VG101 — Intoduction to Computers & Programming

Lab 1

Instructor: Manuel Charlemagne

TA: Yihao Liu – UM-JI (Summer 2018)

Goals of the lab

- Basic scripting in MATLAB
- Control and loop statements
- File I/O operations
- C-style print function `fprintf`

1 Introduction

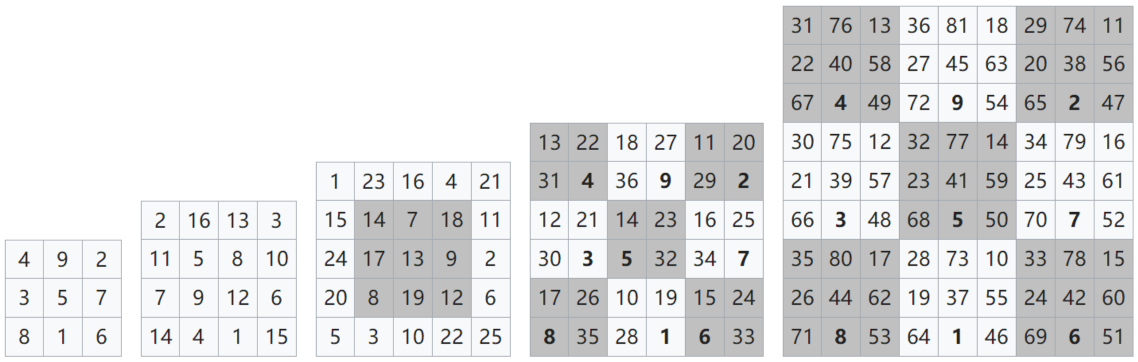
Frank and Krystor are interested in some Ancient Chinese Mathematics. Recently, they are attracted by Yang Hui, a great Chinese mathematician in Song dynasty. Yang Hui is is best known for his contribution of presenting Yang Hui's Triangle, which is also called Pascal's Triangle. After researching more about Yang Hui, Frank and Krystor found that Yang Hui also developed some methods of constructing magic squares, which is the basis of the `magic` function in MATLAB. They want to discover more about magic squares.

Their friend Simon, who has a nickname "encyclopaedia", knows all about magic squares. He explained:

Magic Sqaures

a magic square is a $n \times n$ square grid (where n is the number of cells on each side) filled with distinct positive integers in the range $1, 2, ..., n^2$ such that each cell contains a different integer and the sum of the integers in each row, column and diagonal is equal. The sum is called the magic constant or magic sum of the magic square. A square grid with n cells on each side is said to have order n.

According to Simon's explanation, Frank drew some magic squares taken from Yang Hui's treatise, as shown in Figure 1.



4	9	2
3	5	7
8	1	6

2	16	13	3
11	5	8	10
7	9	12	6
14	4	1	15

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

13	22	18	27	11	20
31	**4**	36	**9**	29	**2**
12	21	14	23	16	25
30	**3**	**5**	32	34	**7**
17	26	10	19	15	24
8	35	28	**1**	**6**	33

31	76	13	36	81	18	29	74	11
22	40	58	27	45	63	20	38	56
67	**4**	49	72	**9**	54	65	**2**	47
30	75	12	32	77	14	34	79	16
21	39	57	23	41	59	25	43	61
66	**3**	48	68	**5**	50	70	**7**	52
35	80	17	28	73	10	33	78	15
26	44	62	19	37	55	24	42	60
71	**8**	53	64	**1**	46	69	**6**	51

Figure 1: Magic squares of orders 3, 4, 5, 6, and 9 taken from Yang Hui's treatise.

Krystor thought it will make things easier if they can write some script to draw the magic squares instead of hand drawing. He convinced Frank so that they are planning to write a MATLAB script, which can

i) Get a input value n from a file.

ii) Print a magic square of order n.

iii) Save the result to another file.

However, they have forgot everything they learnt in the course VG101, so they don't know much about file I/O and formatted printing in MATLAB. After trying to find some useful information on Baidu but failed, they turned to you, experts in MATLAB, for help.

2 Working flow

2.1 Construct a magic square

After asking Simon for more information, he said:

Construction of Magic Sqaures

There are many ways to construct magic squares, but the standard (and most simple) way is to follow certain configurations/formulas which generate regular patterns. Magic squares exist for all values of n, with only one exception: it is impossible to construct a magic square of order 2. Magic squares can be classified into three types: odd, doubly even (n divisible by four) and singly even (n even, but not divisible by four).

Krystor decided to write three functions to generate those types of magic squares. He divided you into three sections and each help him complete one of the function.

Simon will also provide your the detailed construction method of the type you are working on.

2.1.1 Magic Square of Odd Order (Lab Section 1)

Write a function `mymagicodd(n)`, which takes an odd integer $n > 0$ as input, and return a magic square of order n as a matrix similar to `magic(n)`.

A method for constructing magic squares of odd order was published by the French diplomat de la Loubère in his book, A new historical relation of the kingdom of Siam (Du Royaume de Siam, 1693), in the chapter entitled The problem of the magical square according to the Indians. The method operates as follows:

The method prescribes starting in the central column of the first row with the number 1. After that, the fundamental movement for filling the squares is diagonally up and right, one step at a time. If a filled square is encountered, one moves vertically down one square instead, then continues as before. When an "up and to the right" move would leave the square, it is wrapped around to the last row or first column, respectively.

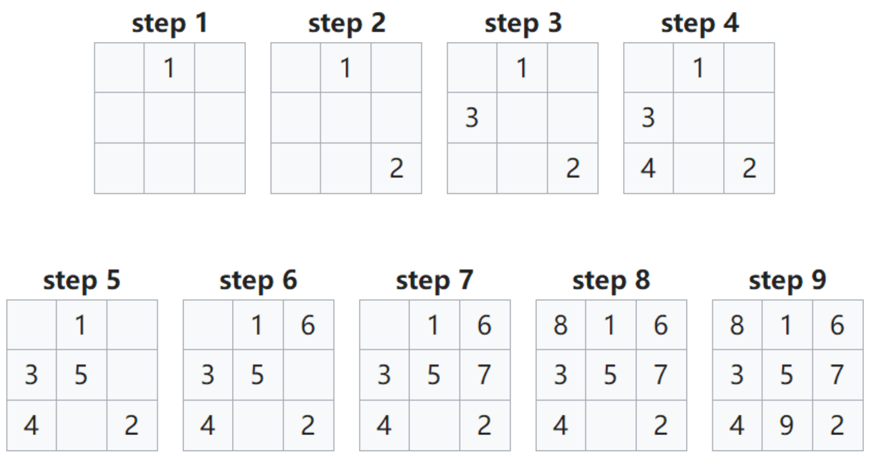


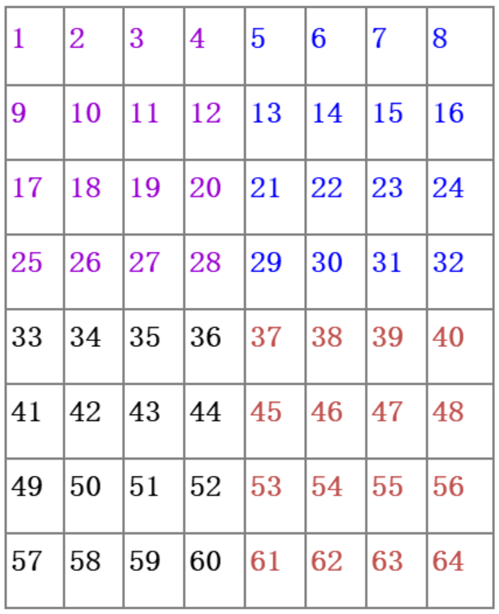
Figure 2: Construction of Magic Square of Odd Order.

2.1.2 Magic Square of Doubly Even Order (Lab Section 2)

Write a function `mymagicdoublyeven(n)`, which takes an doubly even integer $n > 2$ as input, , and return a magic square of order n as a matrix similar to `magic(n)`.

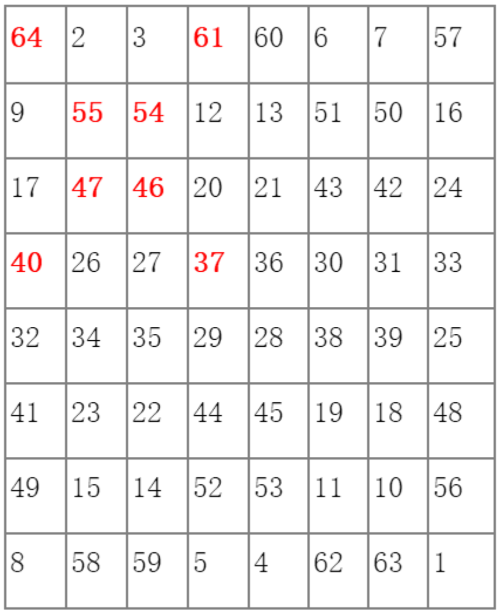
Doubly even means that n is an even multiple of an even integer; or $4k$ (e.g. 4, 8, 12), where k is an integer. Here is an example of Narayana-De la Hire's method.

All the numbers are written in order from left to right across each row in turn, starting from the top left hand corner. The square is split into $n^2/16$ parts of 4x4 small squares. Numbers in the small squares are then retained in the same place if they are not on the diagonal line, or interchanged with their diametrically opposite numbers if they are on the diagonal line. Two numbers a, b are diametrically opposite means that $a + b = n^2 + 1$.



1	2	3	4	5	6	7	8
9	10	11	12	13	14	15	16
17	18	19	20	21	22	23	24
25	26	27	28	29	30	31	32
33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48
49	50	51	52	53	54	55	56
57	58	59	60	61	62	63	64

Figure 3: Initialization of Magic Square of Order 8.



64	2	3	**61**	60	6	7	57
9	**55**	**54**	12	13	51	50	16
17	**47**	**46**	20	21	43	42	24
40	26	27	**37**	36	30	31	33
32	34	35	29	28	38	39	25
41	23	22	44	45	19	18	48
49	15	14	52	53	11	10	56
8	58	59	5	4	62	63	1

Figure 4: a Magic Square of Order 8.

2.1.3 Magic Square of Singly Even Order (Lab Section 3)

Write a function `mymagicsinglyeven(n)`, which takes an singly even integer $n > 2$ as input, , and return a magic square of order n as a matrix similar to `magic(n)`.

Conway's LUX method for magic squares is an algorithm by John Horton Conway for creating magic squares of order $4k + 2$, where k is a natural number.

Start by creating a $(2k + 1)$-by-$(2k + 1)$ square array consisting of

- $k + 1$ rows of Ls
- 1 row of Us
- $k - 1$ rows of Xs

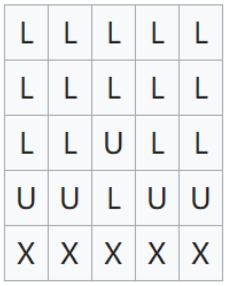
and then exchange the U in the middle with the L above it.

Each letter represents a 2x2 block of numbers in the finished square.

Now replace each letter by four consecutive numbers, starting with 1, 2, 3, 4 in the centre square of the top row, and moving from block to block in the manner of the Siamese method (Section 2.2.1): move up and right, wrapping around the edges, and move down whenever you are obstructed. Fill each 2x2 block according to the order prescribed by the letter:

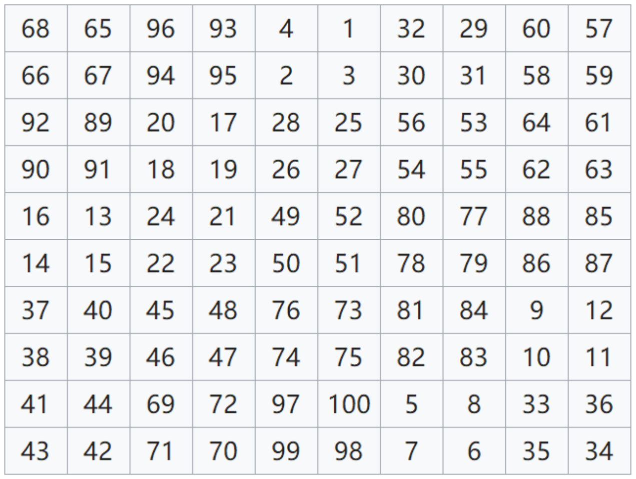
$$\text{L}: \begin{tikzcd} 4 & 1 \arrow[dl] \\ 2 \arrow[r] & 3 \end{tikzcd} \qquad \text{U}: \begin{tikzcd} 1 \arrow[d] & 4 \\ 2 \arrow[r] & 3 \arrow[u] \end{tikzcd} \qquad \text{X}: \begin{tikzcd} 1 \arrow[dr] & 4 \\ 3 \arrow[ur] & 2 \end{tikzcd}$$

For example, let $k = 2$, so that the array is 5x5 and the final square is 10x10. Start with the L in the middle of the top row, move to the 4th X in the bottom row, then to the U at the end of the 4th row, then the L at the beginning of the 3rd row, etc.



L	L	L	L	L
L	L	L	L	L
L	L	U	L	L
U	U	L	U	U
X	X	X	X	X

Figure 5: LUX of a Magic Square of Order 10.



68	65	96	93	4	1	32	29	60	57
66	67	94	95	2	3	30	31	58	59
92	89	20	17	28	25	56	53	64	61
90	91	18	19	26	27	54	55	62	63
16	13	24	21	49	52	80	77	88	85
14	15	22	23	50	51	78	79	86	87
37	40	45	48	76	73	81	84	9	12
38	39	46	47	74	75	82	83	10	11
41	44	69	72	97	100	5	8	33	36
43	42	71	70	99	98	7	6	35	34

Figure 6: a Magic Square of Order 10.

2.2 Print a magic square

Frank asks you to help them write a MATLAB script to print a magic square, the script is like:

i) Open a file `input.txt` and read an integer n from it. It is grarunteed that the input file only contains an integer $n > 0$.

ii) Open a file `output.txt` with write permission.

iii) Call the function you wrote in the previous section with the integer n read from `input.txt` and print the returned matrix in `output.txt`. If the integer doesn't meet your function (i.e., $n = 2$, or n is even but you wrote the function `mymagicodd`), print some information about it.

The result should be similar to the output of `magic`. You don't need to make the numbers center-aligned (may try it after completing all of other tasks if you wish to.), keep them right-aligned is also fine. You are supposed to use the c-style formatted print function `fprintf`.

Don't forget to close the opened file before your script ends.

Note

Please use monospaced font in MATLAB (by default), or you will find it hard to align the numbers!

It is also recommended to use monospaced font in all of your coding environment. For more information about monospaced font, see Simon's knowledge about Monospaced font.

2.3 Perfect Magic Square Generation (Optional)

After receiving your code on constructing three different types of magic squares, Frank and Krystor are able to read your code and write a function `mymagic` to generate a magic square of arbitrary order. They will be happy if you can write that for them, by forming a group of three from three different sections and combining your code.

It's an optional work since they may finish it after several days without your help. Are you willing to save a week for them?

3 Ending

You completed Frank and Krystor's request successfully, and proved your mastery in MATLAB. It can be predicted that they are going to ask you for help again in the near future, MAYBE in the next week?