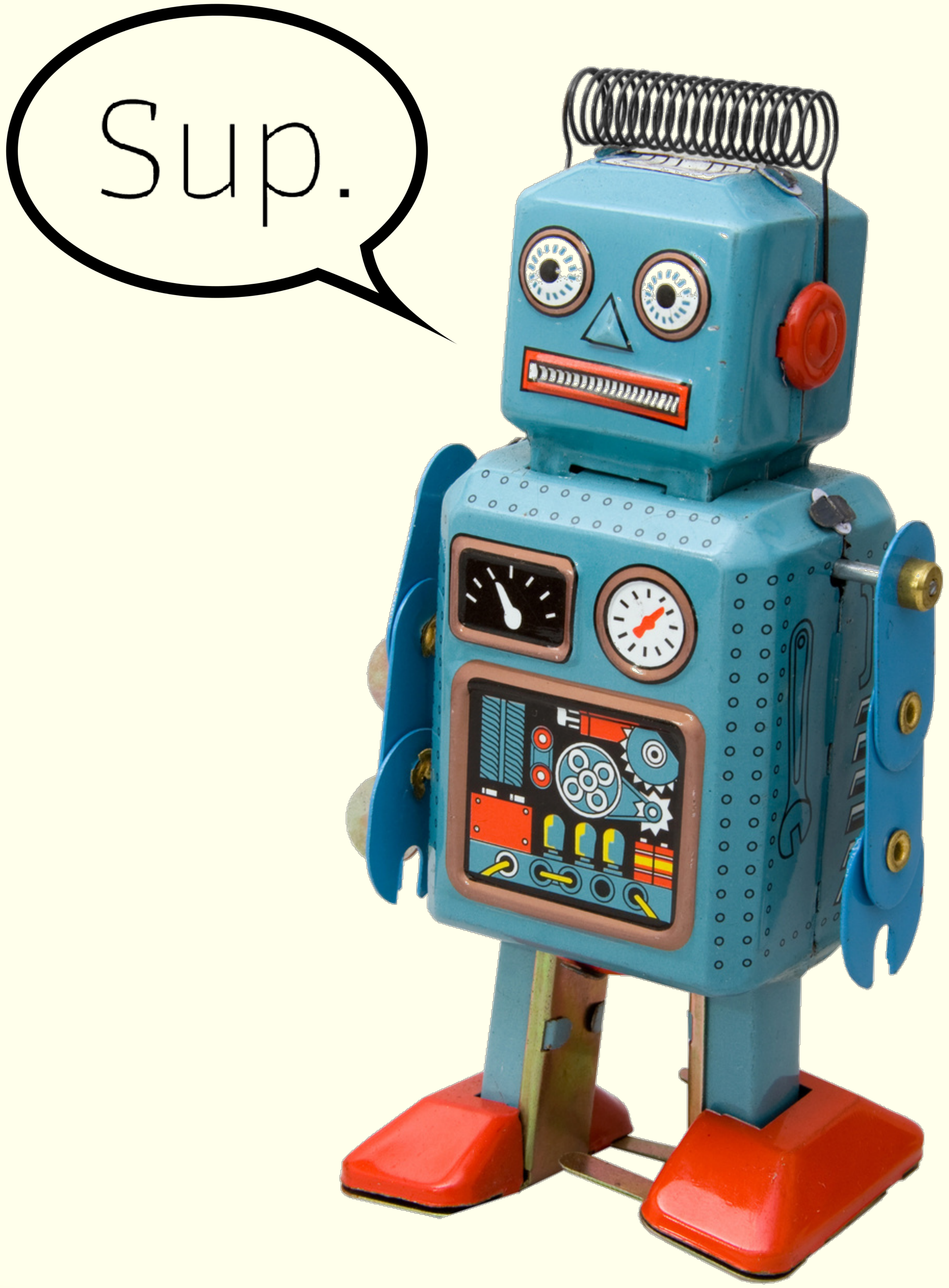
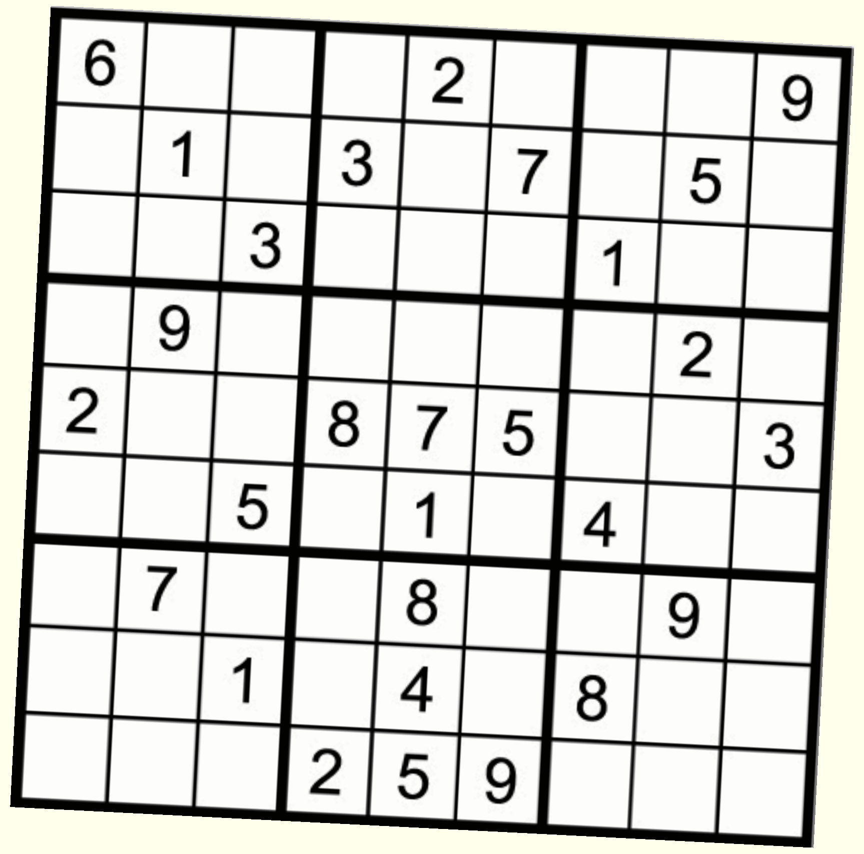
Hello, Sentient

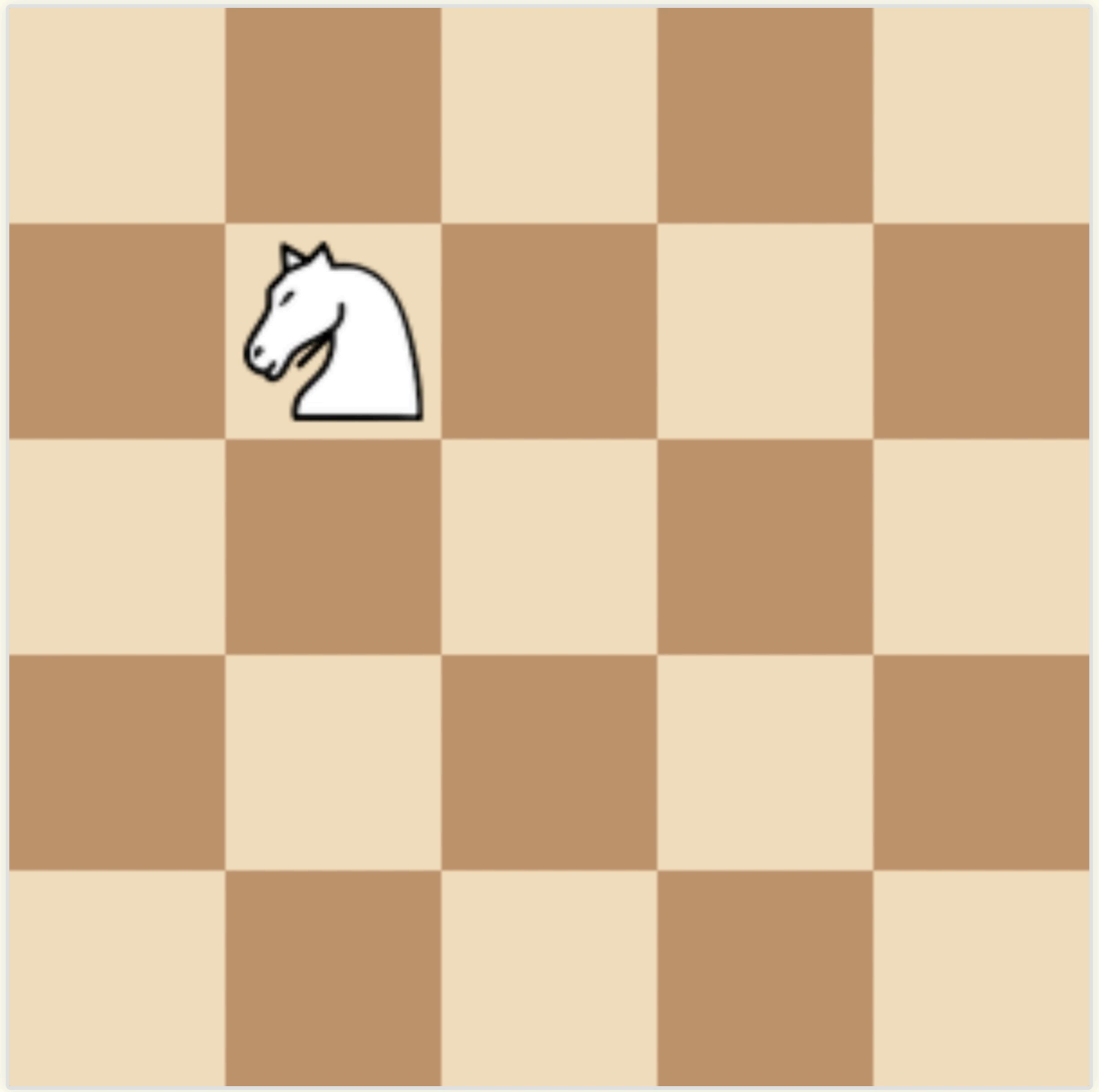


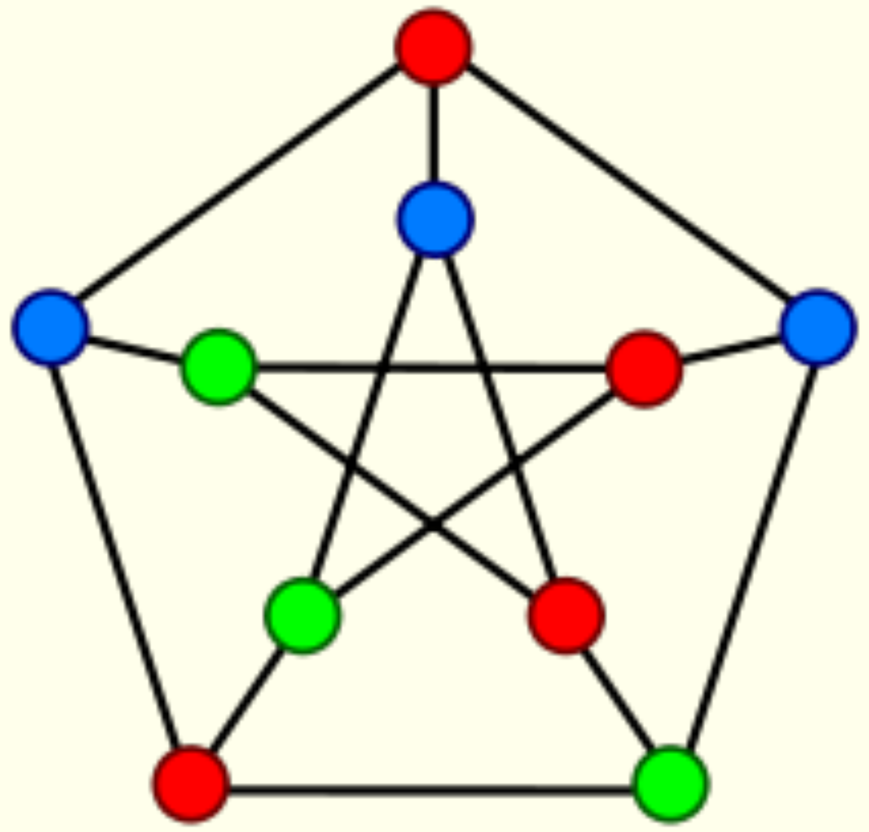
by Chris Patuzzo
Ember London, 2017-01-12
@cpatuzzo

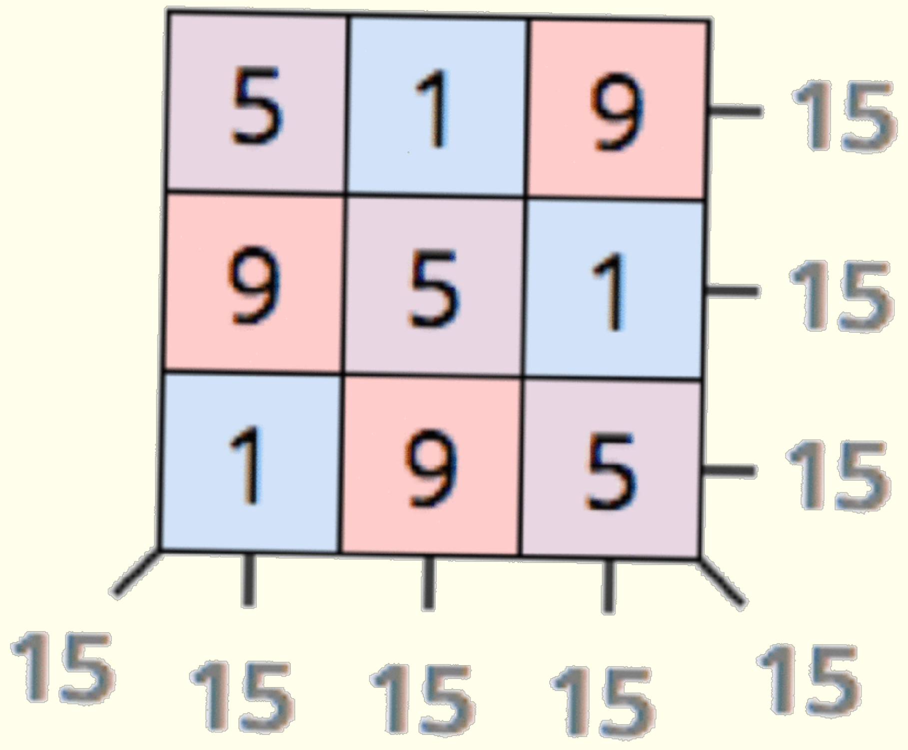
Firstly,

What is Sentient?









Most languages

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

Some algorithm

For each empty square

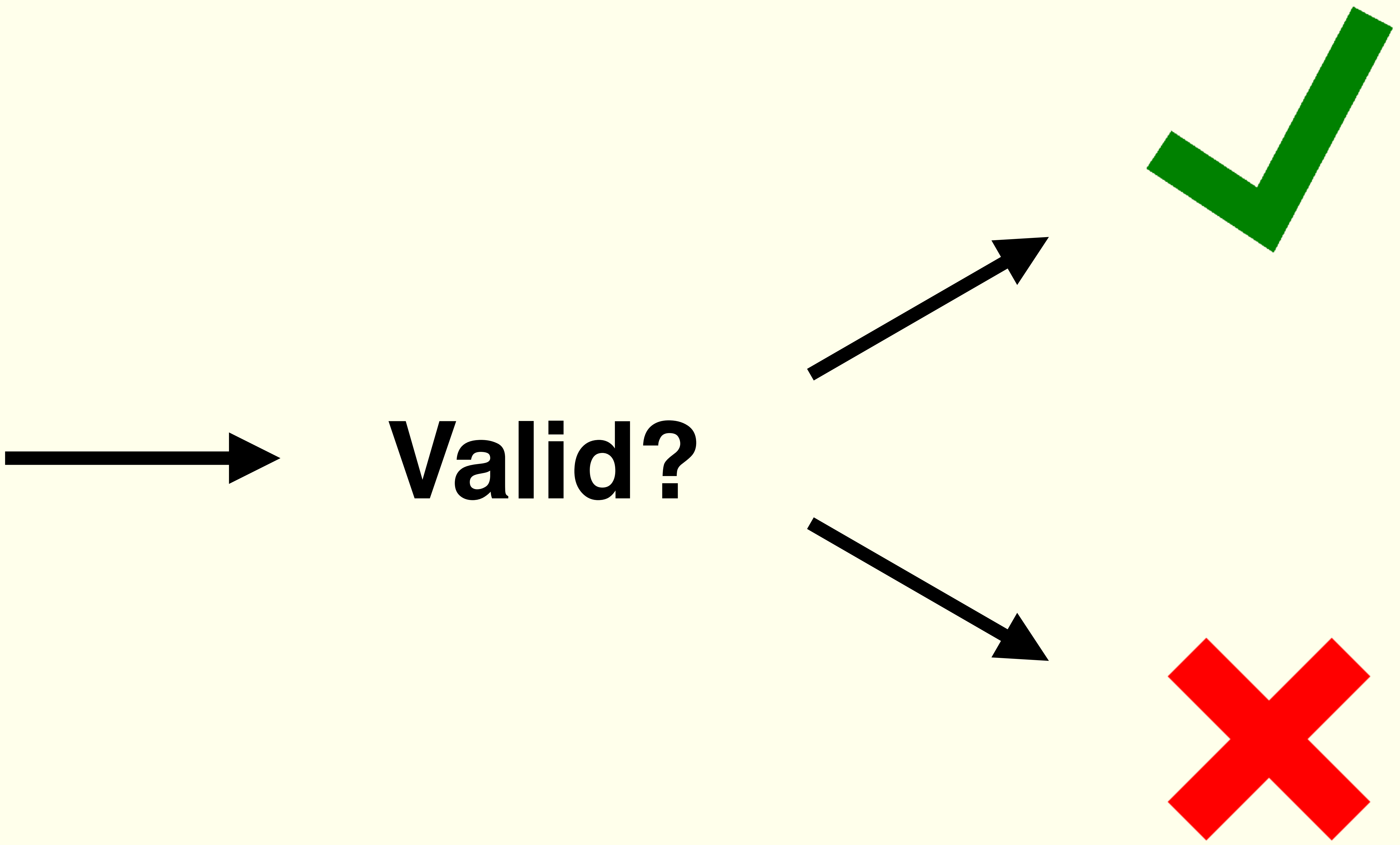
Try a number that fits

If no numbers fit

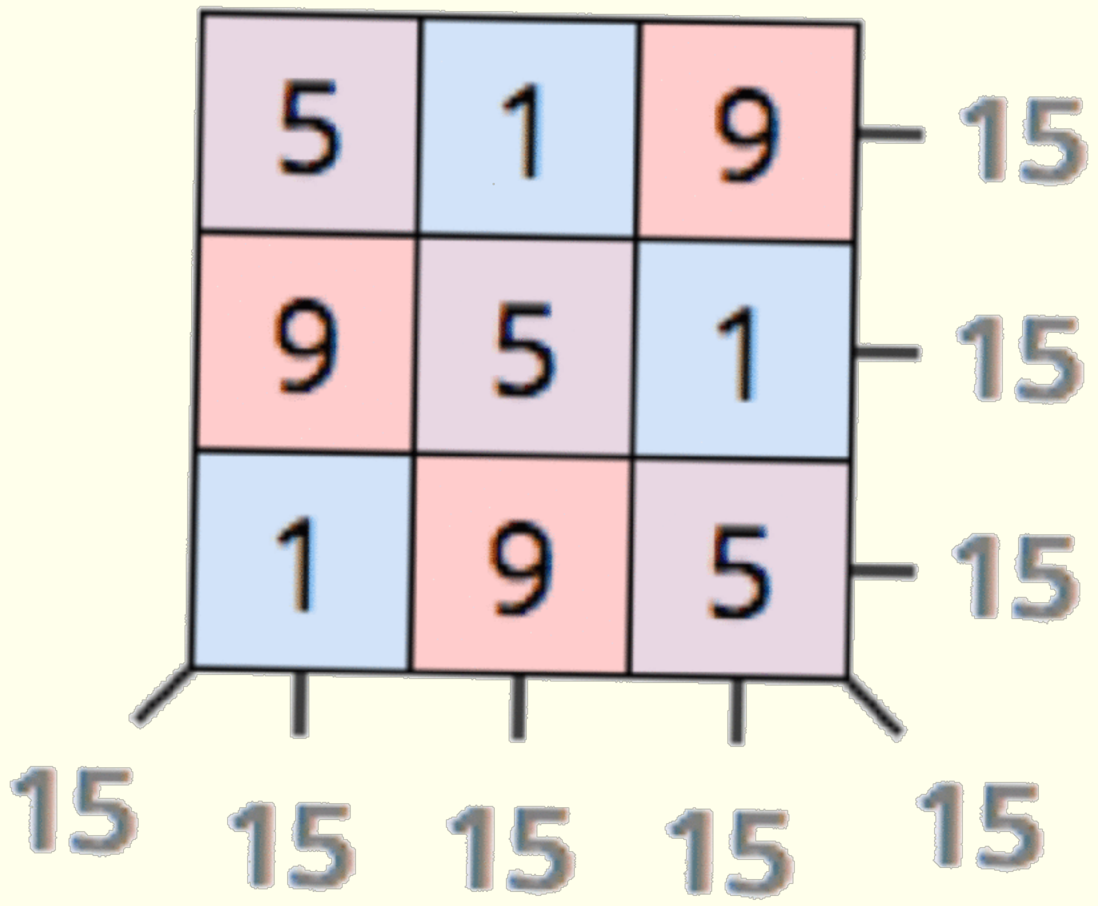
Backtrack

Sentient

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



An example



1) The **rows** must sum to the same target

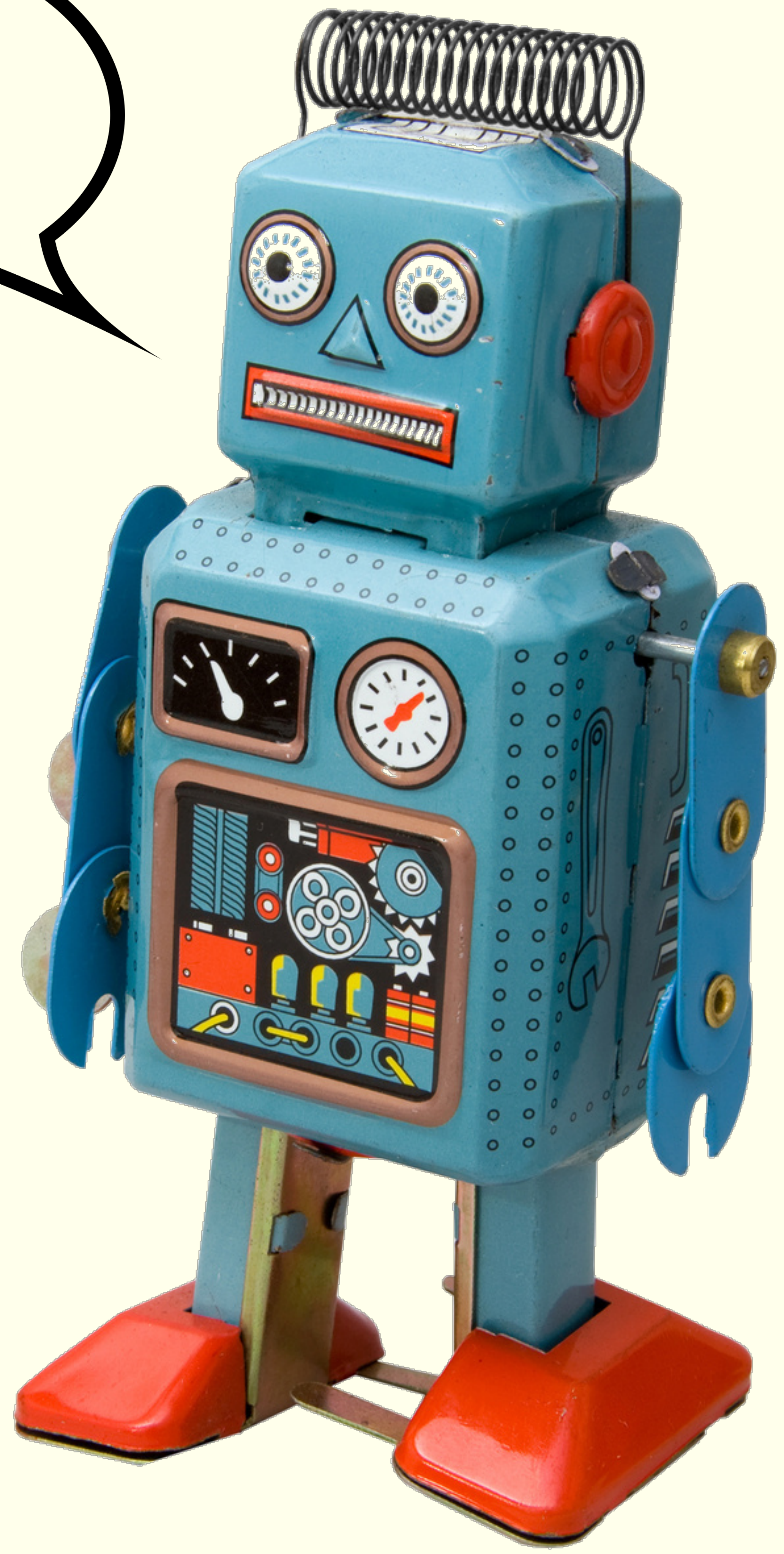
2) The **columns** must sum to the same target

3) The **diagonals** must sum to the same target

Here's how to check a magic square

Now go find some!

OK



```
array3<array3<int>> magic_square;
int target;

magic_square.each(function^ (row) {
  invariant row.sum == target;
  invariant row.all?(*positive?);
});

magic_square.transpose.each(function^ (column) {
  invariant column.sum == target;
});

left_diagonal = magic_square.map(function (row, index) {
  return row[index];
});

right_diagonal = magic_square.map(function (row, index) {
  return row.reverse[index];
});

invariant left_diagonal.sum == target;
invariant right_diagonal.sum == target;

expose magic_square, target;
```

```
array3<array3<int>> magic_square;
int target;
```

```
magic_square.each(function^ (row) {
  invariant row.sum == target;
  invariant row.all?(*positive?);
});
```

rows

```
magic_square.transpose.each(function^ (column) {
  invariant column.sum == target;
});
```

columns

```
left_diagonal = magic_square.map(function (row, index) {
  return row[index];
});

right_diagonal = magic_square.map(function (row, index) {
  return row.reverse[index];
});

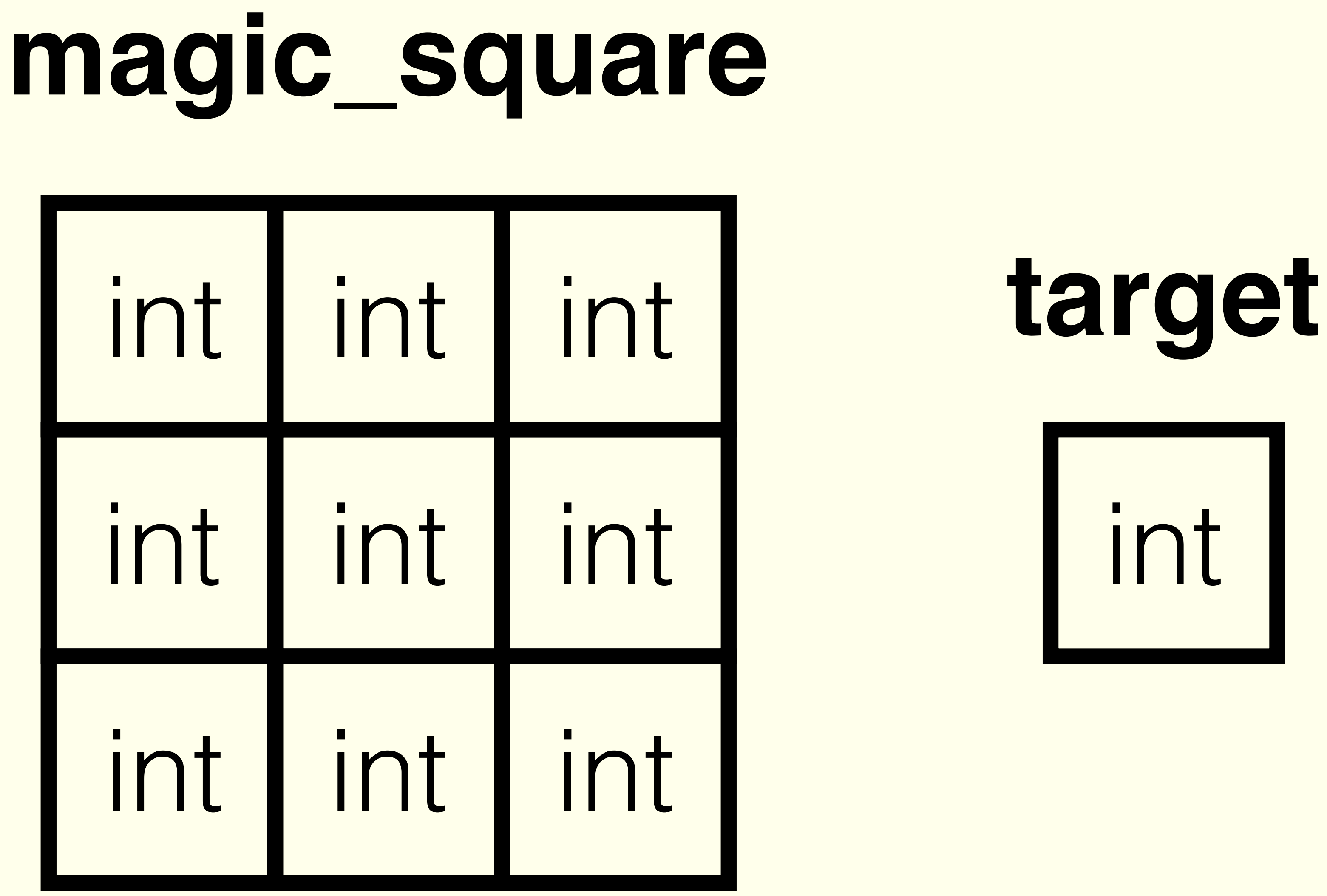
invariant left_diagonal.sum == target;
invariant right_diagonal.sum == target;
```

diagonals

```
expose magic_square, target;
```

```
array3<array3<int>> magic_square;
int target;
```

```
array3<array3<int>> magic_square;
int target;
```



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int target;

magic_square.each(function^ (row) {
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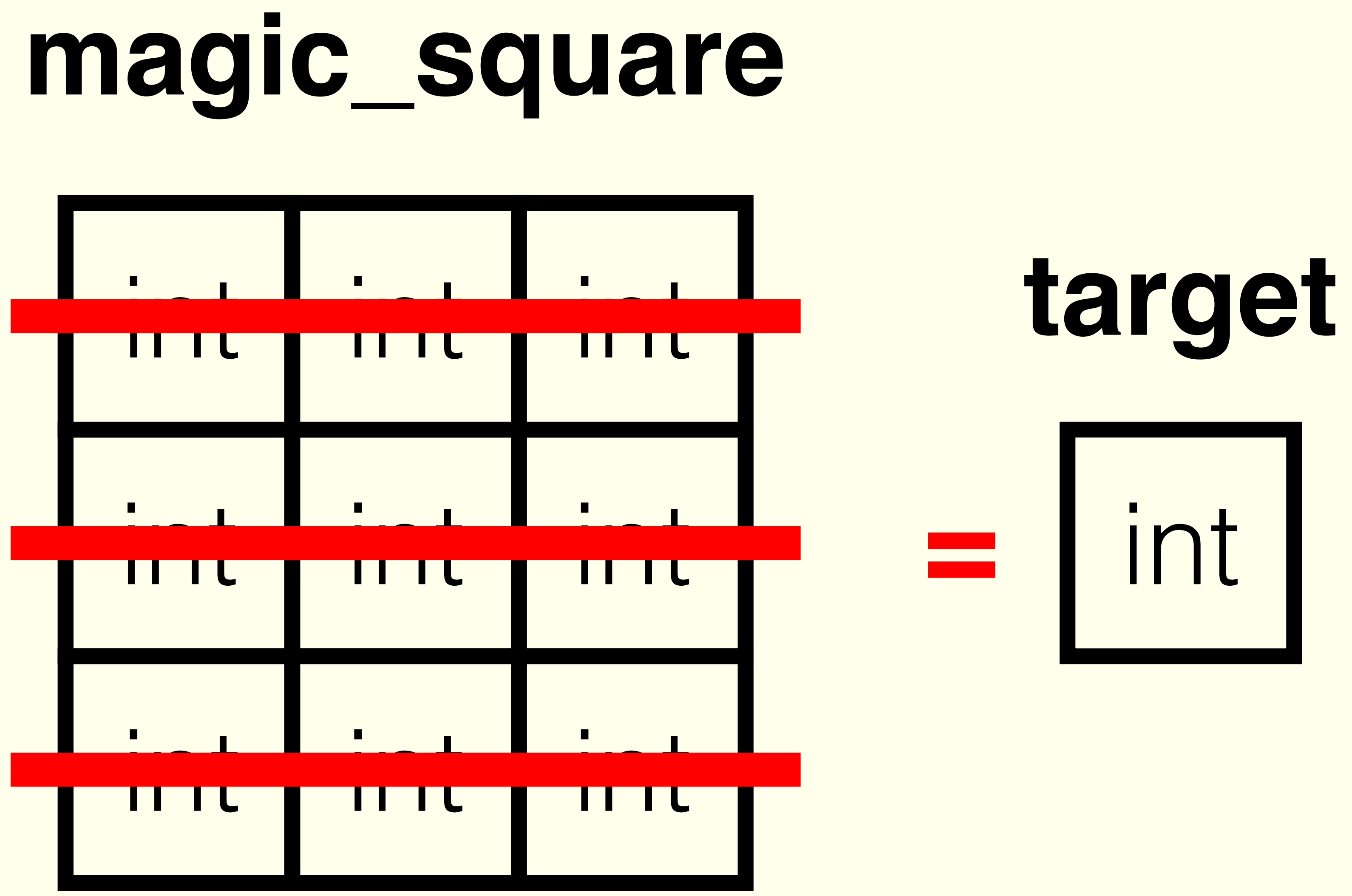
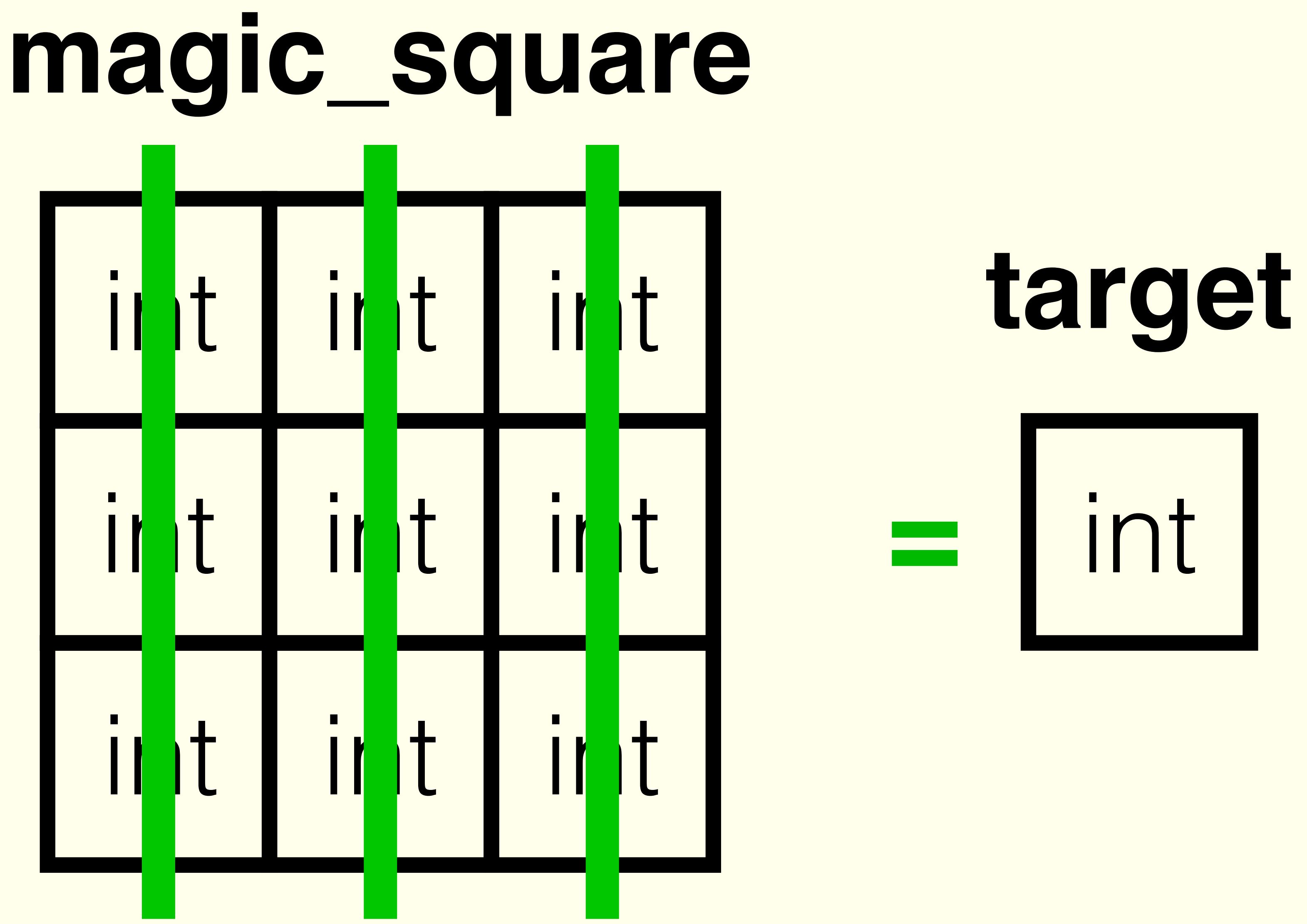
  invariant row.all?(*positive?);
});
```



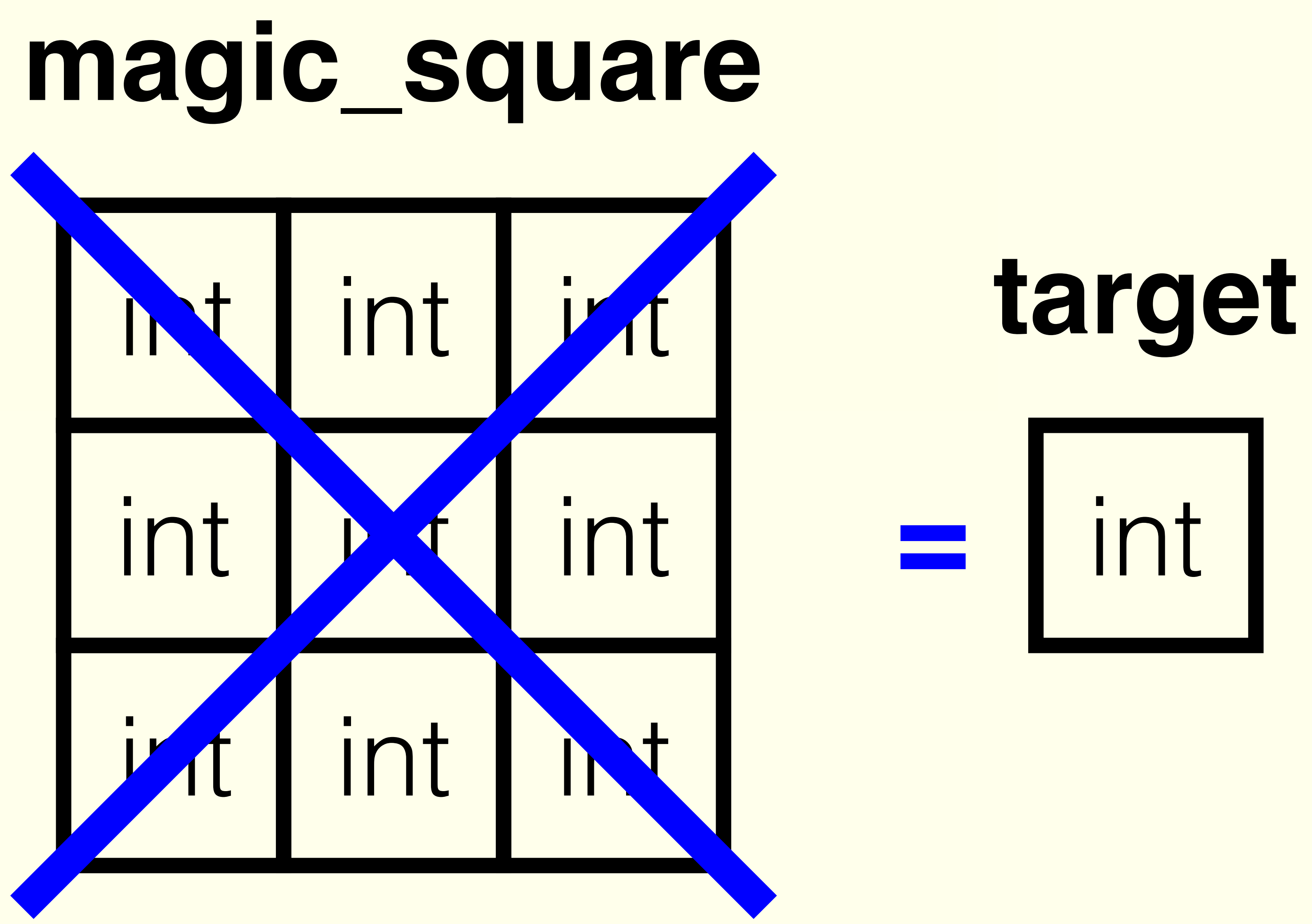
```
magic_square.transpose.each(function^ (column) {
  invariant column.sum == target;
});
```



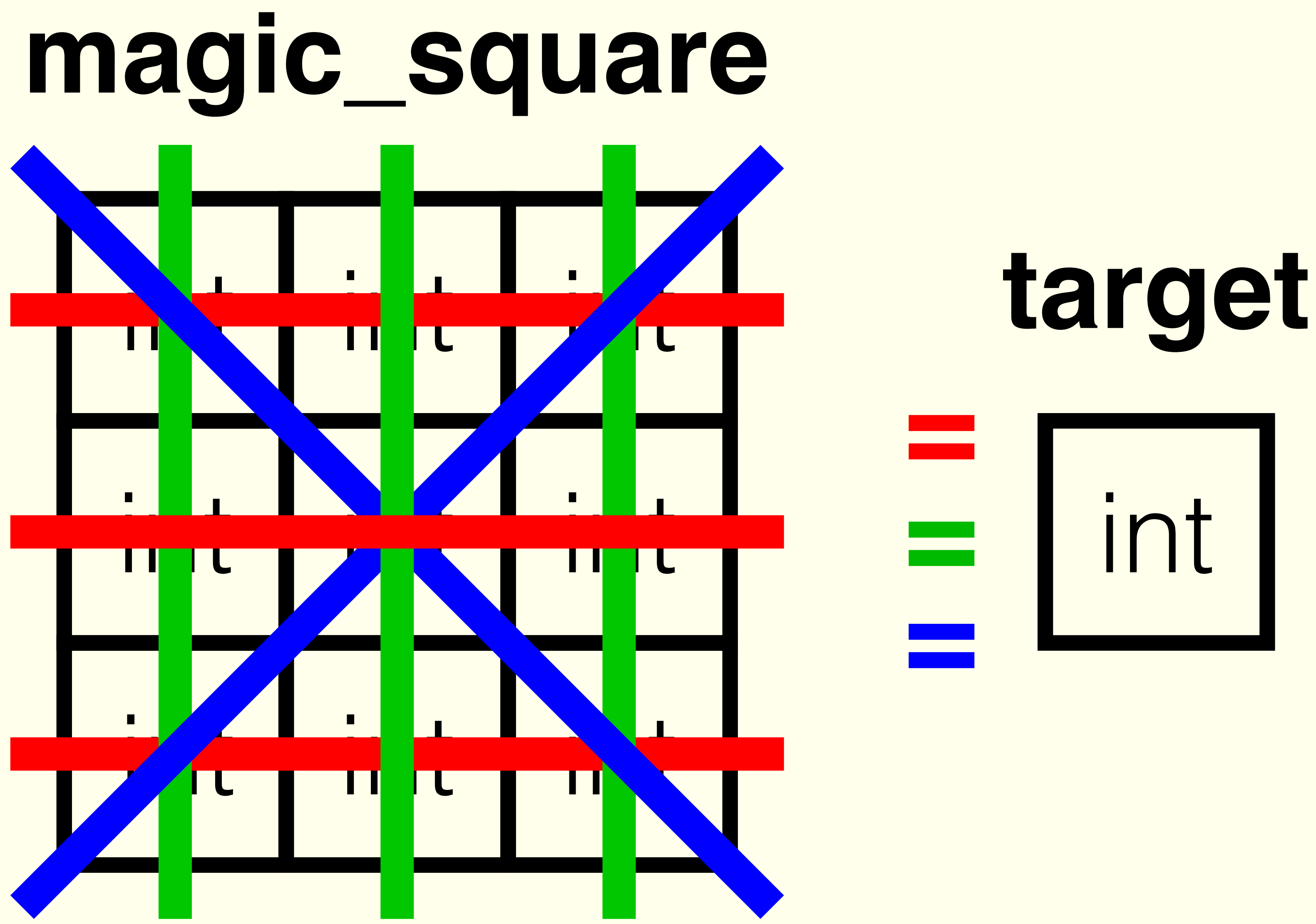
```
left_diagonal = magic_square.map(function (row, index) {
  return row[index];
});

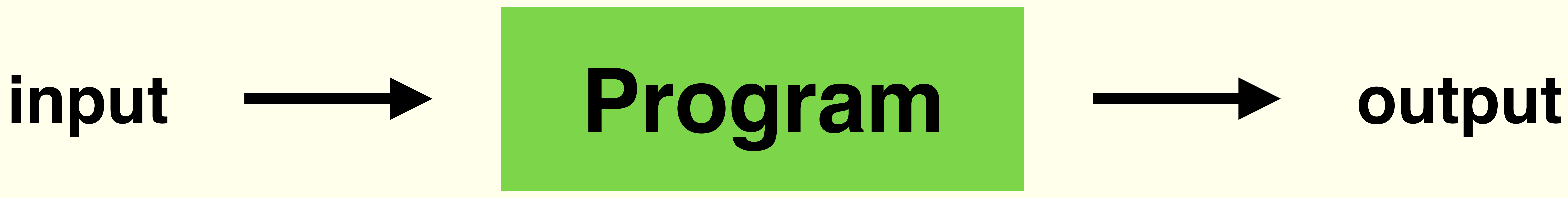
right_diagonal = magic_square.map(function (row, index) {
  return row.reverse[index];
});

invariant left_diagonal.sum == target;
invariant right_diagonal.sum == target;
```



```
expose magic_square, target;
```



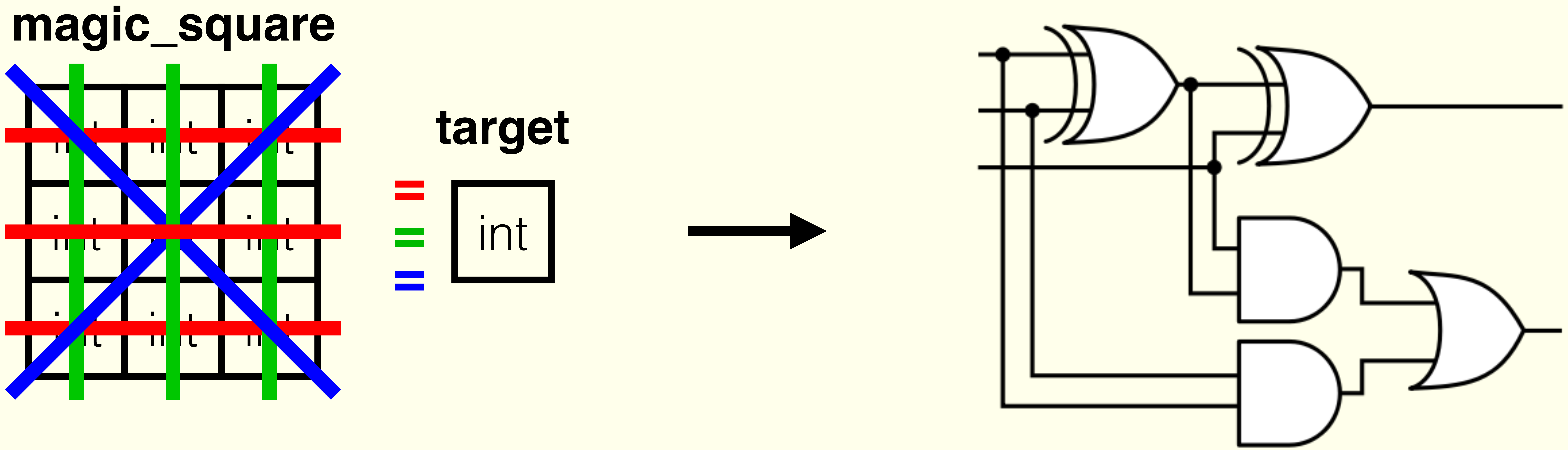

input
Program
output

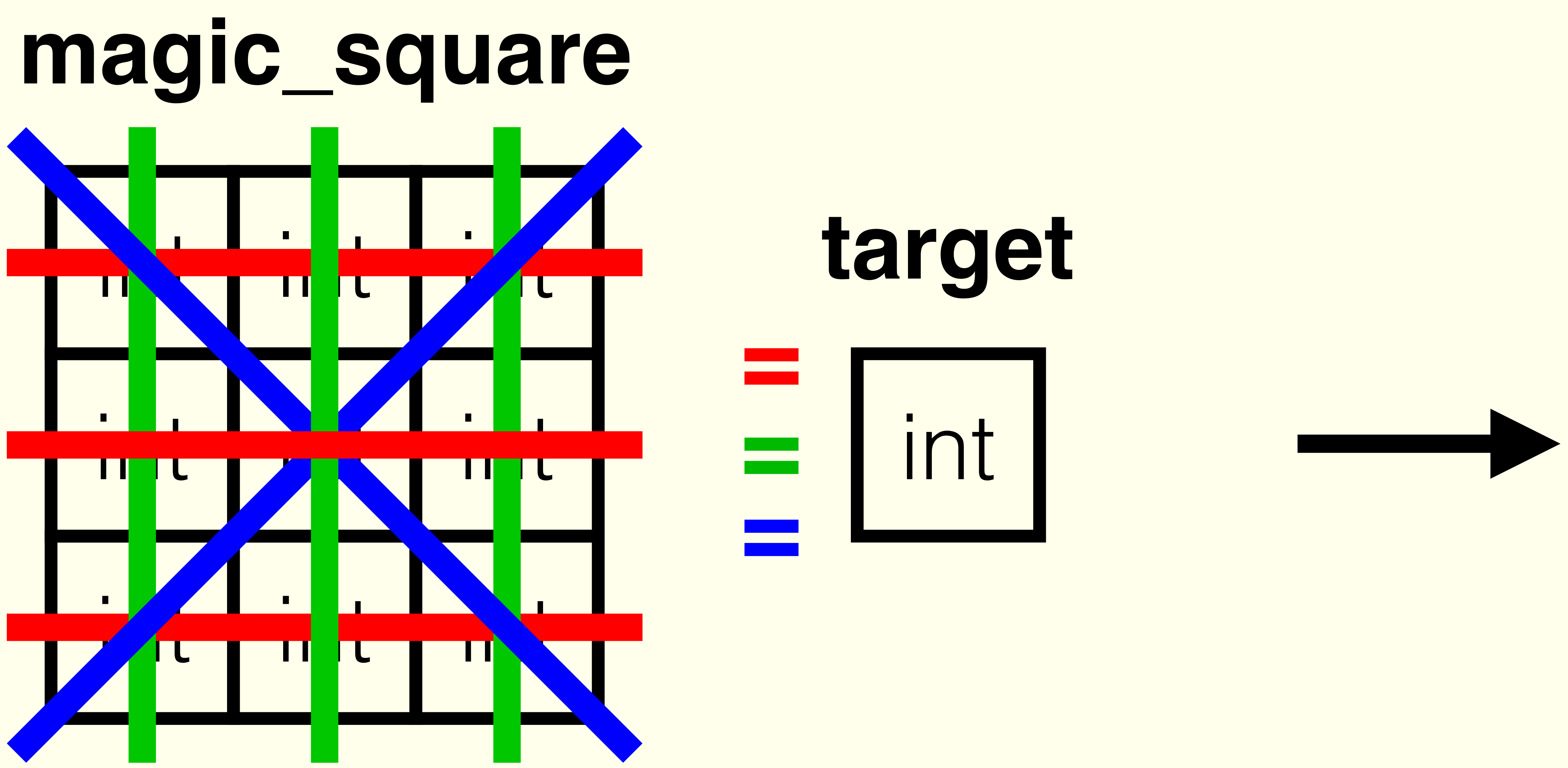

input
output
Program
input
output

```
chris:~ chris$
```


Google
Chris
Secure
https://www.google.co.uk
Mail
Images
C
Google
UK
Google Search
I'm Feeling Lucky
Advertising
Business
About
Privacy
Terms
Settings

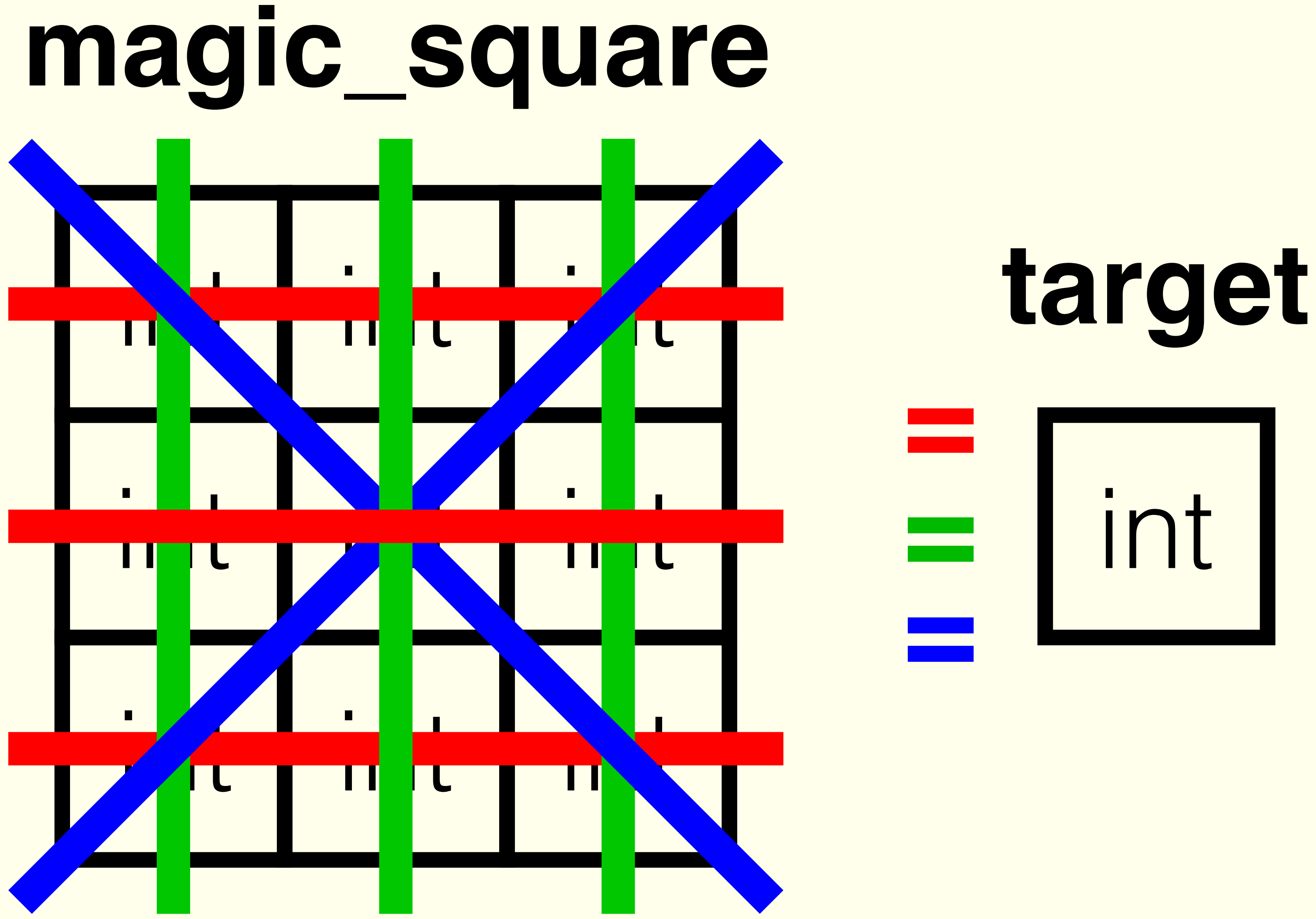
How does it work?


magic_square
target
int

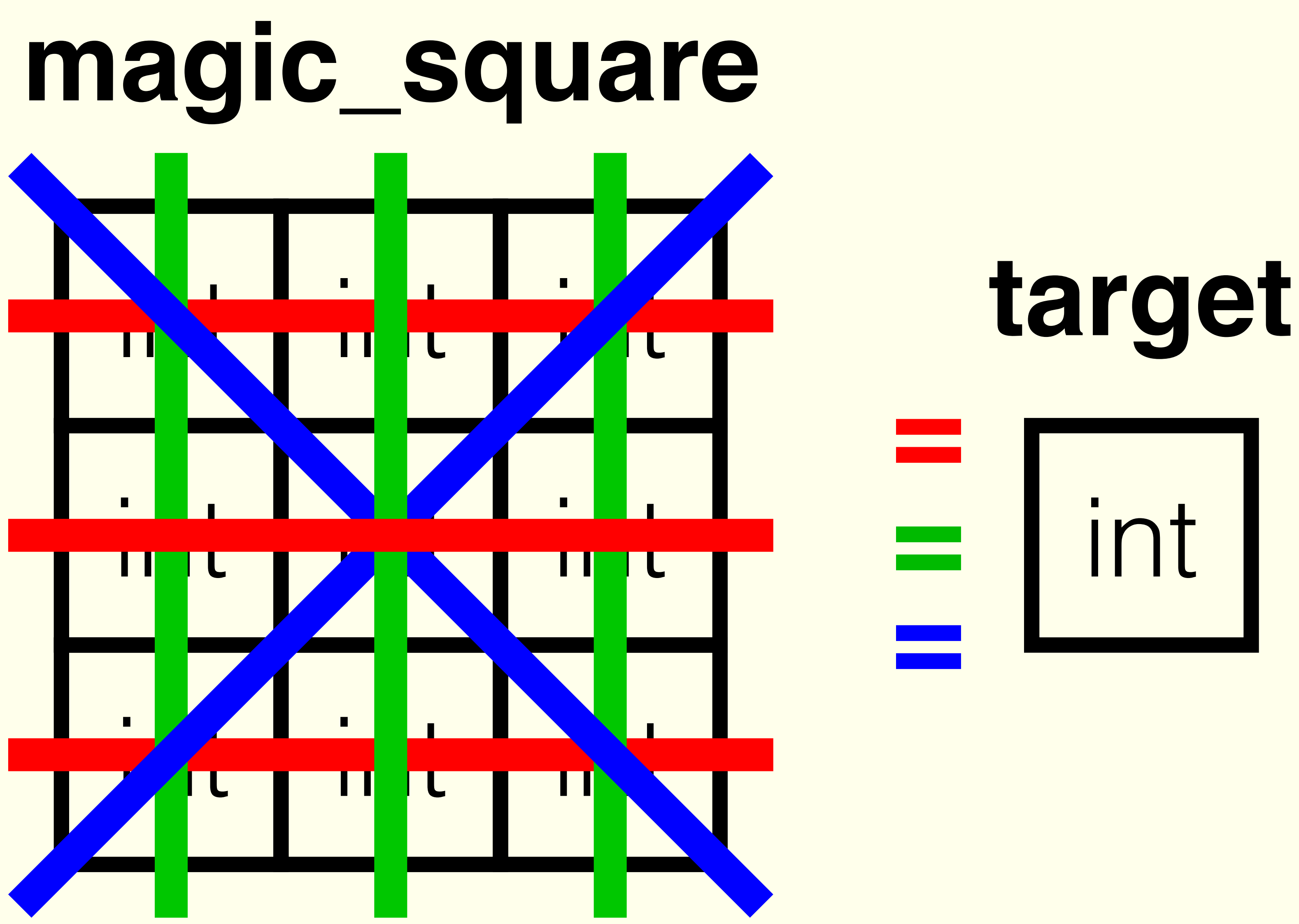


(a || b) && (!a || !c) && (a || !d)
&& (b || c) && (c || !d)

* This process is called a “Tseitin” transform which is how “Sentient” gets its name



$$(a \mid\mid b) \;\&\&\; (!a \mid\mid !c) \;\&\&\; (a \mid\mid !d) \;\&\&\; (b \mid\mid c) \;\&\&\; (c \mid\mid !d) \; \mathbf{== true}$$

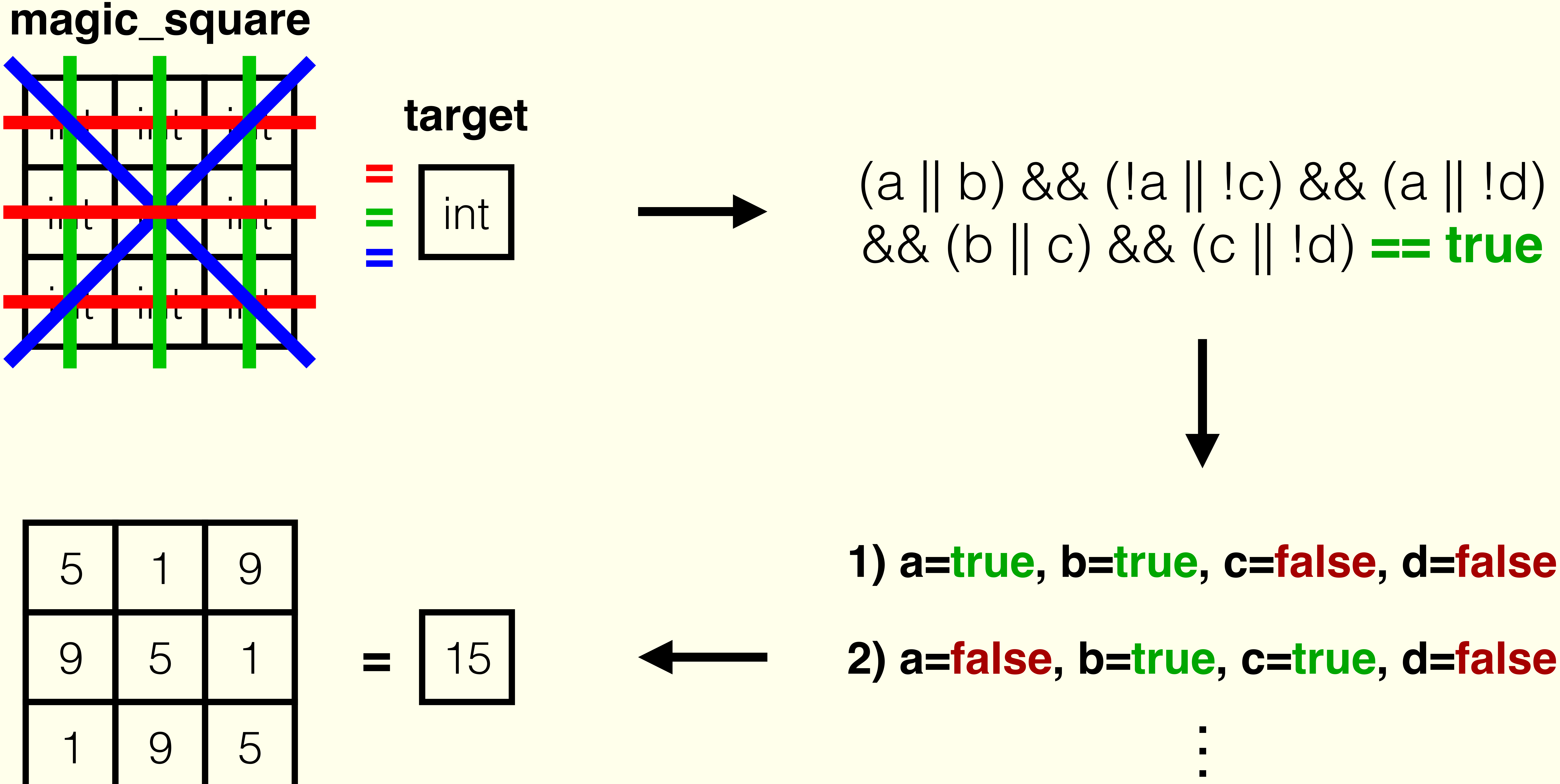


(a || b) && (!a || !c) && (a || !d) && (b || c) && (c || !d) **== true**

1) a=true, b=true, c=false, d=false

2) a=false, b=true, c=true, d=false

⋮


magic_square
target
int
=
=
=
int
(a || b) && (!a || !c) && (a || !d)
&& (b || c) && (c || !d) == true
1) a=true, b=true, c=false, d=false
2) a=false, b=true, c=true, d=false
⋮
5 1 9
9 5 1
1 9 5
=
15

(!x49) && (!x33) && (!x17) && (!x73) && (!x65) && (!x1) && (!x41) && (!x57) && (!x9) && (!x25) && (x8 || !x16 || x81) && (x8 || x16 || !x81) && (!x8 || !x16 || !x81) && (!x8 || x16 || x81) && (!x8 || !x16 || x82) && (x8 || !x82) && (x16 || !x82) && (x7 || !x15 || x83) && (x7 || x15 || !x83) && (!x7 || !x15 || !x83) && (!x7 || x15 || x83) && (!x82 || x83 || x84) && (x82 || x83 || !x84) && (!x82 || !x83 || !x84) && (x82 || !x83 || x84) && (x6 || !x14 || x86) && (x6 || x14 || !x86) && (!x6 || !x14 || !x86) && (!x6 || x14 || x86) && (!x85 || x86 || x87) && (x85 || x86 || !x87) && (!x85 || !x86 || !x87) && (x85 || !x86 || x87) && (x5 || !x13 || x89) && (x5 || x13 || !x89) && (!x5 || !x13 || !x89) && (!x5 || x13 || x89) && (!x88 || x89 || x90) && (x88 || x89 || !x90) && (!x88 || !x89 || !x90) && (x88 || !x89 || x90) && (x4 || !x12 || x92) && (x4 || x12 || !x92) && (!x4 || !x12 || !x92) && (!x4 || x12 || x92) && (!x91 || x92 || x93) && (x91 || x92 || !x93) && (!x91 || !x92 || !x93) && (x91 || !x92 || x93) && (x3 || !x11 || x95) && (x3 || x11 || !x95) && (!x3 || !x11 || !x95) && (!x3 || x11 || x95) && (!x94 || x95 || x96) && (x94 || x95 || !x96) && (!x94 || !x95 || !x96) && (x94 || !x95 || x96) && (!x94 || !x95 || x97) && (x95 || !x97) && (x94 || !x97) && (!x10 || x98) && (x2 || x10 || !x98) && (!x2 || x98) && (!x98 || x99) && (!x2 || !x10) && (!x24 || x80 || x81) && (x24 || !x80 || x81) && (!x24 || !x80 || !x81) && (x24 || x80 || !x81) && (!x24 || !x81 || x100) && (x81 || !x100) && (x24 || !x100) && (!x23 || x84 || x101) && (x23 || x84 || !x101) && (!x23 || !x84 || !x101) && (x23 || !x84 || x101) && (x79 || !x100 || x101) && (!x79 || x100 || x101) && (!x79 || !x100 || !x101) && (x79 || x100 || !x101) && (!x22 || x87 || x103) && (x22 || x87 || !x103) && (!x22 || !x87 || !x103) && (x22 || !x87 || x103) && (x78 || !x102 || x103) && (!x78 || x102 || x103) && (!x78 || !x102 || !x103) && (x78 || x102 || !x103) && (!x21 || x90 || x105) && (x21 || x90 || !x105) && (!x21 || !x90 || !x105) && (x21 || !x90 || x105) && (x77 || !x104 || x105) && (!x77 || x104 || x105) && (!x77 || !x104 || !x105) && (x77 || x104 || !x105) && (!x20 || x93 || x107) && (x20 || x93 || !x107) && (!x20 || !x93 || !x107) && (x20 || !x93 || x107) && (x76 || !x106 || x107) && (!x76 || x106 || x107) && (!x76 || !x106 || !x107) && (x76 || x106 || !x107) && (!x19 || x96 || x109) && (x19 || x96 || !x109) && (!x19 || !x96 || !x109) && (x19 || !x96 || x109) && (x75 || !x108 || x109) && (!x75 || x108 || x109) && (!x75 || !x108 || !x109) && (x75 || x108 || !x109) && (!x108 || !x109 || x110) && (x109 || !x110) && (x108 || !x110) && (!x18 || x111) && (x18 || x99 || !x111) && (!x99 || x111) && (x74 || !x111) && (!x18 || !x99) && (x32 || !x40 || x112) && (x32 || x40 || !x112) && (!x32 || !x40 || !x112) && (!x32 || x40 || x112) && (!x32 || !x40 || x113) && (x32 || !x113) && (x40 || !x113) && (x31 || !x39 || x114) && (x31 || x39 || !x114) && (!x31 || !x39 || !x114) && (!x31 || x39 || x114) && (!x113 || x114 || x115) && (x113 || x114 || !x115) && (!x113 || !x114 || !x115) && (x113 || !x114 || x115) && (x30 || !x38 || x117) && (x30 || x38 || !x117) && (!x30 || !x38 || !x117) && (!x30 || x38 || x117) && (!x116 || x117 || x118) && (x116 || x117 || !x118) && (!x116 || !x117 || !x118) && (x116 || !x117 || x118) && (x29 || !x37 || x120) && (x29 || x37 || !x120) && (!x29 || !x37 || !x120) && (!x29 || x37 || x120) && (!x119 || x120 || x121) && (x119 || x120 || !x121) && (!x119 || !x120 || !x121) && (x119 || !x120 || x121) && (x28 || !x36 || x123) && (x28 || x36 || !x123) && (!x28 || !x36 || !x123) && (!x28 || x36 || x123) && (!x122 || x123 || x124) && (x122 || x123 || !x124) && (!x122 || !x123 || !x124) && (x122 || !x123 || x124) && (x27 || !x35 || x126) && (x27 || x35 || !x126) && (!x27 || !x35 || !x126) && (!x27 || x35 || x126) && (!x125 || x126 || x127) && (x125 || x126 || !x127) && (!x125 || !x126 || !x127) && (x125 || !x126 || x127) && (!x27 || !x35 || x128) && (x27 || !x128) && (x35 || !x128) && (!x34 || x129) && (x26 || x34 || !x129) && (!x26 || x129) && (!x129 || x130) && (!x26 || !x34) && (!x48 || x80 || x112) && (x48 || !x80 || x112) && (!x48 || !x80 || !x112) && (x48 || x80 || !x112) && (!x48 || !x112 || x131) && (x112 || !x131) && (x48 || !x131) && (!x47 || x115 || x132) && (x47 || x115 || !x132) && (!x47 || !x115 || !x132) && (x47 || !x115 || x132) && (x79 || !x131 || x132) && (!x79 || x131 || x132) && (!x79 || !x131 || !x132) && (x79 || x131 || !x132) && (!x46 || x118 || x134) && (x46 || x118 || !x134) && (!x46 || !x118 || !x134) && (x46 || !x118 || x134) && (x78 || !x133 || x134) && (!x78 || x133 || x134) && (!x78 || !x133 || !x134) && (x78 || x133 || !x134) && (!x45 || x121 || x136) && (x45 || x121 || !x136) && (!x45 || !x121 || !x136) && (x45 || !x121 || x136) && (x77 || !x135 || x136) && (!x77 || x135 || x136) && (!x77 || !x135 || !x136) && (x77 || x135 || !x136) && (!x44 || x124 || x138) && (x44 || x124 || !x138) && (!x44 || !x124 || !x138) && (x44 || !x124 || x138) && (x76 || !x137 || x138) && (!x76 || x137 || x138) && (!x76 || !x137 || !x138) && (x76 || x137 || !x138) && (!x43 || x127 || x140) && (x43 || x127 || !x140) && (!x43 || !x127 || !x140) && (x43 || !x127 || x140) && (x75 || !x139 || x140) && (!x75 || x139 || x140) && (!x75 || !x139 || !x140) && (x75 || x139 || !x140) && (!x139 || !x140 || x141) && (x140 || !x141) && (x139 || !x141) && (!x42 || x142) && (x42 || x130 || !x142) && (!x130 || x142) && (x74 || !x142) && (!x42 || !x130) && (x56 || !x64 || x143) && (x56 || x64 || !x143) && (!x56 || !x64 || !x143) && (!x56 || x64 || x143) && (!x56 || !x64 || x144) && (x56 || !x144) && (x64 || !x144) && (x55 || !x63 || x145) && (x55 || x63 || !x145) && (!x55 || !x63 || !x145) && (!x55 || x63 || x145) && (!x144 || x145 || x146) && (x144 || x145 || !x146) && (!x144 || !x145 || !x146) && (x144 || !x145 || x146) && (x54 || !x62 || x148) && (x54 || x62 || !x148) && (!x54 || !x62 || !x148) && (!x54 || x62 || x148) && (!x147 || x148 || x149) && (x147 || x148 || !x149) && (!x147 || !x148 || !x149) && (x147 || !x148 || x149) && (x53 || !x61 || x151) && (x53 || x61 || !x151) && (!x53 || !x61 || !x151) && (!x53 || x61 || x151) && (!x150 || x151 || x152) && (x150 || x151 || !x152) && (!x150 || !x151 || !x152) && (x150 || !x151 || x152) && (x52 || !x60 || x154) && (x52 || x60 || !x154) && (!x52 || !x60 || !x154) && (!x52 || x60 || x154) && (!x153 || x154 || x155) && (x153 || x154 || !x155) && (!x153 || !x154 || !x155) && (x153 || !x154 || x155) && (x51 || !x59 || x157) && (x51 || x59 || !x157) && (!x51 || !x59 || !x157) && (!x51 || x59 || x157) && (!x156 || x157 || x158) && (x156 || x157 || !x158) && (!x156 || !x157 || !x158) && (x156 || !x157 || x158) && (!x51 || !x59 || x159) && (x51 || !x159) && (x59 || !x159) && (!x58 || x160) && (x50 || x58 || !x160) && (!x50 || x160) && (!x160 || x161) && (!x50 || !x58) && (!x72 || x80 || x143) && (x72 || !x80 || x143) && (!x72 || !x80 || !x143) && (x72 || x80 || !x143) && (!x72 || !x143 || x162) && (x143 || !x162) && (x72 || !x162) && (!x71 || x146 || x163) && (x71 || x146 || !x163) && (!x71 || !x146 || !x163) && (x71 || !x146 || x163) && (x79 || !x162 || x163) && (!x79 || x162 || x163) && (!x79 || !x162 || !x163) && (x79 || x162 || !x163) && (!x70 || x149 || x165) && (x70 || x149 || !x165) && (!x70 || !x149 || !x165) && (x70 || !x149 || x165) && (x78 || !x164 || x165) && (!x78 || x164 || x165) && (!x78 || !x164 || !x165) && (x78 || x164 || !x165) && (!x69 || x152 || x167) && (x69 || x152 || !x167) && (!x69 || !x152 || !x167) && (x69 || !x152 || x167) && (x77 || !x166 || x167) && (!x77 || x166 || x167) && (!x77 || !x166 || !x167) && (x77 || x166 || !x167) && (!x68 || x155 || x169) && (x68 || x155 || !x169) && (!x68 || !x155 || !x169) && (x68 || !x155 || x169) && (x76 || !x168 || x169) && (!x76 || x168 || x169) && (!x76 || !x168 || !x169) && (x76 || x168 || !x169) && (!x67 || x158 || x171) && (x67 || x158 || !x171) && (!x67 || !x158 || !x171) && (x67 || !x158 || x171) && (x75 || !x170 || x171) && (!x75 || x170 || x171) && (!x75 || !x170 || !x171) && (x75 || x170 || !x171) && (!x67 || !x158 || x172) && (x158 || !x172) && (x67 || !x172) && (!x66 || x173) && (x66 || x161 || !x173) && (!x161 || x173) && (x74 || !x173) && (!x66 || !x161) && (x8 || !x32 || x174) && (x8 || x32 || !x174) && (!x8 || !x32 || !x174) && (!x8 || x32 || x174) && (!x8 || !x32 || x175) && (x8 || !x175) && (x32 || !x175) && (x7 || !x31 || x176) && (x7 || x31 || !x176) && (!x7 || !x31 || !x176) && (!x7 || x31 || x176) && (!x175 || x176 || x177) && (x175 || x176 || !x177) && (!x175 || !x176 || !x177) && (x175 || !x176 || x177) && (x6 || !x30 || x179) && (x6 || x30 || !x179) && (!x6 || !x30 || !x179) && (!x6 || x30 || x179) && (!x178 || x179 || x180) && (x178 || x179 || !x180) && (!x178 || !x179 || !x180) && (x178 || !x179 || x180) && (x5 || !x29 || x182) && (x5 || x29 || !x182) && (!x5 || !x29 || !x182) && (!x5 || x29 || x182) && (!x181 || x182 || x183) && (x181 || x182 || !x183) && (!x181 || !x182 || !x183) && (x181 || !x182 || x183) && (x4 || !x28 || x185) && (x4 || x28 || !x185) && (!x4 || !x28 || !x185) && (!x4 || x28 || x185) && (!x184 || x185 || x186) && (x184 || x185 || !x186) && (!x184 || !x185 || !x186) && (x184 || !x185 || x186) && (x3 || !x27 || x188) && (x3 || x27 || !x188) && (!x3 || !x27 || !x188) && (!x3 || x27 || x188) && (!x187 || x188 || x189) && (x187 || x188 || !x189) && (!x187 || !x188 || !x189) && (x187 || !x188 || x189) && (!x187 || !x188 || x190) && (x188 || !x190) && (x187 || !x190) && (!x26 || x191) && (x2 || x26 || !x191) && (!x2 || x191) && (!x191 || x192) && (!x2 || !x26) && (!x56 || x80 || x174) && (x56 || !x80 || x174) && (!x56 || !x80 || !x174) && (x56 || x80 || !x174) && (!x56 || !x174 || x193) && (x174 || !x193) && (x56 || !x193) && (!x55 || x177 || x194) && (x55 ||

My favourite puzzle

This pangram contains ___ a's, ___ b's, ___ c's, ___ d's, ___ e's, ___ f's, ___ g's, ___ h's, ___ i's, ___ j’s, ___ k’s, ___ l's, ___ m's, ___ n's, ___ o's, ___ p’s, ___ q’s, ___ r's, ___ s's, ___ t's, ___ u's, ___ v's, ___ w's, ___ x's, ___ y’s and ___ z’s.

This pangram contains **four** a's, **two** b's, **one** c,
___ d's, ___ e's, ___ f's, ___ g's, ___ h's, ___ i's,
___ j’s, ___ k’s, ___ l's, ___ m's, ___ n's, ___ o's,
___ p’s, ___ q’s, ___ r's, ___ s's, ___ t's, ___ u's,
___ v's, ___ w's, ___ x's, ___ y’s and ___ z’s.

$40^{26} =$

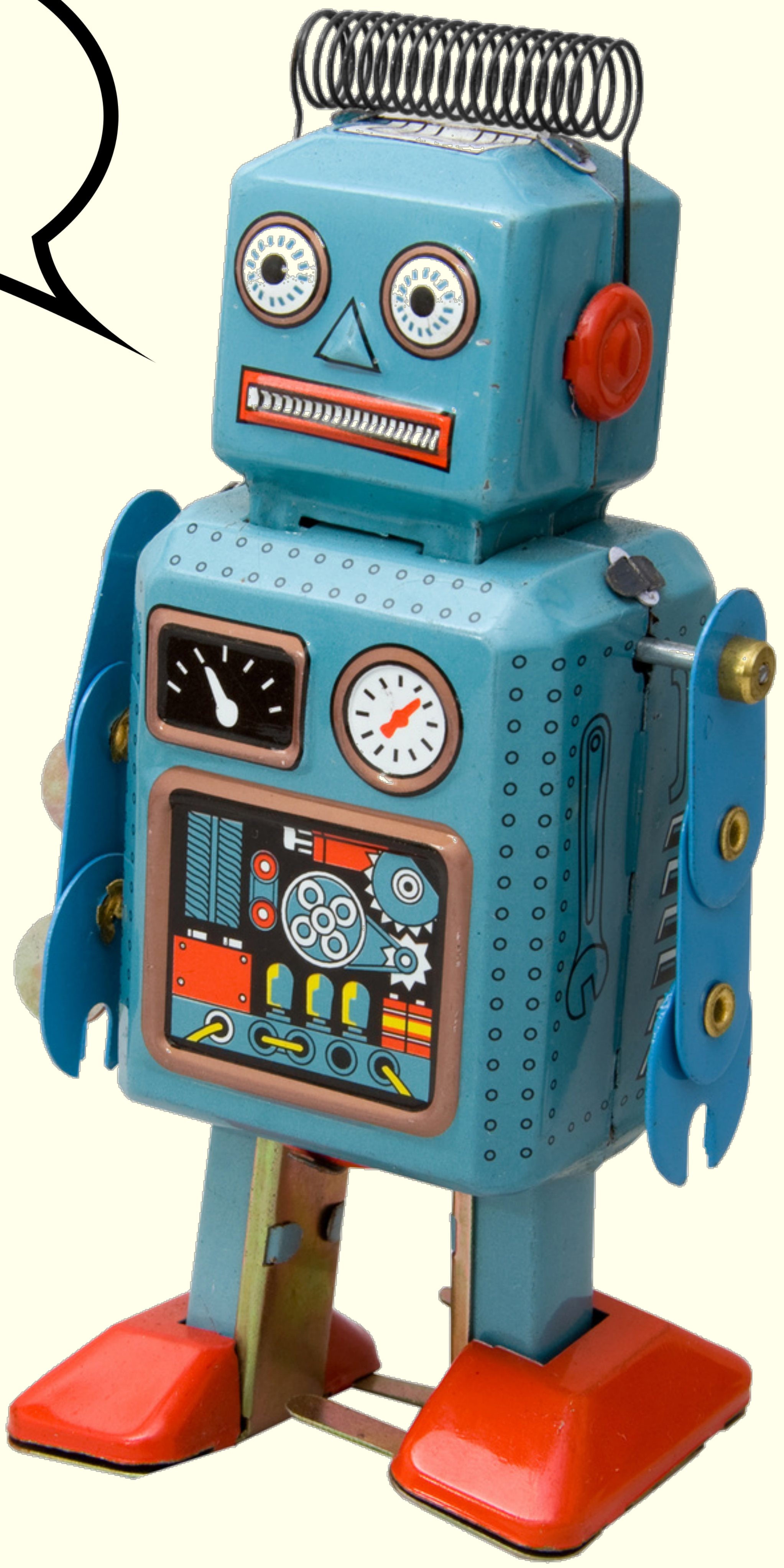
450,359,962,737,049,600,000,
000,000,000,000,000,000,000

This pangram contains ___ a's, ___ b's, ___ c's, ___ d's, ___ e's, ___ f's, ___ g's, ___ h's, ___ i's, ___ j’s, ___ k’s, ___ l's, ___ m's, ___ n's, ___ o's, ___ p’s, ___ q’s, ___ r's, ___ s's, ___ t's, ___ u's, ___ v's, ___ w's, ___ x's, ___ y’s and ___ z’s.

Here's how to check a pangram

Now go find some!

OK



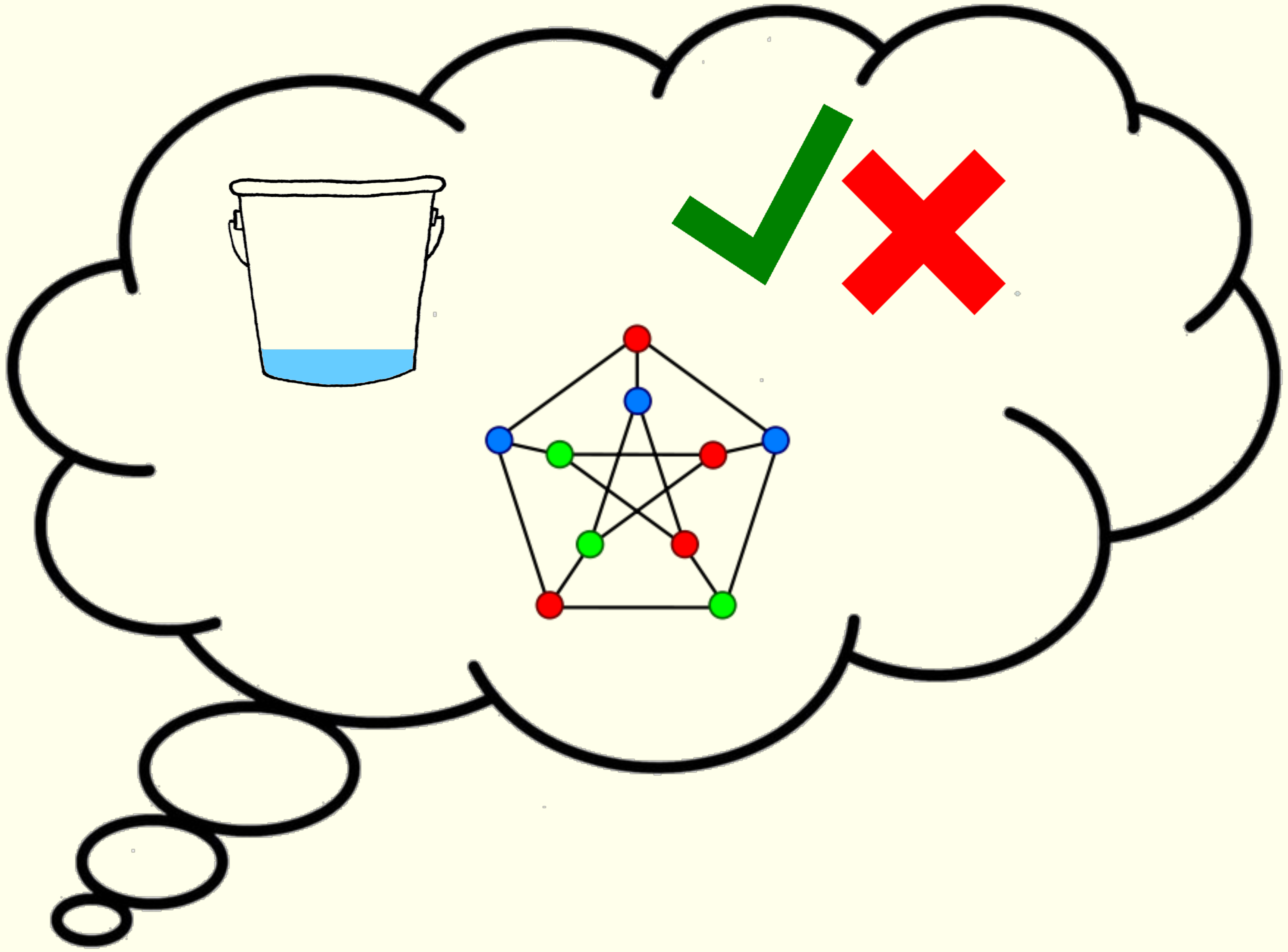
2 minutes

This sentence is dedicated to Ember London and it contains five a's, two b's, four c's, seven d's, thirty-four e's, eight f's, four g's, eight h's, sixteen i's, one j, one k, two l's, two m's, twenty-three n's, eighteen o's, one p, one q, nine r's, thirty s's, twenty-four t's, five u's, seven v's, seven w's, two x's, five y’s and one z.

This sentence is dedicated to Ember London and it contains five a's, two b's, four c's, seven d's, thirty-four e's, eight f's, four g's, eight h's, sixteen i's, one j, one k, two l's, two m's, twenty-three n's, eighteen o's, one p, one q, nine r's, thirty s's, twenty-four t's, five u's, seven v's, seven w's, two x's, five y’s and one z.

This sentence is dedicated to Em**b**er London and it contains five a's, two **b**'s, four c's, seven d's, thirty-four e's, eight f's, four g's, eight h's, sixteen i's, one j, one k, two l's, two m's, twenty-three n's, eighteen o's, one p, one q, nine r's, thirty s's, twenty-four t's, five u's, seven v's, seven w's, two x's, five y’s and one z.

To wrap up



sentient-lang.org

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Thanks!

by Chris Patuzzo
Ember London, 2017-01-12
@cpatuzzo