Source File: `~/2336/03/lab03.(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 Lab 02 to provide the following additional member functions:

- Addition of two `Rational` numbers. The result should be stored in reduced form.
- Additive inverse of a `Rational` number. The rational number `a/b` is returned as `-a/b`.
- Subtraction of two `Rational` numbers. The result should be determined by calling the addition and additive inverse member functions. The result is returned in reduced form.
- Multiplication of two `Rational` numbers. The result should be stored in reduced form.
- Multiplicative inverse of a `Rational` number. The rational number `a/b` is returned as `b/a`.
- Division of two `Rational` numbers. The result should be determined by calling the multiply and multiplicative inverse member functions. The result is returned in reduced form.
- Printing `Rational` numbers in the form `a/b` where `a` is the numerator and `b` is the denominator. The output should be written to the given output stream.
- Reading `Rational` numbers. The function should read two `int`s from the given input stream, where the first represents the numerator and the second the denominator. Use the "set" functions to perform the initialization of the `private` members.

The least common multiple of two integers u and v, written $\text{lcm}(u, v)$, is the smallest non-negative integer that is a multiple of (i.e., evenly divisible by) both u and v; and $\text{lcm}(0, 0) = 0$. For non-zero values of u and v, define the least common multiple as

$$\text{lcm}(u, v) = \frac{uv}{\text{gcd}(u, v)}$$

where $\text{gcd}(u, v)$ is the greatest common divisor of u and v.

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 `lab03` to `targets2srcfileswithlibrary`.

```
1  #ifndef LAB03_H
2  #define LAB03_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
```

Figure 1. `/usr/local/2336/include/lab03.h` (Part 1 of 2)

```
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
32   private:
33    pair<int, int> data;                                  // member first -> numerator
34                                                          // member second -> denominator
35    int gcd(int m, int n) const;                          // returns the greatest
36                                                          //   common divisor of m
37                                                          //   and n
38    int lcm(int m, int n) const;                          // returns the least common
39                                                          //   multiple of m and n
40  };
41
42  #endif
```

Figure 1. `/usr/local/2336/include/lab03.h` (Part 2 of 2)

```
1   #include <lab03.h>
2   #include <iostream>
3   #include <cstdlib>
4   #include <string>
5
6   using namespace std;
7
8   int main()
9   {
10    unsigned i;
11    Rational first(1, -2), second(-3, 0), result;
12    string operators = "+-*/";
13
14    first.print(cout);
15    cout << ' ';
16    second.print(cout);
17    cout << ' ';
18    result.print(cout);
19    cout << endl;
20
```

Figure 2. `/usr/local/2336/src/lab03main.C` (Part 1 of 2)

```
21    while (first.read(cin) && second.read(cin))
22    {
23      for (i = 0; i < operators.length(); ++i)
24      {
25        first.print(cout);
26        cout << ' ' << operators[i] << ' ';
27        second.print(cout);
28        cout << " = ";
29
30        switch (operators[i])
31        {
32          case '+':  result = first.add(second); break;
33          case '-':  result = first.subtract(second); break;
34          case '*':  result = first.multiply(second); break;
35          case '/':  result = first.divide(second); break;
36          default :  cerr << "Unknown op"; exit(EXIT_FAILURE);
37        }
38
39        result.print(cout);
40        cout << endl;
41      }
42    }
43
44    return EXIT_SUCCESS;
45  }
```

Figure 2. `/usr/local/2336/src/lab03main.C` (Part 2 of 2)

```
1  newuser@csunix ~> cd 2336
2  newuser@csunix ~/2336> ./getlab.ksh 03
3    * Checking to see if a folder exists for Lab 03. . .No
4    * Creating a folder for Lab 03
5    * Checking to see if Lab 03 has sample input and output files. . .Yes
6    * Copying input and output files for Lab 03
7      from folder /usr/local/2336/data/03 to folder ./03
8    * Checking to see if /usr/local/2336/src/lab03main.C exists. . .Yes
9    * Copying file /usr/local/2336/src/lab03main.C to folder ./03
10   * Checking to see if /usr/local/2336/include/lab03.h exists. . .Yes
11   * Copying file /usr/local/2336/include/lab03.h to folder ./03
12   * Copying file /usr/local/2336/src/Makefile to folder ./03
13   * Adding a target of lab03 to targets2srcfileswithlibrary
14   * Touching file ./03/lab03.cpp
15   * Edit file ./03/lab03.cpp in Notepad++
16 newuser@csunix ~/2336> cd 03
17 newuser@csunix ~/2336/03> ls
18 01.dat       01.out       Makefile     lab03.cpp    lab03.h      lab03main.C
```

Figure 3. Commands to Compile, Link, & Run Lab 03 (Part 1 of 2)

```
g++ -g -Wall -std=c++11 -c lab03main.C -I/usr/local/2336/include -I.
g++ -g -Wall -std=c++11 -c lab03.cpp -I/usr/local/2336/include -I.
g++ -o lab03 lab03main.o lab03.o -L/usr/local/2336/lib \
-Wl,-whole-archive -llab03 -Wl,-no-whole-archive -lm -lbits
```

```
newuser@csunix ~/2336/03> 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 ~/2336/03> cat 01.dat | ./lab03
1/-2 -3/1 0/1
-3/4 + 3/4 = 0/1
-3/4 - 3/4 = -3/2
-3/4 * 3/4 = -9/16
-3/4 / 3/4 = -1/1
3/-4 + -3/-4 = 0/1
3/-4 - -3/-4 = -3/2
3/-4 * -3/-4 = -9/16
3/-4 / -3/-4 = -1/1
25/45 + 8/99 = 7/11
25/45 - 8/99 = 47/99
25/45 * 8/99 = 40/891
25/45 / 8/99 = 55/8
1/1 + 2/1 = 3/1
1/1 - 2/1 = -1/1
1/1 * 2/1 = 2/1
1/1 / 2/1 = 1/2
129/6579 + 1935/249 = 32978/4233
129/6579 - 1935/249 = -32812/4233
129/6579 * 1935/249 = 215/1411
129/6579 / 1935/249 = 83/32895
1331/1651 + 2301/1079 = 402700/137033
1331/1651 - 2301/1079 = -181754/137033
1331/1651 * 2301/1079 = 235587/137033
1331/1651 / 2301/1079 = 110473/292227
3/1260 + 6/198 = 151/4620
3/1260 - 6/198 = -43/1540
3/1260 * 6/198 = 1/13860
3/1260 / 6/198 = 11/140
43/1935 + 207/6579 = 1766/32895
43/1935 - 207/6579 = -304/32895
43/1935 * 207/6579 = 23/32895
43/1935 / 207/6579 = 731/1035
5/7 + -25/-35 = 10/7
5/7 - -25/-35 = 0/1
5/7 * -25/-35 = 25/49
5/7 / -25/-35 = 1/1
-83/1651 + 127/-1079 = -23018/137033
-83/1651 - 127/-1079 = 9240/137033
-83/1651 * 127/-1079 = 1/169
-83/1651 / 127/-1079 = 6889/16129
1079/1651 + -1651/1079 = -9240/10541
1079/1651 - -1651/1079 = 23018/10541
1079/1651 * -1651/1079 = -1/1
1079/1651 / -1651/1079 = -6889/16129
```

```
newuser@csunix ~/2336/03> cat 01.dat | ./lab03 > my.out
newuser@csunix ~/2336/03> diff 01.out my.out
newuser@csunix ~/2336/03>
```

Figure 3. Commands to Compile, Link, & Run Lab 03 (Part 2 of 2)