Tricks of the Eye
Grades 3-5

The Big Idea
Today you get to be math magicians. You'll learn what an **optical illusion** is and **uncover the math** behind how our eyes play tricks on us.

Supplies
- ★ Drinking glasses with smooth clear glass: 2
- ★ Index cards, 4x6 inches: 2 per kid, plus 2 for the coach
- ★ Laptop, smartphone, or tablet with internet access (optional, but encouraged)
- ★ Paper: 1 per kid
- ★ Pencils: 1 per kid
- ★ Rulers: 1 per kid
- ★ Scissors: enough pairs for kids to share
- ★ Water for 2 glasses
- ★ Writing surface (whiteboard, chalkboard, or large piece of paper)
- ★ **To print:** Chocolate Bar Printable, 1 per kid
- ★ **To print** (optional): Optical Illusions Packet, 1 per kid
  See note in Other Key Prep

Room Set-up
- ★ You'll need a room with some desks or tables for this week

Other Key Prep
- ★ **Print 1 copy per kid** of the Chocolate Bar Printable. You may want to have a few extras on hand in case someone accidentally cuts the wrong squares.
- ★ **Print 1 copy per kid** of the Optical Illusions Packet if you're using this activity as an **alternative** to the Grand Finale video.

What's the Math?
- ★ Linear measurement
- ★ Estimation
- ★ Area

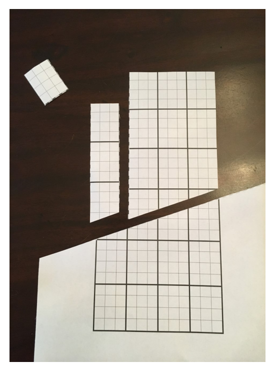
Kickoff

Intro to the kids: "Have your eyes ever played tricks on you? Maybe you thought you saw one shape, but it turned out to be something else?" (Discuss.) "An **optical illusion** happens when our eyes send information to our brains that tricks us into seeing something that isn't really there. It turns out there's a lot of math happening behind the scenes!"

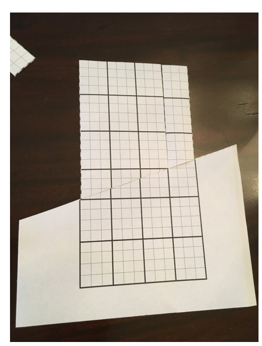
Infinite Chocolate Bar (10-15 minutes)

To the kids: "First we'll start with a very cool optical illusion. Have you ever wished you could have an endless supply of chocolate? What if you had a chocolate bar that you could break apart, eat a bite, and put back together again, just like new? Let's practice with this grid!"

1. Give each kid a **Chocolate Bar Printable**.
2. Start by counting the number of rectangles along the **right-hand column.**
3. Now, ask kids to share the scissors to cut out their Chocolate Bars:



- ★ First, cut across the diagonal line and set the bottom piece aside.
- ★ Then **cut the top pieces along the dotted lines**. Make sure kids trim the solid white margins off the pieces.
- ★ Ask kids to **set aside** the smallest "bite" of chocolate
- ★ Like a puzzle, rearrange the **remaining** pieces to form a **complete chocolate bar**.



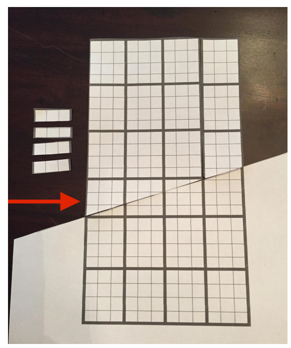
4. Ask the kids to count the rectangles along the **right-hand column.**

Ask the kids:

- ★ "What's going on here?! Is it really possible to take away a piece of chocolate and still have a complete chocolate bar?" (Discuss. Let the kids examine the bar closely until they discover it's a little shorter than it was before. This means the total **area** of the new bar is smaller than the original one.)

To the kids: "If you look at the little bite of chocolate bar that we set aside, you'll see that it's a grid 3 squares **wide** and 4 squares **long** for a total **area** of 12 tiny squares (width x length = area)."

- ★ "Now, look back at your reassembled chocolate bar. Notice that the rectangles in the 4th row, through which we made our diagonal cut, are still 3 squares wide but only 3 squares long - that's a total area of 9 squares in each of those bites, unlike the other bites that have 12 squares."



- ★ "So, if 4 bites are missing 3 squares each, that means we're missing a total of 12 squares from the whole chocolate bar."
- ★ "Can we cut our little bite into 4 mini-bites of 3 squares each?" Let the kids figure out that they should cut the little bite into 4 rows to discover it's the same number of rows and squares that are missing from the diagonal cut of the giant chocolate bar!

Reversing Arrows (10-15 minutes)

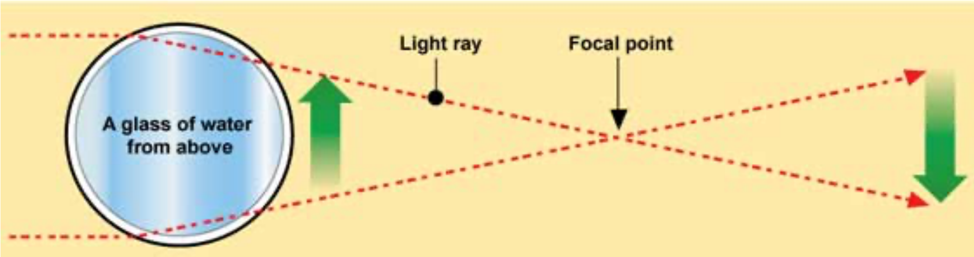
To the kids: "Next up is an optical illusion called reversing arrows."

1. Give each kid an index card and ask them to **draw a thick arrow** on the card.
2. Fill 2 clear glasses with water and put them on a table.
3. Divide the kids into 2 groups and have each gather around a glass.
4. One at a time, have kids place their arrow cards **behind the water and against the glass** pointing either left or right, and then slowly **move the card backward** while watching through the water.

Ask the kids:

★ "What happens when you move your arrows backward?" (Discuss. They appear to change direction!)

★ "Why do you think the arrow reverses itself?" (Discuss. It happens because of **refraction**, the **bending of light**. When light travels through water, it bends, so the rays pop out shining toward a single center point, called the focal point. Any images on the other side the focal point will look reversed to us.)



To See or Not to See (10 minutes)

To the kids: "OK, are you ready for one more optical illusion? Does anyone know what a **blind spot** is?" (Discuss.) "It's a spot in the air where your eye can't see anything. There is 1 spot on the inside of your eyeball where there are no **cones** or **rods**, which are the parts in your eye that pick up light. Everyone has a blind spot, so let's find yours!"

1. Give each kid **another index card**, **1 ruler**, **and 1 pencil**. Have them draw an **x** on the right side of the card. Then have them measure about 5 inches to the left of the **x** and draw a dot the size of a penny. (Draw them on your own index card to demonstrate.)

2. Have the kids hold their cards at **eye level** an arm's length away. Make sure the **x** is on the **right**.
3. Tell them to **close their right eye** and look **directly at the x** with their **left eye**. (They should be able to see both shapes.)
4. Have them **slowly** bring the card toward their face, focusing on the **x**. They **must** keep looking right at it – no looking to the side!

Ask the kids: "What happens as you bring the card closer?" (Discuss. The dot should **disappear, then reappear** as they bring the card even closer to their face. Let them try moving the card closer and farther to pinpoint where it happens!)

5. Now have the kids **close their left eye** , look directly at the **dot** with their right eye, and repeat the game.

Ask the kids:

- ★ "What happened this time?" (Discuss. This time the **x disappears**, then reappears as the card comes closer.)
- ★ "Is the distance from your face about the same for both eyes?"
- ★ "Will the dot still disappear if it's as big as a quarter?" (Let the kids **fill in** around the dot to try a new size.)
- ★ "What if it's a different shape, like a triangle or square?"

6. Next, have the kids draw a **straight line** from the **dot** to the **x** using a ruler.
7. Have the kids repeat the exercise, focusing on the **x** with their **left eye**.

Ask the kids:

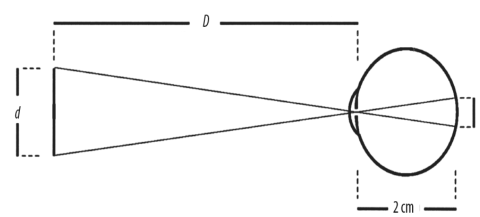
★ "What happens when you bring the card closer?" (Discuss. The dot disappears, but the line looks continuous without a gap where the dot used to be.)

★ "Why isn't there a gap where the dot used to be?" **Party Fun Fact:** When our eye can't see what's in a certain spot, our brain fills in that area to **match** what surrounds it.

Bonus (optional): To the kids: "Now that you've found your blind spot, let's figure out how big it is by measuring its **diameter**, or width."

8. Have kids **pair up**, with one holding the index card at arm's length from his/her face, and the other holding a pencil and a ruler.
9. First, **measure the distance** from the card to their eye, and write it down.
10. Next, the card holders **close their right eye** and look **directly at the x** with their **left eye**. They **move** the card **side to side**, and mark on the card where the **x** disappears and where it reappears. Measure the distance between the two places.
11. Kids can measure the **diameter of their blind spot** using this simple equation, assuming the pupil is 0.78 inches (2 centimeters) from the retina:

$$s/2 = d/D$$



s = size of the blind spot on the retina

d = diameter of the blind spot on the card

D = distance from the eye to the card

*Thanks to www.exploratorium.edu for coming up with this activity!

Grand Finale: Crazy Circles (5 minutes)

Show the kids **this cool 2-minute optical illusion video** from your laptop, phone or tablet: http://safeshare.tv/v/ss571e3c0b2ad60

*If you don't have access to the Internet, you can distribute the **Optical Illusion Packets** and work on them together. Each kid will need a pencil and a ruler handy.

Bonus, if you have time: Math Magic (10-15 minutes)

Intro to the kids: "Now that we've learned about the math behind optical illusions, here's a couple of math tricks to wow your family and friends! First, I'm going to read your minds!"

1. Give each kid a pencil and piece of paper. Lead kids through the following directions, pausing between each step to give them time to complete the math:

- ★ Write down any number between 1 and 20.
- ★ Double that number by adding the same number to it.
- ★ Add 10 to that sum.
- ★ Divide the new sum in half.
- ★ Subtract the starting number from this new number.

To the kids (when everyone is finished): "The last number you wrote down is 5!" Ask if they'd like to repeat the steps with another number!

To the kids: "Now, I'll bet that I can take a 3-digit number that *you* make up and turn it into 1,089."

Ask the kids:

- ★ "Give me any **3-digit number** that has numbers in **descending order.**" (e.g. 631, 410, 973) Write that number on the board or large piece of paper.
- ★ "Now let's write this number backwards." Write that number below the first and ask the kids to help you subtract those numbers to find the **difference**.
- ★ "Now let's write *this* number backwards."
- ★ **Add** those numbers together - it should **equal 1,089**!