

Cracking the Code, Part 2: Codes & Combinations



From fire signals to computer programming, coding has always been an essential skill for communication. This second set of lessons in the series engages students in decoding and creating codes.

There are many codes that are used on a daily basis. Perhaps the first digital code, Morse code was developed by Samuel Morse between 1832 and 1844 when he presented his telegraphic invention before Congress. A pattern composed of long and short signals, Morse code is both auditory and visual. It still used today in navigation. To those not fluent, Braille may be considered a visual and kinesthetic code. In this lesson, students will crack a “Rubik’s® code.” They will then be challenged to create their own visual codes using the six colors on a single face of a Rubik’s® Cube.

Standards Addressed in this Lesson:

Texas Essential Knowledge & Skills (TEKS):

K-12 Process Standards

(B) use a problem-solving model that incorporates analyzing given information, formulating a plan or strategy, determining a solution, justifying the solution, and evaluating the problem solving process and the reasonableness of the solution;

(D) communicate mathematical ideas, reasoning, and their implications using multiple representations, including symbols, diagrams, graphs, and language as appropriate;

(E) create and use representations to organize, record, and communicate mathematical ideas;

(F) analyze mathematical relationships to connect and communicate mathematical ideas;

Proportionality

7.6 (D) make predictions and determine solutions using theoretical probability for simple and compound events;

7.6 (I) (I) determine experimental and theoretical probabilities related to simple and compound events using data and sample spaces.

Two-dimensional shapes.

8.10 (A-C) (A) generalize the properties of orientation and congruence of rotations, reflections, translations, and dilations of two-dimensional shapes on a coordinate plane; (B) differentiate between transformations that preserve congruence and those that do not; (C) explain the effect of translations, reflections over the x- or y-axis, and rotations limited to 90° , 180° , 270° , and 360° as applied to two-dimensional shapes on a coordinate plane using an algebraic representation; and

Materials:

A Rubik’s® cube for each student

Handout for each student or group

9 block grid paper (attached)

red, green, blue, yellow, orange colored pencils, markers, or crayons

journal for each student (optional)

Background knowledge:

Students should be familiar with the skills needed to solve one face of the Rubik’s® Cube. While it may be helpful to be able to solve one face, it is not an essential skill.

| Rubik's® Code | Translation | Got it | Didn't get it |
|---------------|-------------|--------|---------------|
| | | | |
| | | | |



What is the purpose of the red square?



What was the first part of the code that you cracked?
What about that part made it easy to crack?

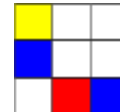


Some of the alphabet letters are missing. Based on the letters you know, what do you think the code for each of the missing letters is? Draw them on the grid paper.

Cracking the Code: Challenges



Some codes use their symbols to create a shorter way of saying several words. For example, when someone sends a text message they might write "SC" which stands for "stay cool". That might look like this in Rubik's® code:



How would you code these? Use the grid paper to record your solutions. Share them with someone. Do they agree with your code?

| | |
|----|---------------|
| RU | Are you? |
| JK | Just kidding! |
| BF | Best Friend |

What other codes can you make?



Braille is a written language for the blind. It uses a code of 6 raised dots punched on paper. Ask your teacher for the Braille alphabet sheet. Use the grid paper to create the Braille alphabet using one face of the cube for each letter. How many colors will you need?

Rules for the Braille alphabet:

- You must have a way of letting the reader know how to hold the cube.
- You must be able to create the code for one letter on one face of the Rubik's® cube.
- Create some words or phrases with your code for others to crack.
- Create an answer key.



Think about what makes a good code. Use the grid paper to help you create your own Rubik's® Code.

Rules for the code:

- You must have a way of letting the reader know how to hold the cube.
- You must be able to create the code for one letter on one face of the Rubik's® cube.
- Create some words or phrases with your code for others to crack.
- Create an answer key.



Use the Rubik's® Code to put a hidden message in a mosaic design.



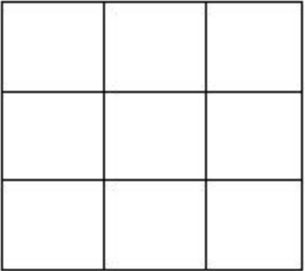
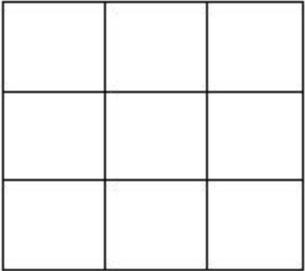
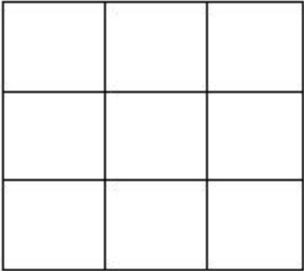
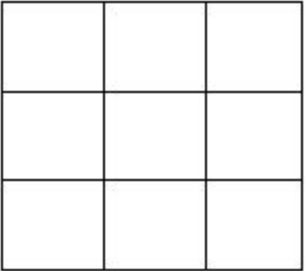
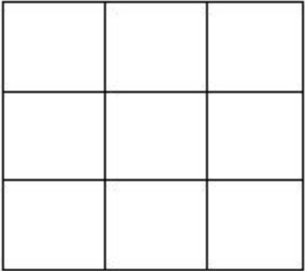
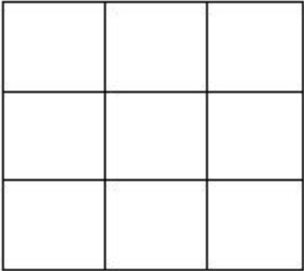
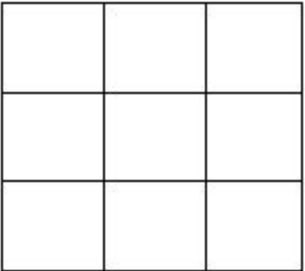
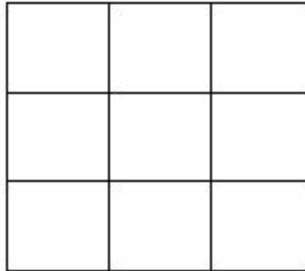
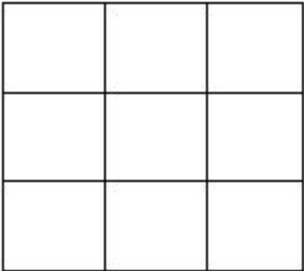
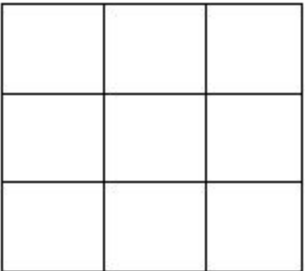
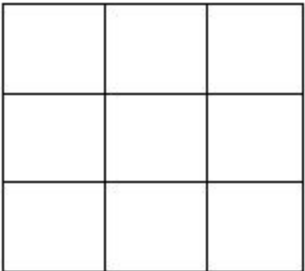
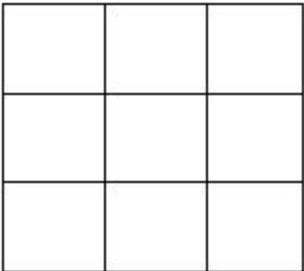
Can you create a word using the Rubik's® code and on more than one face of the cube? For example, can you create the word "hi" on your cube? Make a list of the words you can create. Challenge a classmate to create your words on a Rubik's® cube.



Make a scavenger hunt. Leave a Rubik's® code to find the next location or hint.

Cracking the Code: Create a Rubik's® Code

Each set of 9 squares represents one face of a Rubik's® cube.



Cracking the Code: Braille



In the first column, write a list of words or phrases written in Braille. Can you crack the code? Ask your teacher for the Braille alphabet.

| Braille | Translation | got it | didn't get it |
|---------|-------------|--------|---------------|
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |



How many colors did you use to create your Braille alphabet?



Color blocks on your grid paper to make the words.



Share the words with someone else.
Check the column in the table above if the other person got the word or didn't.

Cracking the Code: Create Your Own Code



In the first column, write a list of words or phrases you can make with your Rubik's® code.

| word or phrase | got it | didn't get it |
|----------------|--------|---------------|
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |



Color blocks on your grid paper to make the words.



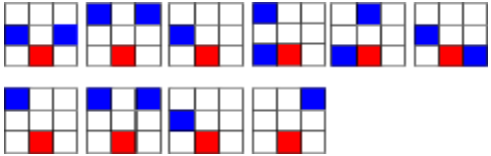
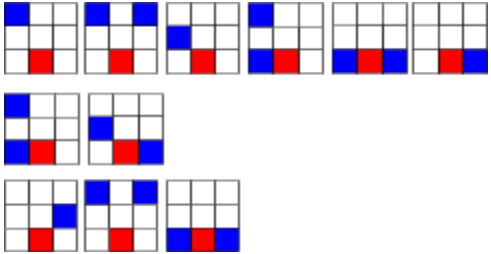
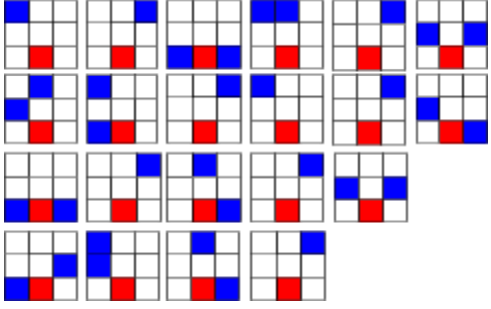
Share the words with someone else.
Check the column in the table above if the other person got the word or didn't.

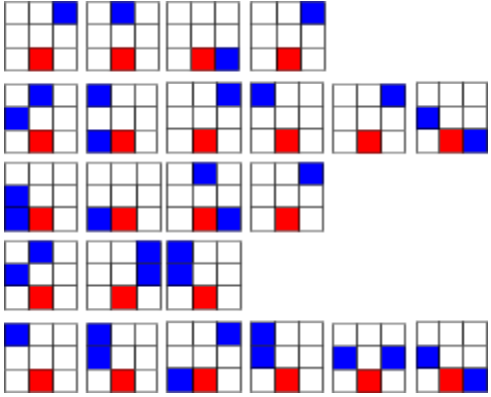
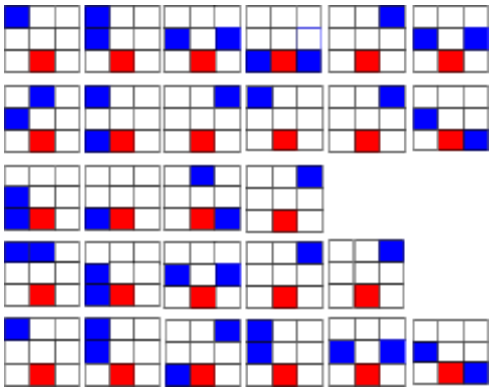
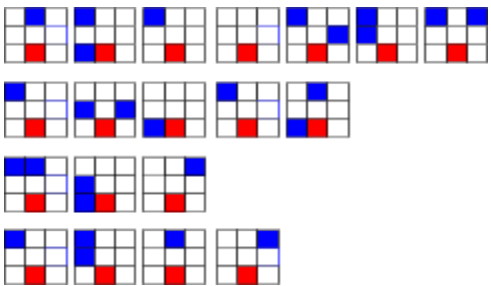
Teacher Notes: Cracking the Code: “Rubik’s® Code”

Students may work alone or in groups. This may be done over several days in periods of 15 - 30 minutes. In one day, you may want to have students work for 15 - 20 minutes trying to crack the code. Perhaps at the end of each session, you ask volunteers to share their findings or have students record their findings in a journal.



In the first column, write the words or phrases written in “Rubik’s® Code”.
Can you crack the code?

| “Rubik’s® Code” | Translation | got it | didn't get it |
|---|----------------------------------|--------|---------------|
|  | <p>Rubiks Cube</p> | | |
|  | <p>Cubing is fun.</p> | | |
|  | <p>Center pieces never move.</p> | | |

| | | | |
|---|---|--|--|
|  | <p>Edge pieces have two colors.</p> | | |
|  | <p>Corner pieces have three colors.</p> | | |
|  | <p>Did you crack the code?</p> | | |



What is the purpose of the red square?

The red square is a tag. It tells the reader how to orient the cube. The red square is always the bottom edge.



What was the first part of the code that you cracked? What about that part made it easy to crack? *Answers will vary.*



Some of the alphabet letters are missing. Based on the letters you know, what do you think the code for each of the missing letters is? Draw them on the grid paper. [See the attached key.](#) The "Rubik's® code" as presented here is the Semaphore alphabet.

Teacher Notes: Cracking the Code: Challenges



Some codes use their symbols to create a shorter way of saying several words. For example, when someone sends a text message they might write "SC" which stands for "stay cool". That might look like this in Rubik's® code:



How would you code these? Use the grid paper to record your solutions. Share them with someone. Do they agree with your code?

| | |
|----|---------------|
| RU | Are you? |
| JK | Just kidding! |
| BF | Best Friend |

What other codes can you make?

One approach to these codes would be to make the first letter code in blue and the second letter in a different color (yellow). Challenge students to find a way of letting the reader know the same letter has been used twice (BFF). Solutions will vary.



Braille is a written language for the blind. It uses a code of 6 raised dots punched on paper. Ask your teacher for the Braille alphabet sheet. Use the grid paper to create the Braille alphabet using one face of the cube for each letter. How many colors will you need?

Rules for the Braille alphabet:

- You must have a way of letting the reader know how to hold the cube.
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<https://www.nbp.org/downloads/alphsamp.pdf>

Braille Alphabet

The six dots of the braille cell are arranged and numbered:



The capital sign, dot 6, placed before a letter makes a capital letter.



The number sign, dots 3, 4, 5, 6, placed before the characters a through j, makes the numbers 1 through 0. For example: a preceded by the number sign is 1, h is 2, etc.



| | | | | | | | | | |
|-----|------|-------|--------|---------|----------|--------------|-------------|-------------|--------------|
| a | b | c | d | e | f | g | h | i | j |
| • | •• | ••• | •••• | ••••• | •••••• | ••••••• | •••••••• | ••••••••• | •••••••••• |
| k | l | m | n | o | p | q | r | s | t |
| •• | ••• | •••• | ••••• | •••••• | ••••••• | •••••••• | ••••••••• | •••••••••• | ••••••••••• |
| u | v | w | x | y | z | Capital Sign | Number Sign | Period | Comma |
| ••• | •••• | ••••• | •••••• | ••••••• | •••••••• | ••••••••• | •••••••••• | ••••••••••• | •••••••••••• |

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BOSTON, MA 02115
www.nbp.org



Think about what makes a good code. Use the grid paper to help you create your own Rubik's® Code.

Rules for the code:

- You must have a way of letting the reader know how to hold the cube.
- You must be able to create the code for one letter on one face of the Rubik's® cube.
- Create some words or phrases with your code for others to crack.
- Create an answer key.

What makes a good code - it has to have a pattern to its solution. The author has to be able to explain how to crack the code. It might be good to have students describe the pattern in the Rubik's® code or the pattern in Braille before they attempt to create their own code.



Use the Rubik's® Code to put a hidden message in a mosaic design.

<http://www.youcandothecube.com/cube-mosaics/>



Can you create a word using the Rubik's® code and more than one face of the cube? For example, can you create the word "hi" on your cube? Make a list of the word you can create. Challenge a classmate to create your words on a Rubik's® cube. Record your words and cube patterns in your journal.

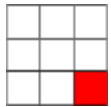
Answers will vary.



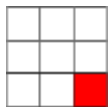
Make a scavenger hunt. Leave a Rubik's® code to find the next location or hint.

Cracking the Code: How Many Combinations Are There?

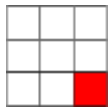
This time, there is no "tag" that orients the cube.



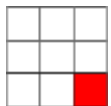
Choose a color. On the grid paper, draw all codes that can be made with one color on one face of the Rubik's® cube. How many different codes did you make? How does not having a tag affect the number of combinations you can make?



Check your codes with someone else. Are your codes the same? Why or why not? Are there some codes you don't agree with? Why? Do you have enough combinations to make a code for every letter in the alphabet? Do you have enough codes to also represent the digits 0 - 9?



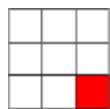
Choose a second color. Using 2 colors, draw all the codes that can be made with 2 colors on one face of the Rubik's® cube. How many different codes did you make? Do you have enough combinations to make a code for every letter in the alphabet and the numbers 0 - 9? What is the fewest number of colors you would need to make a code for each of the 26 letters of the alphabet? Show or explain how you know.



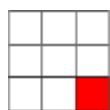
Challenge: Can you make the opposite face display the same code?

Teacher Notes: Cracking the Code: How Many Combinations Are There?

This time, there is no "tag" that orients the cube.

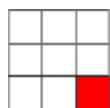


Choose a color. On the grid paper, draw all codes that can be made with one color on one face of the Rubik's® cube. How many different codes did you make? How does not having a tag affect the number of combinations you can make? **Students will discover that without a tag the number of combinations with a single color become limited due to the *rotational* symmetry of the cube. Since the cube face can't be folded, line symmetry is not a code eliminator. Have students make the code on their cube and then turn the cube to test the pattern.**

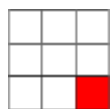


Check your codes with someone else. Are your codes the same? Why or why not? Are there some codes you don't agree with? Why? Do you have enough combinations to make a code for every letter in the alphabet? Do you have enough codes to also represent the digits 0 - 9?

Due to the symmetry of the cube, the codes should be the same. Ask students which codes they would eliminate to make their code easier to use. Again, there could be some nice conversation about symmetry, both line and rotational. Perhaps those codes with line symmetry are eliminated.



Choose a second color. Using 2 colors, draw all the codes that can be made with 2 colors on one face of the Rubik's® cube. How many different codes did you make? Do you have enough combinations to make a code for every letter in the alphabet and the numbers 0 - 9? What is the fewest number of colors you would need to make a code for each of the 26 letters of the alphabet? Show or explain how you know. **With a second color, the codes students create may be different. Discuss how a second color may help with some of the some of the confusion caused by rotations of the cube.**






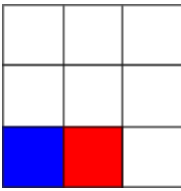
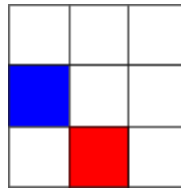
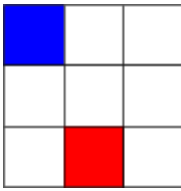
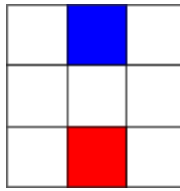
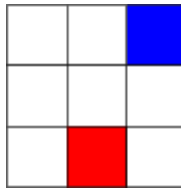





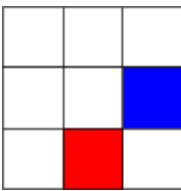
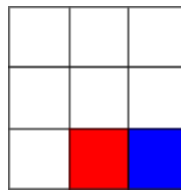
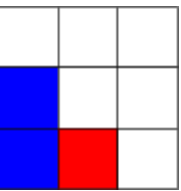
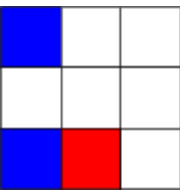
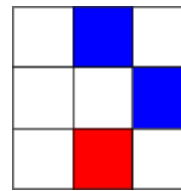





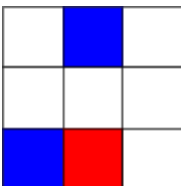
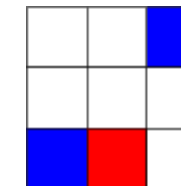
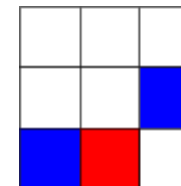
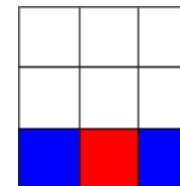
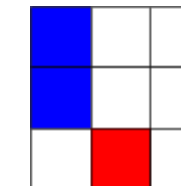


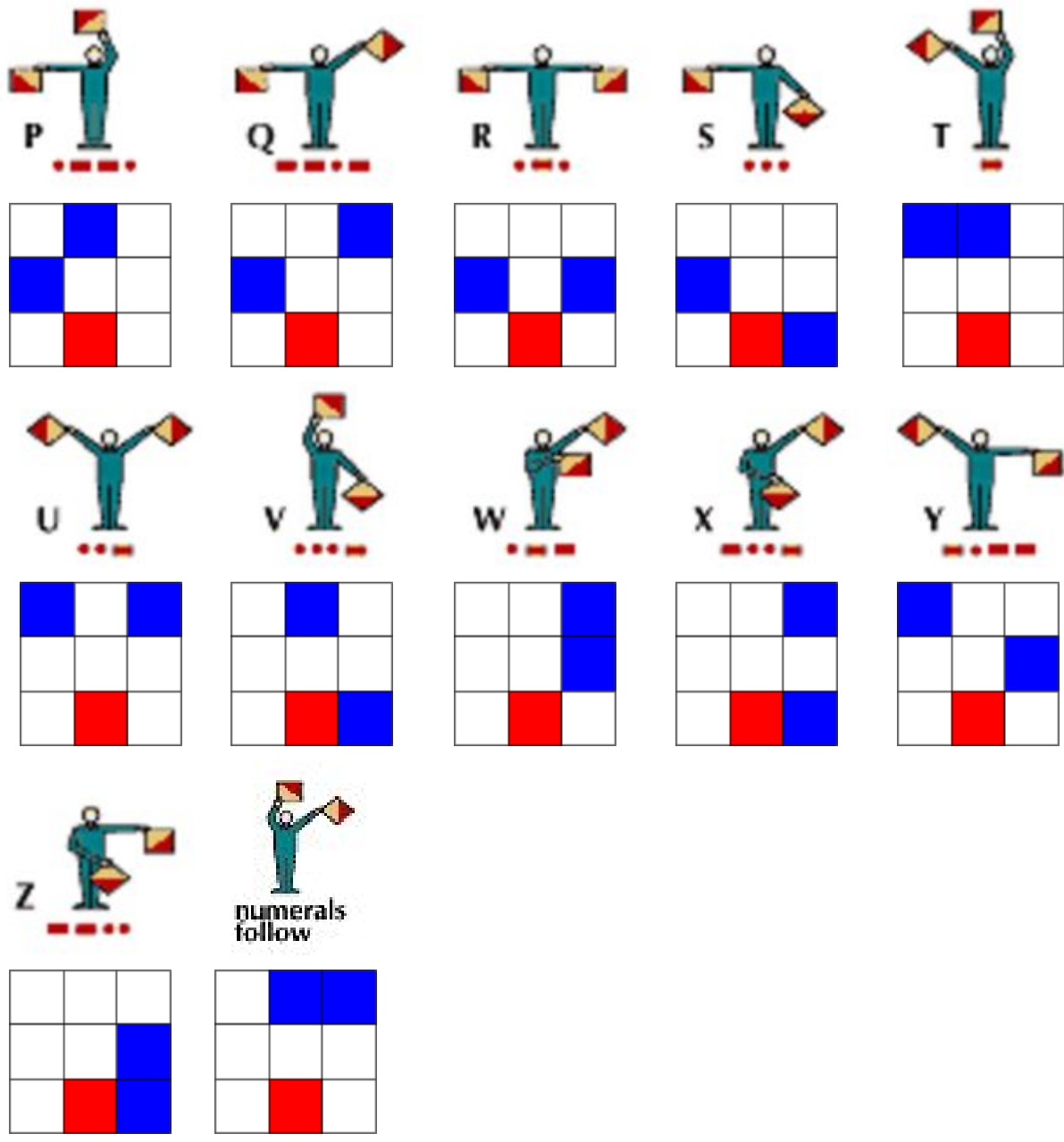
Challenge: Can you make the opposite face display the same code?

Rubik's® Cube version of the Semaphore Alphabet

<http://kids.britannica.com/comptons/art-53980/In-the-fast- semaphore-system-of-signaling-the-positions-of>

The Semaphore Alphabet and The International Morse Code

| | | | | |
|--|--|--|---|--|
|  A |  B |  C |  D |  E |
|  |  |  |  |  |
|  F |  G |  H |  I |  J |
|  |  |  |  |  |
|  K |  L |  M |  N |  O |
|  |  |  |  |  |



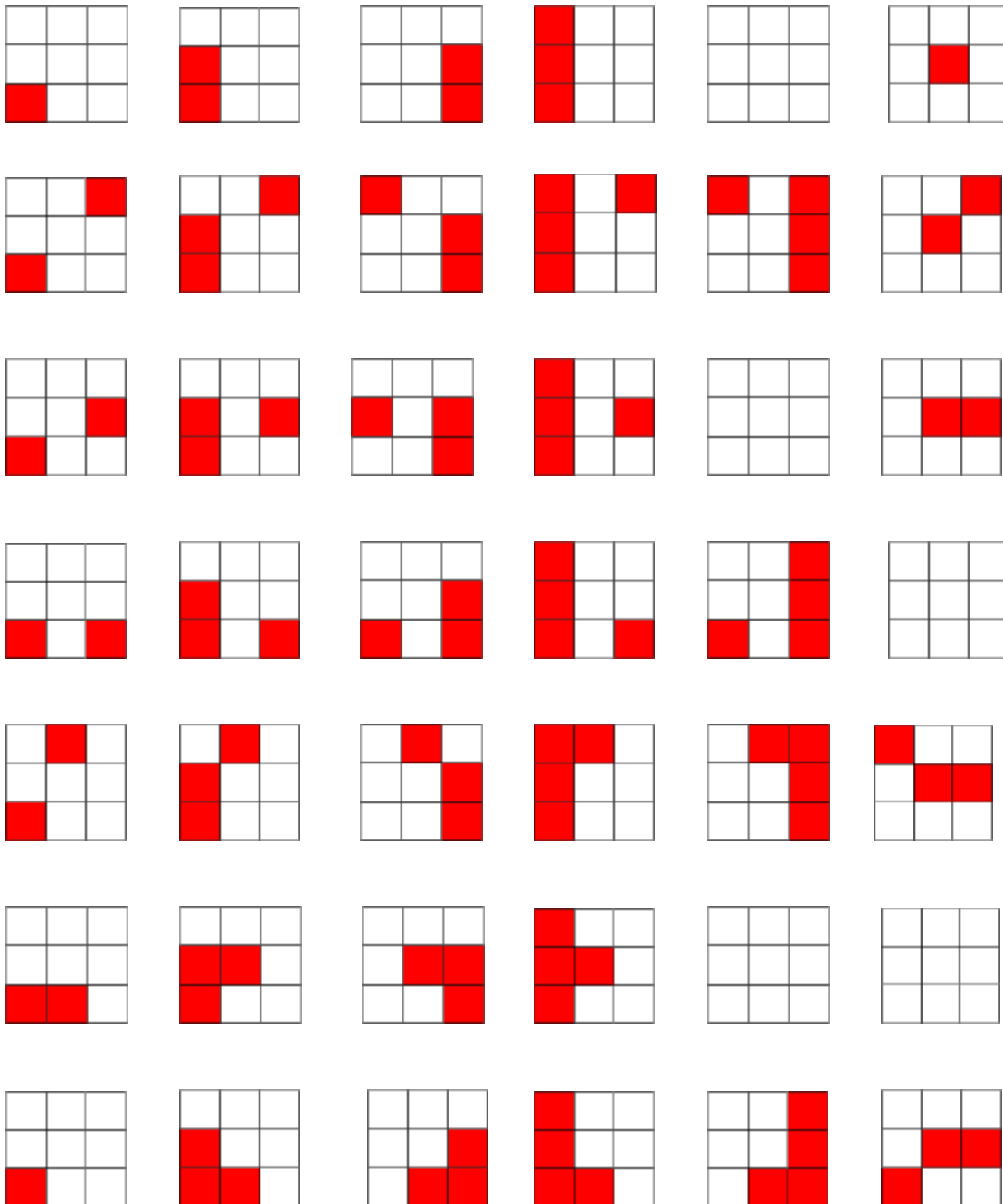
There are semaphore signals for the digits 0 - 9, as well as a few coded signals. The numerals follow signal would precede the signals for A (1) - I (9) and K (0).

For more information about semaphore code:

- <https://flagexpressions.wordpress.com/2010/03/23/history-behind-semaphore-flags/>
- <http://www.bbc.com/news/magazine-22909590> BBC article about restoring the towers
- <https://sites.google.com/site/codesforscouts/semaphore>
- <http://www.gomelscouts.com/signalling.html>
- [http://encyclopedia.kids.net.au/page/se/Semaphore_\(communication\)](http://encyclopedia.kids.net.au/page/se/Semaphore_(communication))
- <http://www.cranburyscouts.org/Image/Semaphore/SamsCourse.htm>

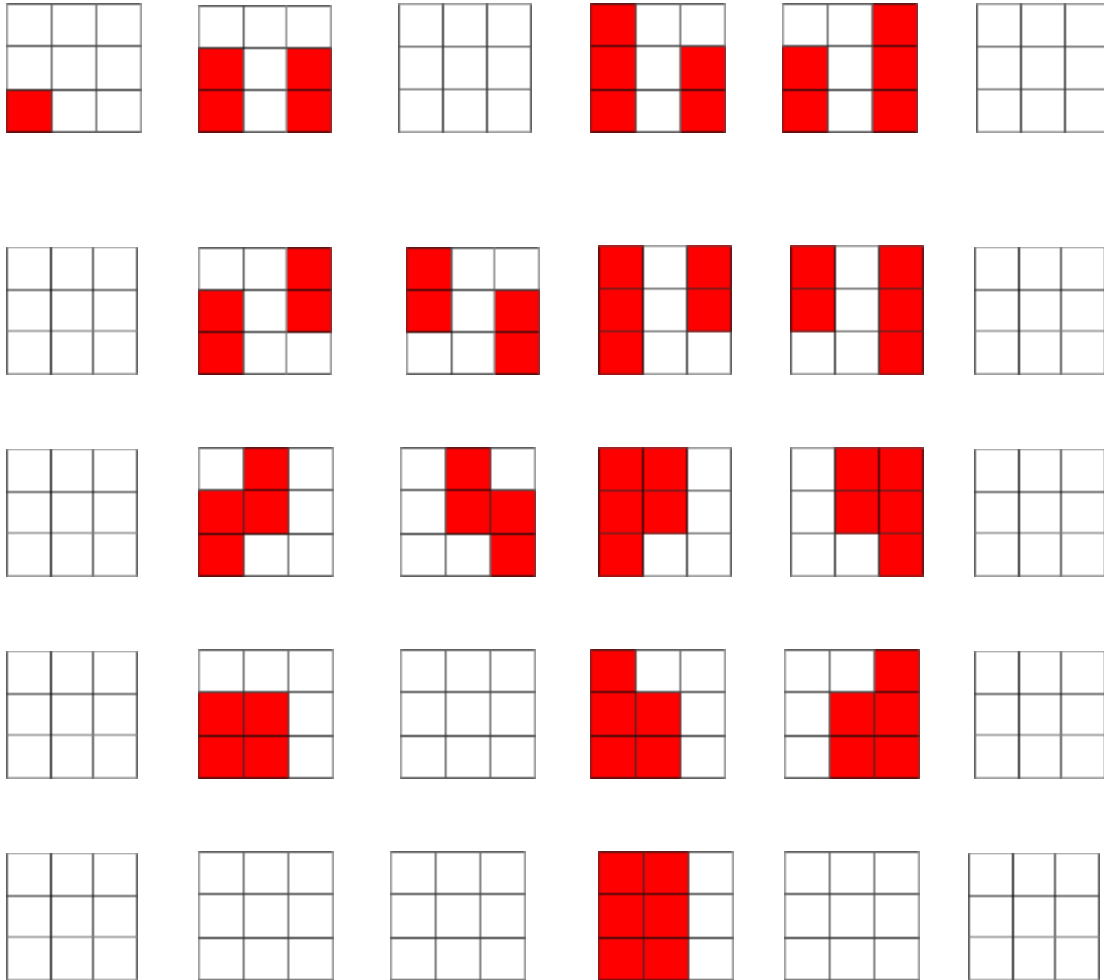
SOLUTION KEY: Code Combinations: No Tag to Orient the Cube

Blank patterns have been inserted to highlight the pattern being used.



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Additional Resources:

Codes, Ciphers and Secret Writing (Dover Children's Activity Books) by Martin Gardner (1984)

The Kids' Book of Secret Codes, Signals and Ciphers by E. A. Grant (1989)

The Cracking Code Book by Simon Singh (2004)

The Code Book: The Science of Secrecy from Ancient Egypt to Quantum Cryptography by Simon Singh (2000)

Fiction books that involve codes:

Chasing Vermeer by Blue Balliett

The Wright 3 by Blue Balliett

The Calder Game by Blue Balliett

The Blackthorn Key by Kevin Sands

| FLAG AND NAME | SPOKEN | WRITTEN | FLAG AND NAME | SPOKEN | WRITTEN | FLAG AND NAME | SPOKEN | WRITTEN |
|---|---------|---------|---|----------|---------|---|--------|---------|
|  | ALFA | A |  | MIKE | M |  | YANKEE | Y |
|  | BRAVO | B |  | NOVEMBER | N |  | ZULU | Z |
|  | CHARLIE | C |  | OSCAR | O |  | ONE | 1 |
|  | DELTA | D |  | PAPA | P |  | TWO | 2 |
|  | ECHO | E |  | QUEBEC | Q |  | THREE | 3 |
|  | FOXTROT | F |  | ROMEO | R |  | FOUR | 4 |
|  | GOLF | G |  | SIERRA | S |  | FIVE | 5 |
|  | HOTEL | H |  | TANGO | T |  | SIX | 6 |
|  | INDIA | I |  | UNIFORM | U |  | SEVEN | 7 |
|  | JULIETT | J |  | VICTOR | V |  | EIGHT | 8 |
|  | KILO | K |  | WHISKEY | W |  | NINE | 9 |
|  | LIMA | L |  | XRAY | X |  | ZERO | 0 |

Nautical Flags:

http://navyadvancement.tpub.com/12018/css/12018_139.htm

Figure 4-14.—Alphabet and numeral flags.