CSC112   Fundamentals of Computer Science   Spring 2016
Lab 2

Continuing with C++ − Using loops

0. Write a function named "is_prime" with the following header

   ```
   bool is_prime(int k)
   ```

   Your function should return true if `k` is a prime number and return false otherwise. We have not discussed arrays yet, so we will **not** be using the sieve of Eratosthenes method for finding primes. To check if a number is prime:

   (a) If the integer `k` is less than two, then it is not prime.

   (b) If the integer `k` is equal to two, then it is prime.

   (c) If `k` is greater than two, check if it is divisible by two. If `k` is divisible by two, then it is not prime.

   (d) If checks 0a, 0b, or 0c have not resolved the question, then do the following:
   For every odd integer `j` from three up to the square root of `k`, check if `k` is divisible by `j`, but stop searching if you find such `j`.

   (e) If a divisor of `k` was found in step 0d return *false*, otherwise, return *true*.

1. Write a simple main program that reads a number, calls your function "is_prime" and outputs the conclusion "prime" or "not prime". Run your program with several different numbers to convince yourself that `is_prime()` is working correctly. Don't forget to check the so-called "corner cases", i.e., for this example, try inputting 2, try again, inputting zero, and again inputting -5. This process is called "unit testing". The file name for this program should be[1] named `lab2_part1.cc`.

2. Using your function `is_prime()`, write a program that prints all prime numbers less than 100. The file for the program in this part should be named `lab2_part2.cc`

3. Using your function `is_prime()`, write a program that accepts a number `N` and prints all the factors. If a prime factor `p` of `N` occurs with multiplicity greater than one, your program should output `p` the correct number of times. For example, if `N = 372`, then the output should be `2 2 3 31`. The file for the program in this part should be named `lab2_part3.cc`

   You can use the UNIX command `factor` to check the correctness of your program. E.g.,

   ```
   gottlieb% factor 372

   372: 2 2 3 31
   ```

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[1]You may often see C++ program files ending with a **.cpp** file name extension. According to the Google Style Guide regarding file names: "Filenames should be all lowercase and can include underscores (_) or dashes (-). Follow the convention that your project uses. If there is no consistent local pattern to follow, prefer "_". C++ files should end in **.cc** and header files should end in **.h**."

Turn in: Write your programs in a directory named "Lab2". Change to your home directory (the parent directory of "Lab2"), and create a file named "lab2.tar" using the command:

```
tar cf lab2.tar Lab2
```

Use `sftp` to upload the file "lab2.tar" to your account on telesto.

The New York Times

By KENNETH CHANG
January 21, 2016

The largest known prime number, newly discovered, is almost five million digits longer than the previous record-holder.

In a computer laboratory at a satellite campus of the University of Central Missouri, an otherwise nondescript desktop computer, machine No. 5 in Room 143, multiplied 74,207,281 twos together and subtracted 1. It then checked that this number was not divisible by any positive integer except 1 and itself -- the definition of a prime number.

This immense number can only be practically written down in mathematical notation using exponents: $2^{74,207,281} - 1$.

The previous largest was $2^{57,885,161} - 1$, which has a mere 17 million or so digits.

This is the 15th prime number found by the Great Internet Mersenne Prime Search, or Gimps, for short, a volunteer project that has been running for 20 years. "I've always been interested in prime numbers," said George Woltman, who founded Gimps after he had retired. "I had a lot of time on my hands," he said.

Mersenne primes are those that can be written in the form 2^{n-1} where n is an integer. They are named after Marin Mersenne, a French theologian and mathematician who studied them in the early 17th century.

For example, 3 is a Mersenne prime. Plug in '2' for n, and you find $2^2 - 1 = 4 - 1 = 3$.

But not all integers plugged into this expression generate a prime number. Put in n = 4, and the result is $2^4 - 1 = 15$, which is not a prime number, because 15 is divisible by 3 and 5.

As integers get bigger, prime numbers become rarer, but there is always a bigger prime number to be found. It is just much harder to find. In total, only 49 Mersenne primes are known.

Gimps takes advantage of otherwise idle computers. Volunteers download free software that runs unobtrusively when no one is using the computer.

At the University of Central Missouri, Curtis Cooper, a math professor, was one of the early enthusiasts, joining Gimps in 1997. He has the program currently installed on 800 PCs on the university's two campuses. Dr. Cooper does research in the mathematical realm of number theory and teaches computer science classes. "This kind of marries the two fields together," he said.

The university's computers had previously turned up three other Mersenne primes, most recently in 2013.

PC No. 5 in Room 143 churned for 31 days before completing its calculation that $2^{74,207,281} - 1$ is a prime. It dutifully reported the result on Sept. 17 to a computer server in Seattle that coordinates the worldwide Gimps effort.

No one noticed.

Because of a glitch on the server, emails that should have been sent to Dr. Cooper and Gimps administrators were never sent.

The discovery remained unknown until Jan. 7, when Aaron Blosser, the administrator of the server, came across it during routine maintenance. He verified it on a much faster computer and notified Dr. Cooper two days later.

After further checking, the new finding was announced publicly on Tuesday.

Prime numbers are crucial to fields like cryptography, but this one is so big that it has no practical use, at least not anytime soon. (The Gimps software does have a practical use, playing a key role in uncovering a flaw in Intel's latest Skylake processors.)

How big is this big prime number?

I timed how quickly I could write down a number: about four seconds for 10 digits. If I had enough paper and ink -- and made the impossible assumption that my hand could maintain this pace -- it would take me more than three months to write down the 22,338,618 digits of $2^{74,207,281} - 1$.

Printing it out could fill 6,000 to 7,000 sheets of paper, depending on the font size.

If you're wondering: If a prime number is discovered and no one is there to notice, is it really discovered? -- the answer is no. The official discovery date is Jan. 7, when Mr. Blosser found it, and not when the computer calculated it.

Dr. Cooper said, however, that the computer would be set aside for posterity, like the ones that had made the three earlier discoveries.

"It's kind of a dumb computer," he said. "It doesn't know it's so popular."

"Just a darn minute! — Yesterday you said that X equals **two**!"