12.010 Computational Methods of Scientific Programming
Fall 2008

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Lecturers

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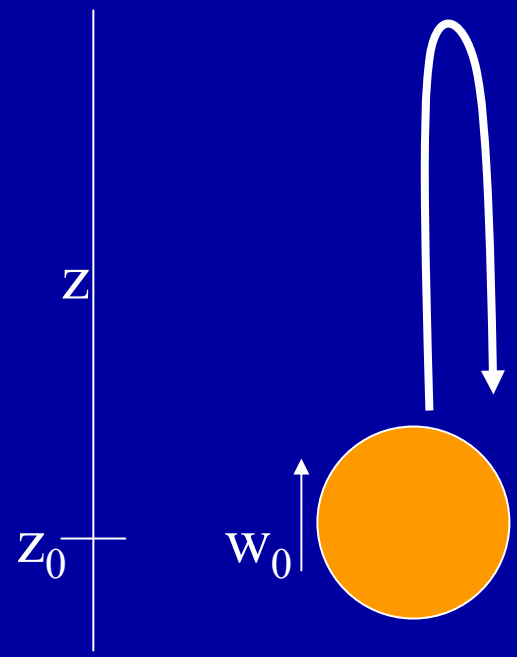
Summary

- 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
- Today:
  - Example class in an example
  - Inheritance
  - Overloading (allows re-definition of methods for certain classes)

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”.

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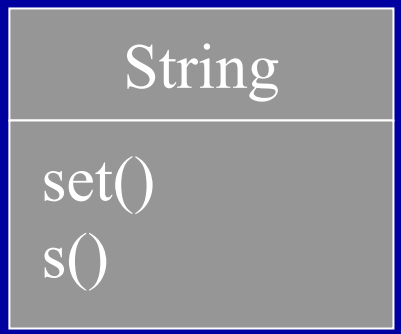
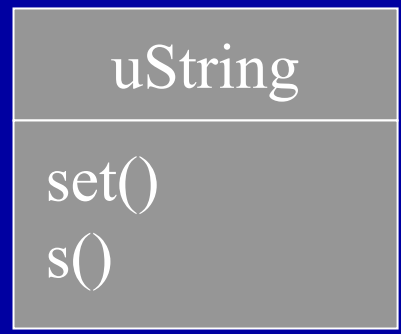
Inheritance

- Want new class uString. Like String except that the strings will be converted and stored in upper case. e.g.



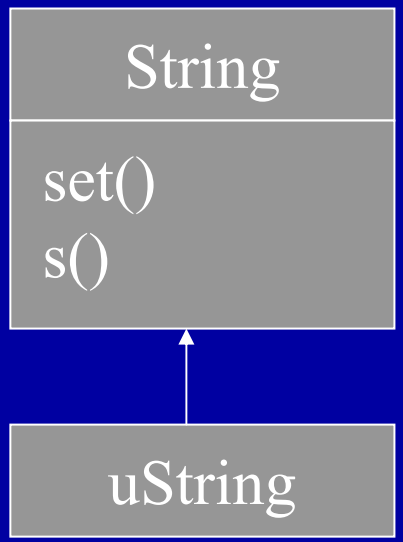



```
String s;
s.set("Hello");
printf("%s\n",s.s());
```
➔Hello

```
uString s;
s.set("Hello");
printf("%s\n",s.s());
```
➔HELLO

uString extends String

- No need to write uString from scratch.
- Inherit most code from String.
- Extend String::set to capitalise.
- A uString is a String with some extra feature.



Base class

Derived class

C++ Inheritance Example

- New interface for uString

```
/* Extend String class to uString         */
/* uString stores strings as upper case */
class uString : public String {
 public:
  void set( char *);    /* Set a uString */
};
```

uString *set* method

```
/* Set str to point to a private copy of s */
void uString::set(char *s) {
 int i;
 String::set(s);
 for (i=0;i<strlen(s);++i) {
  if ( str[i] >= 'a' && str[i] <= 'z' ) {
   str[i] = toupper(str[i]);
  }
 }
}
```

Base class method

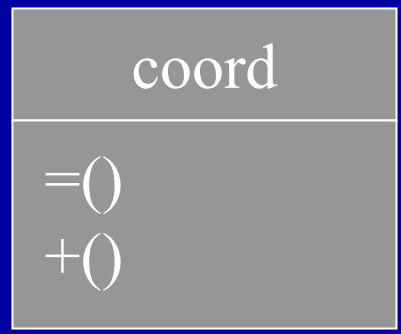
"protected"
(not "private")

uString in action!

```
main()
{
 String  s1;
 uString s2;

 printf("Executable code starting\n");

 s1.set("Hello");
 printf("%s\n",s1.s());
 s2.set("Hello");
 printf("%s\n",s2.s());

 printf("Executable code ending\n");
}
```

Overloading

Can redefine operators e.g. + to operate on classes e.g.



coord p1, p2, p3;
p3 = p1 + p2

This would then do
➔if p1=p2=(1,1,1) p3 = (2,2,2)

Overloading

- Have to define the meaning of + and = for a coord class object. Language defines meaning for integer, float, double etc but now we can define extra meanings.

```
class coord{
 public:
   coord operator+(coord );
private:
   int cx;   int cy; int cz;
};
```

```
coord coord::operator+ (coord c2)
{ coord temp;
  temp.cx = cx + c2.cx;
  temp.cy = cy + c2.cy;
  temp.cz = cz + c2.cz;
  return(temp);
}
```

Conclusion

- C and C++: Characteristics similar to Fortran: Core program languages which are very powerful but programmer needs to do much of the work
  - Libraries of routines can be made and are available but these need to be carefully designed in C and Fortran (potentially routines can cause problems)
  - C++ classes minimize some of these problems but do not eliminate them completely.
  - Good modular program design can minimize problems.
- Remainder of class: Examine C++ examples and contrast Fortran and C if time available (see link on class web page)
  C_Basics.html C_Fortan_compare.html C_Pointers.html
- Homework 3 has been posted to web site (Due October 30, 2008)