Source File: `~/2336/05/lab05.(C|CPP|cpp|c++|cc|cxx|cp)`
Input: Under control of `main` function
Output: Under control of `main` function
Value: 2

Extend the `Rational` class from Labs 02 and 03 to provide the following additional member functions:

- Functions to implement the equality operators; that is, develop functions for equality and inequality.
- Functions to implement the various relational operators; that is, develop functions for $<$, $\leq$, $>$, and $\geq$.

It is only necessary to write code for one of the equality operators and one of the relational operators. Once these two functions are written, the remaining four functions are then written in terms of the original two functions. It is traditional to write the code for equality and $<$. Construct this assignment in this fashion.

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 `lab05` to `targets2srcfileswithlibrary`.

```
1  #ifndef LAB05_H
2  #define LAB05_H
3
4  #include <iostream>
5  #include <utility>
6
7  using namespace std;
8
9  class Rational
10 {
11  public:
12   Rational();                                        // default constructor
13   Rational(int num, int denom);                      // additional constructor
14   void setNumerator(int num);                        // set numerator to num
15   void setDenominator(int denom);                    // set denominator to denom
16   int getNumerator() const;                          // returns numerator
17   int getDenominator() const;                        // returns denominator
18   void reduce();                                     // Reduce to lowest terms
19                                                      //   and normalize
20   Rational add(const Rational& addend) const;        // Addition
21   Rational additiveInverse() const;                  // Returns the additive
22                                                      //   inverse
23   Rational subtract(const Rational& subtrahend) const; // Subtraction
24   Rational multiply(const Rational& multiplicand) const; // Multiplication
25   Rational multiplicativeInverse() const;            // Returns the
26                                                      //   multiplicative inverse
27   Rational divide(const Rational& divisor) const;   // Division
28   ostream& print(ostream& os) const;                 // Print Rational to output
29                                                      //   stream
30   istream& read(istream& is);                        // Read Rational from input
31                                                      //   stream
```

Figure 1. `/usr/local/2336/include/lab05.h` (Part 1 of 2)

```
32    bool isEqualTo(const Rational& other) const;    // *this == other
33    bool isNotEqualTo(const Rational& other) const; // *this != other
34    bool isLessThan(const Rational& other) const;   // *this < other
35    bool isLessThanOrEqualTo(const Rational& other) const; // *this <= other
36    bool isGreaterThan(const Rational& other) const; // *this > other
37    bool isGreaterThanOrEqualTo(const Rational& other) const; // *this >= other
38  private:
39    pair<int, int> data;                            // member first -> numerator
40                                                    // member second -> denominator
41    int gcd(int m, int n) const;                    // returns the greatest
42                                                    //   common divisor of m
43                                                    //   and n
44    int lcm(int m, int n) const;                    // returns the least common
45                                                    //   multiple of m and n
46  };
47
48  #endif
```

Figure 1. `/usr/local/2336/include/lab05.h` (Part 2 of 2)

```
1   #include <lab05.h>
2   #include <iostream>
3   #include <iomanip>
4
5   using namespace std;
6
7   int main()
8   {
9     Rational first(1, -2), second(-3, 0), result;
10
11    cout << boolalpha;
12    first.print(cout);
13    cout << ' ';
14    second.print(cout);
15    cout << ' ';
16    result.print(cout);
17    cout << endl;
18
19    while (first.read(cin) && second.read(cin))
20    {
21      first.print(cout);
22      cout << " == ";
23      second.print(cout);
24      cout << " = " << first.isEqualTo(second) << endl;
25
```

Figure 2. `/usr/local/2336/src/lab05main.C` (Part 1 of 2)

```
26      first.print(cout);
27      cout << " != ";
28      second.print(cout);
29      cout << " = " << first.isNotEqualTo(second) << endl;
30
31      first.print(cout);
32      cout << " <  ";
33      second.print(cout);
34      cout << " = " << first.isLessThan(second) << endl;
35
36      first.print(cout);
37      cout << " <= ";
38      second.print(cout);
39      cout << " = " << first.isLessThanOrEqualTo(second) << endl;
40
41      first.print(cout);
42      cout << " >  ";
43      second.print(cout);
44      cout << " = " << first.isGreaterThan(second) << endl;
45
46      first.print(cout);
47      cout << " >= ";
48      second.print(cout);
49      cout << " = " << first.isGreaterThanOrEqualTo(second) << endl;
50    }
51
52    return EXIT_SUCCESS;
53  }
```

Figure 2. `/usr/local/2336/src/lab05main.C` (Part 2 of 2)

```
1  newuser@csunix ~> cd 2336
2  newuser@csunix ~/2336> ./getlab.ksh 05
3    * Checking to see if a folder exists for Lab 05. . .No
4    * Creating a folder for Lab 05
5    * Checking to see if Lab 05 has sample input and output files. . .Yes
6    * Copying input and output files for Lab 05
7      from folder /usr/local/2336/data/05 to folder ./05
8    * Checking to see if /usr/local/2336/src/lab05main.C exists. . .Yes
9    * Copying file /usr/local/2336/src/lab05main.C to folder ./05
10   * Checking to see if /usr/local/2336/include/lab05.h exists. . .Yes
11   * Copying file /usr/local/2336/include/lab05.h to folder ./05
12   * Copying file /usr/local/2336/src/Makefile to folder ./05
13   * Adding a target of lab05 to targets2srcfileswithlibrary
14   * Touching file ./05/lab05.cpp
15   * Edit file ./05/lab05.cpp in Notepad++
16 newuser@csunix ~/2336> cd 05
17 newuser@csunix ~/2336/05> ls
18 01.dat       01.out       Makefile     lab05.cpp    lab05.h      lab05main.C
```

Figure 3. Commands to Compile, Link, & Run Lab 05 (Part 1 of 2)

```
g++ -g -Wall -std=c++11 -c lab05main.C -I/usr/local/2336/include -I.
g++ -g -Wall -std=c++11 -c lab05.cpp -I/usr/local/2336/include -I.
g++ -o lab05 lab05main.o lab05.o -L/usr/local/2336/lib \
-Wl,-whole-archive -llab05 -Wl,-no-whole-archive -lm -lbits
```

```
newuser@csunix ~/2336/05> cat 01.dat
-3  4  3  4
 3 -4 -3 -4
25 45  8 99
 1  0  2  0
129 6579 1935 249
1331 1651 2301 1079
3 1260 6 198
43 1935 207 6579
5 7 -25 -35
-83 1651 127 -1079
1079 1651 -1651 1079
newuser@csunix ~/2336/05> cat 01.dat | ./lab05
1/-2 -3/1 0/1
-3/4 == 3/4 = false
-3/4 != 3/4 = true
-3/4 <  3/4 = true
-3/4 <= 3/4 = true
-3/4 >  3/4 = false
-3/4 >= 3/4 = false
3/-4 == -3/-4 = false
3/-4 != -3/-4 = true
3/-4 <  -3/-4 = true
3/-4 <= -3/-4 = true
3/-4 >  -3/-4 = false
3/-4 >= -3/-4 = false
25/45 == 8/99 = false
25/45 != 8/99 = true
25/45 <  8/99 = false
25/45 <= 8/99 = false
25/45 >  8/99 = true
25/45 >= 8/99 = true
1/1 == 2/1 = false
1/1 != 2/1 = true
1/1 <  2/1 = true
1/1 <= 2/1 = true
1/1 >  2/1 = false
1/1 >= 2/1 = false
129/6579 == 1935/249 = false
129/6579 != 1935/249 = true
129/6579 <  1935/249 = true
129/6579 <= 1935/249 = true
129/6579 >  1935/249 = false
129/6579 >= 1935/249 = false
1331/1651 == 2301/1079 = false
1331/1651 != 2301/1079 = true
1331/1651 <  2301/1079 = true
1331/1651 <= 2301/1079 = true
1331/1651 >  2301/1079 = false
1331/1651 >= 2301/1079 = false
3/1260 == 6/198 = false
3/1260 != 6/198 = true
3/1260 <  6/198 = true
3/1260 <= 6/198 = true
3/1260 >  6/198 = false
3/1260 >= 6/198 = false
43/1935 == 207/6579 = false
43/1935 != 207/6579 = true
43/1935 <  207/6579 = true
43/1935 <= 207/6579 = true
43/1935 >  207/6579 = false
43/1935 >= 207/6579 = false
5/7 == -25/-35 = true
5/7 != -25/-35 = false
5/7 <  -25/-35 = false
5/7 <= -25/-35 = true
5/7 >  -25/-35 = false
5/7 >= -25/-35 = true
-83/1651 == 127/-1079 = false
-83/1651 != 127/-1079 = true
-83/1651 <  127/-1079 = false
-83/1651 <= 127/-1079 = false
-83/1651 >  127/-1079 = true
-83/1651 >= 127/-1079 = true
1079/1651 == -1651/1079 = false
1079/1651 != -1651/1079 = true
1079/1651 <  -1651/1079 = false
1079/1651 <= -1651/1079 = false
1079/1651 >  -1651/1079 = true
1079/1651 >= -1651/1079 = true
```

```
newuser@csunix ~/2336/05> cat 01.dat | ./lab05 > my.out
newuser@csunix ~/2336/05> diff 01.out my.out
newuser@csunix ~/2336/05>
```

Figure 3. Commands to Compile, Link, & Run Lab 05 (Part 2 of 2)