Lecture 7

Arrays, Dynamic Arrays
& Copy Constructors

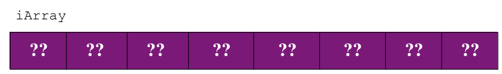
"Absolute C++"
Sections 5.1 - 5.3, 10.2

Arrays

- What is an Array?
  - An array is a "chunk" of memory which contains consecutive instances of a given data type.
  - Think of it as a "list" of data, each data item of the same data type.
  - An array is declared by declaring a variable of a given type and then suffixing the declaration with a `[n]` where `n` is the number of elements you want in your array.

```
int iArray[8];    // declares an 8 element array
```

- At this point, `iArray` might look like this (in memory):

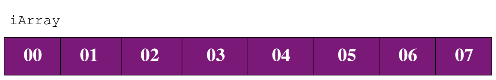


- Memory is allocated, but not initialized (hence the ??'s)

Accessing Array Elements

- To get at the contents of one of the array elements…
  - Take the variable used to declare the array and suffix it with a left square bracket, the element number you wish to retrieve, followed by a right square bracket. This expression will evaluate to the value in the array at the specified index. The first index is at item 0, not 1.
- WARNING! C++ does no bounds checking on array accesses.
- Let's take a look...

```
int iArray[8];    // declares an 8 element array
for (int k=0; k<8; k++)    // arbitrary initialization
  iArray[k] = k;
```

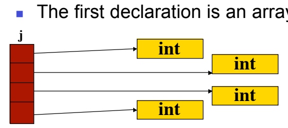


Pointers in Array Declarations

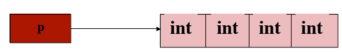
- What's the difference between...

```
int *j[4];
int (*p)[4];
```

- The first declaration is an array of 4 pointers to int



- The second is a pointer to an array of 4 integers



Static Initialization

- You can assign values to an array immediately right where they are declared...

```
int smallPrimes[7] = {2,3,5,7,11,13,17};
```

- The same can be done for a multiple dimension array:

```
int d[2][3] = {{0,1}, {1,0}, {1,1}};
```

- Let's see it in action...

Demonstration #1

Basic Arrays

Pointers and Arrays

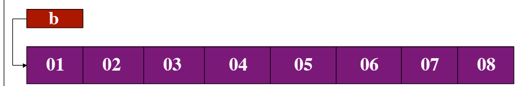
- Pointers and Arrays seem very closely related
  - Both seem to deal with accessing “chunks” of memory
  - Yet they both seem to be geared towards different tasks
    - Arrays are used for creating a list of elements of fixed length
    - Pointers are used for dynamically allocating data structures at runtime
- Well, in C++ an array is really just a pointer.
- Consider the following...

```
int main()
{
  int *a, b[8] = {1,2,3,4,5,6,7,8};
  a = b;
  cout << "*a is " << *a << endl;
}
```

- What will be printed out as the value of `*a`?

Pointers and Arrays (cont)

- To better understand, consider a graphical representation of b:



- Now, since an array *is* a pointer, b actually *points* at its first element.
- That means that for any array, the following is true:

```
int main()
{
  int b[8] = {1,2,3,4,5,6,7,8};
  if (b == &b[0])
    cout << "This will always be true."
  return 0;
}
```

Demonstration #2

Sanity Check
(Arrays as Pointers)

Pointer Arithmetic

- You might be wondering…
  - If `*b` is the same as `b[0]` can I access other elements of `b` without using `[n]` notation?
- Yes.
- Actually, for any array `p` :
  - p[n] == *(p+n)
  - This is called *pointer arithmetic*
  - To add to the confusion, p[n] == n[p] (because *(p+n) == *(n+p))
- So...

```
int main()
{
  int b[8] = {1,2,3,4,5,6,7,8};
  cout << "b[1] = " << b[1] << endl;     // Prints out b[1]
  cout << "b[2] = " << 2[b] << endl;     // Prints out b[2]
  cout << "b[3] = " << *(b+3) << endl;   // Prints out b[3]
  return 0; }
```

Back to Arrays…

- Since every array is a pointer, what do you suppose this does...

```
void swap(int A[8], int j, int k)
{
  int temp = A[j];
  A[j] = A[k];
  A[k] = temp;
}

int main()
{
  int b[8] = {1,2,3,4,5,6,7,8};
  swap(b,2,3);
  cout << "b[2]=" << b[2] << " and b[3]=" << b[3] << endl;
  return 0;
}
```

- Let’s check it out...

Demonstration #3

Pointers as Parameters

Pointers as Parameters

- Since every array is passed by pointer it has the same effect as being “passed by reference”.
- Remember, C++ does no bounds checking.

```
int main()
{
  int a1[8];
  int a2[20];
  int a3[5];
  swap(a1,2,7);  // a1 is the right size
  swap(a2,2,7);  // a2 is too big
  swap(a3,2,7);  // a3 is too small, there’s no a3[7]
}
```

- These are all “legal”… Why?
- Remember, an array is just a pointer.   That’s why.

Dynamic Allocation of Arrays

- Yes, an array can be dynamically allocated. But you won’t use:

```
int a1[8] = new int;     // WRONG!
```

- Remember, when you use the [n] notation in a declaration you are actually allocating memory at that point.
- Remember also that an array is just a pointer.
- When dynamically allocating space for an array, you will be receiving a pointer back...

```
int *a = new int[8];     // RIGHT!
```

- The `[8]` tells the `new` operator to allocate an array of 8 `ints`.
- How do you delete such a dynamic allocation?

```
delete [] a;    // Must use this, delete a is undefined
```

Dynamic Allocation of Arrays (cont)

- What’s nice about this method of dynamic allocation is that the size of the array does not need to be known at compile time.
- Consider the following:

```
int main()
{
  Course *courses;
  int numCourses;
  cout << “How many courses to enter? “;
  cin >> numCourses;
  courses = new Course[numCourses];
  // Rest of program
  delete [] courses;
}
```

- Let’s see this actually work...

Demonstration #4

Dynamic Allocation of Arrays

That Nasty Scope Thing Again

- As always, there are dangers...

```
int *MakeArray()    // Will compile, but I wouldn’t advise it
{
  int iArray[50];
  return iArray;
}

int *MakeArray(int size)  // Will compile, and is safe
{
  int *anArray = new int[size];
  if (anArray == NULL)
    cout << “Couldn’t allocate array of size “ << size << endl;
  return anArray;
}
```

Copy Constructors

- Consider a constructor which takes an object of same type

```
class Point
{
public:
  Point(){}
  Point(Point anotherPoint);
  void setXY(int newX,int newY) {x =newX; y=newY; }
  void getXY(int &curX,int &curY) {curX=x; curY = y; }
private:
  int x,y;
};

Point::Point(Point anotherPoint)
{
  anotherPoint.getXY(x,y);
}
```

Copy Constructors (cont)

- In a pass by value situation you are actually creating a copy of a given argument on the stack.
- If the argument is a class and has a constructor, it will be called.
- If the parameter to the “copy constructor” is declared pass by value, it will be called
- You can see this would produce infinite recursion!
- Thus, for a copy constructor, the argument *must* be passed by reference.

Lecture 7

Final Thoughts