MAGIC SQUARES

GROUP 16

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PROBLEM STATEMENT

- Imagine a 3 *X* 3 array of squares. The challenge is to put the integers 1 to 9, one in each square, so that each row and each column adds up to the same number.
- The best magic squares not only have all the rows and all the columns summing to the same number, but also the diagonals sum to the same number.
- How about 5 X 5 magic squares? or even more ...



DEFINITION OF MAGIC SQUARE

- A magic square of order n is an arrangement of n^2 numbers usually distinct successive positive integers, in a $n \times X$ n matrix, with each number occurring exactly **once**.
- Such that the sum of the entries of any row, any column, or any main diagonals is the same.
- This constant sum is called the magic constant or magic sum, calculated as

$$\frac{n(n^2+1)}{2}$$

• **NB:**There only exists magic squares for $n \ge 3$

(Gorain, 2010)



EXAMPLE OF A MAGIC SQUARE

Figure: 1

8	1	6
3	5	7
4	9	2



TYPES OF MAGIC SQUARES

The method of obtaining the best magic square differs depending on the size of the magic square. Thus, we were able to identify 3 different cases:

- **odd**: When the size of the square is not divisible by "2" (Example: 3,5,7,....)
- **doubly even**: When the size of the square is divisible more than once by 2 (Example : 4, 8,)
- **Singly even**: When the size of the square can be divided by 2 only once (Example: 6, 10, 14, ...)



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ODD MAGIC SQUARE

To obtain our (n X n) odd magic square we proceed as follows:

- Given any n, we are going to have n^2 elements in our magic square
- For any odd magic square, begin by placing 1 in the middle of the top row
- we then fill the other squares in an "upward-rightward" movement in ascending order.
- if a square is already occupied, move back to your last entry point and fill the cell below it.



GENERATION OF (3 X 3) MAGIC SQUARE



	1	
3		
4		2

		1	6
3	3	5	7
_	1		2

	1	
		2

	1	
3	5	
4		2

8	1	6
3	5	7
4		2

	1	
3		
		2

	1	6
3	5	
4		2

8	1	6
3	5	7
4	9	2



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Figure: 2

GENERATION OF DOUBLY EVEN MAGIC SQUARE

To obtain our (n X n) doubly even magic square we proceed as follows:

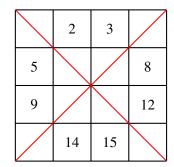
- Draw the main diagonal and anti-diagonal for the matrix.
- we fill the squares in ascending order whilst avoiding the squares affected by the main and anti diagonal
- we then fill the affected squares in descending order with numbers which have not been entered yet.



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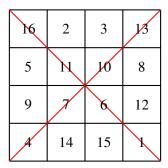
GENERATION OF (4 X 4) MAGIC SQUARE

Figure: 3





CONT'





SINGLY EVEN MAGIC SQUARE

To obtain our (n X n) singly even magic square, we proceed as follows:

- we divide the magic square into four quadrants.
- we then obtain four odd magic squares
- we apply the odd magic square procedure in the following order:
 - Top-left
 - Bottom-right
 - Top-right
 - Bottom-left



GENERATION OF (6 X 6) MAGIC SQUARE

Figure: 4

(1-9)	8	1	6			
	3	5	7			
	4	9	2			
				17	10	15
				12	14	16
				13	18	11

(10-18)



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



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



THE MAGIC SQUARE ALGORITHM

LINK TO THE MAGIC SQUARE ALGORITHM



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RESULTS

```
Enter the order of the magic square (n must be greater than or equal to 3): 12
```

```
Magic Square:
[[144
             3 141 140
                               7 137 136
                                           10
                                               11 1331
                16
                     17 127 126
                                  20
                                       21 123 122
   13 131 130
                                                    241
      119 118
                28
                     29
                        115
                             114
                                  32
                                       33
                                          111
                                              110
                                                    361
 [108
       38
            39 105
                    104
                         42
                             43 101
                                     100
                                           46
                                               47
                                                    971
   96
       50
            51
                93
                     92
                         54
                              55
                                  89
                                       88
                                           58
                                               59
                                                    851
   61
       83
            82
                64
                     65
                         79
                              78
                                  68
                                       69
                                           75
                                               74
                                                    721
   73
       71
            70
                76
                     77
                         67
                              66
                                  80
                                      81
                                           63
                                               62
                                                    841
   60
            87
               57
                     56
                         90
                             91
                                  53
                                       52
                                           94
                                               95
       86
                                                    491
       98
                45
                     44 102
                             103
                                  41
                                       40
                                          106
                                              107
   48
            99
                                                    371
            34 112 113
                         31
                              30 116 117
                                           27
 [109
                                                26 1201
 [121
       23
            22 124 125
                         19
                              18 128 129
                                           15
                                               14 1321
                      8 138 139
                                        4 142 143
 [ 12 134 135
                                   5
                                                     111
```

Sum of secondary diagonal: 870





REFERENCES

Gorain, G. C. (2010). Mathematics of magic squares.



THANK YOU.

