MAGIC SQUARES

GROUP 16

December 28, 2024

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OUTLINE

AIMS

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 …

AIMS

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 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 $n \geq 3$

(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, ...)

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	

	1	
		2

	1	
3		
		2

	1	
3		
4		2

	1	
3	**5**	
4		2

	1	**6**
3	5	
4		2

	1	6
3	5	**7**
4		2

8	1	6
3	5	7
4		2

8	1	6
3	5	7
4	**9**	2

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.

GENERATION OF $(4\ X\ 4)$ MAGIC SQUARE

Figure: 3

	2	3	
5			8
9			12
	14	15	

CONT'

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

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:
  1. Top-left
  2. Bottom-right
  3. Top-right
  4. 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

$(10-18)$

	8	1	6	26	19	24	
$(1-9)$	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	

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	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

RESULTS

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

Magic Square:
[[144   2   3 141 140   6   7 137 136  10  11 133]
 [ 13 131 130  16  17 127 126  20  21 123 122  24]
 [ 25 119 118  28  29 115 114  32  33 111 110  36]
 [108  38  39 105 104  42  43 101 100  46  47  97]
 [ 96  50  51  93  92  54  55  89  88  58  59  85]
 [ 61  83  82  64  65  79  78  68  69  75  74  72]
 [ 73  71  70  76  77  67  66  80  81  63  62  84]
 [ 60  86  87  57  56  90  91  53  52  94  95  49]
 [ 48  98  99  45  44 102 103  41  40 106 107  37]
 [109  35  34 112 113  31  30 116 117  27  26 120]
 [121  23  22 124 125  19  18 128 129  15  14 132]
 [ 12 134 135   9   8 138 139   5   4 142 143   1]]

Sum of each row: [870, 870, 870, 870, 870, 870, 870, 870, 870, 870, 870, 870]
Sum of each column: [870, 870, 870, 870, 870, 870, 870, 870, 870, 870, 870, 870]
Sum of main diagonal: 870
Sum of secondary diagonal: 870
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Figure: 5

REFERENCES

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

THANK YOU.