*Magic Crosses*

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Contents

1. What do I notice about these crosses?
2. What is the same about these crosses?



1. What is different about these crosses?
2. The definition of a magic cross?



1. My findings of magic crosses

i) Crosses with 1 in the middle

ii) Crosses with 3 in the middle

iii) Crosses with 5 in the middle

6. Other problems

i) Are there magic crosses using the digits 2-6

ii) Are there any magic crosses using the digits 3-7

iii) Are there any magic crosses using the digits 98-102

iv) How many magic crosses are there with 50 in the middle?

v) What if the numbers went up in 2s instead?

vi) What if the numbers went up in 3s instead?

vii) What if the numbers went up in 10s?

viii) What if the numbers went up in 20s?

What do I notice about these crosses ?

What I’ve noticed in these crosses is that the numbers in both crosses are from 1-5. I have also noticed that in both crosses the digit 4 and the digit 2 remain stationary in the two images.

What is the same about these crosses ?

The similarities that I have noticed between the crosses are that all the digits between 1 and 5 have been used.

In the centre of each cross there is always an odd number. In the first image 3 is in the middle and in the second image it is 1.

What is different between the two images ?

The differences I notice are that the numbers are in a different configuration and in the second one the horizontal and vertical additions are equal.

The definition of a *Magic cross*

The definition of a magic cross is that the vertical and horizontal additions need to be equal. Therefore the second cross is a magic cross because the addition of 5, 1, 2 and 4, 1, 3 is 8.

My findings of *Magic Crosses*

*Magic crosses* with 1 in the middle

|  |  |  |
| --- | --- | --- |
|  | 5 |  |
| 4 | 1 | 3 |
|  | 2 |  |

|  |  |  |
| --- | --- | --- |
|  | 5 |  |
| 3 | 1 | 4 |
|  | 2 |  |

|  |  |  |
| --- | --- | --- |
|  | 2 |  |
| 4 | 1 | 3 |
|  | 5 |  |

|  |  |  |
| --- | --- | --- |
|  | 2 |  |
| 3 | 1 | 4 |
|  | 5 |  |

|  |  |  |
| --- | --- | --- |
|  | 3 |  |
| 5 | 1 | 2 |
|  | 4 |  |

|  |  |  |
| --- | --- | --- |
|  | 3 |  |
| 2 | 1 | 5 |
|  | 4 |  |

|  |  |  |
| --- | --- | --- |
|  | 4 |  |
| 5 | 1 | 2 |
|  | 3 |  |

|  |  |  |
| --- | --- | --- |
|  | 4 |  |
| 2 | 1 | 5 |
|  | 3 |  |

*Crosses* with 3 in the middle

|  |  |  |
| --- | --- | --- |
|  | 5 |  |
| 2 | 3 | 4 |
|  | 1 |  |

|  |  |  |
| --- | --- | --- |
|  | 5 |  |
| 4 | 3 | 2 |
|  | 1 |  |

|  |  |  |
| --- | --- | --- |
|  | 1 |  |
| 2 | 3 | 4 |
|  | 5 |  |

|  |  |  |
| --- | --- | --- |
|  | 1 |  |
| 4 | 3 | 2 |
|  | 5 |  |

|  |  |  |
| --- | --- | --- |
|  | 2 |  |
| 5 | 3 | 1 |
|  | 4 |  |

|  |  |  |
| --- | --- | --- |
|  | 2 |  |
| 1 | 3 | 5 |
|  | 4 |  |

|  |  |  |
| --- | --- | --- |
|  | 4 |  |
| 1 | 3 | 5 |
|  | 2 |  |

|  |  |  |
| --- | --- | --- |
|  | 4 |  |
| 5 | 3 | 1 |
|  | 2 |  |

*Magic crosses* with 5 in the middle

|  |  |  |
| --- | --- | --- |
|  | 1 |  |
| 2 | 5 | 3 |
|  | 4 |  |

|  |  |  |
| --- | --- | --- |
|  | 1 |  |
| 3 | 5 | 2 |
|  | 4 |  |

|  |  |  |
| --- | --- | --- |
|  | 4 |  |
| 2 | 5 | 3 |
|  | 1 |  |

|  |  |  |
| --- | --- | --- |
|  | 4 |  |
| 3 | 5 | 2 |
|  | 1 |  |

|  |  |  |
| --- | --- | --- |
|  | 3 |  |
| 4 | 5 | 1 |
|  | 2 |  |

|  |  |  |
| --- | --- | --- |
|  | 3 |  |
| 1 | 5 | 4 |
|  | 2 |  |

|  |  |  |
| --- | --- | --- |
|  | 2 |  |
| 4 | 5 | 1 |
|  | 3 |  |

|  |  |  |
| --- | --- | --- |
|  | 2 |  |
| 1 | 5 | 4 |
|  | 3 |  |

I have found every solutions using the numbers 1, 2, 3 ,4, 5. I have worked in a systematic way to find every solution by using the number in the centre as a way to simplify the problem.

I can convince myself that I have found every single possibility because I for each odd number in the centre there are 8 possibilities. Therefore there are (8 x 3) 24 solutions to this problem. Even numbers cannot go in the centre because if an even number is in the centre the cross can’t be a magic cross.

E.g.

|  |  |  |
| --- | --- | --- |
|  | 1 |  |
| 3 | 2 | 4 |
|  | 5 |  |

As you can see, the closest you can get to a magic cross is not balanced. The vertical addition 8 and the horizontal addition 9.

Other problems

Are there *Magic crosses* with the digits from 2-6 ?

There are definitely magic crosses using the numbers between 2 and 6 because there are additions between 2 and 6 that are equal. If I was to put 4 in the middle: 2, 4, 6 and 3,4,5 both make 12. In a magic cross this is one layout.

|  |  |  |
| --- | --- | --- |
|  | 2 |  |
| 3 | 4 | 5 |
|  | 6 |  |

This magic cross has different rules the main difference being that even numbers are allowed in the middle and odd numbers are not. As before there would be an imbalance of the question if an odd number was in the middle.

E.g.

|  |  |  |
| --- | --- | --- |
|  | 2 |  |
| 4 | 3 | 5 |
|  | 6 |  |

The same problem appears as before , the question is not a magic cross.

Because the main rules are followed there are 24 different ones using the numbers between 2 and 6.

*Magic crosses* using 3-7?

There are definitely magic crosses using the numbers between 3 and 7. There are 24 solutions. One of which is,

|  |  |  |
| --- | --- | --- |
|  | 3 |  |
| 4 | 5 | 6 |
|  | 7 |  |

The rules reset.

Magic crosses using 98-102?

There must be some solutions and of course there are 24 possibilities.

|  |  |  |
| --- | --- | --- |
|  | 98 |  |
| 99 | 100 | 101 |
|  | 102 |  |

The rules go back to the ones which the 2 & 6 ones followed because of the even number in the centre.

How many possibilities are there with 50 in the middle?

Here are the possibilities with consecutive numbers.

Possibilities with numbers 48-52

|  |  |  |
| --- | --- | --- |
|  | 49 |  |
| 48 | 50 | 52 |
|  | 51 |  |

|  |  |  |
| --- | --- | --- |
|  | 51 |  |
| 48 | 50 | 52 |
|  | 49 |  |

|  |  |  |
| --- | --- | --- |
|  | 49 |  |
| 52 | 50 | 48 |
|  | 51 |  |

|  |  |  |
| --- | --- | --- |
|  | 51 |  |
| 52 | 50 | 48 |
|  | 49 |  |

|  |  |  |
| --- | --- | --- |
|  | 52 |  |
| 51 | 50 | 49 |
|  | 48 |  |

|  |  |  |
| --- | --- | --- |
|  | 48 |  |
| 51 | 50 | 49 |
|  | 52 |  |

|  |  |  |
| --- | --- | --- |
|  | 52 |  |
| 49 | 50 | 51 |
|  | 48 |  |

|  |  |  |
| --- | --- | --- |
|  | 48 |  |
| 49 | 50 | 52 |
|  | 52 |  |

The other 2 possible solutions are that using the numbers 46-50 and 50-54. Which by themselves each have 8 solutions creating 24 solutions for the problem of having 50 in the middle of a magic cross using 5 consecutive numbers.

What if the numbers went up in 2s instead?

If the numbers went up in 2s then the few things in the problem that would actually change is that the difference between the numbers would double.

Here are a few examples . . .

|  |  |  |
| --- | --- | --- |
|  | 7 |  |
| 1 | 5 | 9 |
|  | 3 |  |

|  |  |  |
| --- | --- | --- |
|  | 6 |  |
| 4 | 8 | 12 |
|  | 10 |  |

And that the numbers in each cross would revolve even more closely around the number in the centre of the cross. This is seen as the difference that all the numbers in the cross are either odd or even according to the number in the centre.

What if the numbers went up in 3s?

If the numbers went up in 3s then the rule about the even and odd numbers would change back to the original but the numbers would go up in much larger amount.

For example . . .

|  |  |  |
| --- | --- | --- |
|  | 7 |  |
| -2 | 4 | 10 |
|  | 1 |  |

|  |  |  |
| --- | --- | --- |
|  | 13 |  |
| 4 | 10 | 16 |
|  | 7 |  |

What if the numbers went up in 10s?

If the numbers went up in 10s then the difference between the numbers would change drastically but other than that not much would change from what we have seen so far.

E.g.

|  |  |  |
| --- | --- | --- |
|  | 40 |  |
| 30 | 50 | 70 |
|  | 60 |  |

|  |  |  |
| --- | --- | --- |
|  | 94 |  |
| 84 | 104 | 124 |
|  | 114 |  |

What if the numbers went up in 20s?

If the numbers went up in 20s again the numbers would drastically rise in size .

E.g.

|  |  |  |
| --- | --- | --- |
|  | 980 |  |
| 960 | 1000 | 1040 |
|  | 1020 |  |

|  |  |  |
| --- | --- | --- |
|  | 135 |  |
| 115 | 155 | 195 |
|  | 175 |  |

What if the numbers went up in 100s?

If the numbers went up in 100s then the numbers would drastically change again.

E.g.

|  |  |  |
| --- | --- | --- |
|  | -100 |  |
| -200 | -300 | -400 |
|  | -500 |  |

|  |  |  |
| --- | --- | --- |
|  | 299,900 |  |
| 299,800 | 300,000 | 300,200 |
|  | 300,100 |  |