C++ Kitchen Sink

Lecture 14

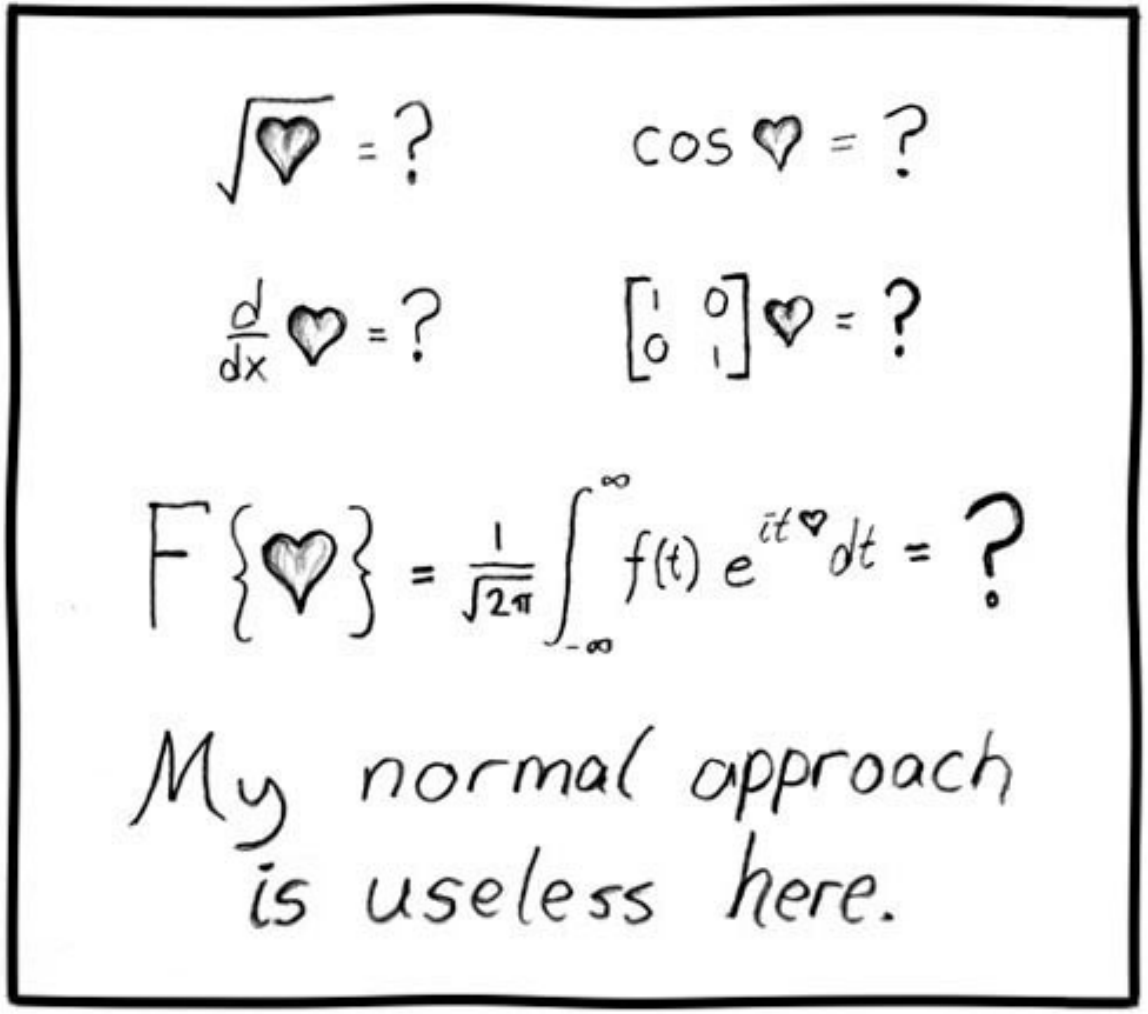
Outline

- Exceptions
- Iterators
- Random numbers
- Casting
- Enumerations
- Pairs
- The Big Three

Error Handling

- It is often easier to write a program by first assuming that nothing incorrect will happen
- Once it works correctly for the expected cases, add code to handle the exceptional cases
- *Exception* handling is commonly used to handle error situations
  - Once an error is handled, it is no longer an error

Motivational XKCD



Exceptions

- In C++, exception handling proceeds by:
  - Some library software or your code signals that something unusual has happened
    - This is called *throwing an exception*
  - At some other place in your program you place the code that deals with the exceptional case
    - This is called *handling* or *catching* the exception

Example

```
#include <iostream>
using namespace std;

int main()
{
   double a, b;

   cin >> a >> b;
   cout << ( a / b )
        << endl;

   return 0;
}
```

```
./a
3
5
0.6
./a
3
0
inf
```

Try-Throw-Catch

```
#include <iostream>
using namespace std;

int main()
{
	double a, b;
	cin >> a >> b;

	try
	{
		if ( b == 0 )
			throw a;

		cout << ( a / b )
		     << endl;
	}
	catch (double a)
	{
		cout << "Can't divide "
		     << a << " by zero"
		     << endl;
	}

	return 0;
}
```

```
./a
3
5
0.6
./a
3
0
Can't divide 3 by zero
```

The Basics

- In C++ you can throw any type
  - Commonly a class that carries useful information to catch
- Code within the try block is suspected to throw an exception
  - Similar to if-else, but with messaging
- There can be multiple catch blocks with different types

Advanced Example

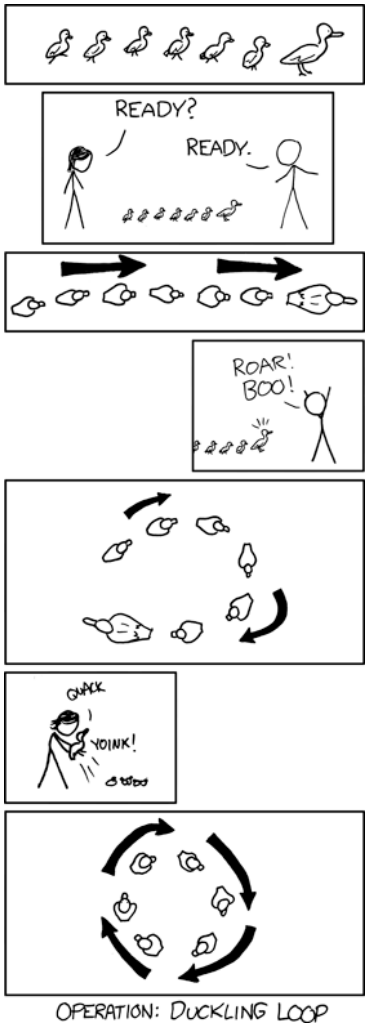
```
#include <iostream>
using namespace std;

class DivideException
{
public:
     DivideException(double val):
     val( val ) {}
     double getVal() { return val; }

private:
     double val;
};

double div(double a, double b)
throw (DivideException)
{
     if ( b == 0 )
          throw DivideException( a );

     return ( a / b );
}
```

```
int main()
{
     double a, b;

     cin >> a >> b;

     try
     {
          cout << div( a, b ) << endl;
     }
     catch (DivideException e)
     {
          cout << "Can't divide "
               << e.getVal()
               << " by zero" << endl;
     }

     return 0;
}
```

Iterators

- An iterator is a generalization of a pointer
  - Typically implemented using a pointer, but saves you from the details and provides a uniform interface to numerous collection classes
- Think of an iterator like a pointer
  - Has many similar operators overloaded

Motivational XKCD



Common Usage

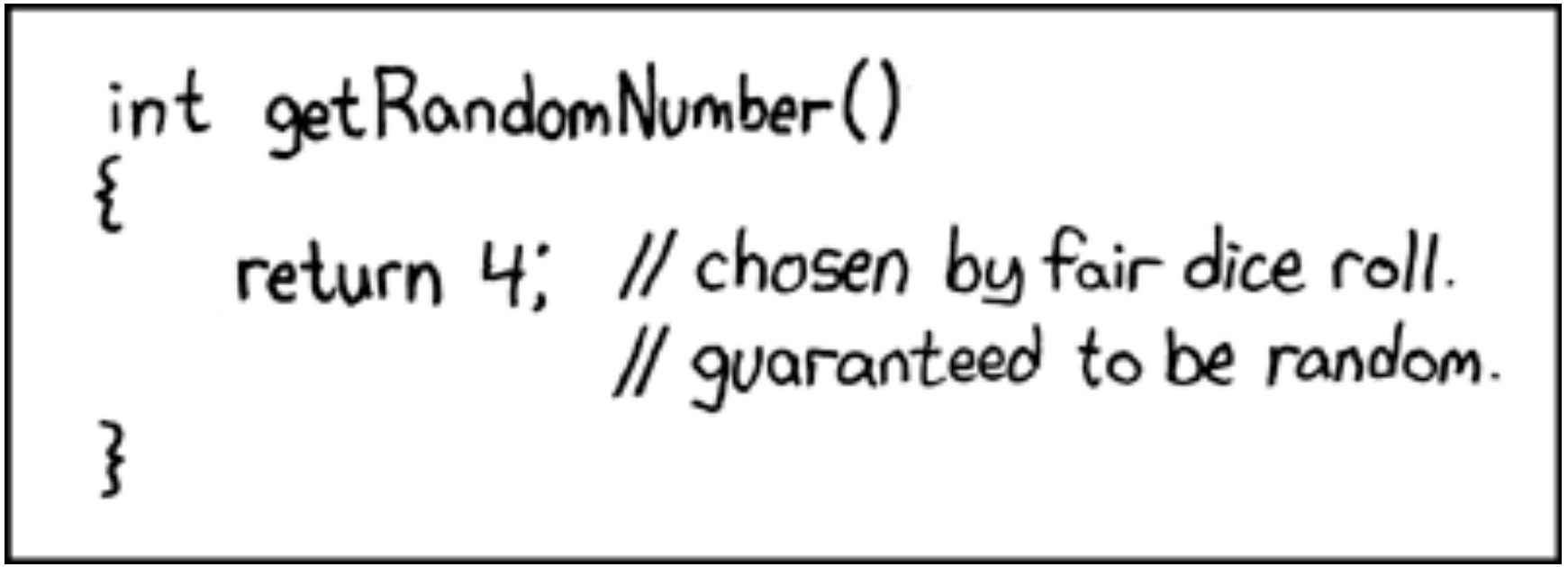
```
#include <iostream>
#include <vector>
using namespace std;

int main()
{
     vector<int> v;
     v.push_back( 1 );
     v.push_back( 2 );
     v.push_back( 3 );

     for ( vector<int>::iterator it=v.begin();
           it!=v.end();
           it++ )
     {
          cout << *it << endl;
     }

     return 0;
}
```

```
1
2
3
```

Random Number Generator

- With most computers it is difficult to devise a method by which to produce truly random numbers
  - These are useful in many situations (e.g. games, statistic simulation, AI, …)
- A random number generator (RNG) is an algorithm designed to generate a sequence of numbers or symbols that appear random

Motivational XKCD



The Basic Pattern

- With most RNGs, there is the concept of a *seed* – a value that is used to produce a distinct sequence
  - If you provide the same seed, you should always get the same sequence

- So…
  - Seed the RNG
  - Ask for as many random values as you need
    - May need computation to get in useful bounds

Example

```
#include <iostream>
#include <cstdlib>
using namespace std;

int main()
{
    srand( 42 ); // seed the rng
    for ( int i=0; i<5; i++ )
    {
        // rand() = [0, RAND_MAX]
        cout << ( rand() % 100 )
             << endl;
    }

    return 0;
}
```

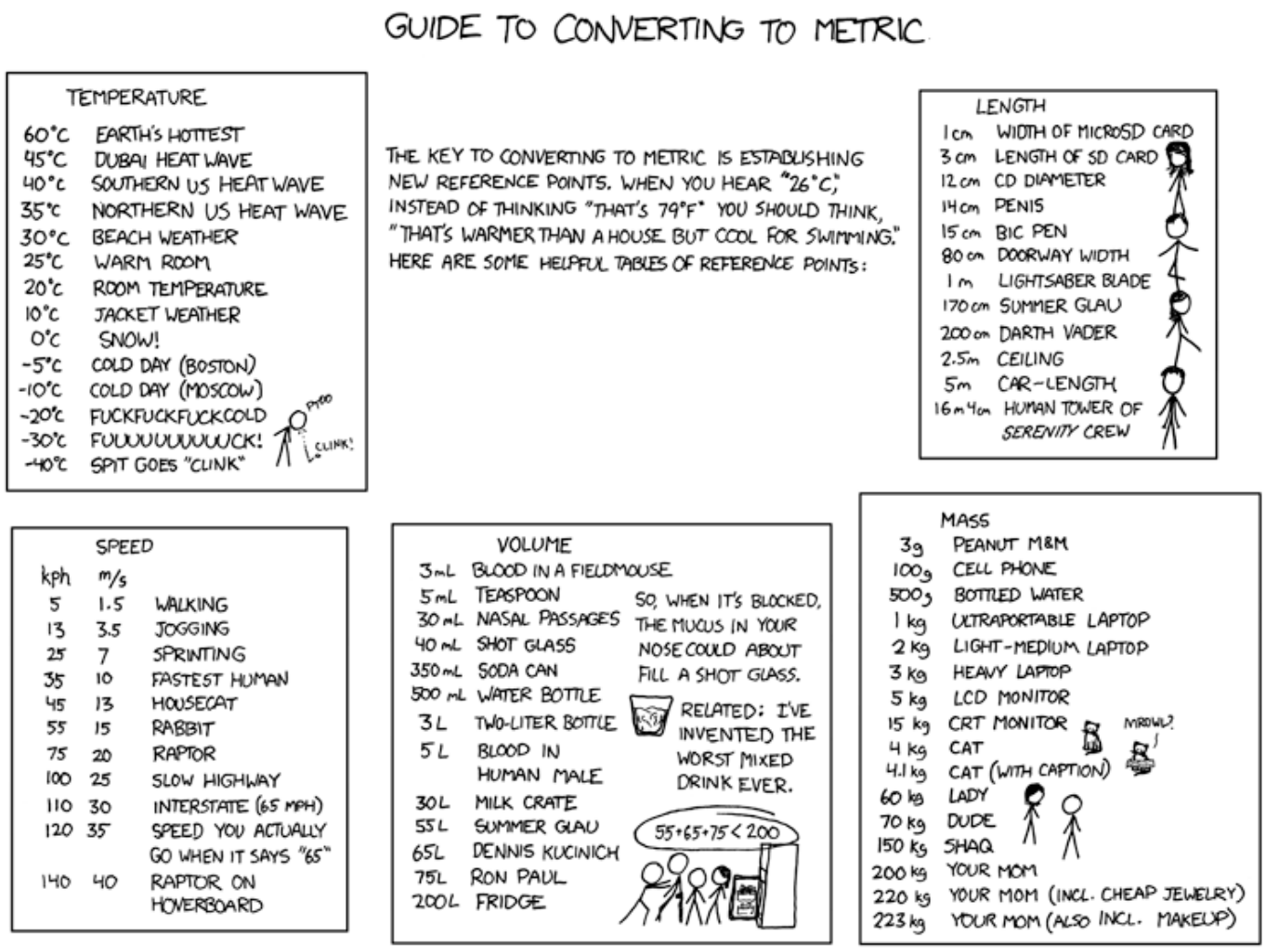
```
94
23
9
43
26
```

Casting

- Whenever you need to convert between data types, a form of type *casting* is involved

- There are many issues, including pointers, inheritance, const

Motivational XKCD (a stretch)



Example

```
#include <iostream>
#include <cstdlib>
using namespace std;

class Base
{
public:
     void foo()
     {
          cout << "Base" << endl;
     }
};

class Derived: public Base
{
public:
     void foo()
     {
          cout << "Derived" << endl;
     }
};
```

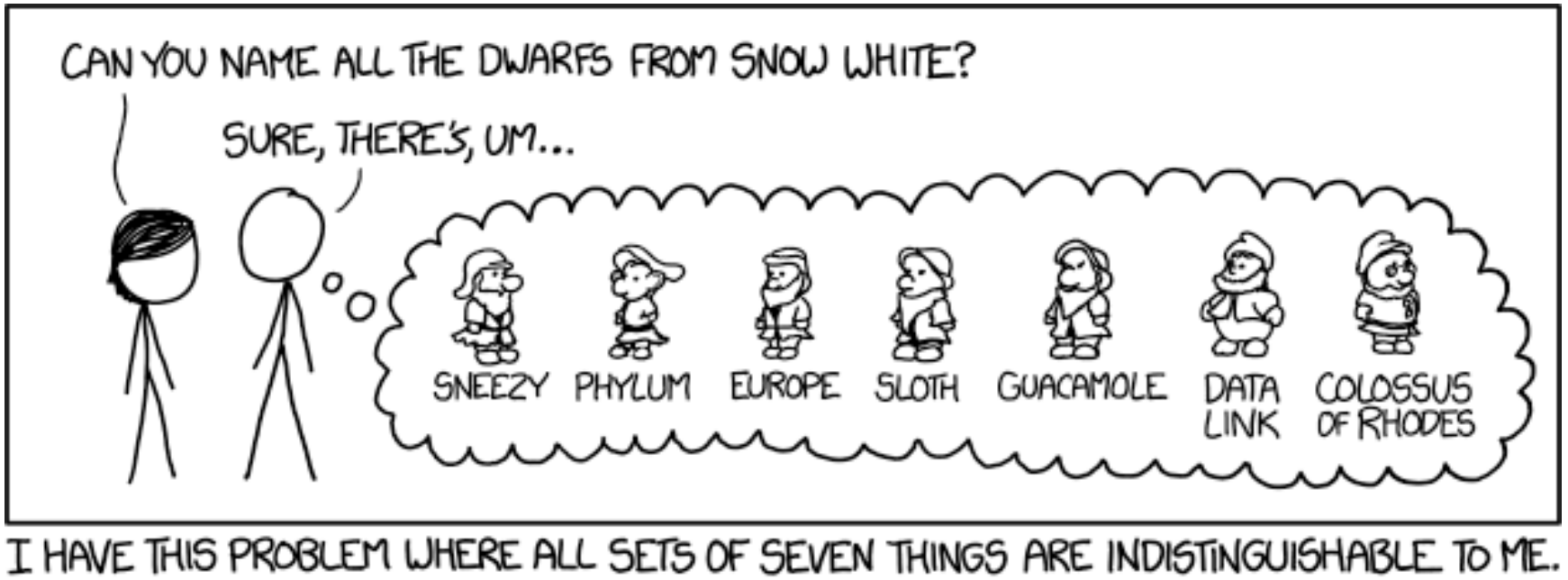
```
int main()
{
     Base* b = new Base();
     Base* d = new Derived();

     b->foo();
     d->foo();
     ((Derived*) d)->foo();

     return 0;
}
```

```
Base
Base
Derived
```

Enumerations

- A distinct type whose value is restricted to one of several explicitly named constants
- The values of the constants are values of an integral type
- Useful to let the compiler keep you from making mistakes when you know the range of values

Motivational XKCD



Example

```
#include <iostream>
using namespace std;

enum suit
{
    hearts, diamonds, spades, clubs
};

int main()
{
    suit a = hearts;
    suit b = spades;

    cout << ( a == b ) << endl;

    return 0;
}
```

```
0
```

Pairs

- It's often useful to bundle two variables together, and so there is a C++ **`pair`** class

- Pairs are templated, and generically referred to by the **`first`** or **`second`** element

Motivational XKCD

Example

```
#include <iostream>
#include <utility>
using namespace std;

int main()
{
    pair<char, int> a =
        make_pair<char, int>( 'a', 1 );

    cout << a.first
         << a.second
         << endl;

    return 0;
}
```

```
a1
```

Deep vs. Shallow Copies

- When assigning objects, a *shallow* copy is performed
  - Values are copied between instances
- This becomes problematic when dealing with dynamically allocated memory
  - All that is copied is a memory address, and so now two objects point to the same memory
- **Rule of the Big Three**. If you have any dynamically allocated storage in a class, you must provide:
  1. A destructor
  2. A copy constructor
  3. An overloaded assignment operator

Motivational XKCD

Shallow Example

```
#include <iostream>
using namespace std;

class Foo
{
public:
     int bar;
};

int main()
{
     Foo a, b;
     a.bar = 5;
     b = a;
     a.bar = 7;

     cout << a.bar << " "
          << b.bar << endl;

     return 0;
}
```

```
7 5
```

Pointer Problem

```
#include <iostream>
using namespace std;

class Foo
{
public:
     int* bar;
};

int main()
{
     Foo a, b;
     a.bar = new int(5);
     b = a;

     *(a.bar) = 7;

     cout << *(a.bar) << " "
          << *(b.bar) << endl;

     return 0;
}
```

```
7 7
```

The Big Three

```
class Foo
{
public:
     Foo() { bar = new int(0); }
     Foo(int x) { bar = new int(x); }

     Foo(const Foo& other)
     {
          bar = new int( *(other.bar) );
     }

     ~Foo() { delete bar; }

     Foo& operator =(const Foo& other)
     {
          *bar = *(other.bar);
          return *this;
     }

     int* bar;
};
```

```
int main()
{
     Foo a(5), b;
     Foo c(a);
     b = a;

     *(a.bar) = 7;

     cout << *(a.bar) << " "
          << *(b.bar) << " "
          << *(c.bar) << endl;

     return 0;
}
```

```
7 5 5
```

Wrap Up

- There are many aspects of C++ that we did not cover in depth
- I hope you continue to explore programming in C++ and other languages
  - Much of what we covered here has its parallels in other languages

End-of-Semester XKCD