The MIDDLE Layer

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The MIDDLE Layer
Lesson 4

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CONTENT STANDARDS & SKILLS: LESSON 4

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<thead>
<tr>
<th>Grade</th>
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  ● Recognize and describe patterns  
  **Geometry**  
  ● Use visualization, spatial reasoning & geometric modeling to solve problems |
  **CCSS.MATH.CONTENT.3.NF.A.1** Understand a fraction 1/b as the quantity formed by 1 part when a whole is partitioned into b equal parts; understand a fraction a/b as the quantity formed by a parts of size 1/b.  
  **CCSS.MATH.CONTENT.3.NF.A.3** Explain equivalence of fractions in special cases, and compare fractions by reasoning about their size.  
  **CCSS.MATH.CONTENT.4.G.A.3** Recognize a line of symmetry for a two-dimensional figure as a line across the figure such that the figure can be folded along the line into matching parts. Identify line-symmetric figures and draw lines of symmetry. | **Number & Operations**  
  ● Understand meanings of operations and how they relate to one another  
  **Algebra**  
  ● Analyze change in various contexts  
  **Geometry**  
  ● Predict and describe the results of sliding, flipping, and turning two-dimensional shapes |
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<tr>
<td>6-8</td>
<td><strong>CCSS.MATH.CONTENT.6.NS.C.5</strong> Understand that positive and negative</td>
<td><strong>Number &amp; Operations</strong></td>
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<tr>
<td></td>
<td>numbers are used together to describe quantities having opposite directions</td>
<td>● Understand and use inverse relationships</td>
</tr>
<tr>
<td></td>
<td>or values…</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>CCSS.MATH.CONTENT.7.NS.A.1.A</strong> Describe situations in which opposite</td>
<td><strong>Geometry</strong></td>
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<tr>
<td></td>
<td>quantities combine to make 0.</td>
<td>● Create and critique inductive and</td>
</tr>
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<td></td>
<td><strong>CCSS.MATH.CONTENT.8.G.A.1</strong> Verify experimentally the properties of</td>
<td>deductive arguments concerning geometric</td>
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<tr>
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<td>rotations, reflections, and translations.</td>
<td>ideas and relationships</td>
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Each lesson in this series begins with a review of the previous lesson and ends with a review of the current lesson. The review of the current lesson is always followed by a math extension which may or may not apply to your grade level. The last slide in each lesson is a trivia question. Many of the slides are animated so what you see in this guide may not appear all at once in the presentation. Please modify your presentation to best meet the needs of your students.

Review: Slides 3-6

**REVIEw – In solving the Middle layer, the UP face is very important.**

**UP Face Move:**
a \(\frac{1}{4}\) clockwise turn of the up face

Think of closing a jar or screwing in a lightbulb!

**Review:**
- Position the **white** face as the UP face.
- Position a **white** corner on the **bottom** layer underneath its intended position.
- Use the algorithm as many times as needed until the corner is in the correct position.
- Repeat the steps for each **white** corner until all four corners are in the correct positions.

**GOAL:**
To get the **white** corners matched with the correct faces

**Vocabulary**

**HORIZONTAL LINE**

Horizontal is the word that describes when a line (or row) is parallel to the horizon. Horizontal lines go across. Rows are horizontal. The layers of the Cube are horizontal.

The **MIDDLE** layer is horizontal.

**VERtICAL LINE**

Vertical is the word that describes when a line is perpendicular to the horizon. Vertical lines go up/down. Columns are vertical. The **LEFT** and **RIGHT** sides of a Rubik’s® Cube are vertical.

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With the **YELLOW** center on the **UP** face, scan the **TOP** layer for an **EDGE** piece that has no **YELLOW** tiles. Once one **EDGE** piece has been located, match the color of the lateral face (not the **UP** face) of this tile with the color of the **CENTER** of the lateral face. If there are no **EDGE** pieces without **YELLOW** tiles, check **TROUBLESHOOTING** p. 6 of this guide.

Now look at the **UP** face of the tile you matched to a **CENTER**. The color of the **UP** tile will determine whether to follow the **LEFT** algorithm or the **RIGHT** algorithm. The algorithms for moving the cube to the **LEFT** or **RIGHT** are essentially the same. Because **LEFT** and **RIGHT** are inverses, the algorithms use inverse moves. Once students have seen the algorithm for moving the cube to the **ORANGE** or **LEFT** face, you may want to challenge them to provide the algorithm for moving the cube to the **RED** or **RIGHT** face.
Slides 12 - 14
That’s all there is to it! Repeat these steps until the bottom 2 layers of the cube are solid colors.

- Find an **EDGE** piece on the **TOP layer/UP face** with no **YELLOW** tiles.
- Match the color of the “side” of the tile with a “side” face **CENTER** tile by twisting the **TOP layer**. You may want to remind students that this is a lightbulb or jar move.
- Look at the color of the **UP** face of the **EDGE** piece to decide whether the **EDGE** piece will move to the **LEFT** or the **RIGHT** face. Follow the appropriate algorithm.
Sometimes there are no EDGE pieces on the TOP layer with no YELLOW tiles. In this case, you will need to follow either the LEFT or the RIGHT algorithm once. This will “swap” a misplaced EDGE piece for the EDGE piece in the TOP layer. (see slide image) Now, there will be an EDGE piece on the TOP layer with no YELLOW tiles.

**TROUBLESHOOTING**

If there are no more non-YELLOW edges to work with, use one of the algorithms to place a YELLOW edge on the RIGHT or LEFT face where there is an unsolved edge.

By moving a non-YELLOW edge to an unsolved place in the middle layer, the non-YELLOW edges will shift to give you the opportunity to work with a non-YELLOW edge.

**TROUBLESHOOTING**

If you accidentally move an EDGE piece to the wrong place:

- Leave it there and continue working with the other EDGE pieces.
- Eventually, you will find the correct EDGE piece and place it in its correct place.
- The misplaced EDGE piece will be moved and available to move to its correct place.

**Examine your Rubik’s Cube**

**GOAL:**

The Middle Layer

The goal of this stage is to solve the Middle Layer while keeping the WHITE face intact (The white cross and white corners)

**Congratulations! Congratulations! Congratulations! Congratulations!**

You have achieved

The Middle Layer

Review: Slides 19 - 20

This slide could be printed as a reference for students, perhaps in a learning center.

**REVIEW** - Repeat these steps until your cube looks like this:

Remember, hold the cube YELLOW UP and WHITE DOWN.

Make the middle column the same color by turning the UP face.

If edge piece belongs on LEFT, do...

If edge piece belongs on RIGHT, do...

**Vocabulary**

**Horizontal:** Extending across from left to right. The layers of a Rubik’s Cube are horizontal.

**Vertical:** Extending from top to bottom. The LEFT and RIGHT sides of a Rubik’s Cube are vertical.

**Inverse:** An opposite action or position. Inverses “undo” an action. In the Rubik’s Cube Solution Guide, an inverse move has the letter I after the turn. R and Ri are inverses.

**Algorithm:** A series of steps.
Math Connections: Slides 21 - 25
There are several math connections for this lesson, a brief look at fractions and a longer look at inverses and solving equations.

Fractions
- Explore fractions on a single face of the Cube. (i.e. What fraction of the face is RED?)
- Challenge students to make 2 faces of a cube ⅓ RED.
- Some fractions can’t be made on a Rubik’s Cube. Which ones? Why?
  - You can’t make more than ⅙ of the Cube RED because only one face of the Cube is RED. However, more than ⅙ of a face could be RED. What is the greatest number of sides you can consider to make a fraction where RED is greater than ½? ⅔?

Inverses
- Inverses are opposites. What other opposites are there?
- Have students create other number tricks.
  - Zero is the identity element for addition because the additive inverses have a sum of 0. Does a Rubik’s Cube have an identity element? What would it be?
  - Identity elements are often included in the properties of a set. What other properties does a Rubik’s Cube have?
Solving Equations

- Have students create a Rubik’s sequence and then challenge a friend to write the inverse sequence.
- Have students highlight the inverses in a sequence.
- Mathematics has an order of operations. Does changing the order of the steps in the sequence change the results?

- Challenge students to write a Rubik’s Cube sequence in a way that mimics the equation solving process.

Question: Who is the inventor of the Rubik’s Cube? Where is he from?
Answer: Erno Rubik (born 7/13/1944) is from Hungary. The first cube was made of wooden blocks.
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