Programming with `cin`, `cout`, and Data Files

November 15, 2010

Object Oriented Programming

class A class is a mechanism that allows a programmer to define new data types.

- A class can be used to add functionality to an existing data type or to create a new data type.
- A class definition combines data and functionality.

object An object is a variable of a defined class type, also referred to as an instance of a class .

`cin` & `cout` as Instances

`cin` is an input stream

- `cin` object of type `istream`
- `istream` class is defined in file `iostream`
  - `#include <iostream>`

```
1  int N(0); // number of datapoints
2  double sumx(0), sumy(0);
3  double x, y;
4  while( cin >> x >> y ) {
5      sumx += x;
6      sumy += y;
7      N++;
8  }
9  if( N ) {
10     cout.setf( ios::fixed );
11     cout.precision( 3 );
12     cout << "Averages ";
13     cout << " x:" << sumx/N;
14     cout << " y:" << sumy/N;
15 }
```

`cin` & `cout` as Instances

`cout` is an output stream

- `cout` object of type `ostream`
- `ostream` class is defined in file `iostream`
  - `#include <iostream>`
- Member functions!
  - `cout.setf( ios::fixed );`
  - `cout.precision(3);`

```
1  int N(0); // number of datapoints
2  double sumx(0), sumy(0);
3  double x, y;
4  while( cin >> x >> y ) {
5      sumx += x;
6      sumy += y;
7      N++;
8  }
9  if( N ) {
10     cout.setf( ios::fixed );
11     cout.precision( 3 );
12     cout << "Averages ";
13     cout << " x:" << sumx/N;
14     cout << " y:" << sumy/N;
15 }
```

Try questions 2 and 5.

Goals

- Learn how to reliably read input from `cin`.
- Leverage our familiarity of `cout` and `cin` to write and read from our own files (not just the keyboard and console).
- Learn how to format the output of `cout`.

cin Properties

- cin ignores all *leading* whitespace or line endings before it parses "real" (non-whitespace) character data.
- once the first valid character of data has been read, cin *stops* parsing ...
  - successfully at whitespace or end-of-file.
  - successfully at the first nonsensical character for the type of value being read.
- if at least one valid character of data can not be read, then cin enters the failure state!
- "nonsensical" depends on *where* the character is encountered.
  Only the fourth plus symbol is nonsensical in this stream of integers:

```
+1234 +123++4
```

- Demo: Edit Program Run Program

Reading Whole Lines

Why can’t we read whole lines in C++?

Reading Whole Lines

Why can't we read whole lines in C++?
You can, by reading into a `string` variable type with the `getline` function:

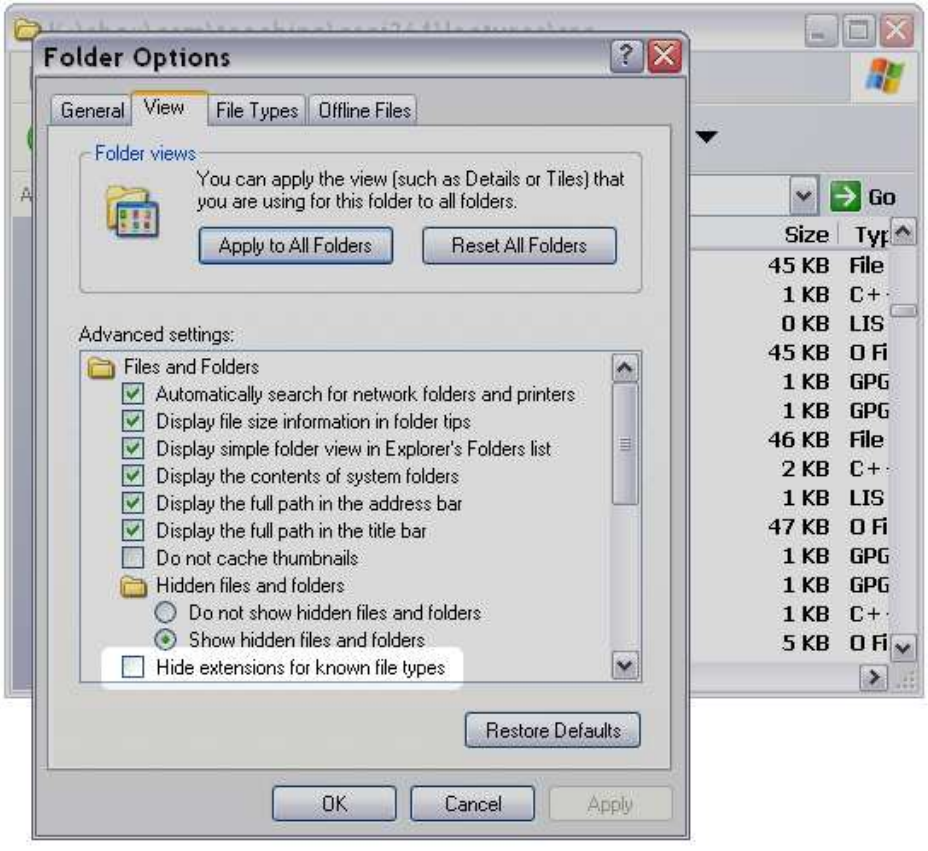
```
1 /***
2  * Display numbered lines of cin input
3  */
4 string inputLine;
5 int lineNo(1);
6
7 cout << "Enter lines of any length. " ;
8 cout << "CTRL-D or CTRL-Z to quit" <<  endl;
9
10 // The '\n' represents the newline character,
11 // otherwise known as the Enter key.
12 while( getline( cin, inputLine, '\n' )) {
13     cout << lineNo++ << ": ";
14     cout << inputLine << endl;
15 }
```

<<Interactive Program>>

RUN EDIT ../src/0_t.cxx

File I/O

Some Disk File Details



1. An “open file” in C++ does not mean a new window will appear on your screen.
2. Don’t use spaces or punctuation when naming files (name them like valid variable names).
3. Windows, by default, does not show you the entire filename, it typically hides the file “extension” (`.txt`, `.cpp`, `...`).

$\Longleftarrow$

Simple File Pattern: Reading Data

```
1  ifstream inFile( "data3.dat" );
2  if( !inFile ) {
3      cout << "Error opening file." << endl;
4      exit(1);
5  }
6  cout << "File opened!" << endl;
7
8  // Now read data from file. Print every other
9  // number (beginning with the first)
10 int counter(0);
11 double data;
12 while( inFile >> data ) {
13     if( ++counter % 2 ) {
14         cout << counter << " " << data
15                 << endl;
16     }
17 }
18
19 cout << "Total " << counter << " data points."
20         << endl;
21
22 inFile.close();
```

Run Read Example

- Simple, not very flexible, but it works well.
- Opens file on variable declaration.
- Note the `!inFile` to check failure.
- NICE! The `while` loop reads from the file until all data is consumed, or there is a parsing error.

  Engineers need to do this a lot!
- Must use `#include <fstream>` for the file i/o library.

Simple File Pattern: Writing Data

Run Write Example

- Simple, not very flexible, but it works well.
- Opens (overwrites!) file on variable declaration.
- Note the `!outFile` to check failure.

```
1  ofstream outFile( "JUNK~" );
2  if( !outFile ) {
3      cout << "Error opening file." << endl;
4      exit(1);
5  }
6
7  // write some data
8  outFile << "First line in JUNK~" << endl;
9  // a bool, a char, an int, and a double
10 char letter( 'K' );
11 double avogadro(6.0221415e23);
12 outFile << true << "\t" << letter << "\t" <<
13         104729 << "\n" << avogadro << endl;
14
15 // close the file, always!
16 outFile.close();
```

Simple File Pattern Similarities

- `ifstream` and `ofstream` types are both from `#include <fstream>`
- Test open success with `if( !fileVariable ) ...`
- `exit(1)` on failure (in `#include <cstdlib>`)
- `.close()` when finished with file.

Reading Data

Simple Average

Averages from `cin`

```
1  int N(0); // number of datapoints
2  double sumx(0), sumy(0);
3  double x, y;
4  while( cin >> x >> y ) {
5      sumx += x;
6      sumy += y;
7      N++;
8  }
9  if( N ) {
10     cout.setf( ios::fixed );
11     cout.precision( 3 );
12     cout << "Averages ";
13     cout << " x:" << sumx/N;
14     cout << " y:" << sumy/N;
15 }
```

Run Program | Data File

```
1  ifstream infile( "data3.dat" );
2  if( !infile ) {
3      cout << "Error opening file." << endl;
4      exit(1);
5  }
6
7  int N(0); // number of datapoints
8  double sumx(0), sumy(0);
9  double x, y;
10 while( infile >> x >> y ) {
11     sumx += x;
12     sumy += y;
13     N++;
14 }
15 if( N ) {
16     cout.setf( ios::fixed );
17     cout.precision( 3 );
18     cout << "Averages";
19     cout << " x:" << sumx/N;
20     cout << " y:" << sumy/N;
21 }
22
23 infile.close();
```

inFile » strData vs. getline

```
1  ifstream inFile( "asciibeast.txt" );
2  if( !inFile ) {
3      cout << "asciibeast.txt could not be opened." << endl;
4      exit(1);
5  }
6
7  string data;
8  while( getline( inFile, data, '\n' )) {
9      cout << data << endl;
10 }
11
12 inFile.close();
```

Run
getline

Run
inFile >> strData

```
1  ifstream inFile( "asciibeast.txt" );
2  if( !inFile ) {
3      cout << "asciibeast.txt could not be opened." << endl;
4      exit(1);
5  }
6
7  string data;
8  while( inFile >> data ) {
9      cout << data;
10 }
11
12 inFile.close();
```

» Equations

Understanding » Equations

What steps are taken for the calculation of R?

```
1 int i1(1), i2(2), i3(3);
2 double d1(10.5), R;
3
4 R =  i1 + i2 + d1 + i3;
```

Understanding » Equations

```
1 int i1(1), i2(2), i3(3);
2 double d1(10.5), R;
3
4 R =  i1 + i2 + d1 + i3;
5 R =  tmpInt1 + d1 + i3;    //       i1 + i2 –> tmpInt1
6 R =       tmpDbl1 + i3;    // tmpInt1 + d1 –> tmpDbl1
7 R =            tmpDbl2;    // tmpDbl1 + i3 –> tmpDbl2
8                            // tmpDbl2 saved into R
```

The compiler simplification of this equation is analogous to the simplification of algebraic expressions in mathematics.

Understanding » Equations

How is this equation similar or different than the last?

```
1 int i1, i2, i3;
2 double d1;
3
4 cin >> i1 >> i2 >> d1 >> i3;
```

Understanding » Equations

```
1 int i1, i2, i3;
2 double d1;
3
4 cin >> i1 >> i2 >> d1 >> i3;
5       cin >> i2 >> d1 >> i3; // cin>>i1 -> cin + s/e
6             cin >> d1 >> i3; // cin>>i2 -> cin + s/e
7                   cin >> i3; // cin>>d1 -> cin + s/e
8                         cin; // cin>>i3 -> cin + s/e
```

Again, the simplification is similar to that of mathematics, as long as you understand that:

`cin >> variable` $\rightarrow$ `cin` + side effect

Understanding » Equations

```
1 int i1, i2, i3;
2 double d1;
3
4 cin >> i1 >> i2 >> d1 >> i3;
5       cin >> i2 >> d1 >> i3; // cin>>i1 -> cin + s/e
6             cin >> d1 >> i3; // cin>>i2 -> cin + s/e
7                   cin >> i3; // cin>>d1 -> cin + s/e
8                         cin; // cin>>i3 -> cin + s/e
9                              // ...cin "thrown-away"
```

There was no assignment operator (=, +=, . . .) in the expression, so the final value (`cin`) is “thrown away” by the compiler.

Try question 7.

Stream Conversions to Boolean

In C++, `0==false`, any other number is `true` (We know this already).

Stream Conversions to Boolean

In C++, `0==false`, any other number is `true` (We know this already). Fundamental I/O Concept$\Longrightarrow$ C++ converts any stream (`cin` or `cout`, or `ifstream`, `ofstream`) to a Boolean that tells if an input or output error has occured.

No I/O Error $\rightarrow$ `true`

Stream Conversions to Boolean

In C++, `0==false`, any other number is `true` (We know this already).
Fundamental I/O Concept$\Longrightarrow$ C++ converts any stream (`cin` or `cout`, or `ifstream`, `ofstream`) to a Boolean that tells if an input or output error has occured.

No I/O Error $\rightarrow$ `true`

```
1  int N(0); // number of datapoints
2  double sumx(0), sumy(0);
3  double x, y;
4  while( cin >> x >> y ) {
5      sumx += x;
6      sumy += y;
7      N++;
8  }
9  if( N ) {
10     cout.setf( ios::fixed );
11     cout.precision( 3 );
12     cout << "Averages ";
13     cout << " x:" << sumx/N;
14     cout << " y:" << sumy/N;
15 }
```

When a parsing error or end-of-file is encountered, the `while()` loop is broken.
Why?

The Reading Data Mantra

DON'T use member functions to detect failures
(avoid `.eof()` and `.fail()`),

DO USE one-liner input statements as predicates,

DO USE stream conversion to Boolean to detect failures.

Formatting cout

Operation	C++ statement
Print left justified	`cout.setf( ios::left );`
Print right justified	`cout.setf( ios::right );`
Print in a fixed width	`cout.width(10);`
(Optionally) use fixed decimal points	`cout.setf( ios::fixed );`
Specify fixed points	`cout.precision(4);`
(Optionally) use scientific notation	`cout.setf( ios::scientific );`
Print words for Booleans	`cout.setf( ios::boolalpha );`

See textbook § 6.2 for details. You may need to call `cout.unsetf()` to "unset" left or right justification.

Formatting cout

```
7  // console cell numbers
8  for( int i(1); i<=40; i++ ) cout << i % 10;
9  cout << endl;
10
11 // reformat sets of four data elements into
12 // horizontal 'records'.
13 int row(1), x;
14 double y, z;
15 string s;
16 while( inputfile >> x >> y >> z >> s ) {
17     cout.unsetf( ios::right ); // undo
18     cout.setf( ios::left );  // left justify
19     cout.width( 4 ); cout << row++ << "␣";
20     cout.width( 4 ); cout << x << "␣";
21     cout.setf( ios::fixed );
22     cout.precision( 3 );
23     cout.width( 9 ); cout << y << "|";
24     cout.unsetf( ios::left); // undo
25     cout.setf( ios::right ); // right justify
26     cout.setf( ios::scientific );
27     cout.precision(5);
28     cout.width(14); cout << z << "␣";
29     cout.width(5); cout << s << endl;
30 }
31
32 // another set of cell numbers
33 for( int i(1); i<=40; i++ ) cout << i % 10;
34 cout << endl;
```

Data File

```
1201 0.001
314159002718 a
203 0.0001
30123483751 ab
3748 0.00001
31231298.4320 c
837 1e-6
.312323198774 abc
38 0.002
83.7493343890 abc
```

Example Output

```
12345678901234567890123456789012345678901234567890
1    1201 0.001    |    3.1416e+11     a
2    203  0.0001   |    3.0123e+10    ab
3    3748 1e-05    |    3.1231e+07     c
4    837  1e-06    |       0.31232   abc
5    38   0.002    |        83.749   abc
12345678901234567890123456789012345678901234567890
```

Formatting cout

- `.precision()`, `.setf( ios::scientific )`, and `.setf( ios::fixed )`, appear to be meer suggestions to the formatting engine in C++. Not absolute rules.
- Significant digits appear to be highly respected.

Data File

```
1201 0.001
314159002718 a
203 0.0001
30123483751 ab
3748 0.00001
31231298.4320 c
837 1e-6
.312323198774 abc
38 0.002
83.7493343890 abc
```

Example Output

```
12345678901234567890123456789012345678901
1    1201 0.001    |    3.1416e+11     a
2    203  0.0001   |    3.0123e+10    ab
3    3748 1e-05    |    3.1231e+07     c
4    837  1e-06    |       0.31232   abc
5    38   0.002    |        83.749   abc
12345678901234567890123456789012345678901
```

Formatting cout

```
7  // console cell numbers
8  for( int i(1); i<=40; i++ ) cout << i % 10;
9  cout << endl;
10
11 // reformat sets of four data elements into
12 // horizontal 'records'.
13 int row(1), x;
14 double y, z;
15 string s;
16 while( inputfile >> x >> y >> z >> s ) {
17     cout.unsetf( ios::right ); // undo
18     cout.setf( ios::left );  // left justify
19     cout.width( 4 ); cout << row++ << "␣";
20     cout.width( 4 ); cout << x << "␣";
21     cout.setf( ios::fixed );
22     cout.precision( 3 );
23     cout.width( 9 ); cout << y << "|";
24     cout.unsetf( ios::left); // undo
25     cout.setf( ios::right ); // right justify
26     cout.setf( ios::scientific );
27     cout.precision(5);
28     cout.width(14); cout << z << "␣";
29     cout.width(5); cout << s << endl;
30 }
31
32 // another set of cell numbers
33 for( int i(1); i<=40; i++ ) cout << i % 10;
34 cout << endl;
```

Bad Data File

```
1201 0.001
314159002718 abcdefg
203 0.0001
30123483751 ab
3748 0.00001
31231298.4320 c
8374382 1e-6
.312323198774 abc
38 0.002
83.7493343890 abc
```

Example Output

```
12345678901234567890123456789012345678901234567890
1    1201 0.001    |    3.1416e+11 abcdefg
2    203  0.0001   |    3.0123e+10    ab
3    3748 1e-05    |    3.1231e+07     c
4    8374382 1e-06    |       0.31232   abc
5    38   0.002    |        83.749   abc
12345678901234567890123456789012345678901234567890
```

Formatting cout

When values don't conform to the expected output windows, C++ considers the data more important than the formatting.

Bad Data File

```
1201 0.001
314159002718 abcdefg
203 0.0001
30123483751 ab
3748 0.00001
31231298.4320 c
8374382 1e-6
.312323198774 abc
38 0.002
83.7493343890 abc
```

Example Output

```
12345678901234567890123456789012345678901
1    1201 0.001    |    3.1416e+11 abcdefg
2    203  0.0001   |    3.0123e+10    ab
3    3748 1e-05    |    3.1231e+07     c
4    8374382 1e-06    |       0.31232   abc
5    38   0.002    |        83.749   abc
12345678901234567890123456789012345678901
```

Complete questions 9 and 12.

finis

(Reference Slides Follow)

Reference: Using an Input File from Disk

Required Preprocessor	`#include <fstream>`
Declare & Open	`ifstream inFile( "file.dat" );`
Open name in `string fname`	`ifstream inFile;` `inFile.open( fname.c_str() );`
Read values from file	`inFile » car1time » car1accel;`
∞ Value Reading	`while( inFile » var ) {...}`
Return read position to “home”	`inFile.clear(), inFile.seekg(0);`
close File	`inFile.close();`

File OK?	`if( !inFile ) { ... }`
“Reset” File to OK	`inFile.clear();`

Reference: Using an Output File on Disk

Required Preprocessor	`#include <fstream>`
Open and Overwrite `"file.dat"`	`ofstream outFile("file.dat");`
Open and Append `"file.dat"`	`ofstream outFile("file.dat", ios::app);`
Write to name in `string fname`	`ofstream outFile;` `outFile.open( fname.c_str() );`
Write constants or variables (`diameter`) to file	`outFile « 3.14 « diameter « endl;`
close File	`outFile.close();`

File OK?	`if( !outFile ) { ... }`
“Reset” File to OK	`outFile.clear();`