

## **Problem 1: Lattice paths**

([www.projecteuler.net](http://www.projecteuler.net)) Write a console program that takes as a **command line arguments** the height and width of a lattice.

Example for a lattice 20 high and 10 wide.

**Problem1.exe -h 20 -w 10**

Using the logic described below use multithreading to determine the number of possible paths through the lattice as quickly as possible. You should output to the console the number of paths exactly like the following (remember to add a line feed at the end of the output)

> **Problem1.exe -h 2 -w 2**

> **Number of Routes: 6**

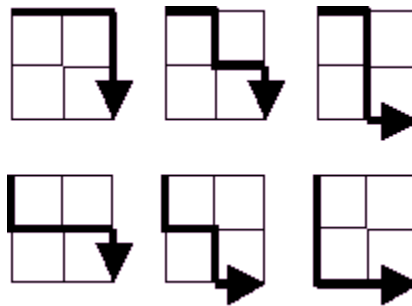
>

### **Path rules:**

Starting in the top left corner of the lattice, and only being able to move to the right and down, determine the number of routes to the bottom right corner of the lattice.

### **Example:**

There are exactly 6 routes to the bottom right corner of a 2 x 2 lattice.



## Problem 2: Largest Product in a Grid

([www.projecteuler.net](http://www.projecteuler.net)) Write a **multithreaded** console program using **OpenMP** that takes as a **command line argument** the name of a data file. The data file will contain a **M x N** grid of numbers. Your program must read in the data file and determine the **largest product** of four adjacent numbers in the same direction (up, down, left, right, or diagonally). Below is an example of 4 adjacent diagonal numbers in **Red**:

```
08 02 22 97 38 15 00 40 00 75 04 05 07 78 52 12 50 77 91 08
49 49 99 40 17 81 18 57 60 87 17 40 98 43 69 48 04 56 62 00
81 49 31 73 55 79 14 29 93 71 40 67 53 88 30 03 49 13 36 65
52 70 95 23 04 60 11 42 69 24 68 56 01 32 56 71 37 02 36 91
22 31 16 71 51 67 63 89 41 92 36 54 22 40 40 28 66 33 13 80
24 47 32 60 99 03 45 02 44 75 33 53 78 36 84 20 35 17 12 50
32 98 81 28 64 23 67 10 26 38 40 67 59 54 70 66 18 38 64 70
67 26 20 68 02 62 12 20 95 63 94 39 63 08 40 91 66 49 94 21
24 55 58 05 66 73 99 26 97 17 78 78 96 83 14 88 34 89 63 72
21 36 23 09 75 00 76 44 20 45 35 14 00 61 33 97 34 31 33 95
78 17 53 28 22 75 31 67 15 94 03 80 04 62 16 14 09 53 56 92
16 39 05 42 96 35 31 47 55 58 88 24 00 17 54 24 36 29 85 57
86 56 00 48 35 71 89 07 05 44 44 37 44 60 21 58 51 54 17 58
19 80 81 68 05 94 47 69 28 73 92 13 86 52 17 77 04 89 55 40
04 52 08 83 97 35 99 16 07 97 57 32 16 26 26 79 33 27 98 66
88 36 68 87 57 62 20 72 03 46 33 67 46 55 12 32 63 93 53 69
04 42 16 73 38 25 39 11 24 94 72 18 08 46 29 32 40 62 76 36
20 69 36 41 72 30 23 88 34 62 99 69 82 67 59 85 74 04 36 16
20 73 35 29 78 31 90 01 74 31 49 71 48 86 81 16 23 57 05 54
01 70 54 71 83 51 54 69 16 92 33 48 61 43 52 01 89 19 67 48
```

The product of these numbers is  $26 \times 63 \times 78 \times 14 = 1788696$ .

### File format:

All values in the text data file are **space** delimited. You can assume that the input data file does not contain errors, such as missing numbers or nonnumeric numbers and all numbers are greater than or equal to 0. You are free to create as many files as you like and use whatever filenames in order to create a solution. All the files \*.cpp and \*.h files you create should reside in a single folder that can be compiled to create the executable.

The first line in the file will have the number of M rows and N columns. The next M lines in the data file will contain the rows of N numbers.

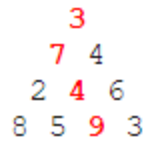
Use the file **data\_Problem2.txt** included in the assignment as a test input file.

### Output:

Your program should create a text file called **output2.txt**, in the same directory as the executable, with just the **numerical answer on a single line**.

### Problem 3 (ECE 6122 students only): Maximum Path Sum

([www.projecteuler.net](http://www.projecteuler.net)) By starting at the top of the triangle below and moving to adjacent numbers on the row below, the maximum total from top to bottom is 23.



That is,  $3 + 7 + 4 + 9 = 23$ .

Similar to Problem #2, write a **multi-threaded** console program using **OpenMP** that takes as a command line argument the name of a data file. Your program must read in a triangle of arbitrary size from a data file. The first line will contain the number of levels in the triangle. A sample data file is attached (**data\_triangle.txt**) to the homework assignment. Your program must find the maximum sum path through the input triangle starting at the top of the triangle.

You can assume that the input data file does not contain errors, such as missing numbers or nonnumeric numbers and all numbers are greater than or equal to 0.

#### Output:

Your program should create a text file called **output3.txt**, in the same directory as the executable, with **just the numerical answer on a single line.**

## **Appendix B: Accessing PACE-ICE Instructions**

### **ACCESSING LINUX PACE-ICE CLUSTER (SERVER)**

To access the PACE-ICE cluster you need certain software on your laptop or desktop system, as described below.

#### **Windows Users:**

##### **Option 0 (Using SecureCRT)- THIS IS THE EASIEST OPTION!**

The Georgia Tech Office of Information Technology (*OIT*) maintains a web page of software that can be downloaded and installed by students and faculty. That web page is:

<http://software.oit.gatech.edu>

From that page you will need to install SecureCRT.

To access this software, you will first have to log in with your Georgia Tech user name and password, then answer a series of questions regarding export controls.

Connecting using SecureCRT should be easy.

- Open SecureCRT, you'll be presented with the "Quick Connect" screen.
- Choose protocol "ssh2".
- Enter the name of the PACE machine you wish to connect to in the "HostName" box (i.e. *coc-ice.pace.gatech.edu*)
- Type your username in the "Username" box.
- Click "Connect".
- A new window will open, and you'll be prompted for your password.

##### **Option 1 (Using Ubuntu for Windows 10):**

Option 1 uses the Ubuntu on Windows program. This can only be downloaded if you are running Windows 10 or above. If using Windows 8 or below, use Options 2 or 3. It also requires the use of simple bash commands.

1. Install Ubuntu for Windows 10 by following the guide from the following link:

<https://msdn.microsoft.com/en-us/commandline/wsl/install-win10>

2. Once Ubuntu for Windows 10 is installed, open it and type the following into the command line:

`ssh **YourGTUsername**@coc-ice.pace.gatech.edu` where **\*\*YourGTUsername\*\*** is

replaced with your alphanumeric GT login. Ex: bkim334

3. When it asks if you're sure you want to connect, type in:  
`yes`

and type in your password when prompted (Note: When typing in your password, it will not show any characters typing)

4. You're now connected to PACE-ICE. You can edit files using vim by typing in:

*vi filename.cc*                      OR                      *nano filename.cpp*

For a list of vim commands, use the following link:

<https://coderwall.com/p/adv71w/basic-vim-commands-for-getting-started>

5. You're able to edit, compile, run, and submit your code from this command line.

#### Option 2 (Using PuTTY):

Option 2 uses a program called PuTTY to ssh into the PACE-ICE cluster. It is easier to set up, but doesn't allow you to access any local files from the command line. It also requires the use of simple bash commands.

1. Download and install PuTTY from the following link: [www.putty.org](http://www.putty.org)
2. Once installed, open PuTTY and for the Host Name, type in:  
*coc-ice.pace.gatech.edu* and  
  
for the port, leave it as 22.
3. Click Open and a window will pop up asking if you trust the host. Click Yes and it will then ask you for your username and password. (Note: When typing in your password, it will not show any characters typing)
4. You're now connected to PACE-ICE. You can edit files using vim by typing in: *vim filename.cc*  
OR  
*nano filename.cpp*

For a list of vim commands, use the following link:

<https://coderwall.com/p/adv71w/basic-vim-commands-for-getting-started>

5. You're able to edit, compile, run, and submit your code from this command line.

#### MacOS Users:

#### Option 0 (Using the Terminal to SSH into PACE-ICE):

This option uses the built-in terminal in MacOS to ssh into PACE-ICE and use a command line text editor to edit your code.

1. Open Terminal from the Launchpad or Spotlight Search.
2. Once you're in the terminal, ssh into PACE-ICE by typing:

`ssh **YourGTUsername**@coc-ice.pace.gatech.edu` where `**YourGTUsername**` is replaced with your alphanumeric GT login. Ex: bkim334

3. When it asks if you're sure you want to connect, type in:  
`yes`

and type in your password when prompted (Note: When typing in your password, it will not show any characters typing)

4. You're now connected to PACE-ICE. You can edit files using vim by typing in:

`vi filename.cc`                      OR                      `nano filename.cpp`

For a list of vim commands, use the following link: <https://coderwall.com/p/adv71w/basic-vim-commands-for-getting-started>

5. You're able to edit, compile, run, and submit your code from this command line.

### **Linux Users:**

If you're using Linux, follow Option 0 for MacOS users.