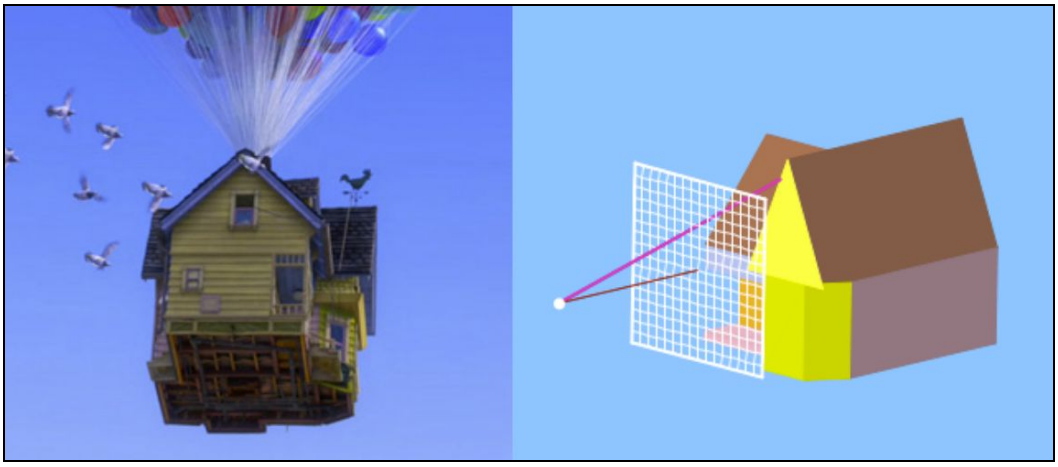
RENDERING 101: FIRST LESSON (link to lesson)



Standards alignment:
NGSS:
MS-PS4-2,
HS-PS4-5

Summary/Overview:
“Rendering” is the final process of a movie, when the technical directors at Pixar calculate the color of every pixel in every frame of every shot in the film. If that sounds incredibly time-consuming, it is! But Pixar gets help from computers which solve mathematical equations.

Lesson Structure: This lesson contains 6 videos and 3 practice exercises which alternate back and forth. One way to run this is to watch and discuss all videos as a group (using a screen at the front of the room) while letting students return to their computers to do the exercises when required.

Total Time Recommended:
Approximately 35-40 minutes to complete the videos and exercises.

Age: Grade 5 - infinity and beyond!

Objectives:
In this lesson, students will:

- Learn more about the basics of rendering and practice some ray tracing and shading

Materials Needed:

- Indoor classroom, lab, or open space with seating and access to the Internet. Space should have enough seating, ideally facing a teacher/facilitator’s projection screen.
- Teacher/facilitator should have a computer connected to a large monitor or projector and speakers.
- This lesson assumes that each student or pair of students will require a device to access the lessons online.

VIDEO 0: Introduction to Rendering (length: 3 mins)

Instructions: Have everyone sit where they can see the screen. From the lesson page, play the video “Introduction to Rendering.” When the video ends, start a discussion with your group using questions below.

Key terms / Vocabulary:

- **Rendering Equation** - A mathematical description of how light bounces around in the environment.
- **Pixel** - A tiny portion of the final image (***fun fact***: the word “Pixel” comes from combining Picture with Element!)

Discussion questions (5 mins):

- **Q:** Why does rendering a film take so long?
- **A:** Because there are so many calculations involved.
- **Q:** What question does the rendering process answer?
- **A:** What is the final color of each pixel in an image?

VIDEO 1: What is Ray Tracing? (length: 4 mins)

Instructions: Introduction to the basics of ray tracing. Have everyone sit where they can see the screen. From the lesson page, play the video “What is Ray Tracing?” When the video ends, start a discussion with your group using questions below.

Key terms / Vocabulary:

- **Render farm-** a collection of thousands of computers that work together to render Pixar films
- **Virtual camera -** a camera inside the computer environment used to “film” movies
- **Image plane** - It represents what the virtual camera will see and is perpendicular to the viewing direction,
- **Ray tracing** - An algorithm that constructs a mathematical ray that determines the color of each pixel in an image.

Discussion Questions (3-4 minutes):

- **Q:** True or False: The image plane is kind of like a *canvas*
- **A:** True, it’s where the renderer paints each individual pixel a particular color
- **Q:** How many pixels are in a real Pixar image?
- **A:** More than two million pixels

PRACTICE: Ray Tracing (5-10 mins)

7 problems covering some key concepts

Instructions: Let's look more closely at how light bounces when it strikes an object. We'll cover reflected and refracted rays. After students are nearly finished, check for understanding before moving on to the next video (remind students they can find help in the hints for each question.)

Exercise Questions:

- **Q:** What did you learn about ray tracing in this exercise?

VIDEO 2: Light Reflection (length: 4 mins)

Instructions: Let's look more closely at how light behaves when it strikes an object. We'll cover *diffuse* and *specular* surface responses. Have everyone sit where they can see the screen. From the lesson page, play the video "Light Reflection." When the video ends, start a discussion with your group using questions below.

Key terms / Vocabulary:

- **Diffuse** - dull surfaces
- **Specular** - shiny surfaces
- **Intensity -** the brightness of the light source
- **Rendering Equation -** Used to calculate the amount of light travelling from a point on a surface back to the camera.

Discussion Questions (4-5 mins):

- **Q:** What are the three factors that make up the rendering equation?
- **A:**
    a. Incoming light - how much light is falling on a point?
    b. Reflection - How the surface of the object at that point reflects light.
    c. Camera position - Location of the camera
- **Q:** What happens to the intensity of light when the flashlight gets closer to the ball?
- **A:** It gets higher or brighter
- **Q:** The brightest point on the surface will be _____ to the light source
- **A:** Perpendicular
- **Q:** Dull surfaces are said to be _____ and shiny surfaces are _____
- **A:** Diffuse, specular
- **Q:** Look around the room and find the object that is the most specular and the most diffuse
- **A:** See what's available in your location! (hint: A mirror is the most specular surface)

PRACTICE: Matching Properties of Lighting (length: 15 mins)

7 problems covering lighting

Instructions: You have been tasked with creating an image of a tennis ball with the lighting condition shown in the image. Use the sliders in the interactive to match the lighting effect as closely as you can. After students are nearly finished, check for understanding before moving on to the next video (remind students they can find help in the hints for each question.)

Exercise Questions:

- **Q:** What did you learn about properties of lighting in this exercise?

VIDEO 3: Light Rays (length: 3 mins)

Instructions: Let's look more closely at how light bounces when it strikes an object. We'll cover *reflected* and *refracted* rays. Have everyone sit where they can see the screen. From the lesson page, play the video “Light Rays.” When the video ends, start a discussion with your group using questions below.

Note: Click here for more detail on refraction!

Key terms / Vocabulary:

- **Shadow Rays** - a ray that starts at the point being shaded and launches off in the direction of the light source
- **Direct Illumination** - light falling on a point comes directly from the light sources
- **Indirect Illumination** - light falling on a point that comes from other objects in a scene
- **Reflected Ray** - bounce off an object
- **Refracted Rays** - pass through an object

Discussion Questions (2-3 mins):

- **Q:** What is the main difference between a reflected ray and a refracted ray?
- **A:** Refracted rays pass through an object while reflected rays bounce off of them.
- **Q:** Can you think of any other surfaces that would refract light? What about refract AND reflect?

PRACTICE: Light Rays (length: 5-10 mins)

7 problems

Instructions: After students are nearly finished, check for understanding before moving on to the next video (remind students they can find help in the hints for each question.)

Exercise Questions:

- **Q:** What did you learn about light rays in this exercise?

VIDEO 4: Rendering Mike Wazowski (length: 2 mins)

Instructions: Case study from Monsters University. Have everyone sit where they can see the screen. From the lesson page, play the video “Rendering Mike Wazowski.” When the video ends, start a discussion with your group using questions below.

Discussion Questions (3-5 mins):

- **Q:** Stop the video at 1:06 after she says “stop the video” and see if students can look at the specular image and identify where the main light source is.
- **A:** Play the video after they respond.

VIDEO 5: Getting to know Susan Fong (length 3 mins)

Instructions: Have everyone sit where they can see the screen. From the lesson page, play the video “Getting to know Susan.” When the video ends, start a discussion with your group using questions below.

Discussion Questions (3-4 mins):

- **Q:** What inspired you about Susan’s experience?
- **Q:** Has anything gotten *you* interested in computer graphics? If yes, what?