Even More C++

Outline

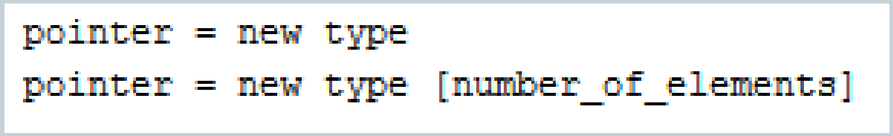
- Dynamic Memory
- Data Structures
- Other Data Types

Dynamic Memory

- Fundamental data types take up a fixed size in memory
  - Memory can be allocated when the variables are declared
- There are times when memory size can only be determined at runtime
  - In these cases, programs need to dynamically allocate (and de-allocate) memory
    - This is done using the `new` and `delete` operators

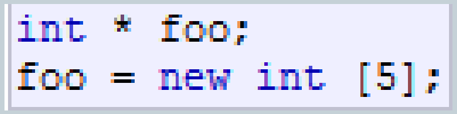
new and new[]

- new is followed by a data type specifier and if there are multiple elements needed, brackets are used, to specify an array



```
pointer = new type
pointer = new type [number_of_elements]
```

- For example:



```
int * foo;
foo = new int [5];
```

- In this example, a pointer to an integer is created, and then a block of memory is allocated to store 5 of them

new and new[]

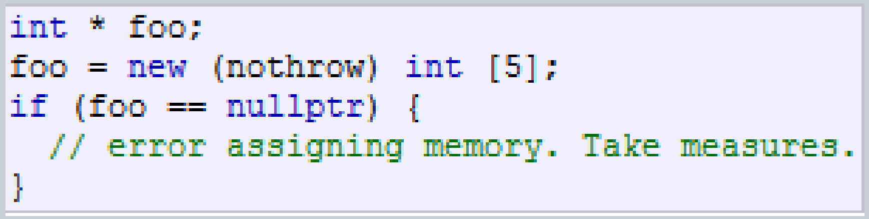
- So why not just create an array?

- Array size must be declared in one way or another at compile time
- Using dynamic memory assigns memory at runtime so you can use a flexible memory size

- Memory is allocated at runtime from the heap
  - There is no guarantee that there is enough memory to handle a given request

Checking for Allocation Success

- By default, C++ will throw an exception if something went wrong with memory allocation
  - In this case, the program will terminate if the exception is not handled
  - You can tell C++ not to throw an exception and then deal with it in your own code:

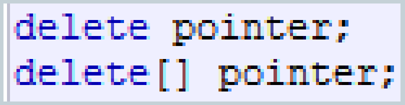


```
int * foo;
foo = new (nothrow) int [5];
if (foo == nullptr) {
  // error assigning memory. Take measures.
}
```

- Using exceptions is more efficient – we will talk about those later

delete and delete[]

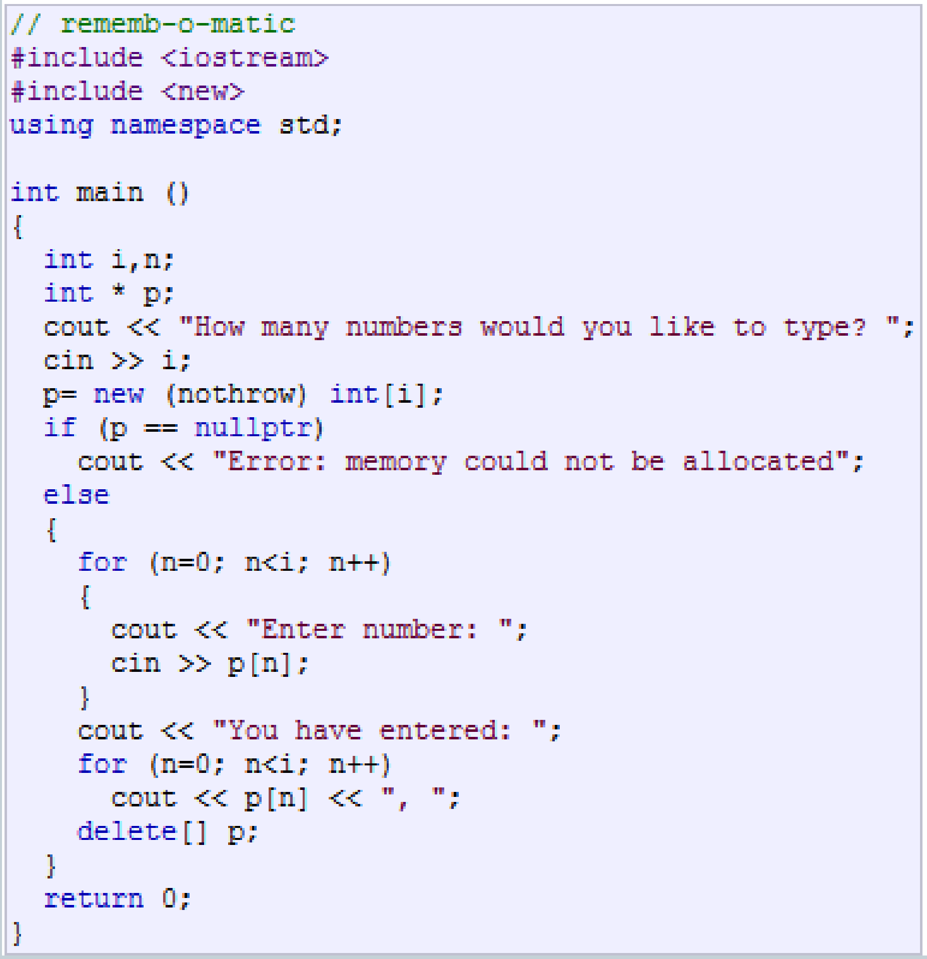
- C++ does not handle garbage collection for you
  - You need to determine when a particular data item is no longer needed and then remove it
  - Use delete and delete[] to do this



```
delete pointer;
delete[] pointer;
```

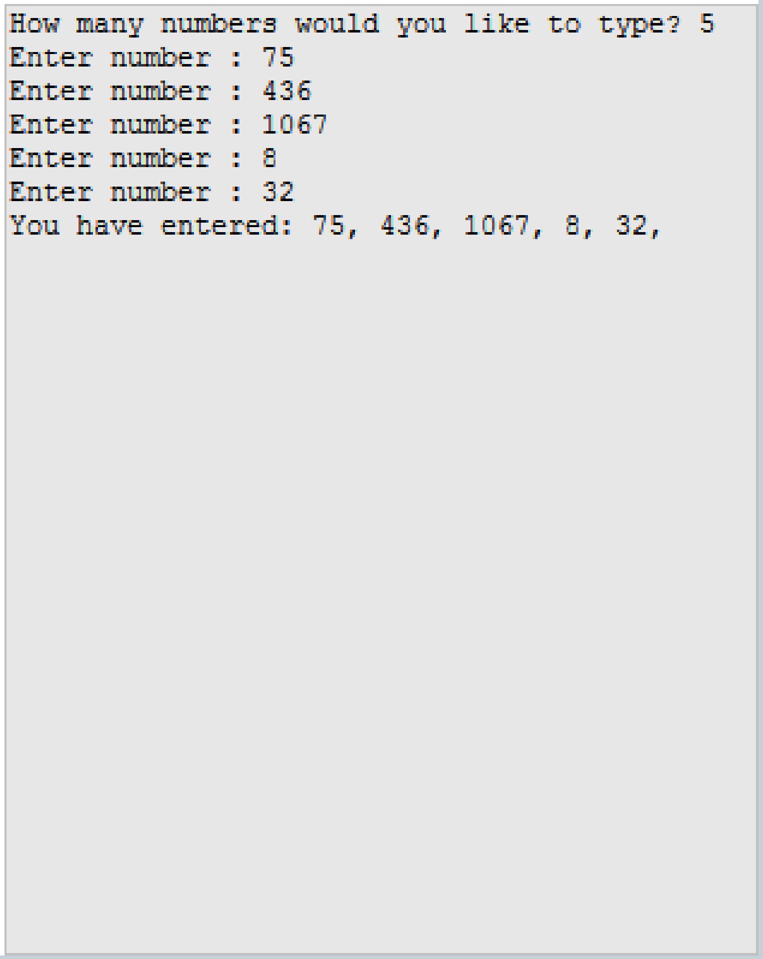
  - The “thing” deleted should be either something that was created with new or new[ ] before, or it should be a null pointer (in which case nothing happens)

An Example



```cpp
// rememb-o-matic
#include <iostream>
#include <new>
using namespace std;

int main ()
{
  int i,n;
  int * p;
  cout << "How many numbers would you like to type? ";
  cin >> i;
  p= new (nothrow) int[i];
  if (p == nullptr)
    cout << "Error: memory could not be allocated";
  else
  {
    for (n=0; n<i; n++)
    {
      cout << "Enter number: ";
      cin >> p[n];
    }
    cout << "You have entered: ";
    for (n=0; n<i; n++)
      cout << p[n] << ", ";
    delete[] p;
  }
  return 0;
}
```



```
How many numbers would you like to type? 5
Enter number : 75
Enter number : 436
Enter number : 1067
Enter number : 8
Enter number : 32
You have entered: 75, 436, 1067, 8, 32,
```

Dynamic Memory in C

- C++ uses new and delete to allocate and free memory
- C uses malloc, calloc, realloc and free
- Since C++ is built on C, you can still use these functions, but you should not mix them
  - if you use new on an item, deallocate it with delete
  - if you use malloc, calloc or realloc, deallocate it with free

Summary

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- Data Structures
- Other Data Types