San José State University
Department of Computer Engineering

CMPE 180-92

Data Structures and Algorithms in C++

Spring 2017

Instructor: Ron Mak

Assignment #3.c

Assigned:	Thursday, September 7
Due:	Thursday, September 14 at 5:30 PM
CodeCheck:	http://codecheck.it/codecheck/files/170117014663fhxdtohb65lgem0zlbnchcs
Canvas:	Assignment 3.c. Prime Spirals
Points:	100

Prime Spirals

Now that you know how to generate prime numbers in a 1-d array and spirals in a 2-d matrix, you can combine the two and generate prime spirals. Curious patterns will emerge in the prime numbers.

In this assignment, use vectors instead of arrays. Represent a two-dimensional matrix as a vector of vectors.

A prime spiral

A prime spiral is like the spiral in the previous assignment, but instead of printing each integer value in the spiral, print the **#** (hash) character if the value is prime and the **.** (dot) character if it isn't. Depending on the size of the spiral and the starting value, patterns will emerge among the primes in the form of diagonal streaks.

Your program should generate and print prime spirals of various odd sizes with different starting values. As before, the maximum starting value is 50. Because you will use vectors, the spirals can be arbitrarily large.

In the previous assignment, you initially had to create a large fixed-size matrix that could accommodate the maximum spiral size. In this assignment, for each pair of size and starting values, create a new matrix made from vectors that are the exact size that you need. Also for each pair, recompute the number of primes that you require, and your prime number vector also should be only as large as necessary.

Expected output

CodeCheck will verify that your program's results match the master output exactly.

```
Prime spiral of size 5 starting at 1

#...#
.#.#.
#..##
.#...
..#..

Prime spiral of size 25 starting at 11

#.........#.....#.#.....#
.....#...#.......#.......
....#.......#...#........
.......#.............#...
........#.....#.....#.#..
.#.#.........#.#...#.....
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Prime spiral of size 35 starting at 0
***** Error: Starting value 0 < 1 or > 50

Prime spiral of size 50 starting at 31
***** Error: Size 50 must be odd.

Prime spiral of size 101 starting at 41
```
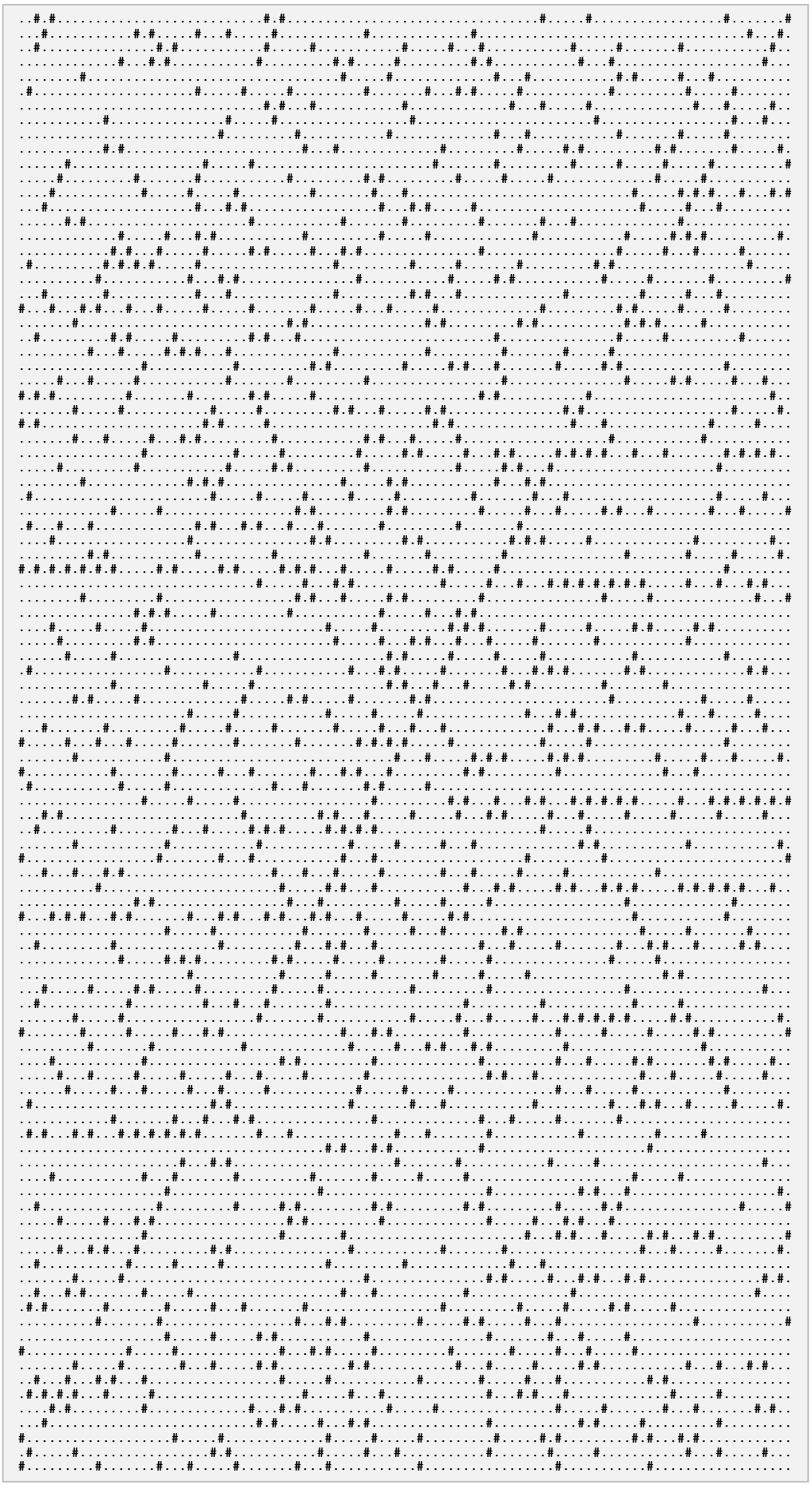



Submission into Canvas

When you're satisfied with your program in CodeCheck, click the "Download" link at the very bottom of the Report screen to download a signed zip file of your solution. Submit this zip file into Canvas. You can submit as many times as you want until the deadline, and the number of submissions will not affect your score. Only your last submission will be graded.

Submit the signed zip file from CodeCheck into Canvas:
Assignment 3.c. Prime Spirals

Note: You must submit the signed zip file that you download from CodeCheck, or your submission will not be graded. Do not rename the zip file.

Rubric

Your program will be graded according to these criteria:

Criteria	Maximum points
Good output (as determined by CodeCheck)	**30**
Good program design • Good implementation of 1-D vector for primes. • Good implementation of 2-D vectors for spirals.	**50** • 25 • 25
Good program style • Descriptive variable names. • Meaningful comments. • Follow the coding style (formatting, braces, indentation, function declarations before the main, etc.) of the Savitch textbook.	**20** • 5 • 5 • 10

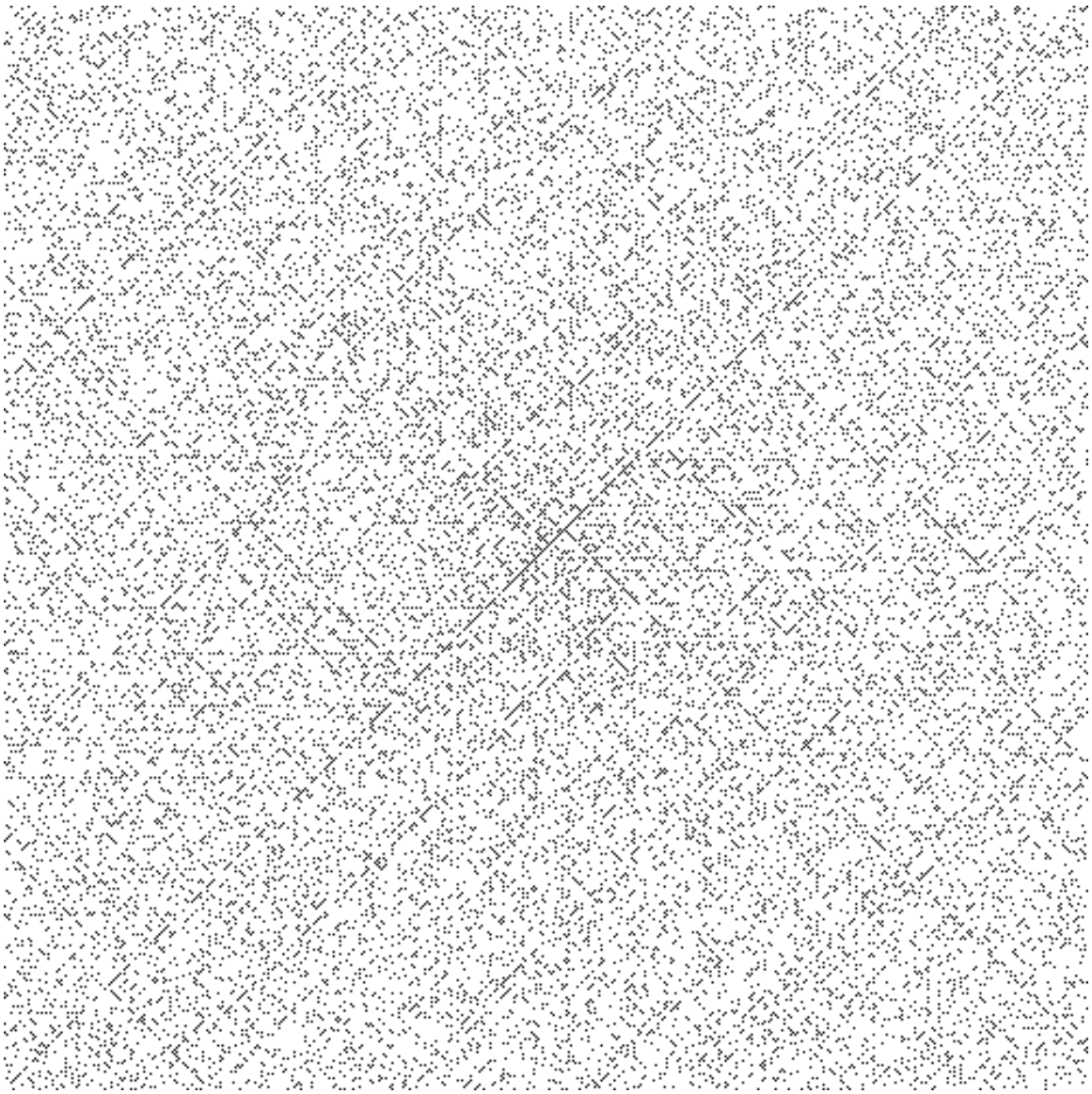
Academic integrity

You may study together and discuss the assignments, but what you turn in must be your individual work. Assignment submissions will be checked for plagiarism using Moss (http://theory.stanford.edu/~aiken/moss/). **Copying another student's program or sharing your program is a violation of academic integrity.** Moss is not fooled by renaming variables, reformatting source code, or re-ordering functions.

Violators of academic integrity will suffer severe sanctions, including academic probation. Students who are on academic probation are not eligible for work as instructional assistants in the university or for internships at local companies.

Background and extra credit

Prime numbers are studied in a field of mathematics called number theory. In the past, mathematicians devised formulas that could generate prime numbers and searched for patterns in the distribution of prime numbers. Leonhard Euler, an eminent Swiss mathematician in the 18th century, discovered that the quadratic polynomial $n^2 + n + 41$ generates only prime numbers for the 80 values of n from -40 through 39, each prime generated twice. There are other prime-generating quadratic polynomials and they explain the diagonal streaks in a prime spiral:



What happens when the numbers are arranged differently from a spiral? Modify your solution for this assignment to explore other arrangements. For example, here is a diagonal arrangement:

```
 1  3  6 10 15
 2  5  9 14 19
 4  8 13 18 22
 7 12 17 21 24
11 16 20 23 25
```

Do other prime patterns emerge? If so, can you describe them?

Up to 25 points extra credit per unique arrangement + pattern description, maximum 100 points. Rotations or reflections of an arrangement do not count as different arrangements.