Tricks of the Eye

The Big Idea:

Sometimes our eyes play tricks on us, and the things we think we see are different from reality. These are called optical illusions. Even though they seem like magic, it turns out there's a lot of math involved!

You Will Need:

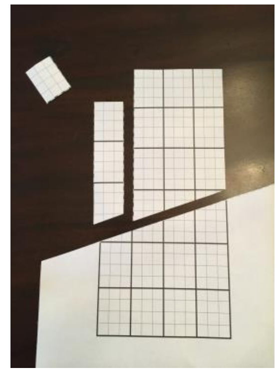
- ★ To print: Bedtime Math's Chocolate Bar Printable: 1 per kid
- ★ To print (optional): Optical Illusions Packet: 1 per kid
- ★ Pair of scissors
- ★ Index cards: 2 per kid
- ★ Marker
- ★ Drinking glass with smooth, clear glass
- ★ Water for the glass
- ★ Ruler
- ★ Laptop, smartphone, or tablet with internet access (optional, but strongly encouraged)

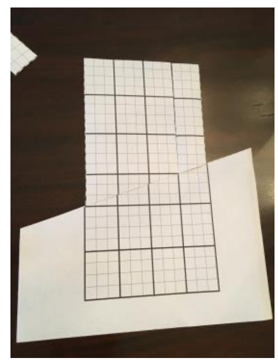
The Math Behind the Scenes:

We'll measure the length and width of rectangles, which helps us calculate their area. We'll also practice our estimation skills. Some optical illusions rely on refraction, the "bending" of light rays. Others rely on our "blind spot" – the area in our eye that can't pick up light. We can use math to figure out how large it is!

Infinite Chocolate Bar:

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, which looks a little like a chocolate bar.



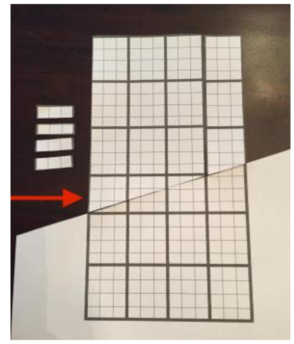


1. Start by counting the number of rectangles along the right-hand column.
2. Now cut out your Chocolate Bar:
   - ★ First, cut across the diagonal line and set the bottom piece aside.
   - ★ Then cut the top pieces along the dotted lines. Make sure to trim the solid white margins off the pieces.
   - ★ Set aside the smallest "bite" of chocolate.
   - ★ Like a puzzle, rearrange the remaining pieces to form a complete chocolate bar.
3. Now how many rectangles are there along the right-hand column?

What's going on here?! Is it really possible to take away a piece of chocolate and still have a complete chocolate bar?

- ★ 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? Yes, and when we do, it's the same number of rows and squares that are missing from the diagonal cut of the giant chocolate bar!



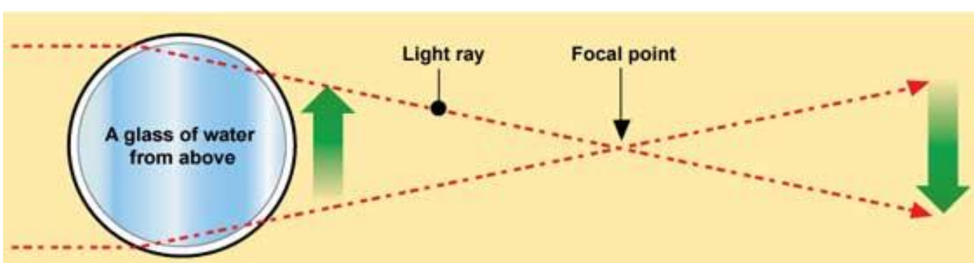
Reversing Arrows:

Next up is an optical illusion called reversing arrows. Forget everything you thought you knew about left and right!

1. Using a marker, draw a thick arrow on an index card.
2. Fill a glass with water and put it on a table.
3. Place your arrow card behind the water and against the glass pointing either left or right, and then slowly move the card backward while watching through the water.

What happens when you move your arrow backward? Why do you think the arrow reverses itself?

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 of the focal point will look reversed to us.



To See or Not to See:

Have you ever heard of a blind spot? 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. Draw an x on the right side of an index card. Then use a ruler to measure about 5 inches to the left of the x and draw a dot the size of a penny.
2. Hold your card at eye level an arm's length away. Make sure the x is on the right.
3. Close your right eye and look directly at the x with your left eye. You should be able to see both shapes.
4. Now slowly bring the card toward your face, focusing on the x. Keep looking at it – no looking side to side!

What happens as you bring the card closer? (The dot should disappear, then reappear as you bring the card even closer to your face. See if you can pinpoint where it happens!)

5. Now close your left eye and look directly at the dot with your right eye. Repeat the game.

What happened this time? 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? Make the dot larger and try.

What if it's a different shape, like a triangle or square? Make another shape on the back of the card, again 5 inches to the left of an x.

6. Next, draw a straight line from the dot to the x using a ruler.
7. Repeat the game, focusing on the x with your left eye (close your right eye).

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

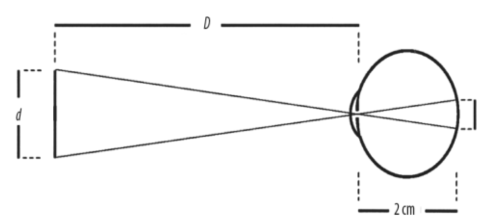
Why isn't there a gap where the dot used to be? Fun Fact: When our eye can't see what's in a certain spot, our brain fills in that area to match what surrounds it.

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

1. Hold your index card at arm's length from your face, and the other holding a pencil and a ruler.
2. Have a family member use a ruler to measure the distance from the card to your eye and write it down.
3. Now close your right eye and look directly at the x with your left eye. Slowly move the card side to side and have your family member mark on the card where the x disappears and where it reappears. Measure the distance between the two places.
4. You can measure the diameter of your blind spot using this simple equation, assuming the pupil is 0.78 inches (2 centimeters) from the retina:

s/2 = d/D

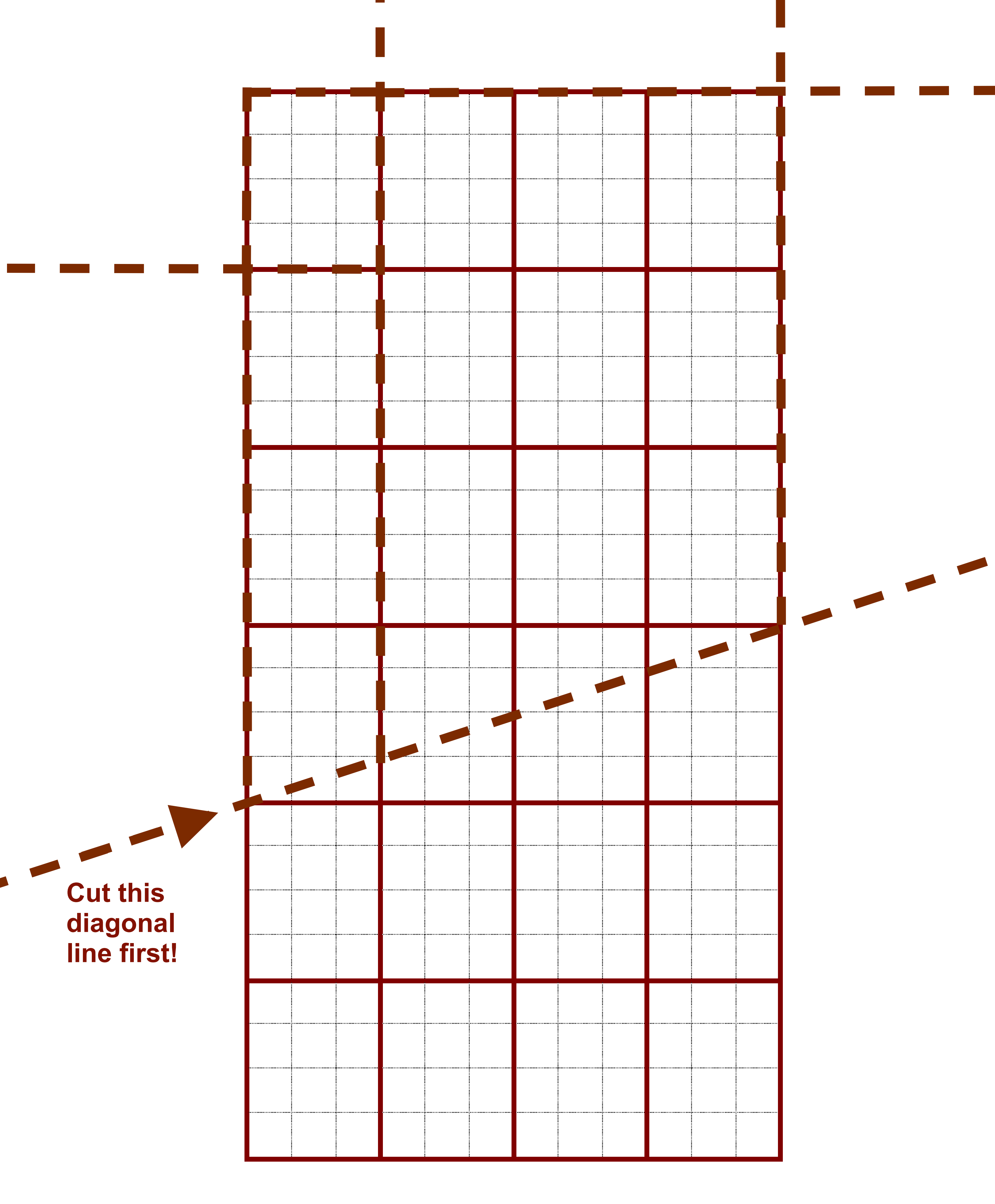
s = size of the blind spot on the retina
d = diameter of the blind spot on the card
D = distance from the eye to the card



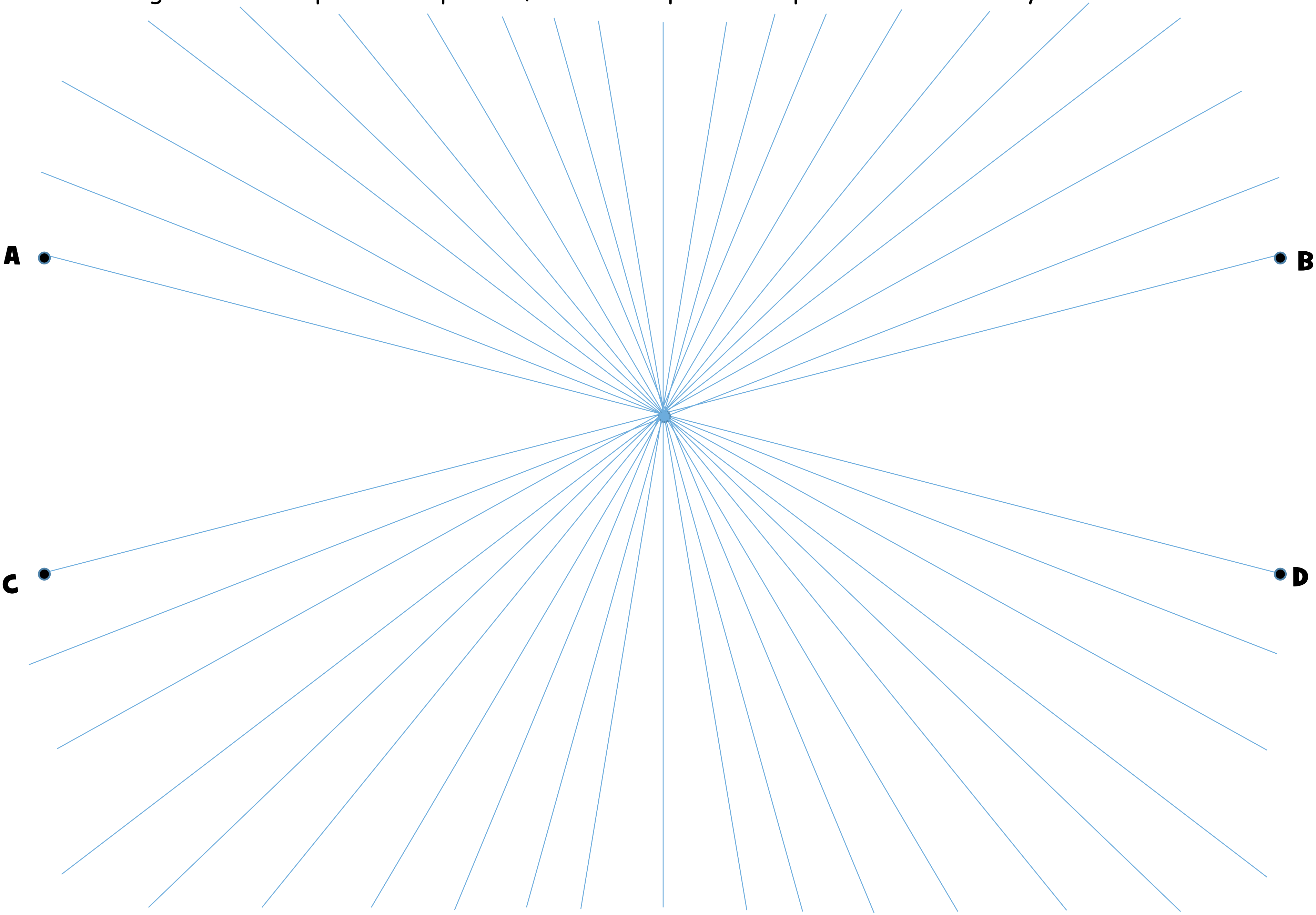
*Thanks to www.exploratorium.edu for coming up with this activity!

Grand Finale: Crazy Circles

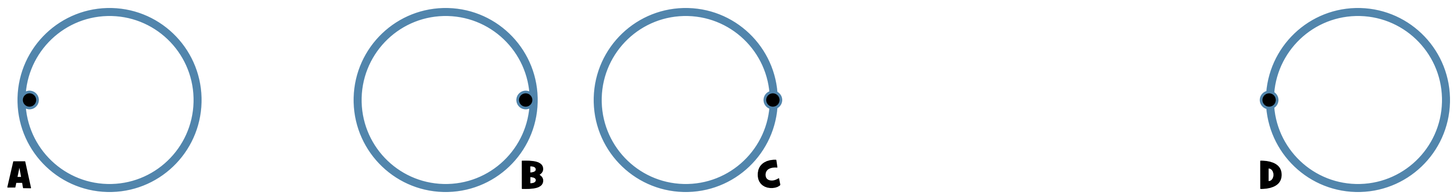
Watch this cool optical illusion video from your laptop, phone or tablet: http://safeshare.tv/v/ss571e3c0b2ad60 and check out the Optical Illusions Packet. Have a pencil and ruler handy.


Cut this diagonal line first!

Draw a straight line from point **A** to point **B**, then from point **C** to point **D**. How do they look?

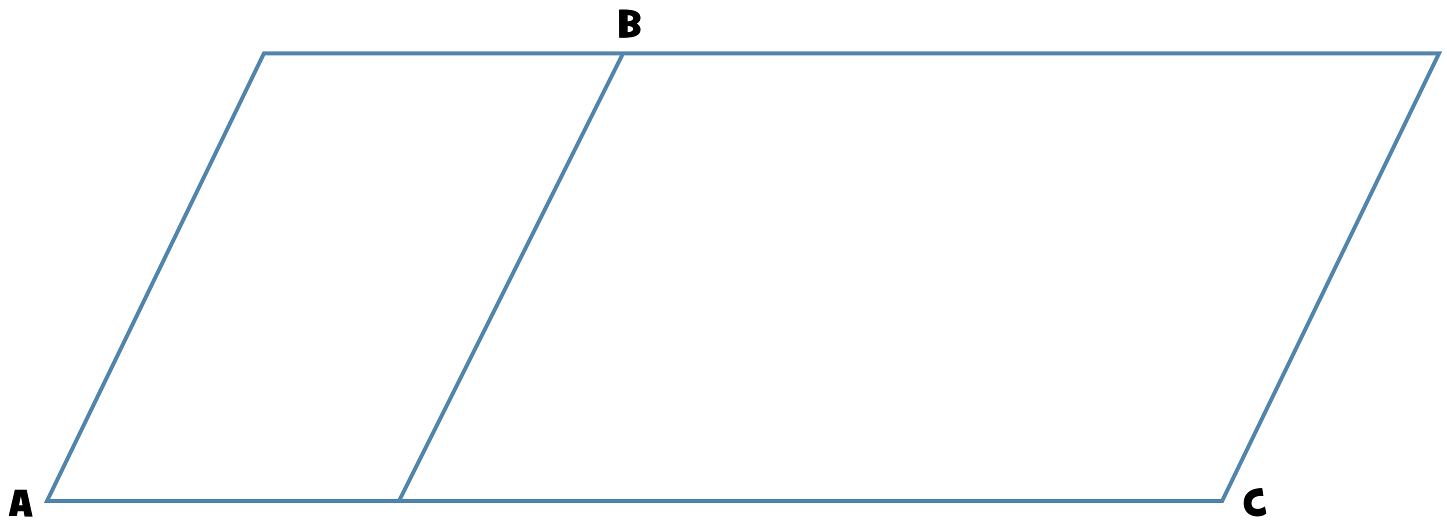


Draw a straight line from point **A** to point **B**. Then draw another from point **C** to point **D**.



Which new line looks longer? **Measure** both to find out!

Draw a straight line from point **A** to point **B**. Then draw a straight line from point **B** to point **C**.



Which new line looks longer? **Measure** both to find out!