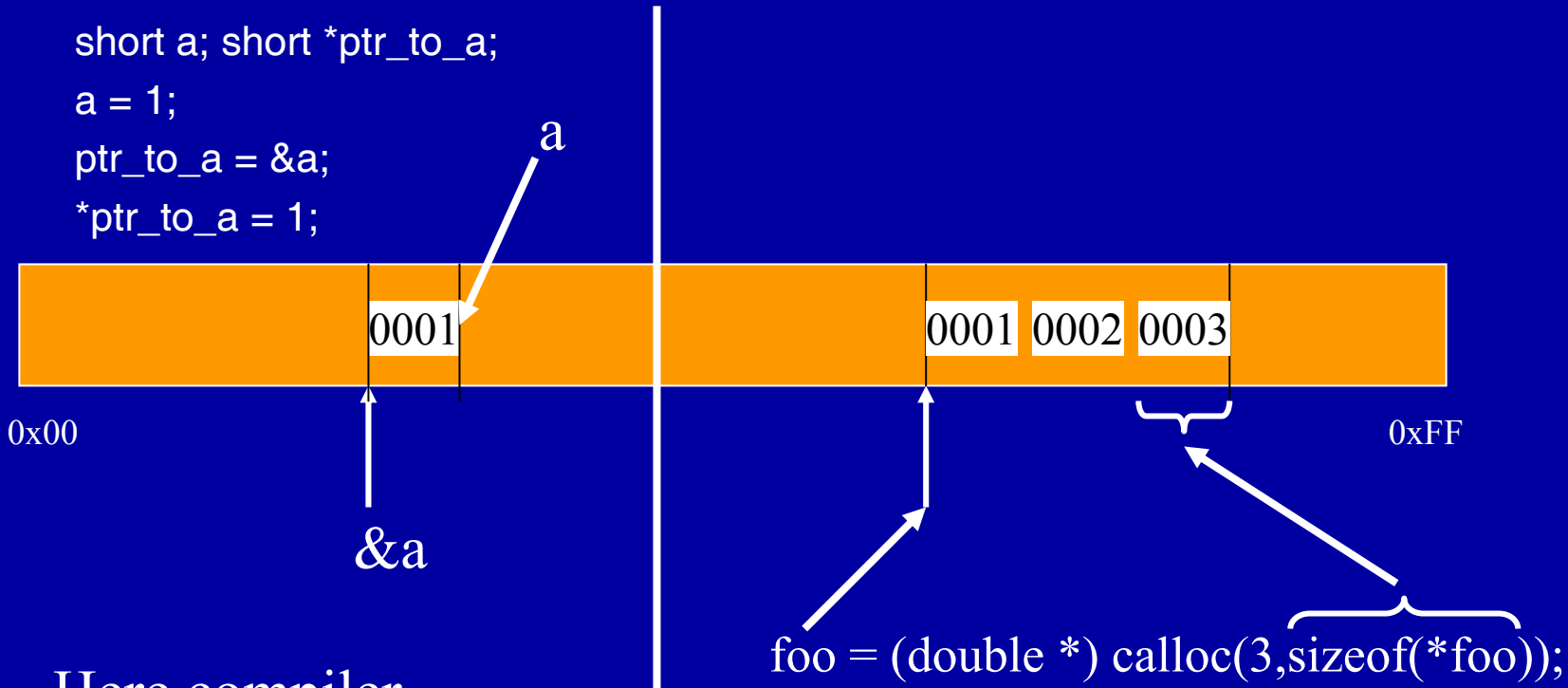
```
main() {
 t_point point[10]; int i;
for (i=0;i<10;++i) {
 point[i].cx = 3.; point[i].cy=3.; point[i].cz=(double)i; }
for (i=0;i<10;++i) {
 plot(point[i]); }
}
```

Memory Management

- Application code creates variables and arrays at runtime
- <stdlib.h> - malloc, calloc, free, realloc + sizeof
- e.g

```
main(int argc, char *argv[]) {
  double *foo; int nel; int i;
   /* Create an array of size nel at runtime */
  sscanf(argv[1],“%d\n”,&nel);
  foo = (double *) calloc(nel,sizeof(*foo));
  if ( foo == NULL ) exit(-1);
 for (i=0;i<nel;++i) { foo[i]=i; }
 free(foo);
}
```

Remember - *, &



Here compiler allocated memory for you

Here application allocates memory explicitly.
Allows more control but requires careful bookkeeping.

Towards C++

- C essentials
  - syntax v. fortran
  - call by reference v. call by value
  - pointers
  - structure, typedef
  - memory management
- C is also the basis for C++

C++

- Object Oriented - Allows you to build/compose v. complex applications from building blocks
- Appeared around 1984 (Bjarne Stroustrup, Bell Labs)
- ANSI standard 1997
- Syntax is like C. Getting started: a few extra keywords + few new formalized concepts.
- Book “C++ The Core Language” – O’Reilly
- Successful because you can compose applications from other peoples building blocks. Windows etc….
- V. complex in detail, like Mathemetica takes many years to learn everything!!

C++ concept

- C language + classes
- Class is a formal way to think about good program design.
  - Modularity, encapsulation, hierarchy, abstraction
- A class has
  - Methods (program logic)
  - Data (variables)
  - can be private or public
- Example “string”
  - Methods: set, get
  - Data: string text, string length

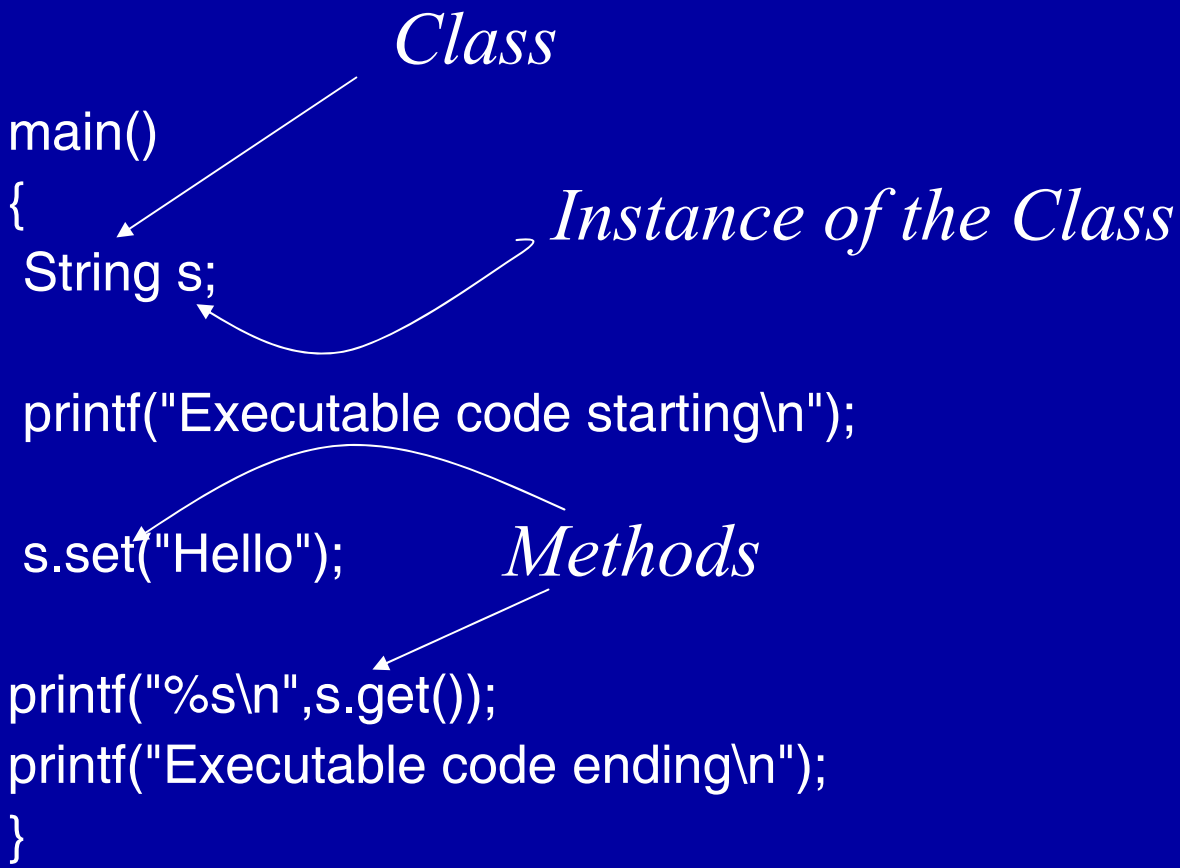
C++ Basic Example

```
main()
{
 String s;
 printf("Executable code starting\n");
 s.set("Hello");
printf("%s\n",s.get());
printf("Executable code ending\n");
}
```

Compile using g++

Will write out hello + some other stuff

C++ Basic Example



String Class - Behind the Scenes

```
/* ===== Class interface definition ===== */
class String {
 public:
  String();                 /* Constructor          */
  ~String();                /* Destructor           */
  void set(char *s);        /* Set a string         */
  char *get();                 /* Get string value      */
 private:
  char *str;                /* Pointer to the string */
  int  lngth;               /* Length of the string  */
};
```

String Class –Example Methods

```
/* Set str to point to a private copy of s */
void String::set(char *s) {
 lngth  = strlen(s);
 str    = new char[lngth+1];
 strcpy(str, s);
}

/* Return the pointer to the string  */
char *String::get() {
 return str;
}
```

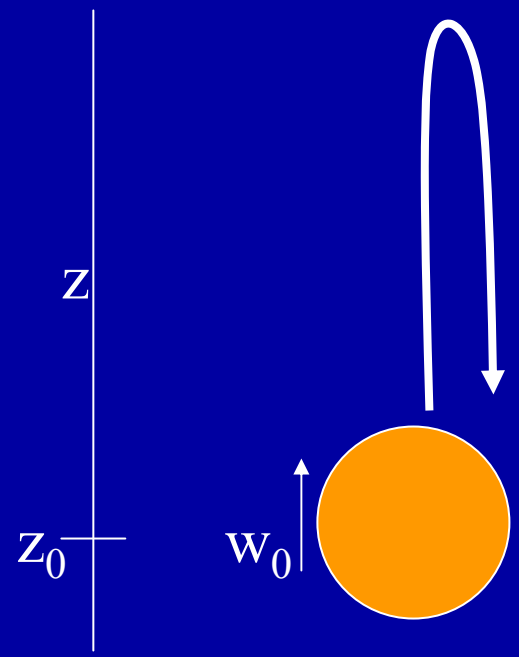
String Class –Example Methods

```
/* Constructor */
String::String() {
 str = 0;
 set("");
 printf("I created a string\n");
}

/* Destructor */
String::~String() {
 delete[] str;
 printf("I deleted a string\n");
}
```

Application Example

Throwing a ball in the air



$$w = w_0 + gt$$

$$z = z_0 + \int_0^t w dt$$

Get initial velocity and length of "experiment".

Calculate time evolution of w and z.

Print out "trajectory"

C “Procedural” Form

```
main (  )
{ float t=10.;  float w0=10.;
 t_gball *theBall;/* Stats for the ball          */

 /* Allocate space for full ball time history */
 createBall(w0, &theBall );
 /* Step forward the ball state */
 stepForwardState( t, &theBall );
 /* Write table of output */
 printTrajectory( t, w0, theBall);
}
```

C++ Using “Ball” Class

```
main()
{float w0 = 10.; float t=10.;
  Ball b;
  b.initialize(w0);
  b.simulate(t);
  b.printTrajectory();
}
```

All info. is held in “b”. Fewer args, cleaner “abstraction”.

Summary

- Finished up C with structures and memory management
- Started with C++
  - C++ is C with the addition of “classes”
  - Class is a formal way to think about good program design.
    - Modularity, encapsulation, hierarchy, abstraction
  - A class has
    - Methods (program logic)
    - Data (variables)
    - can be private or public