22-0: **Errors**

- Errors can occur in program
  - Invalid input / bad data
  - Unexpected situation
  - Logic error in code
- Like to handle these errors gracefully, not just halt the program
  - Running a web server, don't want one piece of bad data to bring the whole thing down

22-1: **Error Checking**

- We could check for any concievable error

```
A[i] = x / y;
```

22-2: **Error Checking**

- We could check for any concievable error

```
if (i >= 0 && i < A.length)
{
   if (y != 0)
   {
      A[i] = x / y
   }
   else
   {
      // Handle division by zero case
   }
   // Handle outside bounds of the array case
}
```

- Problems with this method?

22-3: **Exceptions**

- We can let the system catch all the errors for us

```
A[i] = x / y
```

- Throws an exception if i ¡ 0, i ¿= A.length, y == 0. Program ends.
- Problems with this method?

22-4: **Exceptions**

- We can let the system catch the errors for us
- We can "catch" the errors ourselves

```
try
{
   A[i] = x / y
}
catch (Exception e)
{
   // do some work to clean up after the exception
}
```

22-5: **Try-Catch Block**

```
try
{
   // Any Java Code
}
catch (Exception e)
{
   // Any Java Code
}
```

- If an exception is rasied inside the try block:
  - Stop immediately and execute the code in the catch block
  - Coninue after the catch block as normal
- If no exception is raised inside the try block
  - Ignore the code in the catch block

22-6: **Exceptions**

```
int x;
int y;
try
{
   x = 3;
   y = 0;
   x = x / y;
   System.out.println("Can't get here!");
}
catch (Exception e)
{
   System.out.println("Exception caught!");
}
System.out.println("Done with try block!");
```

22-7: **Exceptions**

```
int x;
int y;
try
{
   x = 3;
   y = 5;
   x = x / y;
   System.out.println("We will get here!");
}
catch (Exception e)
{
   System.out.println("We won't get here!");
}
System.out.println("Done with try block!");
```

22-8: **Exceptions**

```
int A[] = new int[10];
try
{
   for (int i = 0; i < 10; i++)
      System.out.println(i);
   for (int i = 10; i > 0; i--)
      System.out.println(i);
}
catch (Exception e)
{
   System.out.println("Error!");
}
System.out.println("Done with try block!");
```

22-9: **Exceptions**

- Variables declared within a try block are not visible outside
- Actually, variables declated within *any* block are not visible outside the block

```
try
{
   int A[] = new int[10];
   for (int i = 0; i < 10; i++)
      A[i] = i;
}
catch (Exception e)
{
   System.out.println("Error!");
}
A[3] = 5;   // ERROR!
```

22-10: **Exceptions**

- What if you want to know more about what went wrong

```
try
{
   A[i] = x / y;
}
catch (Exception e)
{
   System.out.println("Error!");
}
```

- There are actually two different kinds of errors that could occur – division by 0, and index out of range

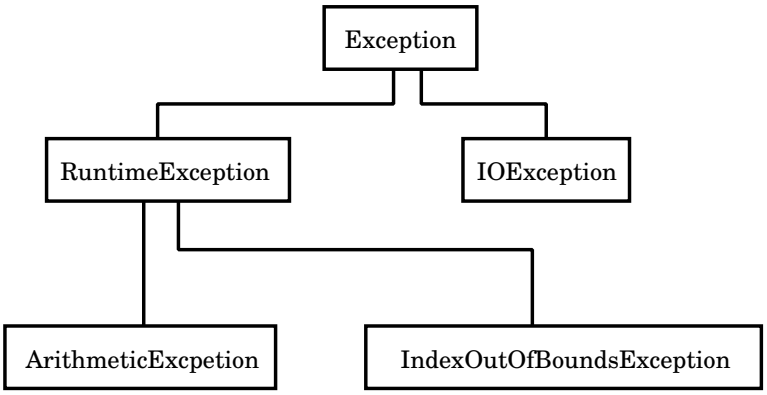
22-11: **Exceptions**

```
try
{
   A[i] = x / y;
}
catch (ArithmeticException e)
{
   // Handle division by zero
}
catch (IndexOutOfBoundsException e)
{
   // Handle Index out of range
}
catch (Exception e)
{
   // Handle anything else
}
```

22-12: **Try-Catch Block**

- If an exception occurs:
  - Find the first catch block that matches the expression, execute that code
  - If more than one catch block matches, use the first one
  - If no catch block matches, the excpetion is uncaught

22-13: **Exception Heirarchies**



22-14: **Exceptions are Objects**

- An exception is an object
  - Contains data members and methods
- All exceptions are subclasses of the base class Exception
  - Some data members and methods that all exceptions have

22-15: **Exceptions are Objects**

- Some methods defined in excpetions:
  - getMessage()
    - return a string that describes what went wrong
  - toString()
    - All exceptions are objects, so must have a toString method. Name of exception, concatenated to the message
  - getStackTrace()
    - What the stack looks like at time of exception. Not commonly used

22-16: **Exceptions**

```
   try
   {
      A[i] = x / y;
   }
   catch (Exception e)
   {
      // Handles ALL exceptions
   }
   catch (ArithmeticException e)
   {
      // CANNOT BE REACHED
   }
   catch (IndexOutOfBoundsException e)
   {
      // CANNOT BE REACHED
   }
```

22-17: **Uncaught Exceptions**

```
int divide(int x, int y)
{
    int result = x / y;
    System.out.println(result);
    return result;
}

void foo()
{
   int x = 5;
   x = divide(x, 2);
   x = divide(x, 1);
   x = divide(x, 0);
   x = divide(x, 2);
}
```

22-18: **Uncaught Exceptions**

```
int divide(int x, int y)
{
    int result = x / y;
    System.out.println(result);
    return result;
}
void foo()
{
   try
   {
      int x = 5;
      x = divide(x, 2);
      x = divide(x, 1);
      x = divide(x, 0);
      x = divide(x, 1);
   }
   catch (ArithmeticException e)
   {
      System.out.println("Error!");
   }
}
```

22-19: **Uncaught Exceptions**

```
int divide(int x, int y)
{
    int result = x / y;
    System.out.println(result);
    return result;
}
void divideBySelf(int A[])
{
   for (int i = 0; i < A.length; i++
   {
      A[i] = divide(A[i], A[i]);
   }
}
```

```
void foo()
{
   int A[] = new int[3];
   A[0] = 4;
   A[1] = 0;
   A[2] = 4;
   try
   {
      divideBySelf(A);
   }
   catch (ArithmeticException e)
   {
      System.out.println("Excp. caught!");
   }
}
```

22-20: **Uncaught Exceptions**

```
class Silly {
   public int x;
   int badFunc()
   {
       x++;
       int y = x / 0;
       x++;
   }
   void foo()
   {
      x++;
      badFunc();
      x++;
   }
```

```
void bar()
{
   x++;
   foo();
   x++;
}
void start()
{
   try
   {
      x = 0;
      bar();
   }
   catch (Exception e) { }
   System.out.println(x);
}
```

22-21: **Exception Messages**

- Exceptions can have a “Message” string
  - Tells you a little bit more about the exception

```
String msg;
try {
   x = y / 0;
}
catch (ArithmeticException e)
{
   msg = e.getMessage();
}
```

- msg = “/ by 0”

22-22: **Exception Messages**

- Exceptions can have a “Message” string
  - Tells you a little bit more about the exception

```
String msg;
try {
   int A[] new int[10];
   A[32] = 6;
}
catch (ArithmeticException e)
{
   msg = e.getMessage();
}
```

- msg = “32”

22-23: **Checked vs. Unchecked**

- Two kinds of exceptions:
  - Unchecked Exceptions

- Typically caused by programming errors (divide by zero, array index out of bounds, etc)
- Often no graceful way to recover
- Program does not need to handle them expilictly

- Checked Exceptions
  - Typically caused by bad data from the user
  - Program does need to handle them explicitly

22-24: **Checked vs. Unchecked**

- If a method *could* throw a checked exception, it needs to declare that in its function header
- If a method calls another method that could throw a checked exception, then it needs to either:
  - Catch the exception and deal with it
  - Declare that the checked exception may be thrown

22-25: **Checked vs. Unchecked**

```
class ExceptionTest{
  static void readFile(String filename)  // ERROR!
  {
    scanner scan = new Scanner(new File(filename));
    System.out.println(scan.nextString());
  }
  public static void main(String args[])
  {
    readFile(args[0]);
  }
}
```

22-26: **Checked vs. Unchecked**

```
class ExceptionTest{
  static void readFile(String filename)
  {
    try
    {
      scanner scan = new Scanner(new File(filename));
      System.out.println(scan.nextString());
    }
    catch (Exception e)
    {

    }
  }
  public static void main(String args[])
  {
    readFile(args[0]);
  }
}
```

22-27: **Checked vs. Unchecked**

```
class ExceptionTest{
  static void readFile(String filename)
  {
    try
    {
      scanner scan = new Scanner(new File(filename));
      System.out.println(scan.nextString());
    }
    catch (IOException e)
    {

    }
  }
  public static void main(String args[])
  {
    readFile(args[0]);
  }
}
```

22-28: **Checked vs. Unchecked**

```
class ExceptionTest{
  static void readFile(String filename)
  {
    try
    {
      scanner scan = new Scanner(new File(filename));
      System.out.println(scan.nextString());
    }
    catch (FileNotFoundException e)
    {

    }
  }
  public static void main(String args[])
  {
    readFile(args[0]);
  }
}
```

22-29: **Checked vs. Unchecked**

```
class ExceptionTest{
  static void readFile(String filename) throws IOException
  {
     scanner scan = new Scanner(new File(filename));
     System.out.println(scan.nextString());
  }
  public static void main(String args[])
  {
    readFile(args[0]);  // ERROR!
  }
}
```

22-30: **Checked vs. Unchecked**

```
class ExceptionTest{
  static void readFile(String filename) throws IOException
  {
     scanner scan = new Scanner(new File(filename));
     System.out.println(scan.nextString());
  }
  public static void main(String args[])
  {
    try
    {
      readFile(args[0]);
    }
    catch (IOException e)
    {

    }
  }
}
```

22-31: **Checked vs. Unchecked**

```
class ExceptionTest{
  static void readFile(String filename) throws IOException
  {
     scanner scan = new Scanner(new File(filename));
     System.out.println(scan.nextString());
  }
  public static void main(String args[]) thows IOException
  {
    readFile(args[0]);
  }
}
```

22-32: **Checked vs. Unchecked**

```
class ExceptionTest{
  static void readFile(String filename) throws FileNotFoundException
  {
     scanner scan = new Scanner(new File(filename));
     System.out.println(scan.nextString());
  }
  public static void main(String args[]) thows IOException
  {
    readFile(args[0]);
  }
}
```

22-33: **Checked vs. Unchecked**

```
class ExceptionTest{
  static void readFile(String filename) throws IOException
  {
     scanner scan = new Scanner(new File(filename));
     System.out.println(scan.nextString());
  }
  public static void main(String args[]) thows FileNotFoundException
  {
    readFile(args[0]);  // ERROR!  (why?)
  }
}
```

22-34: **Creating you own Exception**

- We can create our own Exceptions:

```
public class BadDataException extends Exception
{
   BadDataException(String message)
   {
       super(message);
   }
}
```

22-35: **Throwing Exceptions**

```
int readStudentID(Scanner s) throws BadDataException
{
   int ID = s.nextInt();
   if ((ID < SMALLEST_LEGAL_ID) || (ID > LARGEST_LEGAL_ID))
   {
     BadDataException e = new BadDataException("Malformed ID Number");
     throw e;
   }
   return ID;
}
```

22-36: **Throwing Exceptions**

- Custom exceptions that extend “Exception” must be checked exceptions
- If your function could possibly throw a “custom” exception, needs to tell the world about it
  - Throw custom exception through a “throw” statement
  - Call another function that could throw a custom exception, don’t catch it

22-37: **Throwing Exceptions**

```
int readStudentID(Scanner s) throws BadDataException
{
   int ID = s.nextInt();
   if ((ID < SMALLEST_LEGAL_ID) || (ID > LARGEST_LEGAL_ID))
   {
     BadDataException e = new BadDataException("Malformed ID Number");
     throw e;
   }
   return ID;
}
int readStudentIDs(Scanner s, int A[]) // ERROR!
{
   int size = 0;
   while (s.hasNextInt())
   {
       A[size] = readStudentID(s);
       size++;
   }
   return size;
}
```

22-38: **Throwing Exceptions**

```
int readStudentID(Scanner s) throws BadDataException
{
   int ID = s.nextInt();
   if ((ID < SMALLEST_LEGAL_ID) || (ID > LARGEST_LEGAL_ID))
   {
     BadDataException e = new BadDataException("Malformed ID Number");
     throw e;
   }
   return ID;
}
int readStudentIDs(Scanner s, int A[]) throws BadDataException
{
   int size = 0;
   while (s.hasNextInt())
   {
       A[size] = readStudentID(s);
       size++;
   }
   return size;
}
```

22-39: **Throwing Exceptions**

```
int readStudentIDs(Scanner s, int A[])
{
   int size = 0;
   try
   {
      while (s.hasNextInt())
      {
          A[size] = readStudentID(s);
          size++;
      }
   }
   catch (BadDataException e)
   {
      System.out.println("Bad Data, aborting ...");
   }
   return size;
}
```

22-40: **Throwing Exceptions**

```
int readStudentIDs(Scanner s, int A[])
{
   int size = 0;
   while (s.hasNextInt())
   {
      try
      {
         A[size] = readStudentID(s);
         size++;
      }
      catch (BadDataException e)
      {
         System.out.println("Bad Data, skipping ...");
      }
   }
   return size;
}
```

22-41: **Custom Unchecked**

- All Exceptions that extend Exception directly must be checked exceptions
- Custom Exeception that subclasses RuntimeException may be unchecked
  - Examples with Eclipse
- Why are custom unchecked exceptions usually a bad idea?

22-42: **Finally**

- Finally clause can optionally appear after all of the catch blocks
- Code in the finally clause will *always* be executed at the end of the try/catch block
  - If no exception, finally is executed after normal completion
  - If exception is caught, finally is executed after appropriate catch block
  - If exception is not caught, finally is executed, then exception is thrown to calling function
- Exampes from eclipse

22-43: **Finally**

```
try
{
  int x = 3 / 0;
  System.out.println("Can't get here");
}
catch (Exception e)
{
  System.out.println("Will get here");
}
finally
{
  System.out.println("Will also get here");
}
System.out.println("Will get here.");
```

22-44: **Finally**

```
try
{
  int x = 3 / 3;
  System.out.println("Will get here");
}
catch (Exception e)
{
  System.out.println("Will not get here");
}
finally
{
  System.out.println("Will also get here"");
}
System.out.println("Will get here.");
```

22-45: **Finally**

```
try
{
  int x = 3 / 0;
  System.out.println("Won't get here");
}
catch (IndexOutOfBoundsException e)
{
  System.out.println("Won't get here either");
}
finally
{
  System.out.println("Will get here.");
}
System.out.println("Won't get here");
```

22-46: **Hands-on**

- Minilab, as described on website