Let the Show Begin!

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Field(s) of Interest: Psychology, Cognitive Science, Physics, Optics

Brief Overview (1-3 sentences):
In this lesson, mentees will explore the world of optical illusions, create their own animations by making flipbooks (a type of optical illusion), and build their own movie projector.

Agenda:

- Introduction (2 mins)
- Module 1: Playing Mind Games (10 minutes)
- Module 2: Movie Fully Flip-Booked (15 minutes)
- Module 3: Let the Show Begin! (20 minutes)
- Conclusion (2 mins)

Main Teaching Goals/Key Terms:	**Mentor Development Goals:**
➔ Optical Illusions ➔ Literal Optical Illusions ➔ Physiological Optical Illusions ➔ Cognitive Optical Illusions ➔ 3D Illusions ➔ Perception ➔ Persistence of Vision ➔ 12 Principles of Animation ➔ Projection ➔ Light rays ➔ Convex lens ➔ Refraction	1. **What you see is not what I see** 👀👁️👓 2. **Mind the (skill) Gap** 3. **Being Detail Oriented** 4. **Adjust along the way** ☀️📢🎛️ 5. **Delegate Roles** 🧑‍💼🕺💃

Background for Mentors

Module 1

- **Optical Illusions**
- **Literal Optical Illusions**
- **Physiological Optical Illusions**
- **Cognitive Optical Illusions**
- **3D Illusions**

An **optical illusion** is something that plays tricks on your vision. In general, the eye and brain will choose and focus on specific objects which causes a part of the image to appear one way or the other. Sometimes, your brain fills in gaps when there is incomplete information, or creates an image that isn't even there!

Figure 1: Children looking at optical illusion

Optical illusions can be roughly sorted into three categories: literal optical illusions, physiological optical illusions and cognitive optical illusions. **Literal optical illusions** are a type of illusion consisting of many small pieces that build up to a different larger image. **Physiological Optical Illusions** are a type of illusion caused by excessive stimulation to a type of receptor in the eye. **Cognitive Optical Illusions** are a type of illusion that arises from unconscious inferences.

A **3D image** is an image with two different perspectives of the same image superimposed on each other in the form of an anaglyph image. By using 3D anaglyph glasses, each eye filters chromatically opposite colors (typically red and cyan), so we can see a “3D” appearing object.

	Figure 2: Anaglyph image

Module 2

- **Perception**
- **Persistence of Vision**
- **12 Principles of Animation**

Perception refers to our sensory experience of the world. **Persistence of vision** works because the human eye and brain can only process 10 to 12 separate images per second, retaining an image for up to a fifteenth of a second. If a subsequent image replaces it in this period of time it will create the illusion of continuity. Most movies are played at **24 frames per second**. This is a frame rate that results in a certain amount of motion blur and a distinctive rhythm in movement that can be perceived by viewers as natural or real.

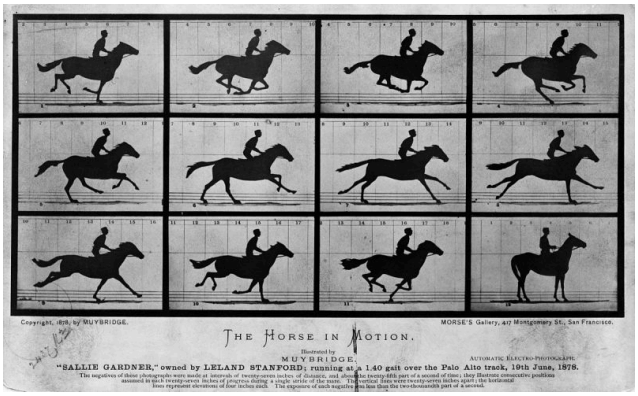


Figure 1: Children looking at optical illusion

The 12 Principles of Animation is a group of key teachings for the professional animators outlined by Disney Animators, Ollie Johnston and Frank Thomas in the 1981 book The Illusion of Life: Disney Animation. The principles include: Squash and stretch, Anticipation, Staging, Straight-ahead action and pose-to-pose, Follow through and overlapping action, Slow in and slow out, Arcs, Secondary action, Timing, Exaggeration, Solid drawing and Appeal. They serve as key principles as to how hand-drawn animation can be perceived as “realistic.”

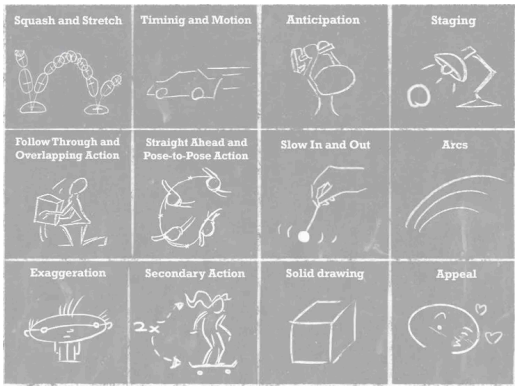


Figure 2: Simplified free body diagram for the CD hovercraft.

Module 3

- **Projection**
- **Light rays**
- **Convex lens**
- **Refraction**

In physics, **projection** is the action of light, heat, or sound reflecting from one surface to another in a different direction. Both a movie projector and smartphone projector utilize similar mechanisms to project a small image onto a larger screen. However, movie projectors utilize more complex optical systems that involve multiple lenses, mirrors, and advanced light modulation technologies, but the basic principles still follow from the smartphone projector.

The first component of a projector is the light source, which is provided by the smartphone. The light coming from the smartphone travels through the air in the form of rays (**light rays**), moving in a straight path until it encounters a material that changes its path - a lens. The redirection of a light wave as it passes through one medium to another is known as **refraction**. A **convex lens**, which is thicker in the middle and thinner at the edges, is used in projectors. When light passes through a convex lens, the light rays change direction, converging to a single point.

In figure 3, it is evident that the light source must be positioned behind a specific point known as the **focal point** for the image to be magnified. The magnified image appears upside down. To correct this, a mirror is used in our smartphone projector to flip the image again, making it right side up.

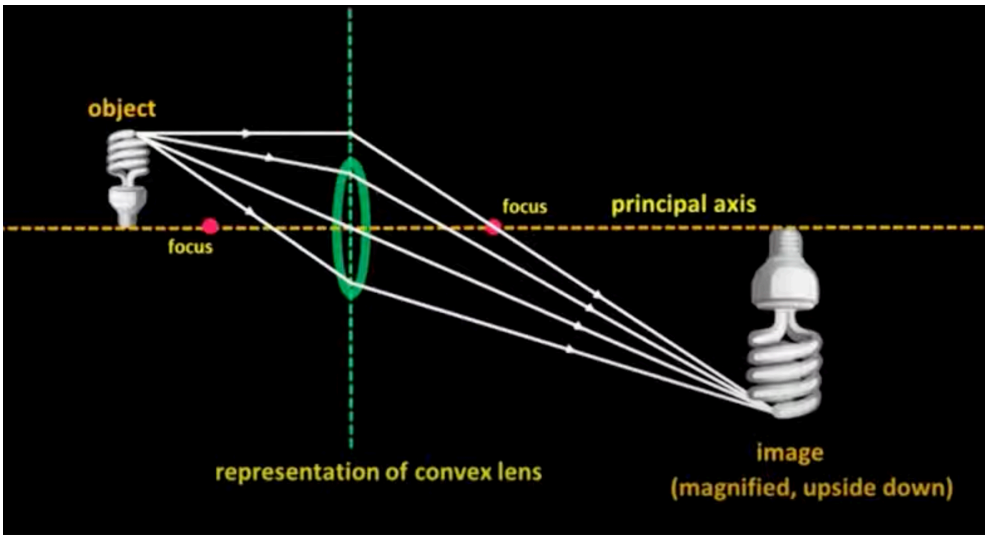


Figure 3: Diagram of a convex lens

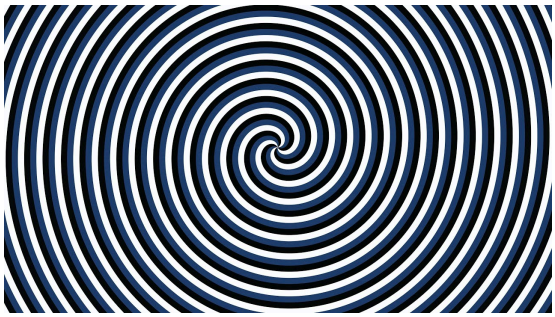
Introduction

Concepts to Introduce

- Optical Illusions
    - Sometimes, they take forms in images or collages that make you take a double look and think “huh?!?”
        - A very classic optical illusion is the blue/black or white/gold dress image that was popular on the internet a couple years ago.
- Animation/Movie
    - Most mentees have probably seen a movie before. Ask them to think about whether or not the object in the movie is actually moving? Or potentially displayed at a very fast frame rate?
- Projection
    - Ask mentees to think about how movie theaters are able to project a movie on a big screen.

Questions to Pique Interest

- Ask mentees about their favorite movies to introduce the topic of the lesson.
- Ask mentees how if they’ve ever looked at a swirly image like the one below and gotten dizzy?



- Ask mentees if they’ve ever looked at an image with their friends but noticed different things first?

Scientists, Current and Past Events

- Check out some more cool optical illusions

Careers and Applications

- Artists - Optical illusions have long been employed in art and design to captivate and engage viewers. Artists use illusions to create intriguing and visually stimulating artworks that play with perspective, depth, and visual perception.
- Therapist - A lot of optical illusions are utilized in cognitive behavior therapy (such as the inkblot test).
- Movie Producer - The reason we can view movies is because of our eye’s capability to chain a series of moving images into a continuous animation.

Module 1: Playing Mind Games

This module will allow mentees to explore various optical illusions and learn about the differences between literal, physiological, cognitive, and 3D illusions.

Teaching Goals

1. **Optical Illusions:** an illusion caused by the visual system that makes what we see different from reality
2. **Literal Optical Illusions:** a type of illusion consisting of many small pieces that build up to a different larger image
3. **Physiological Optical Illusions:** a type of illusion caused by excessive stimulation to a type of receptor in the eye
4. **Cognitive Optical Illusions:** a type of illusion that arises from unconscious inferences
5. **3D Illusions:** a type of illusion that works by making each eye see two different things that combine with human binocular vision

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MD Goals

Mediate conflict - What you see is not what I see

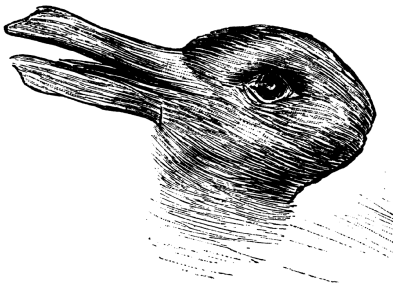
When it comes to optical illusions every kid is not going to visualize the illusion the same way. Be aware of these differences in perception to mitigate arguments, and encourage different perspectives.

Materials

- Computer (or phone) for displaying optical illusions
- 3D glasses (4-5 per site)

Different Methods for Teaching

1. **Optical Illusions:** Encourage mentees to think of optical illusions as a trick one's eyes play on one's brain! Ask if mentees have ever seen the classic duck/rabbit picture.



2. **Literal Optical Illusions:** An example of a literal illusion is a garden that resembles an animal when looked at from afar.
3. **Physiological Optical Illusions:** These optical illusions can make you dizzy!
4. **Cognitive Optical Illusions:** Think of when you mistake one object for another, this is because your brain projects what it wants to see onto the object you're looking at.
5. **3D Illusions:** Ask mentees to think about what 3D movies are like. Do the objects seem to be floating out of the screen? Why might that be?

Procedure

1. Create 4 stations, one for each page of optical illusions (literal, physiological, cognitive) and another for 3D illusions. There should be at least one mentor at each station.
    a. *Note: At least one mentor should bring a laptop to the classroom to display the 3D video. Make sure that the video is downloaded before site.*
2. Have mentees rotate between stations to learn about the different types of illusions.
    a. *Note: For the 3D glasses, the red side should cover the left eye and the blue side should cover the right eye.*
3. Mentees should spend 2-3 minutes at each station.

Reference:
https://docs.google.com/document/d/1sbt-O8eRF57C-zrim3yLC4D8mzUjQPGZGJ7RwROkNHg

Figure 1. *Literal Optical Illusion*

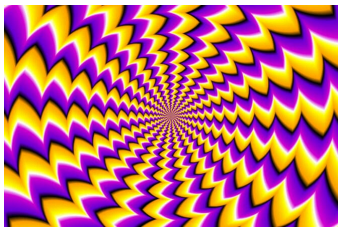


Figure 2: *Physiological Optical Illusion*

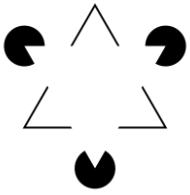


Figure 3: *Cognitive Optical Illusion*

Classroom Notes

Some mentees may find the physiological optical illusions disorientating! If a mentee gets dizzy while looking at this illusion, direct them to rotate to a different station instead. When wearing the glasses, have the red on the left side.

Module 2: Movie Fully Flip-Booked

Mentees will be creating flipbooks in this module. They will utilize the 12 principles of animation to create smooth animations based on the human persistence of vision.

Teaching Goals

1. **Perception:** our brain's ability to interpret things we see and make sense of them
2. **Persistence of Vision:** a "lagging effect" when our eyes remember an image for a split second after it disappears
3. **12 Principles of Animation:** techniques used to make the animation a smoother motion

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MD Goals

Be mindful of different artistic skill levels (grade levels) - Keep it simple, encourage mentees to draw and be creative by focusing on the animation process rather than artistic skills

Being Detail Oriented

This lesson has a lot of small steps that will affect the outcome of the lesson (for example, the mentees must draw from the bottom to the top of the book). Make sure that both you and the mentees slow down and follow steps.

Materials

- Post-it notes
- Colored pencils/ markers

Different Methods for Teaching

1. **Perception:** Perception is how our brain interprets things. When we recognize something as a flower, it is because our brain has processed the color and shape and perceives it as a flower.
2. **Persistence of Vision:** When you flip through the flipbook, you see a continuous moving picture. This is an optical illusion created from the persistence of vision because the pictures are not moving, but because our eyes remember an image for a split second after it disappears, so the pictures blend and create the appearance of smooth motion
3. **12 Principles of Animation:** These principles make hand-drawn animation feel more realistic. Some examples include smear frames and "squashed and stretched images" which are exaggerations of how the object behaved but allow viewers to perceive the animation as more fluid

Figure 1: *Smear Frames*

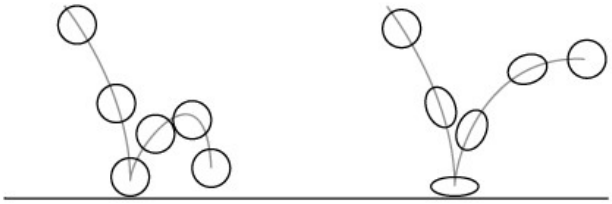

Figure 2: *Squash and Stretch*

Procedure

1. Pass out a sticky note pad to each mentee.
2. Have each mentee plan out an action scene that they want to create, including a starting and ending image.
3. Have each mentee draw the starting image onto the first page of their sticky note pad.
4. For every following page, have each mentee draw the same image as the previous page, but vary it slightly so that it resembles the ending image a little bit more each time.
5. When they finish drawing the entire flipbook, have them flip through the pages with their fingers and observe a moving picture.

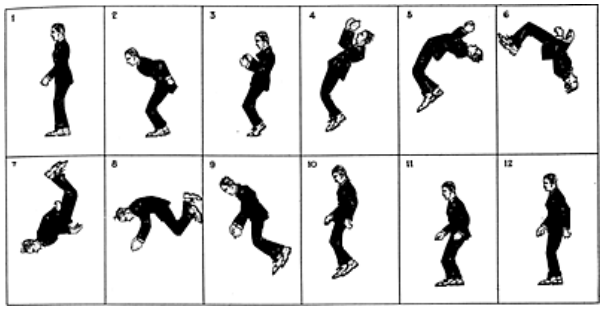

Figure 1: *Example of different pages of a flip book*

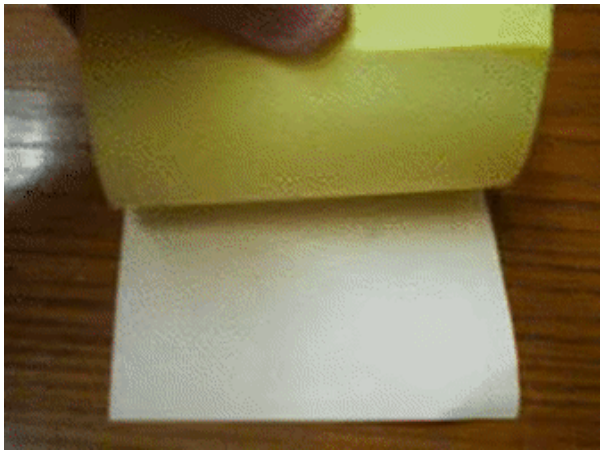

Figure 2: *Flipping through a flip book*

Classroom Notes

It might be easier for mentees to build their animation one object at a time. If the mentees are having trouble keeping their drawings in a similar location, encourage them to build their animations bottom up (draw the later page first so they can see the drawing on the paper on top).

Module 3: Let the Show Begin!

This module will allow mentees to learn about the basic principles of movie projection and they will build their own smartphone projector.

Teaching Goals

1. **Projection:** the action of light, heat, or sound reflecting from one surface to another in a different direction
2. **Light rays:** the path of light energy through a medium
3. **Convex lens:** a transparent material that disperses light rays that pass through it
4. **Refraction:** the redirection of a light wave as it passes through one medium to another

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MD Goals

Adjust along the way - Based on how much time you have at site and the skill level of your site members, you can decide how to adjust the lesson. Take the mentees along with you and be mindful of if they understand how the lesson relates to real life.

Delegate roles - This lesson is best when students can get to the end result. If you don't think you have time to do the whole demo, you can have one of the mentors get the demo started while the other mentor is doing their lecture part! Remember you can rely on your other mentors for help with the activities and getting the mentees to pay attention!

Materials

- Black box
- A small mirror
- Cardboard
- Convex lens
- Pencil
- Scissors
- Clear tape
- Flashlight
- White paper

Different Methods for Teaching

1. **Projection:** Ask mentees why they think movies that they watch at a movie theater are so much bigger than watching movies on your phone or computer.

2. **Light rays:** Sometimes we represent or draw the sun as a circle with lines coming out of it. Those lines represent light rays, showing the path of the light from the sun to our eyes. You can draw this example on the board!
3. **Convex lens:** Demonstrate shining light from a flashlight through a convex lens and show mentees how the light changes as it goes through the lens. You can also demonstrate shining an image of a letter into the convex lens and you will see it projected upside down! Explain that the reason that we need a mirror for the movie projector is because the way that light rays converge on the convex lens causes the image to be projected upside down originally.

Procedure

1. Lay out the unfolded box on the table as seen in Figure 1.
2. Trace out a circle with the lens making sure that one edge of the lens touches the crease between the right bottom pane and the middle bottom pane as seen in Figure 2.
3. Use a pencil to punch a hole in the traced circle and then cut out the circle (Figure 3).
4. Assemble the box by folding along the creases and tucking in the bottom, but do not close the top. The circle cutout should be at the bottom (Figure 4).
5. Tape the convex lens into the hole from the inside of the box. If the lens has a handle, tape the handle to the box, but if the lens does not have a handle, tape the edges of the lens to the box (Figure 5).
6. Create a mirror stand by folding a strip of cardboard into a triangle (Figure 6 left).
7. Tape the mirror to the mirror stand so that the mirror sits at a 45 degree angle (Figure 6 right).
8. Place the mirror stand (with the mirror attached) in the box so that the mirror is directly across from the lens (Figure 7).
9. Turn off the lights and make sure that the projector lens is facing a white surface.
    a. *Note: The white surface can be a wall or you can hold up a piece of paper in front of the projector.*
10. Shine a flashlight into the mirror, pointing it

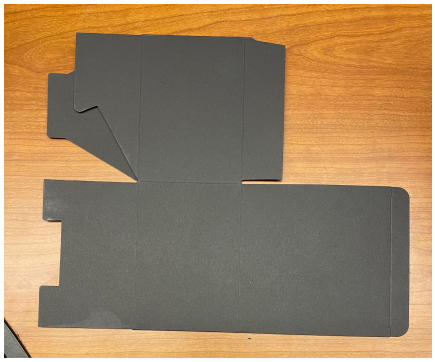

Figure 1: *Box layout*

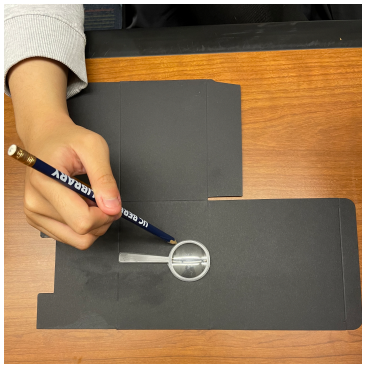

Figure 2: *Lens trace*

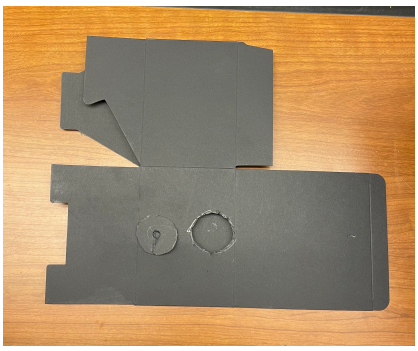

Figure 3: *Circle cutout*

down (Figure 8). You should see the light from the flashlight projected onto the white surface.

   a. *Note: If it doesn't work, you may have to move closer to the white surface. Additionally, you can adjust the distance of the mirror to the lens and you can slightly adjust the flashlight placement to get the best projection.*

11. Play a video on a smartphone, turn the brightness up to maximum, and lay the smartphone on top of the projector. Move closer to the white surface to see the video projected onto the white surface (Figure 9).

   a. *Note: It has to be pretty dark for this step to work because the projection is dim. Additionally, you might have to adjust the placement of the smartphone by moving it backwards or forwards so that the light goes into the mirror.*

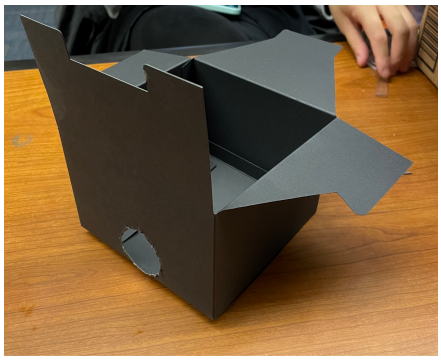

Figure 4: *Assembled box*

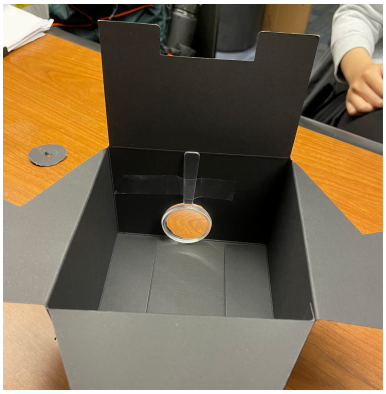

Figure 5: *Inserted lens*

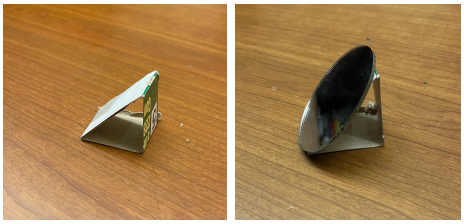

Figure 6: *Mirror stand*

Figure 7: *Mirror placement*

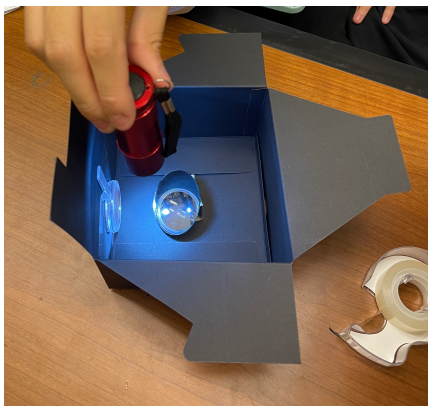

Figure 8: *Flashlight placement*

Figure 9: *Smartphone placement*

Figure 10: *Flashlight projection on a wall*

Classroom Notes

If the projector is not working well with a smartphone just stick to the flashlight instead. Troubleshoot any issues by adjusting the placement of the smartphone, mirror, and white surface.

Conclusion

Mentors should ask the mentees to think about what other optical illusions they can see in day to day life outside of movies/animation. Encourage the mentees to keep an eye out for optical illusions when they go home.

Summary Materials Table

Material	**Amount per Site**	**Expected $$**	**Vendor (or online link)**
3D Glasses	4-5 per site	$9.59	Amazon
Post-it notes	1 per mentee	$16.99	Amazon
Colored pencils/ markers			MCL Inventory
Black boxes	4-5 per site		Amazon
Small Mirrors	4-5 per site	$8.99	Amazon
Lens	4-5 per site	$14.80	Amazon
Scissors/ Hole Puncher	4-5 per site 1 per site	 $13.99	MCL Inventory Amazon
Clear Tape			MCL Inventory

References

1. DIY Projector: https://shotkit.com/diy-projector/