
IIIT Delhi - RAM Maths Circle

Session 5

(Organized by the Department of Mathematics, IIIT Delhi)

IIIT Delhi

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In a magic square, every row, every column, and the two main diagonals have the same sum. This common value is called the *magic sum*.

Problem 1. Complete each square. First determine its magic sum. Then explain why the entries you found are forced.

9		
		10
		15

(a)

20	70	
	30	

(b)

	1	
-7		
6		

(c)

Problem 2. Place the numbers $1, 2, \dots, 9$, using each exactly once, in a 3×3 magic square. Do not stop after finding one arrangement.

- (a) Determine the magic sum before filling the grid.
- (b) Is it possible to make a magic square of size 3×3 (with the numbers 1 to 9) which does not have 5 in the centre?
- (c) Prove that two cells opposite each other through the centre must add to 10.
- (d) Prove that the four corner entries must be even.
- (e) Classify all solutions. (Can you think of it geometrically?)

Problem 3. Suppose every entry x of a magic square is replaced by $ux + v$, where $u \neq 0$ and v are fixed numbers.

- (a) Prove that the new square is again magic, and find its new magic sum.

- (b) Construct a 3×3 magic square using $11, 12, \dots, 19$.
- (c) More generally, can every nine-term arithmetic progression be arranged in a 3×3 magic square? Justify your answer.

Problem 4. Now we want to construct an arbitrary 3×3 magic square.

- (a) Let the centre entry be x . What would be the magic sum?
- (b) Prove that every 3×3 magic square can be written in the form

$$\begin{pmatrix} x+p & x-p-q & x+q \\ x-p+q & x & x+p-q \\ x-q & x+p+q & x-p \end{pmatrix}$$

for some real numbers x, p, q .

- (c) Deduce that one or two revealed entries can never determine an arbitrary 3×3 magic square uniquely.

