The math behind the magic

The trick works because of **binary numbers**. Binary uses only two digits, 0 and 1, instead of the ten digits we usually count with. Computers use binary because their electronic circuits understand two states, on and off, which stand for 1 and 0.

How binary works

In binary, each place is worth double the one to its right: 1, 2, 4, 8, 16, 32 and so on. These are the powers of 2, and they are the numbers in the corners of the six cards.

32	16	8	4	2	1

Every number from 1 to 63 can be made by adding some of these corner numbers, and there is only one way to do it.

Why the trick works

Say the secret number is **19**. 19 = 16 + 2 + 1, so it is on the cards with 16, 2 and 1 in the corner, and not on the 32, 8 or 4 cards.

Corner number	32	16	8	4	2	1
Is 19 on the card?	No	Yes	No	No	Yes	Yes
Binary digit	0	1	0	0	1	1

Write 1 for every Yes and 0 for every No, and you get **010011**: 19 in binary.

Each card holds exactly the numbers that have a 1 in its place when they are written in binary. So when the player says Yes to a card, they are telling you a 1, and No is a 0. Add up the corner numbers of the Yes cards and you have their number.

Why it never goes wrong

Each corner number is bigger than all the smaller ones added together: 1 + 2 + 4 + 8 + 16 is only 31, less than 32. So two different numbers can never land on the same set of cards.

Try it with any number in the interactive guide: scienceseeds.com/pages/magic-number-cards-instructions

Numbers 1 to 63 in binary

Each digit stands for one card, in the order 32, 16, 8, 4, 2, 1. A 1 means the number is on that card.

1	000001	17	010001	33	100001	49	110001
2	000010	18	010010	34	100010	50	110010
3	000011	19	010011	35	100011	51	110011
4	000100	20	010100	36	100100	52	110100
5	000101	21	010101	37	100101	53	110101
6	000110	22	010110	38	100110	54	110110
7	000111	23	010111	39	100111	55	110111
8	001000	24	011000	40	101000	56	111000
9	001001	25	011001	41	101001	57	111001
10	001010	26	011010	42	101010	58	111010
11	001011	27	011011	43	101011	59	111011
12	001100	28	011100	44	101100	60	111100
13	001101	29	011101	45	101101	61	111101
14	001110	30	011110	46	101110	62	111110
15	001111	31	011111	47	101111	63	111111
16	010000	32	100000	48	110000		

Answers to the worksheet (page 3). 1: 5 = 000101, 12 = 001100, 27 = 011011, 42 = 101010, 63 = 111111. 2: 6, 21, 42, 51. 3: 37; 30; the cards with 32, 16 and 2. 4: 63 (111111). 5: the card with 1 in the corner: odd numbers always need the 1, because all the other corner numbers are even. 6: 32 + 16 + 8 + 4 + 2 + 1 = 63, the biggest number six cards can make; 64 would need a seventh card.

WORKSHEET

Try it yourself

Use the corner numbers 32, 16, 8, 4, 2 and 1. Write **1** under each one you use and **0** under the rest.

1. Write each number in binary

Example: 19 = 16 + 2 + 1, so 19 is 010011.

	32	16	8	4	2	1
5						
12						
27						
42						
63						

2. Turn binary back into a number

Add up the corner numbers that have a 1 under them.

32	16	8	4	2	1	
0	0	0	1	1	0	= _____
0	1	0	1	0	1	= _____
1	0	1	0	1	0	= _____
1	1	0	0	1	1	= _____

3. Be the magician

1. The player says Yes to the cards with 32, 4 and 1 in the corner. What is their number? _____
2. The player says Yes to the cards with 16, 8, 4 and 2 in the corner. What is their number? _____
3. Your number is 50. Which cards would you say Yes to?

_____

4. Think about it

4. Which number is on all six cards? _____
5. Every odd number is on the same card. Which one, and why?

_____

6. Why does the trick stop at 63?

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