Source File: `~/2336/45/lab45.(C|CPP|cpp|c++|cc|cxx|cp)`
Input: under control of `main` function
Output: under control of `main` function
Value: 4

Integer data is usually represented in a single word on a computer. The number of bits in a word determines the range of integers representable. For example, a 16-bit word allows integers in the range from −32768 through 32767. Doubling the word size to 32 bits increases the range from −2147483648 through 2147483647. In this latter case, results that are representable within ten digits are possible. It is desirable to be able to represent integral results that are larger (in absolute value) than this. In this assignment you are to develop a class for representing large integers. The large integer will be implemented as a deque of `char`s. Each element in the deque will contain a digit of the large integer. The large integer is to be stored such that the least significant digit is contained in the first element, the next-to-least significant digit in the second element, and so on. No leading zeroes should be stored with the large integer. The number zero (0) should be stored as a single digit of zero (0).

For this assignment, you are to create several constructors and overloaded operators that can be used for comparing large integers. A header file is shown in Figure 1, a sample `main` function for testing your implementation is shown in Figure 2, and a sample execution sequence is shown in Figure 3. To use the `Makefile` as distributed in class, add a target of `lab45` to `targets2srcfiles`.

For the constructor that takes a string parameter, if the `isInt` function returns false, the number should be stored as zero.

```
1  #ifndef LAB45_H
2  #define LAB45_H
3
4  #include <iostream>
5  #include <string>
6  #include <deque>
7
8  using namespace std;
9
10 typedef enum {NEGATIVE, ZERO, POSITIVE} Sign;
11
12 bool isInt(string s);
13
14 class BigInt
15 {
16   friend ostream& operator<<( ostream& output, const BigInt& );
17   friend istream& operator>>( istream& input, BigInt& );
18  public:
19   BigInt();                                    // constructor; digits = 0
20   BigInt( int num );                           // constructor; digits = num
21   BigInt( const string str );                  // constructor; digits = str
22   BigInt( const BigInt& other );               // copy constructor
23
24   bool    operator==( const BigInt& rhs ) const; // Equality
25   bool    operator< ( const BigInt& rhs ) const; // Less Than
26
```

Figure 1. `/usr/local/2336/include/lab45.h` (Part 1 of 2)

```
27   private:
28    Sign sign;                                    // Sign of #
29    deque<char> digits;                           // Deque of digits of #
30  };
31
32  #endif
```

Figure 1. `/usr/local/2336/include/lab45.h` (Part 2 of 2)

```
1   #include <lab45.h>
2   #include <cstdlib>
3   #include <iomanip>
4   #include <regex>
5
6   using namespace std;
7
8   void compareZeroes(const BigInt& a, const BigInt& b, const BigInt& c,
9                      const BigInt& d, const BigInt& e, const BigInt& f,
10                     string v1, string v2, string v3,
11                     string v4, string v5, string v6);
12
13  int main()
14  {
15    BigInt a, b(-507), c("abc"), d("275"),
16           e("     -11111111112222222222333333333334444    ");
17    BigInt f(e), g("     0               "), h("       -0      ");
18    BigInt i("     +0    "), j(+0), k(-0);
19
20    cout << boolalpha;
21    cout << "a = " << a << endl;
22    cout << "g = " << g << endl;
23    cout << "h = " << h << endl;
24    cout << "i = " << i << endl;
25    cout << "j = " << j << endl;
26    cout << "k = " << k << endl;
27
28    compareZeroes(a, g, h, i, j, k, "a", "g", "h", "i", "j", "k");
29    compareZeroes(g, h, i, j, k, a, "g", "h", "i", "j", "k", "a");
30    compareZeroes(h, i, j, k, a, g, "h", "i", "j", "k", "a", "g");
31    compareZeroes(i, j, k, a, g, h, "i", "j", "k", "a", "g", "h");
32    compareZeroes(j, k, a, g, h, i, "j", "k", "a", "g", "h", "i");
33    compareZeroes(k, a, g, h, i, j, "k", "a", "g", "h", "i", "j");
34
```

Figure 2. `/usr/local/2336/src/lab45main.C` (Part 1 of 3)

```
35    cout << "a = " << a << endl << "b = " << b << endl;
36    cout << "c = " << c << endl << "d = " << d << endl;
37    cout << "e = " << e << endl << "f = " << f << endl;
38    c = a = b;
39    cout << "a = " << a << endl << "b = " << b << endl;
40    cout << "c = " << c << endl;
41    cout << "a == b = " << (a == b) << endl;
42    cout << "c == b = " << (c == b) << endl;
43
44    while (cin >> a >> b)
45    {
46      cout << "a = " << a << " b = " << b << endl;
47      cout << a << " == " <<  b << " = " << (a == b) << endl;
48      cout << a << " <  " <<  b << " = " << (a <  b) << endl;
49    }
50
51    return EXIT_SUCCESS;
52  }
53
54  void compareZeroes(const BigInt& a, const BigInt& b, const BigInt& c,
55                     const BigInt& d, const BigInt& e, const BigInt& f,
56                     string v1, string v2, string v3,
57                     string v4, string v5, string v6)
58  {
59    cout << v1 << " == " << v1 << " = " << (a == a) << endl;
60    cout << v1 << " == " << v2 << " = " << (a == b) << endl;
61    cout << v1 << " == " << v3 << " = " << (a == c) << endl;
62    cout << v1 << " == " << v4 << " = " << (a == d) << endl;
63    cout << v1 << " == " << v5 << " = " << (a == e) << endl;
64    cout << v1 << " == " << v6 << " = " << (a == f) << endl;
65  }
66
67  bool isInt(string s)
68  {
69    regex pattern {R"(^\s*[-+]?\d+\s*$)"};
70
71    return regex_match(s, pattern);
72  }
73
74  istream& operator>>(istream& input, BigInt& num)
75  {
76    string s;
77
78    input >> s;
79    num = BigInt(s);
80
81    return input;
82  }
83
```

Figure 2. `/usr/local/2336/src/lab45main.C` (Part 2 of 3)

```
84 ostream& operator<<(ostream& output, const BigInt& num)
85 {
86   deque<char>::const_reverse_iterator itr;
87
88   if (num.sign == NEGATIVE)
89     output << '-';
90
91   for (itr = num.digits.crbegin(); itr != num.digits.crend(); ++itr)
92     output << *itr;
93
94   return output;
95 }
```

Figure 2. `/usr/local/2336/src/lab45main.C` (Part 3 of 3)

```
newuser@csunix ~> cd 2336
newuser@csunix ~/2336> ./getlab.ksh 45
  * Checking to see if a folder exists for Lab 45. . .No
  * Creating a folder for Lab 45
  * Checking to see if Lab 45 has sample input and output files. . .Yes
  * Copying input and output files for Lab 45
    from folder /usr/local/2336/data/45 to folder ./45
  * Checking to see if /usr/local/2336/src/lab45main.C exists. . .Yes
  * Copying file /usr/local/2336/src/lab45main.C to folder ./45
  * Checking to see if /usr/local/2336/include/lab45.h exists. . .Yes
  * Copying file /usr/local/2336/include/lab45.h to folder ./45
  * Copying file /usr/local/2336/src/Makefile to folder ./45
  * Adding a target of lab45 to targets2srcfiles
  * Touching file ./45/lab45.cpp
  * Edit file ./45/lab45.cpp in Notepad++
newuser@csunix ~/2336> cd 45
newuser@csunix ~/2336/45> ls
01.dat       01.out       Makefile     lab45.cpp    lab45.h      lab45main.C
newuser@csunix ~/2336/45> make lab45
g++ -g -Wall -std=c++11 -c lab45main.C -I/usr/local/2336/include -I.
g++ -g -Wall -std=c++11 -c lab45.cpp -I/usr/local/2336/include -I.
g++ -o lab45 lab45main.o lab45.o -L/usr/local/2336/lib -lm -lbits
```

```
newuser@csunix ~/2336/45> cat 01.dat
-12345678901234567890                     0
                   -1                     1
                   +0 -12345678901234567890
                   -0  12345678901234567890
 12345678901234567890 -12345678901234567890
 12345678901234567890                     0
                    0                     0
-98765432109876543210 -12345678901234567890
-99999999999999999999 -99999999999999999998
-99999999999999999998 -99999999999999999999
 -12345678901234567890                -1234
                -1234  -12345678901234567890
 12345678901234567890  12345678901234567890
 99999999999999999999  99999999999999999998
```

```
 99999999999999999998  99999999999999999999
 12345678901234567890  98765432109876543210
 98765432109876543210  12345678901234567890
  12345678901234567890                  1234
                  1234   12345678901234567890
                    -0                    -0
                     0                    -0
                    +0                    -0
                    -0                     0
                     0                     0
                    +0                     0
                    -0                    +0
                     0                    +0
                    +0                    +0
```

```
newuser@csunix ~/2336/45> cat 01.dat | ./lab45
a = 0
g = 0
h = 0
i = 0
j = 0
k = 0
a == a = true
a == g = true
a == h = true
a == i = true
a == j = true
a == k = true
```

```
g == g = true
g == h = true
g == i = true
g == j = true
g == k = true
g == a = true
h == h = true
h == i = true
h == j = true
h == k = true
h == a = true
h == g = true
i == i = true
```

Figure 3. Commands to Compile, Link, & Run Lab 45 (Part 1 of 3)

```
i == j = true
i == k = true
i == a = true
i == g = true
i == h = true
j == j = true
j == k = true
j == a = true
j == g = true
j == h = true
j == i = true
k == k = true
k == a = true
k == g = true
k == h = true
k == i = true
k == j = true
a = 0
b = -507
c = 0
d = 275
e = -11111111112222222222333333333334444
f = -11111111112222222222333333333334444
a = -507
b = -507
c = -507
a == b = true
c == b = true
a = -12345678901234567890 b = 0
-12345678901234567890 == 0 = false
-12345678901234567890 <  0 = true
a = -1 b = 1
-1 == 1 = false
-1 <  1 = true
a = 0 b = -12345678901234567890
0 == -12345678901234567890 = false
0 <  -12345678901234567890 = false
a = 0 b = 12345678901234567890
0 == 12345678901234567890 = false
0 <  12345678901234567890 = true
a = 12345678901234567890 b = -12345678901234567890
12345678901234567890 == -12345678901234567890 = false
12345678901234567890 <  -12345678901234567890 = false
a = 12345678901234567890 b = 0
12345678901234567890 == 0 = false
12345678901234567890 <  0 = false
a = 0 b = 0
0 == 0 = true
0 <  0 = false
a = -98765432109876543210 b = -12345678901234567890
-98765432109876543210 == -12345678901234567890 = false
-98765432109876543210 <  -12345678901234567890 = true
a = -99999999999999999999 b = -99999999999999999998
-99999999999999999999 == -99999999999999999998 = false
-99999999999999999999 <  -99999999999999999998 = true
a = -99999999999999999998 b = -99999999999999999999
-99999999999999999998 == -99999999999999999999 = false
-99999999999999999998 <  -99999999999999999999 = false
a = -12345678901234567890 b = -1234
-12345678901234567890 == -1234 = false
-12345678901234567890 <  -1234 = true
a = -1234 b = -12345678901234567890
-1234 == -12345678901234567890 = false
-1234 <  -12345678901234567890 = false
a = 12345678901234567890 b = 12345678901234567890
12345678901234567890 == 12345678901234567890 = true
12345678901234567890 <  12345678901234567890 = false
a = 99999999999999999999 b = 99999999999999999998
99999999999999999999 == 99999999999999999998 = false
99999999999999999999 <  99999999999999999998 = false
a = 99999999999999999998 b = 99999999999999999999
99999999999999999998 == 99999999999999999999 = false
99999999999999999998 <  99999999999999999999 = true
a = 12345678901234567890 b = 98765432109876543210
12345678901234567890 == 98765432109876543210 = false
12345678901234567890 <  98765432109876543210 = true
a = 98765432109876543210 b = 12345678901234567890
98765432109876543210 == 12345678901234567890 = false
98765432109876543210 <  12345678901234567890 = false
a = 12345678901234567890 b = 1234
```

Figure 3. Commands to Compile, Link, & Run Lab 45 (Part 2 of 3)

```
1234567890123456789 == 1234 = false
1234567890123456789 <  1234 = false
a = 1234 b = 1234567890123456789
1234 == 1234567890123456789 = false
1234 <  1234567890123456789 = true
a = 0 b = 0
0 == 0 = true
0 <  0 = false
a = 0 b = 0
0 == 0 = true
0 <  0 = false
a = 0 b = 0
0 == 0 = true
0 <  0 = false
a = 0 b = 0
0 == 0 = true
0 <  0 = false
a = 0 b = 0
0 == 0 = true
0 <  0 = false
a = 0 b = 0
0 == 0 = true
0 <  0 = false
a = 0 b = 0
0 == 0 = true
0 <  0 = false
a = 0 b = 0
0 == 0 = true
0 <  0 = false
newuser@csunix ~/2336/45> cat 01.dat | ./lab45 > my.out
newuser@csunix ~/2336/45> diff 01.out my.out
newuser@csunix ~/2336/45>
```

Figure 3. Commands to Compile, Link, & Run Lab 45 (Part 3 of 3)