



## ELLEN OCHOA TRADING CARD LESSON AND ACTIVITIES

### SUMMARY

Ellen Ochoa, a veteran of four NASA Space Shuttle flight missions and the first Hispanic American woman in space, is a co-inventor on three patents: An optical inspection system, an optical object recognition method, and a method for noise removal in images. These lessons and activities are designed for Grades 6-12. The activities focus on the physics of light, engineering and design, literacy, and the graphic design of 3-D movies created using PowerPoint®.

# Table of Contents

---

## Ellen Ochoa trading card lesson plan

|  |   |
|--|---|
| Background.....  | 2 |
| Grades 6-12 content and topics.....  | 2 |
| Engage: A USPTO inventor trading card activity challenge: Up close and personal with Ellen Ochoa ..... | 3 |
| Explore: Create a hologram projector: Video in 3-D.....  | 3 |
| Explain: The adventures of Ellen Ochoa: A jigsaw activity.....   | 4 |
| Elaborate: Create your hologram movie! Could it be a trademark?.....                                   | 5 |
| Evaluate: How does it work? Hologram simulations demystified.....                                      | 6 |
| Vocabulary.....  | 7 |
| Standards alignment.....   | 8 |

## Student activity sheets

|   |    |
|---|----|
| A USPTO inventor trading card activity challenge: Up close and personal with Ellen Ochoa..... | 10 |
| Create a hologram projector: Video in 3-D .....   | 13 |
| The adventures of Ellen Ochoa: A jigsaw activity.....   | 19 |
| Create your hologram movie! Could it be a trademark?.....                                     | 23 |
| How does it work? Hologram simulations demystified.....                                       | 33 |

# ELLEN OCHOA

## Trading card lesson plan

### Background

Ellen Ochoa was born in 1958 in Los Angeles, California. She grew up in a single-parent home with three brothers and one sister. Ochoa quickly learned the importance of education by watching her mom attend college courses while simultaneously working. In 1975, Ellen Ochoa graduated as valedictorian of her class at Grossmont High School. She was awarded a four-year scholarship to Stanford University in Palo Alto, California, but she instead chose to stay close to home to be near her younger brothers, who were still in high school. Ochoa graduated from San Diego State and then went to Stanford University to earn her master's degree and a doctorate in electrical engineering. At Stanford, she became interested in the NASA astronaut training program. She was aboard the Space Shuttle Discovery in 1993 and was the first Hispanic woman to travel to space.



### Student activities

- [United States Patent and Trademark Office \(USPTO\) inventor trading card activity challenge: Up close and personal with Ellen Ochoa](#)
- [Create a hologram projector: Video in 3-D](#)
- [The adventures of Ellen Ochoa: A jigsaw activity](#)
- [Create your hologram movie! Could it be a trademark?](#)
- [How does it work? Hologram simulations demystified](#)

### Grades 6-12 content and topics

Engineering, Science, Math, ELA, and Computer Science

## **Engage: A USPTO inventor trading card activity challenge: Up close and personal with Ellen Ochoa**

---

**Time: 40 minutes**

### **Background**

The engage section of this lesson plan will introduce the work of Ellen Ochoa and her patented hologram technology. Students will complete “A USPTO inventor trading card activity challenge: Up close and personal with Ellen Ochoa.” Students will read the background information about Ellen Ochoa, a veteran of four NASA Space Shuttle flight missions and former director of the Johnson Space Center. The teacher will explain patents, and that Ellen Ochoa and other inventors have received patents for methods of creating accurate high-resolution images taken in space through hologram technology. Students will invent a smartphone microscope with materials offered by the teacher. This could involve deconstructing a laser pointer to get a lens or using provided lenses.

### **Materials (per student pair)**

- Inexpensive laser pointer key chains or laser pointer lenses
- Materials used to build a two-level stand: Plexiglass squares (6x6 inches) with holes in the corners, nuts, bolts, and wing nuts
- Large hairpins or bobby pins
- Smartphone or tablet with camera

### **Instructions**

1. Gather materials that students can use to create different smartphone microscopes and set them on a table or counter.
2. Students look at the available materials and determine what problem they would like to solve using a smartphone microscope.
3. Students gather items they want to see through their smartphone microscope.
4. Students sketch their invention, build a prototype, and iterate based on testing.

### **Student activity handout**

- A USPTO inventor trading card activity challenge: Up close and personal with Ellen Ochoa

## **Explore: Create a hologram projector: Video in 3-D**

---

**Time: 40 minutes**

### **Background**

The explore section of this lesson plan engages students in creating a simulated hologram projector. Students use geometric measurements to create a projector from thick plastic sheets. The projector they make will work with hologram movies found on YouTube® or created by the

students. The instructions for creating a hologram movie can be found in the elaborate section of this lesson plan as an optional lesson.

## Materials

- 10-millimeter clear plastic binding covers
- Clear plastic tape or clear glue
- Scissors
- Protractor
- Metric ruler

## Instructions

Students will build a simulated hologram projector according to the instructions in the activity handouts. After they make the hologram projector, students will:

1. Select a hologram movie to view (determined by the teacher).
2. Analyze the design of the hologram projector.
3. Propose changes to the design of the hologram projector based on desired outcomes.

## Student activity handout

- [Create a hologram projector: Video in 3-D](#)

## Explain: The adventures of Ellen Ochoa: A jigsaw activity

---

**Time: 40 minutes**

### Background

The explain section of this lesson plan engages students in understanding Ellen Ochoa's patented technology and learning more about the research she did while working at NASA. Ellen Ochoa's hologram technology is complex and focuses on enhancing imaging. Ask students to read a few of Ochoa's patent abstracts and background sections, and invite them to share what they learned.

### Materials

- Print-outs or links to articles and patents
- Anchor article: [Ellen Ochoa: Optical analysis systems](#)
- Three of Ochoa's patents for the jigsaw activity, each printed on a different color of paper:
  - [System for Enhancement of Optical Features](#)
  - [Position, Rotation, and Intensity Invariant Recognizing Method](#)
  - [Optical Ranked-Order Filtering Using Threshold Decomposition](#)
- Jigsaw instructions and notes in student activity handout

### Instructions

Students will participate in a jigsaw method to research and share Ochoa's inventions.

1. Divide the class into three anchor groups.
2. All students read the anchor article, "Ellen Ochoa: Optical analysis systems."

3. Students share what they learned from the anchor article with their group.
4. At their anchor table, students select a patent. Teachers can print these on colored paper and place them on the anchor group table. You may only want to print the cover page, abstract, background, and patent drawings.
5. Students take notes while they read the abstract and study the patent drawings, then students move to another table to meet with their “patent expert group,” which is based on the color or title of the patent handout they read at their anchor table. They will then share their findings and take notes with their patent expert group.
6. Members of the patent expert group will prepare a presentation to be delivered to members of their anchor group.
7. Patent experts return to their anchor group and share the information discussed in the patent expert group.

### Student activity handout

- [The adventures of Ellen Ochoa: A jigsaw activity](#)

## Elaborate: Create your hologram movie! Could it be a trademark?

---

**Time: 80 minutes**

### Background

The elaborate section of this lesson plan guides students in creating a hologram movie using animation in PowerPoint® and a three-dimensional projection. Students follow the directions in the “Create your hologram movie! Could it be a trademark or copyright?” handout.

Ellen Ochoa developed optical systems to improve imaging to analyze objects in greater detail. In this activity, students create a simulated hologram to view a video or animation in three dimensions. This section of the lesson plan is optional, and you may choose to have students develop their projectors without creating a 3-D movie.

### Materials

- Access to computers with PowerPoint®
- Students will choose images to use to create a movie (use original or open-source images)

### Instructions

1. In the first part of this activity, students select a character to animate using PowerPoint®.
2. Using the step-by-step directions in the activity handout, create an animated character.
3. Follow the directions to create music that will go with the animation.
4. Record the animation and save it as an MP4 movie file with music.
5. Create a hologram movie and save it as an MP4 file.
6. View the hologram movie by placing the simulated hologram projector over the center of the tablet or phone screen.

7. Consider options for different movie types and projections students could create.
8. Teach students about copyright protection. [Copyright.gov](https://www.copyright.gov) will provide additional information.

### Student activity handout

- [Create your hologram movie! Could it be a trademark?](#)

## Evaluate: How does it work? Hologram simulations demystified

---

**Time: 40 minutes**

### Background

The evaluation section of this lesson plan enables students to apply their knowledge to create a new design of a simulated hologram projector. Students can conduct a patent and image search to ensure their invention is new. Optical systems and simulated play with light have been used historically for theater production and entertainment. Although the complexities of techniques developed by Ochoa are much more advanced, an understanding of the behavior of light is essential in studying physics.

### Materials

- 10-millimeter clear plastic binding covers
- Clear plastic tape or clear glue
- Scissors
- Protractor
- Metric ruler

### Instructions

1. Students will read about the historical use of hologram technology.
2. They will study the behavior of light and how it impacts optical systems.
3. Students deconstruct what they have learned in the lesson and create a prototype of a novel simulated hologram projector.

### Student activity handout

- [How does it work? Hologram simulations demystified](#)

# Vocabulary

---

## **Optical system**

A series of elements, such as lenses, mirrors, light sources, filters, fiber optics, prisms, and other components, which are used to construct instruments that utilize light behaviors.

## **Hologram**

A method of creating three-dimensional images through illumination by coherent light sources, such as a laser beam.

## **Reflection**

The return of a light wave from a surface. If the surface is smooth and shiny, the light will reflect at the same angle that it strikes the shiny object. One example of a smooth, shiny surface is a mirror.

## **Refraction**

The bending of light as it passes from one type of transparent material through another transparent material. The change in the speed of light determines the change in direction or angle of refraction.

## **Intellectual property (IP)**

Creations of the mind that may include but are not limited to inventions, written, artistic, and design works. These may be protected by acquiring a patent, trademark, copyright, and trade secret.

## **Patent**

An exclusive property right granted by the United States Patent and Trademark Office to inventors to make, use, or sell their inventions within the United States for a limited period.

## **Trademark**

A word, name, symbol, or device that is used in trade with goods and services to indicate the source of the goods and services and to distinguish them from the goods and services of others.

## **Copyright**

A form of protection provided to the authors of "original works of authorship," including literary, dramatic, musical, artistic, and certain other intellectual works, both published and unpublished.

## **Trade secret**

Information that has either actual or potential independent economic value by not being generally known, has value to others who cannot legitimately obtain the information, and is subject to reasonable efforts to maintain its secrecy. For example, the formula for the beverage Coke®.



# Standards alignment

---

## Math, Grades 3-12

**Draw, construct, and describe geometrical figures and describe the relationships between them.**

Draw (freehand, with ruler and protractor, and with technology) geometric shapes with given conditions.

**Visualize relationships between two-dimensional and three-dimensional objects**

Identify the shapes of two-dimensional cross-sections of three-dimensional objects.

**Apply geometric concepts in modeling situations**

Apply geometric methods to solve design problems.

## Next Generation Science Standards

**Science and Engineering Practices**

Constructing Explanations and Designing Solutions

**Disciplinary Core Ideas**

**PS4.B Electromagnetic Radiation:** When light shines on an object, it is reflected, absorbed, or transmitted through the object depending on the object's material and frequency (color) of the light.

**PS4.C Information Technologies and Instrumentation:** Multiple technologies based on the understanding of waves and their interactions with matter are part of everyday experiences in the modern world (e.g. medical imaging, communications, scanners) and in scientific research. They are essential tools for producing, transmitting, and capturing signals and for storing and interpreting the information contained in them.

**MS-PS4-2** Develop and use a model to describe that waves are reflected, absorbed or transmitted through various materials.

**HS-PS4-5** Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.

**Crosscutting Concepts**

Influence of Science, Engineering, and Technology on Society and the Natural World

## National Core Art Standards

**Media Arts**

**Anchor Standard 1:** Generate and conceptualize artistic ideas and work.

**Anchor Standard 2:** Organize and develop artistic ideas and work.

**Anchor Standard 5:** Develop and refine artistic techniques and work for presentation.

## Computer Science Standards

**2-CS-01** Recommend improvements to the design of computing devices based on an analysis of how users interact with the devices.

**2-CS-03** Systematically identify and fix problems with computing devices and their components.

# A USPTO inventor trading card activity challenge: Up close and personal with Ellen Ochoa

**Ellen Ochoa**

*Optical analysis systems inventor*

*Born: May 10, 1958; Birthplace: Los Angeles, California*

Ellen Ochoa, a veteran of four NASA Space Shuttle flight missions, is a co-inventor of three patents: An optical inspection system, an optical object recognition method, and a method for image noise removal. In 1993, she became the first Hispanic American woman to travel in space. Ochoa served as a mission specialist, payload commander, and flight engineer. In 2013, she became the first Hispanic director of the Johnson Space Center in Houston, Texas. In recognition of her accomplishments, numerous schools have been named after her. Ochoa has also received many awards, including the NASA Distinguished Service Medal, Exceptional Service Medal, and Outstanding Leadership Medal.

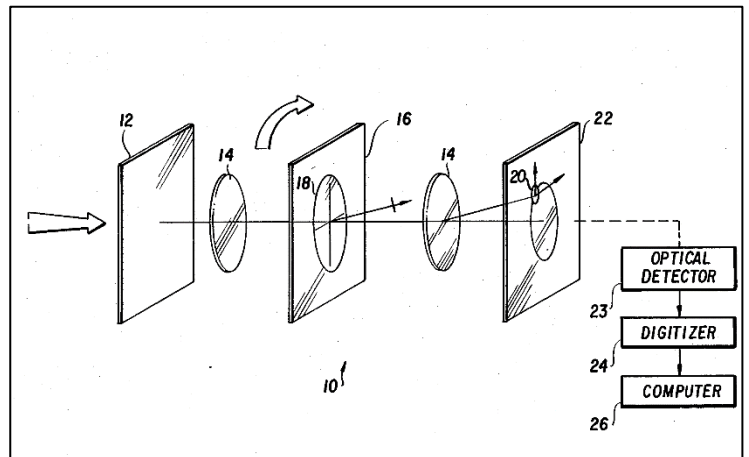


## Activity

Can you create a smartphone microscope using lenses from another tool?

## Background

In this activity, you will explore how to create a macro lens for a smart device. The challenge is to remove the lens from a laser pointer and attach the lens to a smart device. Your teacher may provide lenses, so you do not have to deconstruct a laser pointer.



This patent drawing is from Ellen Ochoa's Position, Rotation, and Intensity Invariant Recognizing Method patent. U.S. Patent 4,838,644

## Materials

- Laser pointers or lenses
- Plexiglass squares (6x6 inches) with holes in the corners
- Nuts, bolts, and wing nuts
- Large hairpins or bobby pins
- Various materials that could secure the lenses



## Directions

Think about the following questions related to the challenge:

1. How will you temporarily attach the lens to a smart device's camera using the materials provided?
2. How will you secure your attachment and not interfere with the lens?
3. How should the convex lens be situated?
4. Sketch and label your plan to create a smartphone microscope.

## Redesign your smartphone microscope to make improvements (iterate)

5. Using materials provided by your teacher (salt, hair, pond water), take pictures with your smartphone camera to test your prototype.
6. How can you improve your prototype? For example, consider how well you can focus your microscope and how well the lens is attached to your smart device.

## What is intellectual property?

Intellectual property (IP) refers to creations of the mind, such as inventions, literary and artistic works, designs, symbols, names, and images used in commerce. There are four types of intellectual property: Patents, trademarks, copyrights, and trade secrets.

**What ideas for an invention, product, or service do you have?**

**How could you express your intellectual property so that it is protected?**

## Ellen Ochoa is an inventor. You can be one too!

Inventors are problem solvers. If you have ever solved a problem or thought of a new way to accomplish a task, you are an inventor. When you did this activity and built a smartphone microscope, you were an inventor. One day, you could invent something new that could benefit society.

**What will you invent?**

## What is a patent?

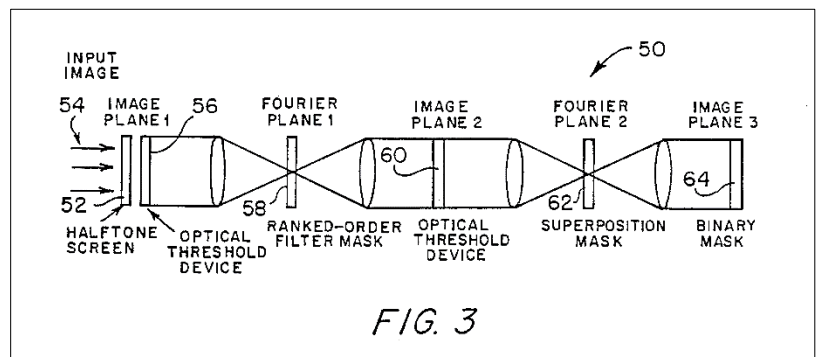
A patent is a property right granted by the government that allows an inventor to stop others from making, using, or selling their invention without permission for a certain amount of time. This right gives the inventor a chance to develop their inventions further to benefit society. Patents also allow the public to learn how an invention works so that others can develop new ways to improve it.

**Do you have an idea for an invention that you could patent?**

## Design your trademark

Trademarks help us distinguish between sources of products or services. Trademarks are source identifiers! They can be words, designs, or a combination of such, but trademarks may also take other forms, such as sounds, scents, shapes, and colors, as long as they distinguish the source of a product or service. Think of a design, name, or symbol you would use to help the world identify and distinguish the source of your invention. Make sure that it is unique and not easily confused with other trademarks.

**How will you create a trademark that will distinguish your invention or product?**



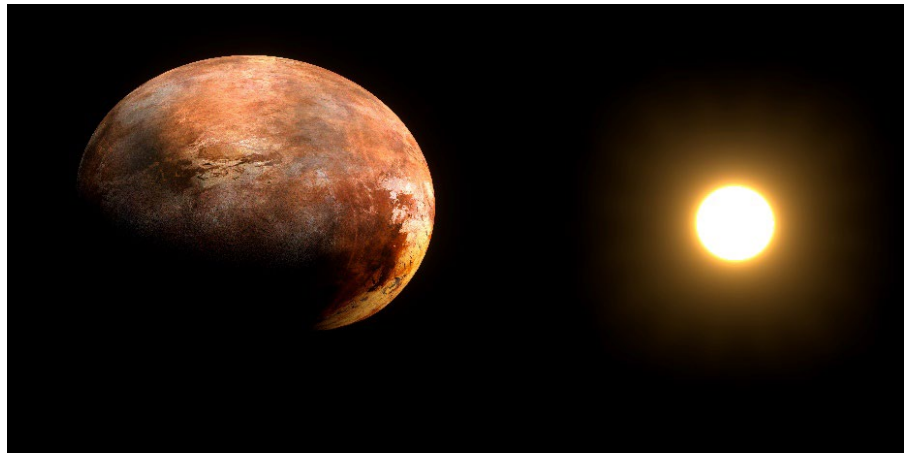
A schematic representation of the total optical embodiment in Ellen Ochoa's Optical Ranked-Order Filtering Using Threshold Decomposition patent. U.S. Patent 4,949,389

# Create a hologram projector: Video in 3-D

## Background

Ellen Ochoa earned her doctorate at Stanford University. She continued researching at Sandia National Laboratories and the NASA Ames Research Center. She is an inventor who created new ways to “look” at objects in outer space. Some of her inventions helped ensure that equipment was safe. Others allowed the recording of events in space by detecting objects and removing image distortion, which makes objects appear to be a different shape, not relatively straight or wavy.

In this picture, the moon is slightly distorted and appears longer than its actual shape. There are mathematical equations that can identify distortions that occur with camera lenses. Based on these equations, researchers and engineers can correct these distortions using innovative equipment, like that developed by Ellen Ochoa.



## Simplest mathematical model of distortion in a camera lens:

$r_u$  - undistorted radius

$r_d$  - distorted radius

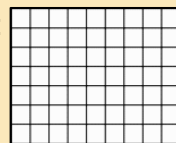
$k$  - arctangent/tangent coefficient

$$r_u = r_d + k_1 r_d^3$$

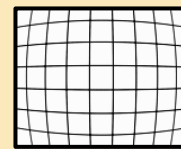
$k_1 > 0$  for barrel distortion

$k_1 < 0$  for pincushion distortion

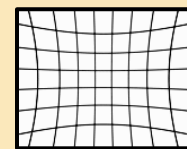
### Types of distortion



None

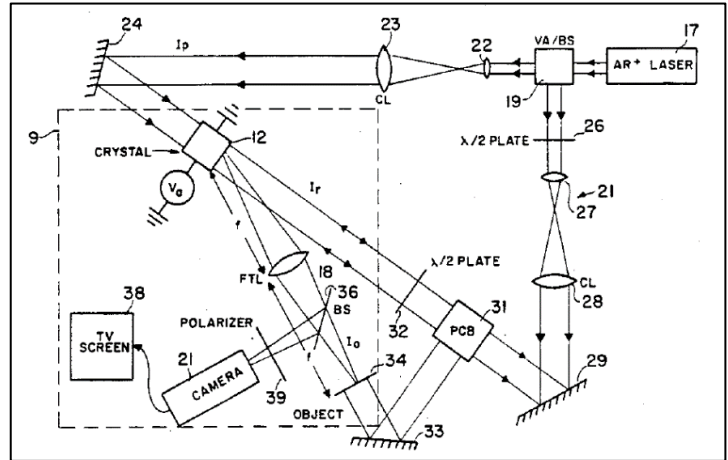


Barrel



Pincushion

Ochoa's invention was based on complex mathematical equations related to the study of optics. In addition to addressing image distortion, the invention allowed the formation of a hologram by using two beams of light that enter the apparatus. Ochoa studied the principles of light, including diffraction, polarization, reflection, and refraction.



Block diagram of Ellen Ochoa's invention, System for Enhancement of Optical Features. US. Patent 4,674,824

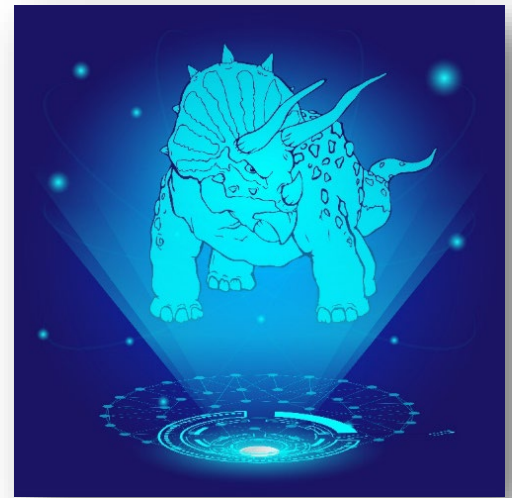
### Vocabulary check

Place a check in the appropriate box in the row for each term.

| Principle of light | I know what this means.... | I do not know what this means... | I have heard of this... | Research, draw, and define |
|--------------------|----------------------------|----------------------------------|-------------------------|----------------------------|
| Distortion         |                            |                                  |                         |                            |
| Hologram           |                            |                                  |                         |                            |
| Beam               |                            |                                  |                         |                            |
| Diffraction        |                            |                                  |                         |                            |
| Polarization       |                            |                                  |                         |                            |
| Reflection         |                            |                                  |                         |                            |
| Refraction         |                            |                                  |                         |                            |

## Build a hologram projector

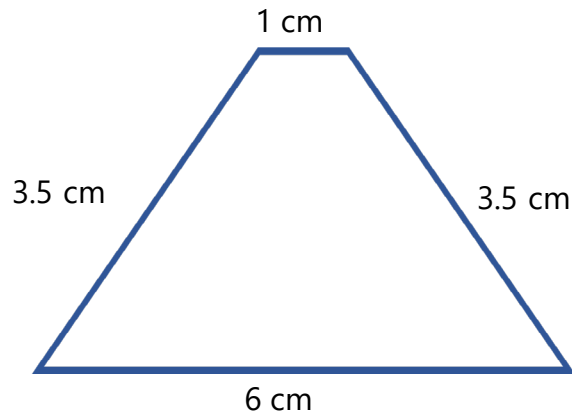
In this activity, you will create a hologram projector. The hologram projector is a simulation of Ellen Ochoa's optic technology. A simulation is an imitation of an actual process or method. The projector will allow the light from your device to reflect so that you can view a three-dimensional image from one of the four sides of the hologram projector.



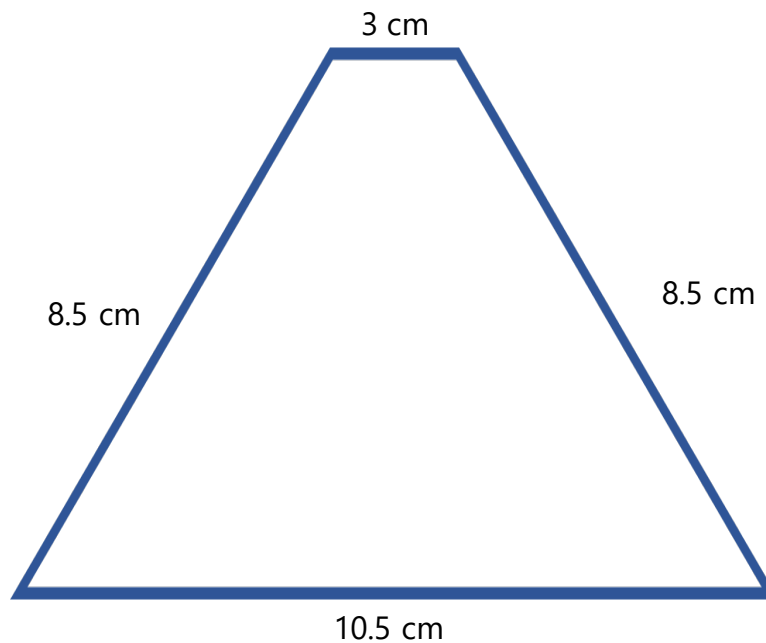
### Directions

1. To create the trapezoid template for a tablet, you need a protractor, metric ruler, and white paper.
2. Use thick plastic sheets (10 mm clear report covers) or acrylic to create a template for four trapezoid shapes with the following measurements:

#### Cell phone:

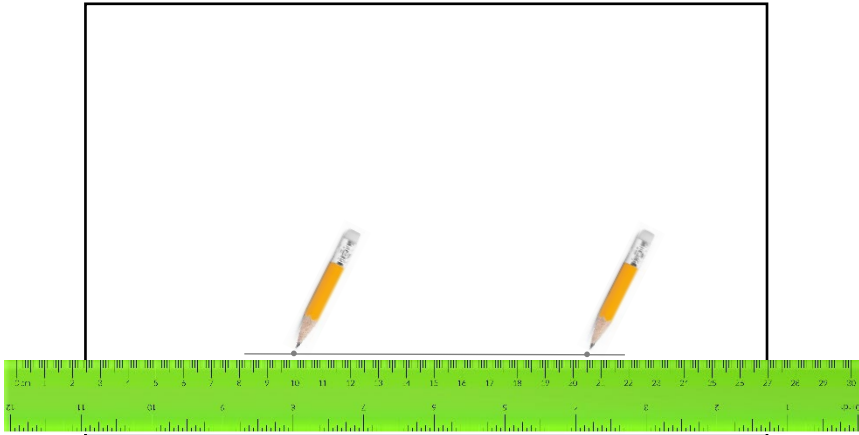


#### Tablet:

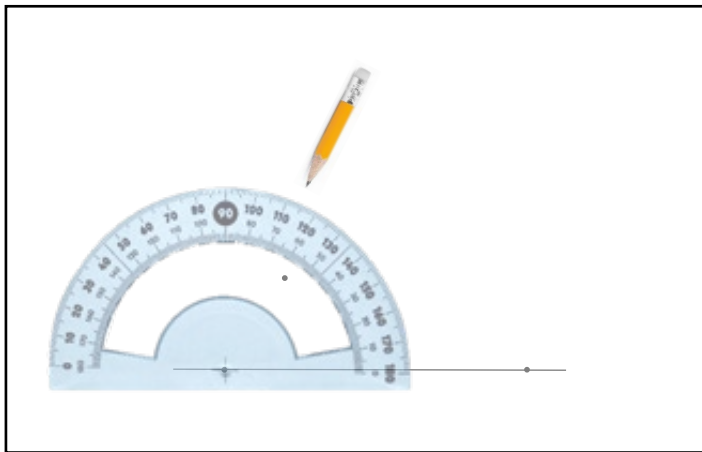




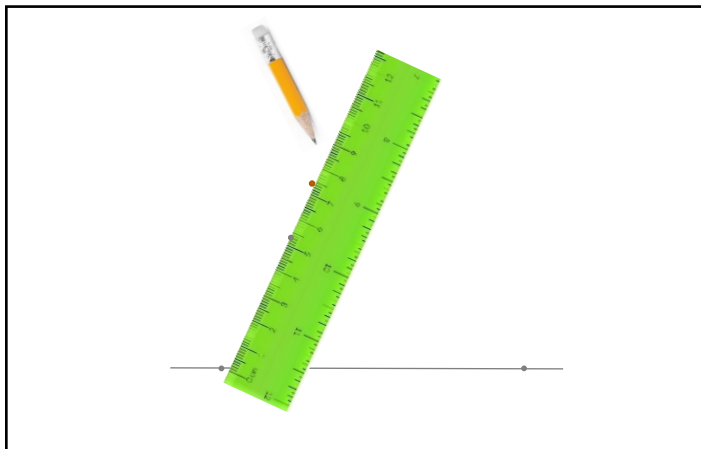
3. Measure 10.5 centimeters (6 cm if using a phone) across the bottom edge of the paper and mark with two dots, as shown below. Draw a straight line connecting the dots. Draw the line about an inch above the bottom of the paper.



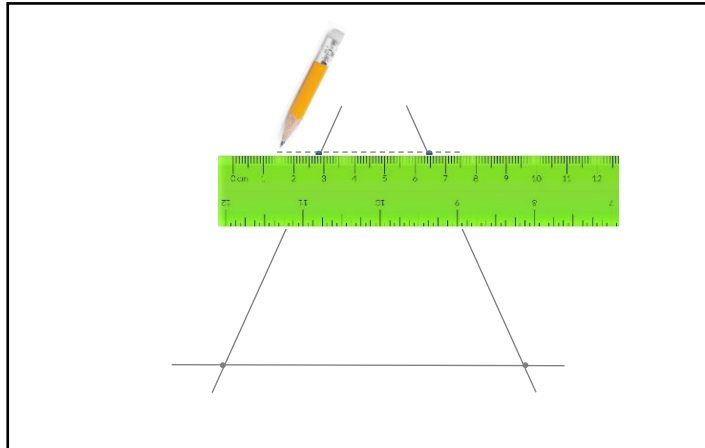
4. Place the protractor's center on the first dot of the 10.5 cm line at the bottom of the paper. Measure a  $65^\circ$  angle from the first dot and mark it with a pencil. Repeat this step with the second dot.



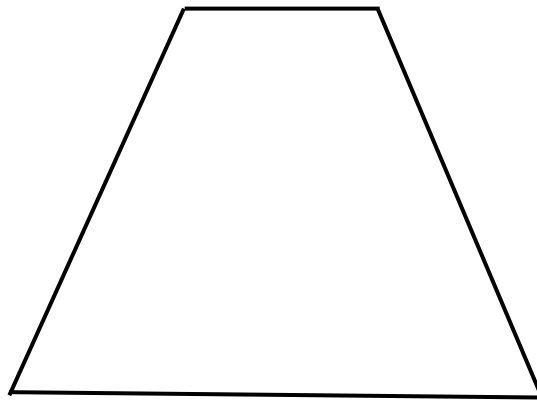
5. Draw a line through the first dot and the dot measuring  $65^\circ$ . Extend the line so that it is at least 8.5 cm long (3.5 cm if using a phone). Do the same step for the other side (second dot on the line).



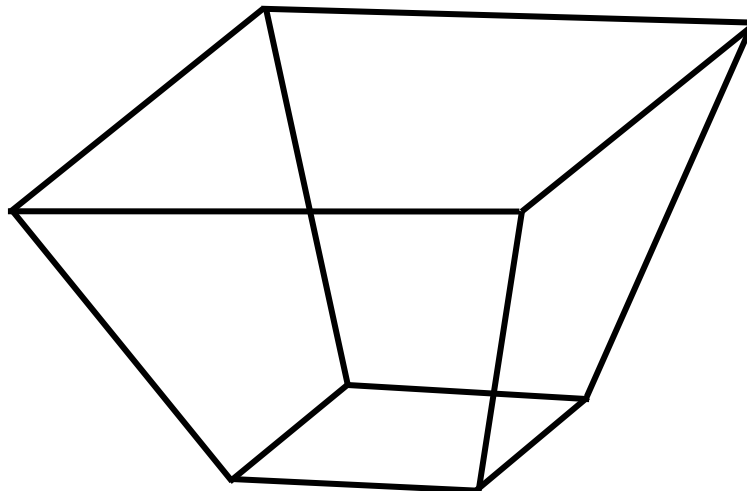
6. Complete the trapezoid by finishing the other side. Draw a line to connect the dots at the top.



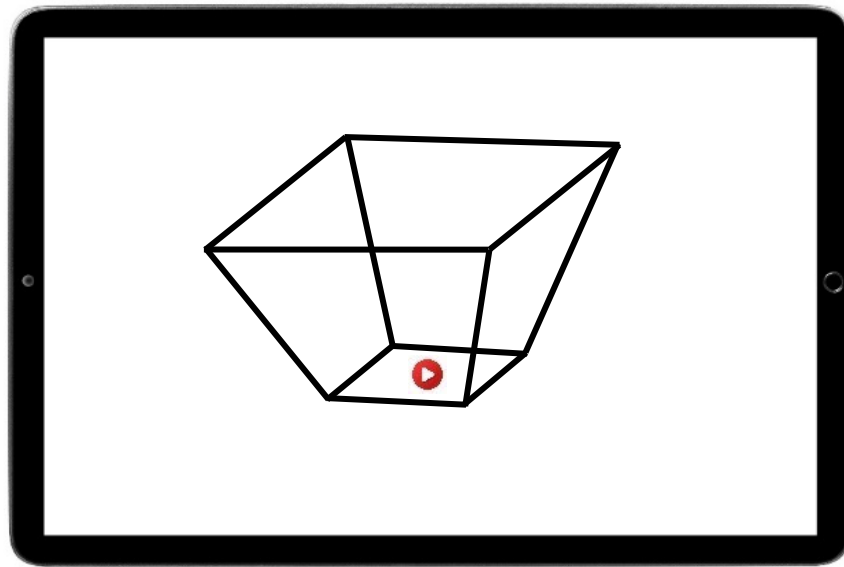
7. Cut out the trapezoid shape and use it as a template to cut four shapes out of the plastic report covers.



8. Tape or glue (if you used acrylic) the shapes together to create a hologram projector for a cell phone or tablet.



9. Place the projector over a hologram movie on a cell phone or tablet and press play. Watch through the side of the projector.



### Observation

1. List observations of how the hologram projector displays the hologram movie you selected. View a regular video using the hologram projector and list observations.

| Hologram video observations | Regular video observations |
|-----------------------------|----------------------------|
|                             |                            |
|                             |                            |
|                             |                            |
|                             |                            |
|                             |                            |

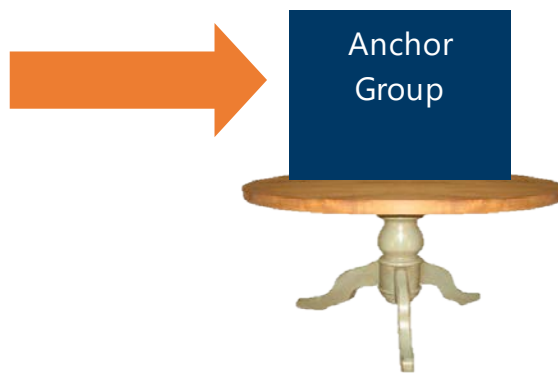
# The adventures of Ellen Ochoa: A jigsaw activity

## Background

Ellen Ochoa's hologram technology is complex and focuses on enhancing imaging. First, you will read the anchor article in your group. Then, you will move to expert groups to focus on one of Ellen Ochoa's patents. Take notes on the abstract and background section of the patent you chose, and ask other members of your expert group to share what they have learned. Return to your anchor group and share your expert findings.

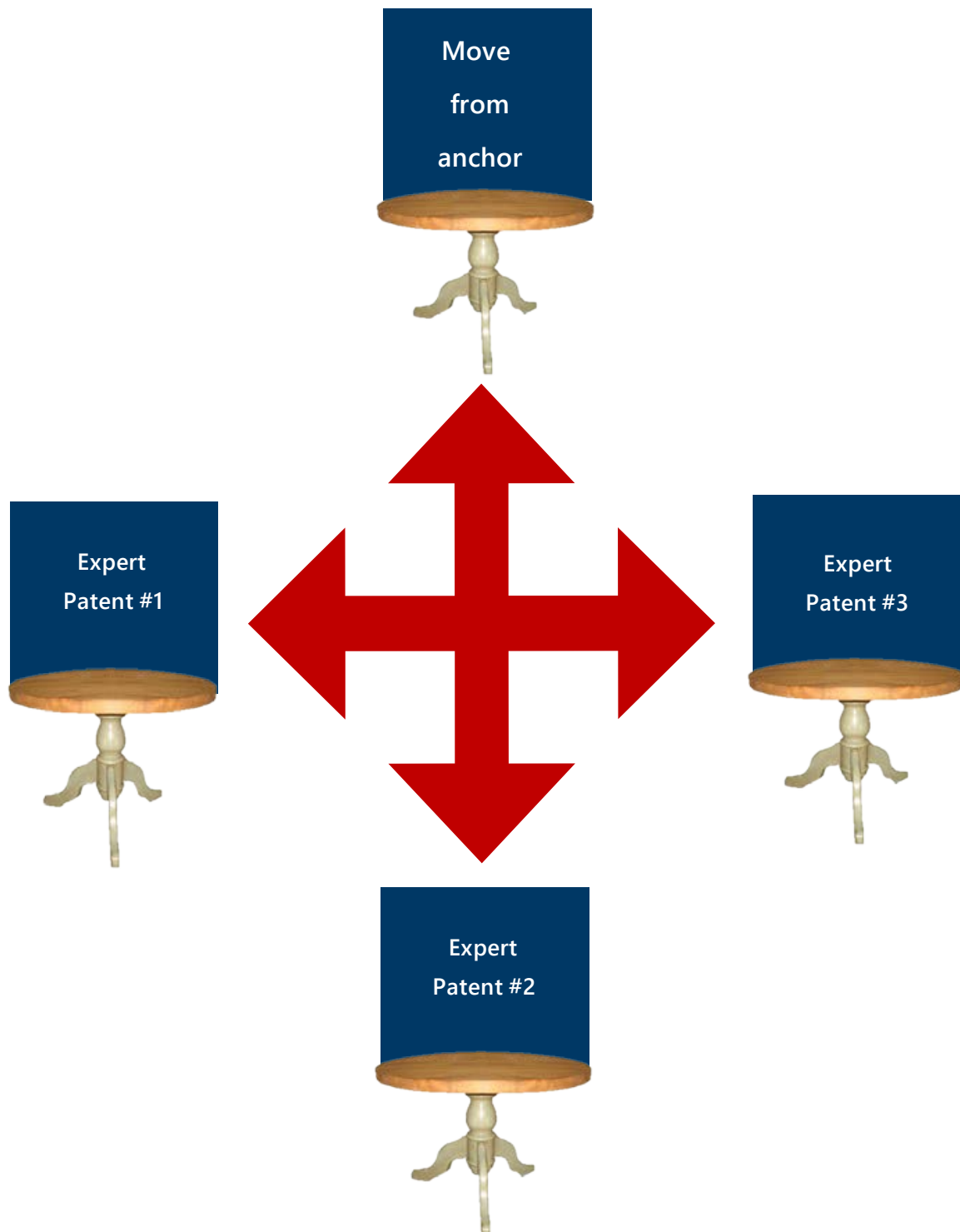
## Directions

1. Read and take notes from the anchor article, "Ellen Ochoa: Optical analysis systems."



2. In your anchor group, discuss the article "Ellen Ochoa: Optical analysis systems" and add information from the discussion to your notes. Be prepared to share your findings with the rest of the class.

3. Select one of the patents your teacher has placed on your anchor table. Each patent is copied on a different colored paper.
4. Read the abstract background and look at the diagrams. Take notes.
5. Move to your patent expert table with other members of the class who read the same patent (same color). Discuss what you have learned and add to your notes.
6. Return to your anchor group and share what you learned in your patent expert group.



## Ellen Ochoa's patents: A jigsaw

Record what you learned from each Patent Expert.

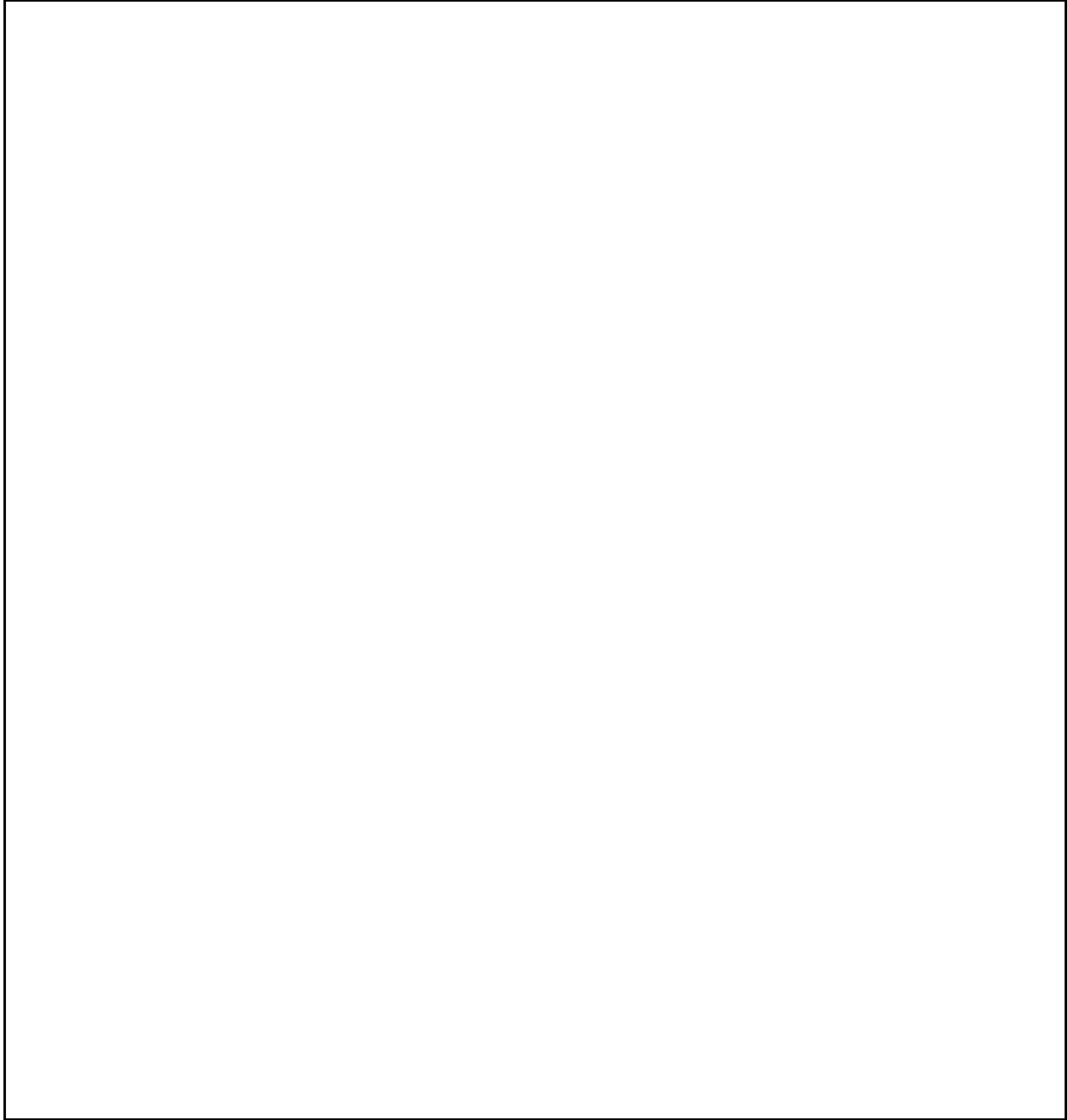
Patent title: \_\_\_\_\_

Patent title: \_\_\_\_\_

Patent title: \_\_\_\_\_

**Return to your anchor group.**

- Each patent expert reports what they learned.
- Record what you learned from the patent experts in your anchor group

A large, empty rectangular box with a black border, intended for recording information. It occupies the central and lower portion of the page.

# Create your hologram movie! Could it be a trademark?

## What is a trademark?

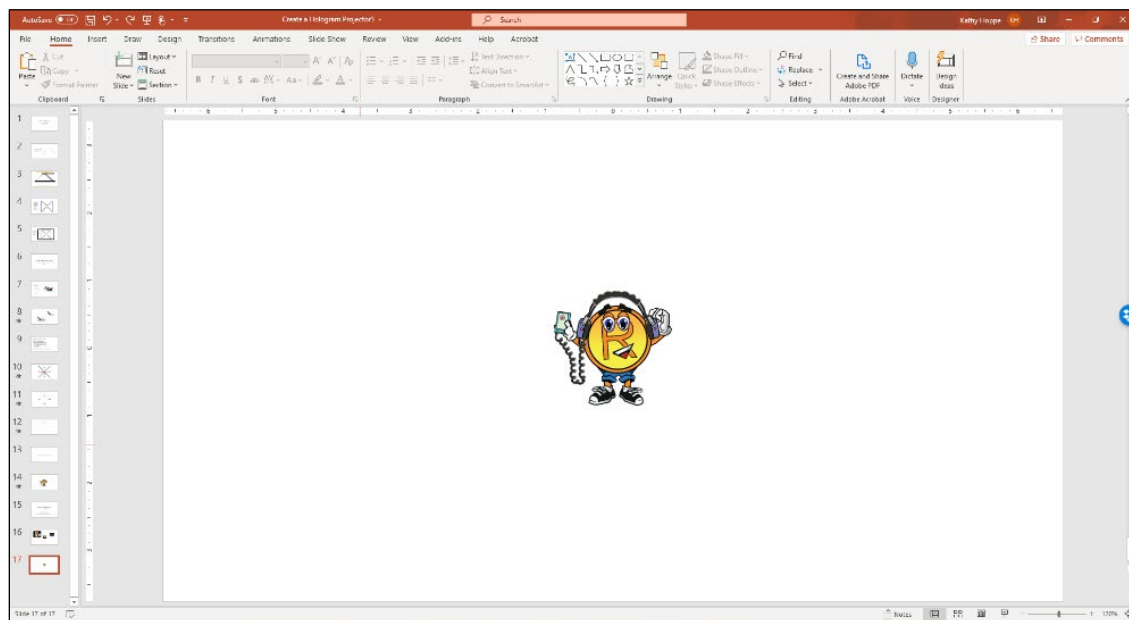
A trademark can be any word, phrase, symbol, design, or combination that identifies a brand or source of a service or product. A trademark identifies and distinguishes the source of goods and services. In this activity, you will create a trademark using motion and sound by creating a hologram movie. The movie may also be protected by copyright.

## Directions

1. Open PowerPoint®. Click **Layout** and select **Blank slide**. Make sure dynamic guides are turned on. (MAC: **View** → **Guides** and **Dynamic Guides**).
2. Select a character or choose your own.

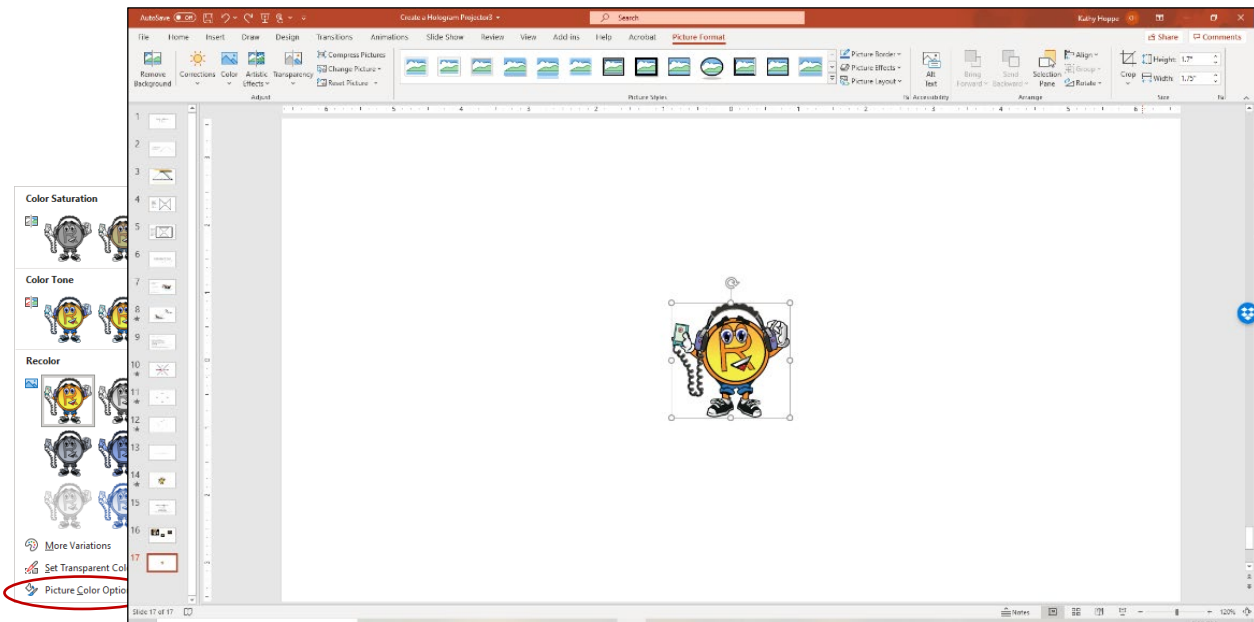


3. Copy a character and paste it into a PowerPoint® slide. Reduce the size of your character by holding down the shift key and dragging one corner of the animation.

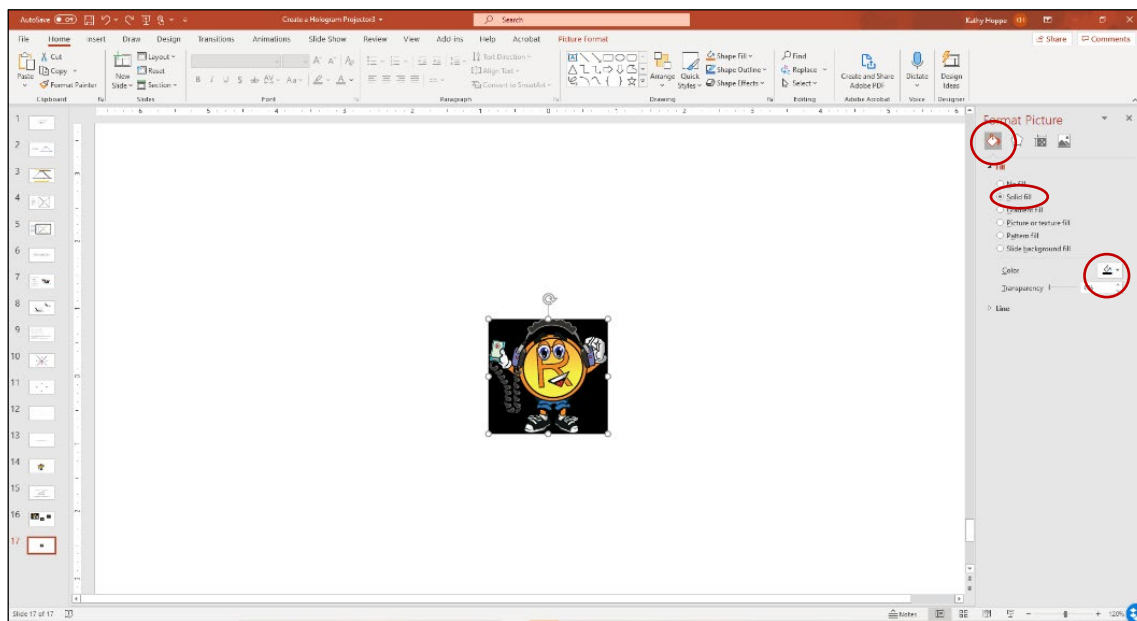




4. Click on the character and then **Picture Format**. Click on the **color icon**.  
Select the **Picture Color Options**. (MAC: **paint bucket**) Make sure the size is less than 2.1 inches in height and width.



5. A Format Background panel will appear on the right side of the slide screen. Click the **paint bucket** → **solid color** → **black** in the dropdown.

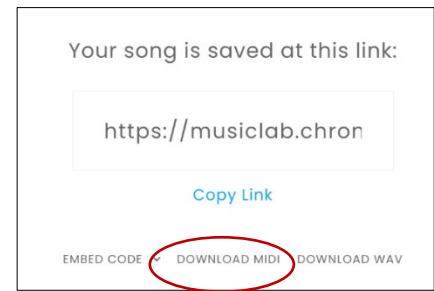
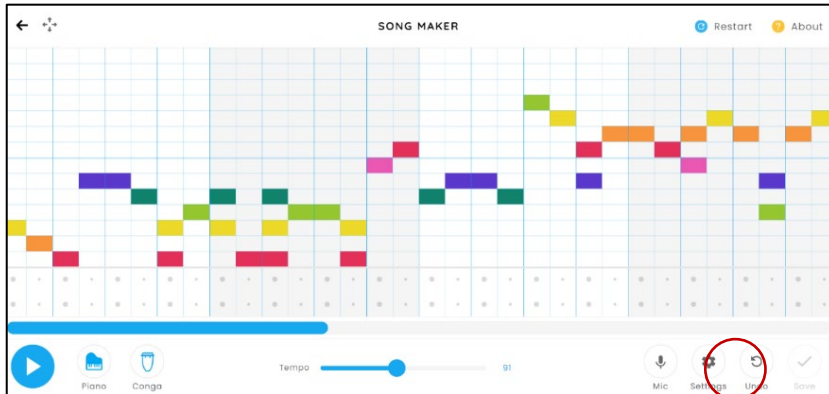


6. (OPTIONAL) Create your music using a Chrome® app linked below called the Music Lab. Save the song using the checkmark at the bottom right side of the screen.

Create a jingle trademark:

<https://musiclab.chromeexperiments.com/Song-Maker/song/5721271388602368>

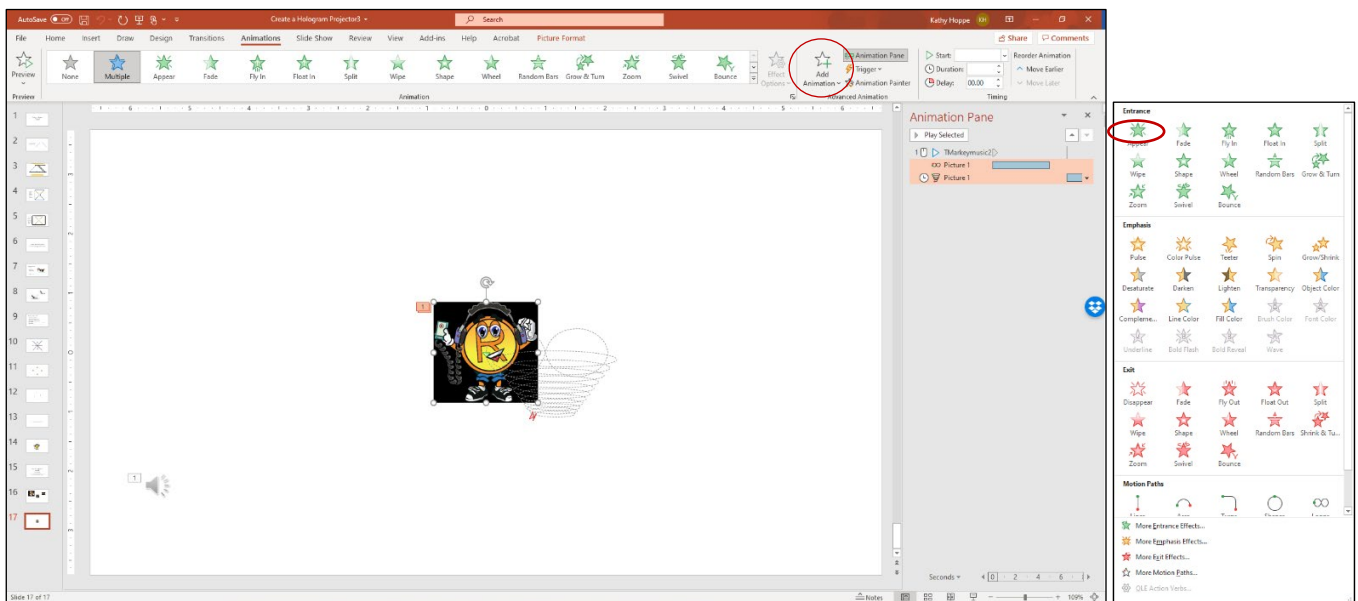
7. On the next screen, download a WAV file of the song created. Go to PowerPoint®, and insert the music on the PowerPoint® slide. **Insert → Audio → On My PC** (find file). Drag the speaker icon to a corner. (MAC: Put character and music on the same slide).



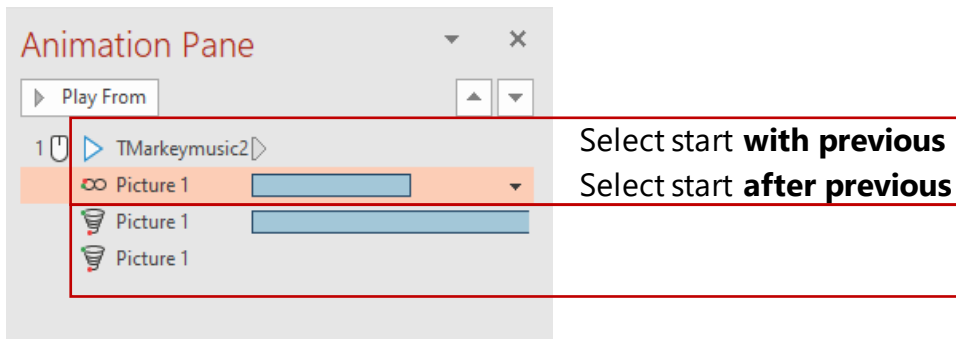
8. Click on your **character** and then **Animations** on the toolbar. Select **Add Animation** and select a **Motion Path**. You may want to repeat this process for multiple movements.

o **Add animation** and create a free-form animation or select a path (MAC: select path animation, then choose to draw free form).

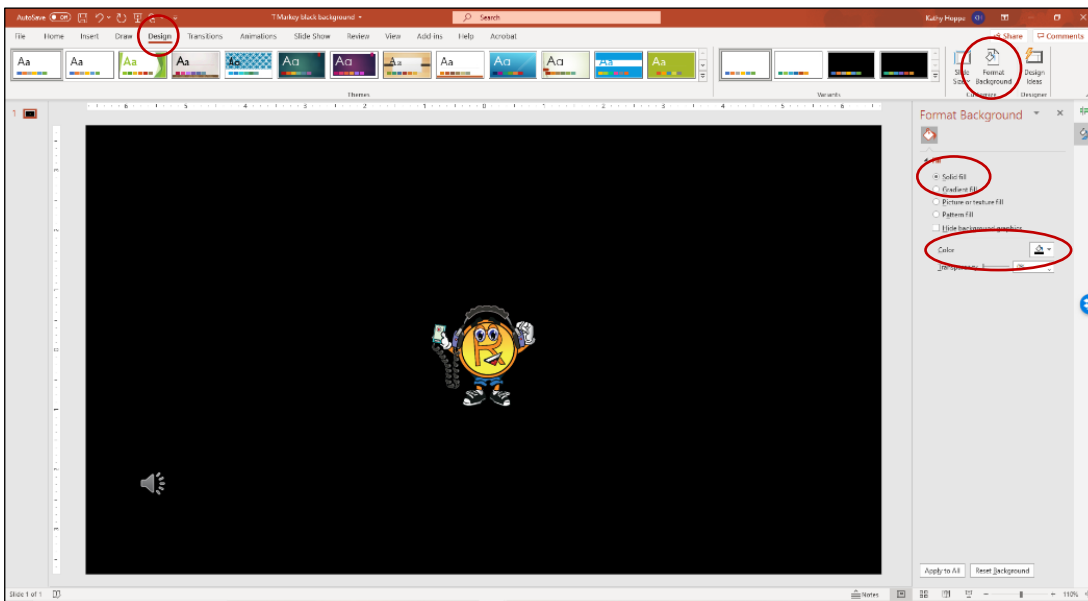
o Create movement that keeps the character close to its original position. (You can make the animation path smaller).



9. Use the animation pane to create a movement to the music. In the animation pane, slide the music file to the top and set it to "start with previous." Select timing and set the music to repeat three times.

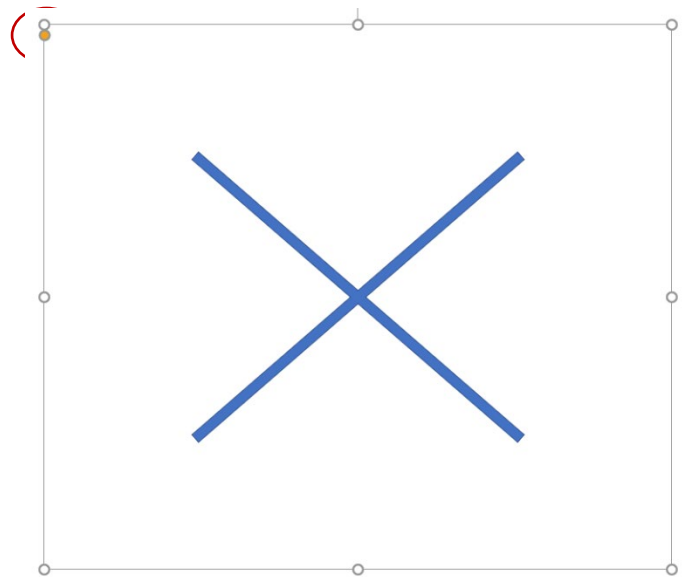
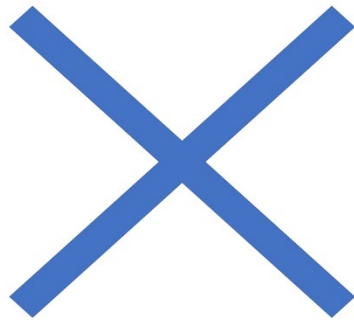


10. Change the background of the slide to black by clicking:  
**Design** → **Format Background** → **Solid Fill** → Select **Black** in the Color option.

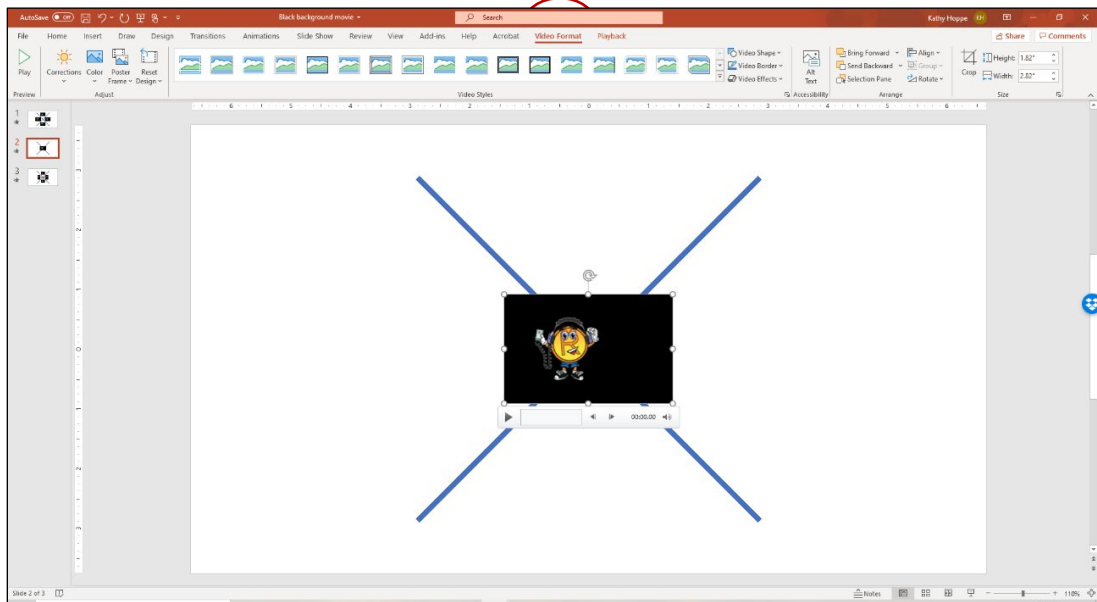


11. Save the slide: **FILE** → **Save As** → **MPEG-4 Video (MP4)** (MAC: -export to a MP4).
12. The simulated hologram uses the behavior of light to create a three-dimensional image inside the projector. Four recordings of the same motion set must be placed at an equal distance to create the 3-D movie.
- Open a new PowerPoint® presentation and set the **layout** to **blank**.
  - From the **Insert** → **shapes**, insert a multiplication sign that will serve as an X.
  - Position the X in the middle of the slide using the guidelines. Hold the down shift key and drag one corner of the X to make it larger.

- Click on the X-shape and use the yellow dot to make the X thinner: this might require dragging with the mouse depressed, releasing, and then dragging the dot again until you get the desired thickness. (MAC: drag the yellow dot up).

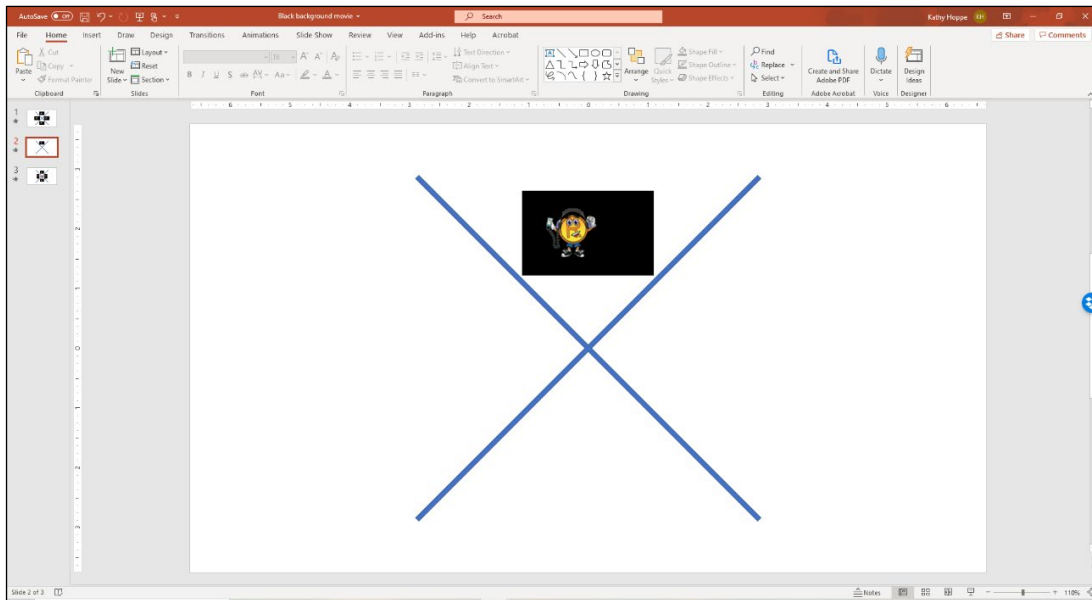


13. **Insert** the **MP4 movie** you saved in step 11 into the PowerPoint® slide with the X.
14. Click on the **Video** and then **Video Format** to **Crop** the movie as much as possible without cropping the motion.

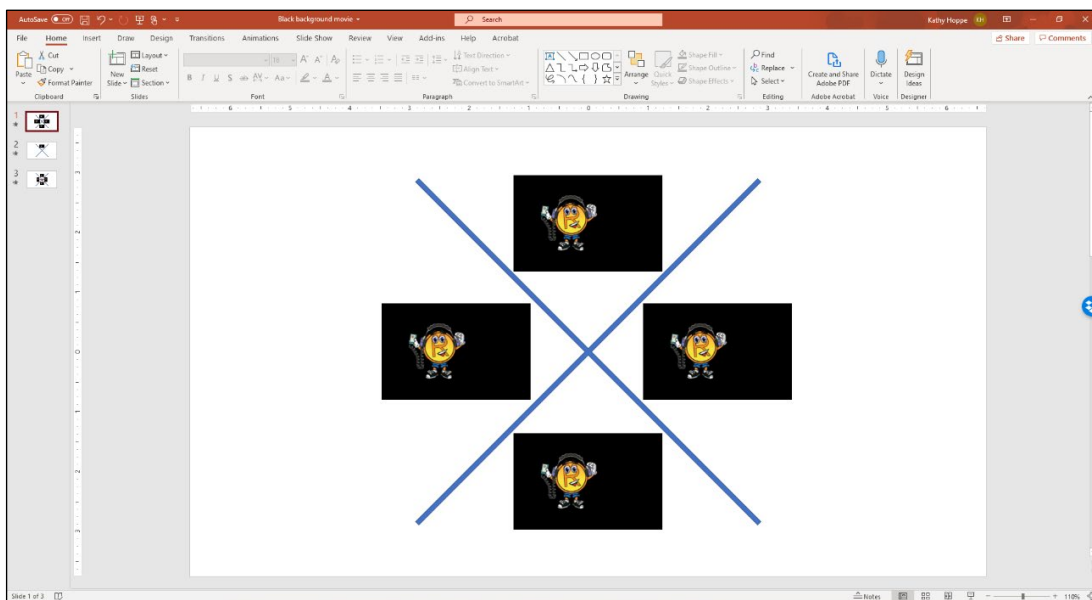


15. Move the movie to the top quadrant of the X.

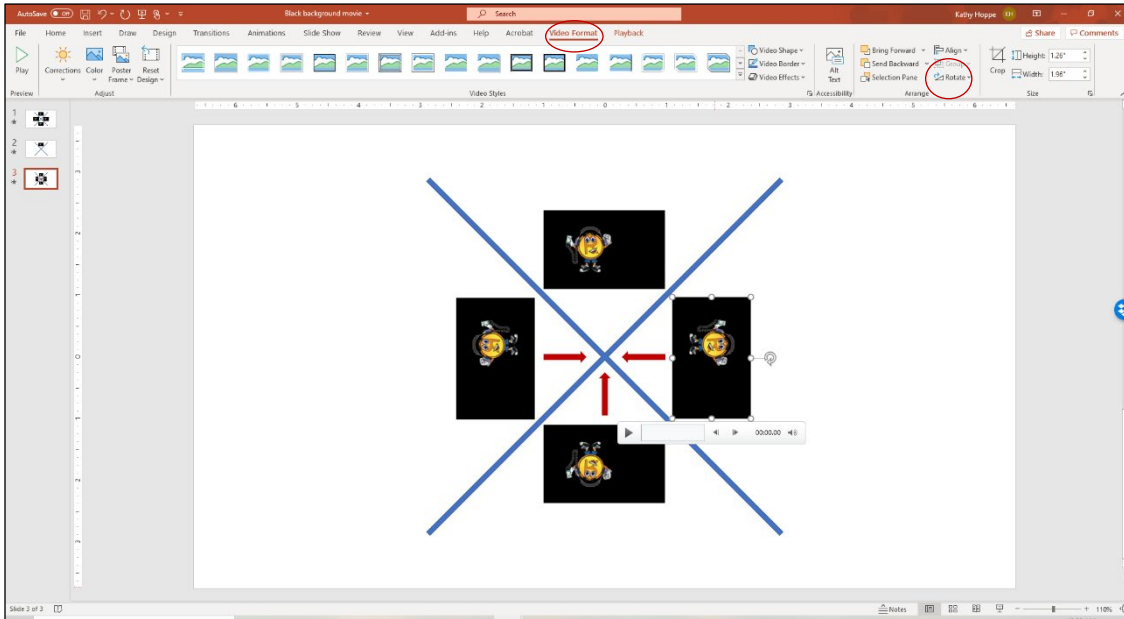
16. Make the movie smaller to keep the motion in the top quadrant of the X when played.



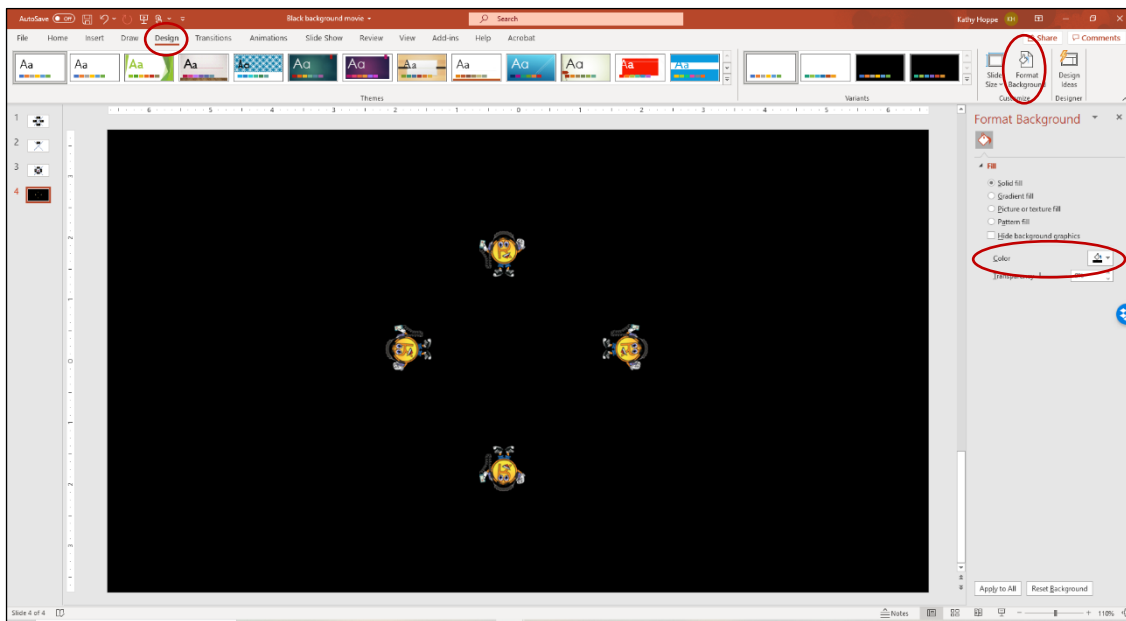
17. Copy and paste three MP4 videos into separate quadrants of the X on the slide.



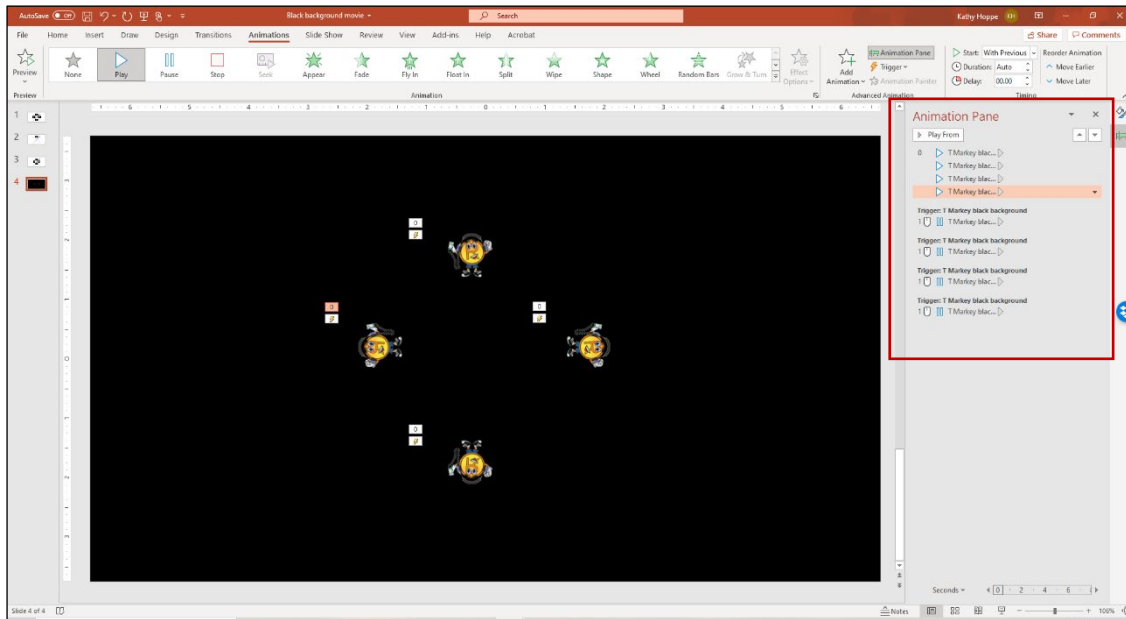
18. Rotate each MP4 video to have the same orientation toward the X as the top image. Click on the **Video**, then on the toolbar, select **Video Format**.
- On the **Video Format** toolbar, select **Rotate**.
  - Rotate each video so that they have the same orientation as the top video toward the intersection of the X.



19. Delete the X from the slide by **clicking the X** and pressing **delete**.
20. Change the background of the slide to black by clicking:  
**Design** → **Format Background** → **Solid Fill** → Select **Black** in the Color option  
(as shown in Step 5).



21. Using the **animation pane**, set each of the MP4 videos so that each **start with previous**, like Step 9. (MAC: go to **Timing** to set this option)



22. Save the slide as a .mp4 video to create the hologram movie.

**FILE → Save As → MPEG-4 Video (.mp4)** (MAC: export to a MP4)

23. Email the video to yourself or save it where you can access it from a cell phone or tablet.

24. Open the hologram movie on your tablet or phone and view it as shown on the next page.

Think about the questions below as you watch the movie.

## Directions for viewing

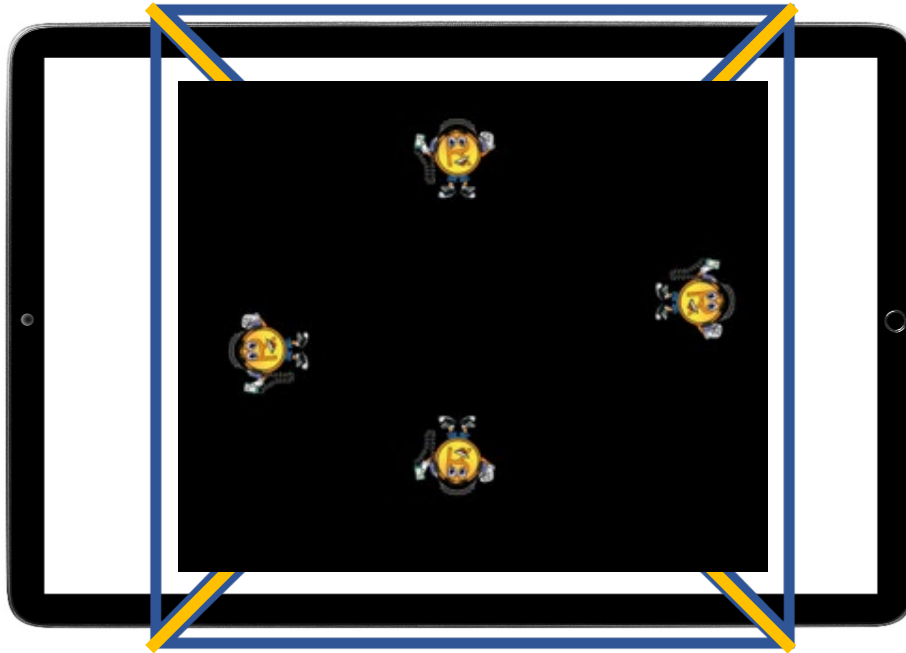
Place the hologram projector over the video you just created on a tablet or phone. View the movie through the side of the projector, as shown in the diagram on the next page. Think about these questions as you view the hologram movie through the projector.

## Questions

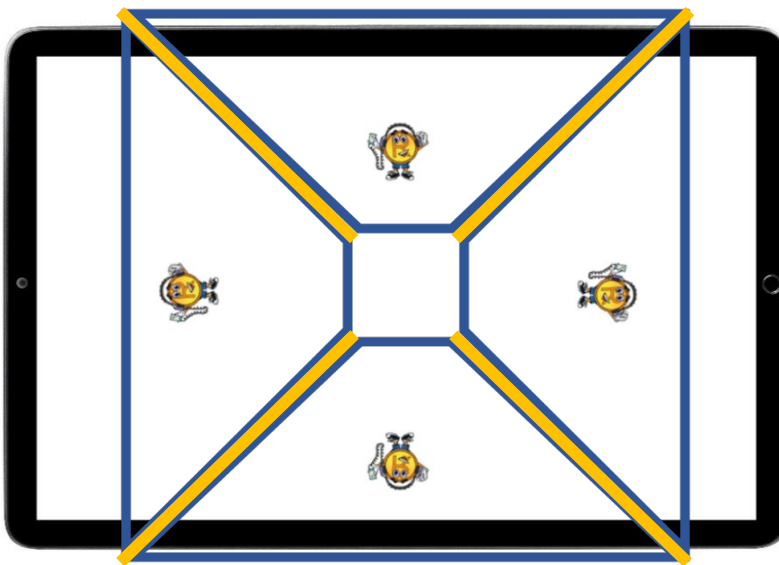
1. How does the projector work to make the videos appear three-dimensional?

2. What properties of light are occurring to make this simulation work?

3. How could you create a different design from the ones you've seen?



4. Draw arrows to demonstrate the behavior of light in the hologram projector. Label and explain what you think happens when the movie projects from the smart device to the simulated projector. Use words describing the behavior of light in your description: Reflection, refraction, polarization, and diffraction.



5. How could a hologram movie like the one you made be used as a trademark?



## Create your own!

Create a new type of simulated hologram projector.

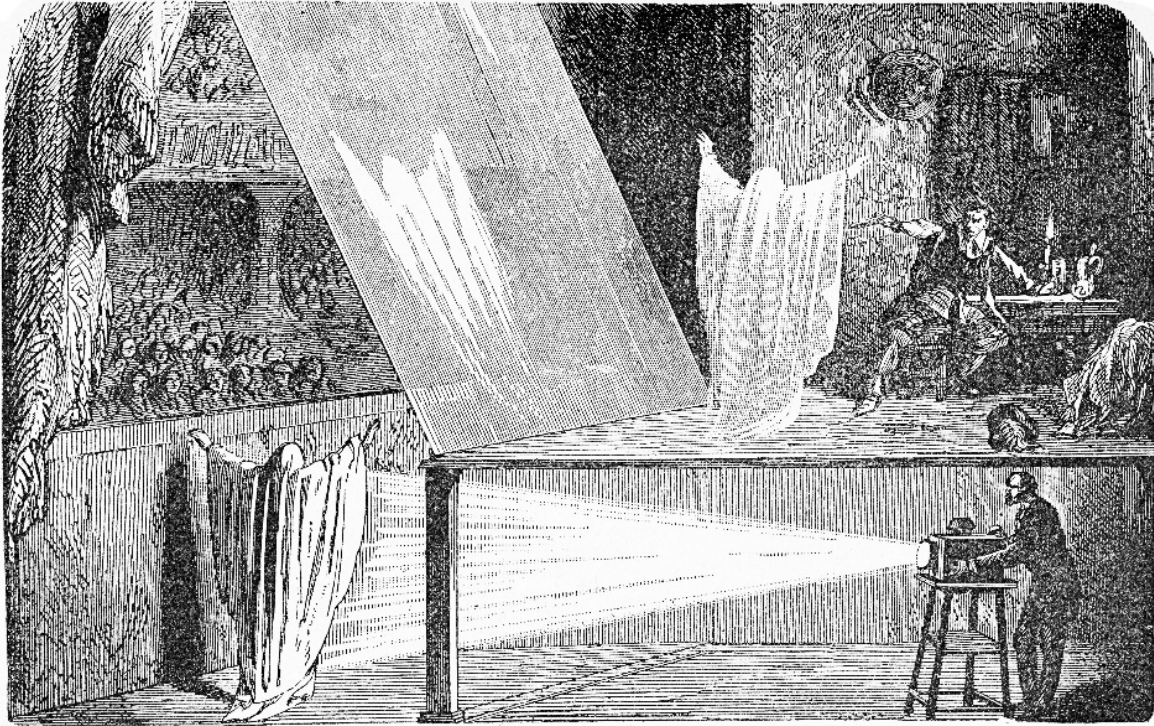
**OPTIONAL:** Create a new video that would work on your hologram projector.



# How does it work? Hologram simulations demystified

## Background

Ellen Ochoa's research helped scientists identify imperfections in equipment deployed to outer space. Her systems for creating holographic images identified structural and engineering faults that could have led to catastrophic events.

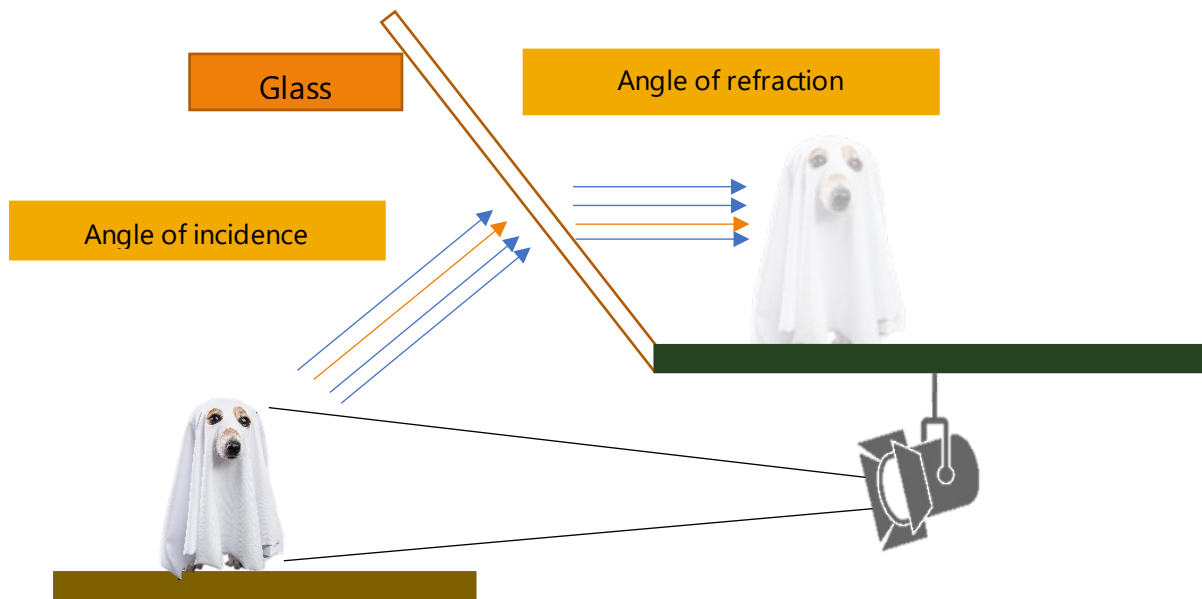


Simulations of holographic images have been a part of history for generations. One example is John Henry Pepper's simulation called "Pepper's Ghost Technique." Pepper used this simulation during theatre presentations in 1862. While Pepper is remembered for developing this projection technique, Henry Dircks was considered the original designer.

The illusion technique used a large glass screen at an angle which would reflect the lighting of an actor in a hidden area not seen by the audience. The actor, or "ghost," would appear on stage with other actors in a play. The "ghost" could be made brighter or dimmer by adjusting the lighting on the hidden actor.

Although holographic technology cannot replicate real life, there are many methods to create a convincing illusion. By understanding how light behaves, scientists can search for optical methods to develop authentic holographic images, as Ellen Ochoa did for the "System for Enhancement of Optical Features" (U.S. Patent 4,674,824).

The image that appeared on stage using “Pepper’s Ghost Technique” is a direct result of the way light behaves. As the diagram below demonstrates, light reflects off smooth, flat surfaces, such as the glass used in Pepper’s technique. As light passes through the glass (the medium), it refracts or bends, resulting in the image of the ghost dog appearing in three dimensions. The angle of incidence and refraction depends on the light speed in each material.



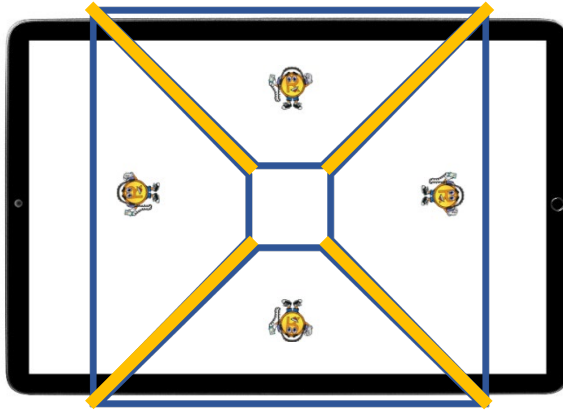
**REFRACTION:** Change of direction or bending of a light wave when it passes through one medium into another. For example, light waves pass through glass and change direction when they enter the air.

**REFLECTION:** When a light wave hits a surface and bounces back. For example, light waves bounce off a mirror at the same angle that they hit the mirror.

### Questions and activity challenge

1. Why is optical imaging technology important for space exploration?

2. Draw arrows on the hologram projector to show how light is reflected and refracted from the movie played on the tablet.



3. Why do the images have to be oriented similarly toward the center of the X?

4. What are some uses of simulated hologram projectors?

5. What are your ideas for creating a new simulated hologram projector?

6. What would you change about the model of the simulated hologram projector you built in this lesson?

7. Draw a diagram and label a new design for a hologram projector. Identify how light will behave in this new design.



8. Do a patent search and see if you can find any inventions like your diagram from question 7. Record your findings.



9. When developing a new hologram projector, what features would you use from the patents you found in question 8?



10. Create a prototype of a hologram projector using available materials.