DIGITAL TRANSMISSION

TGR FOUNDATION

HIGH SCHOOL

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DIGITAL TRANSMISSION

LESSON OVERVIEW

Students will use a smart device to manipulate shutter speed, capture light motion trails and transmit their digital image. Students will describe how a smart device camera works by identifying the wave behavior and how basic physics principles were utilized in the design, creation and transmittance of their image. They will then discuss real–world problems smart device cameras solve, the needs they address and careers in this field.

THIS LESSON FOCUSES ON

DESIGN PROCESS	21ST CENTURY SKILLS
• Defining the Problem	• Collaboration
• Designing Solutions	• Communication
• Creating or Prototyping	• Critical Thinking
• Refine or Improve	• Creativity
• Communicating Results	

OBJECTIVES

Students will be able to:

- Capture a digital image and manipulate shutter speed.
- Describe how a digital image is created and transmitted using properties of light.
- Explore how light waves are captured by a camera and converted to a digital image.

MATERIALS

For each group of students (2–4):

- Exploring the Digital Camera student capture sheet
- Diffraction grating
- Fluorescent and incandescent light bulbs with power source
- At least 1 light source (such as a flashlight or LED toy)
- 1 camera with Shutter Speed Priority setting

OR

- 1 smartphone or tablet with a camera and an application that allows for shutter–speed manipulation
- If using cameras, tripods are useful but not necessarily needed
- A computer and projector or smartboard
- Compact discs

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HAVE YOU EVER WONDERED...

How photos are sent from one device to another?
To put it simply, a digital image is encoded to a grid of pixels. From there, the grid is encoded into numerical codes of ones and zeros. Radio waves then send images using this series of ones and zeros. Once sent, the digital image is converted back to the grid of pixels. These pixels will once again show your digital image.

How photo filters work?
Computers are programmed to create a statistical model of a face by identifying key facial features. When you use a filter to overlap images around your face, the device overlays facial borders on targeted facial features. This helps the device find your nose, mouth, and eyes to overlay graphics. Other applications may filter an entire image. Designers create boosted contrast, blending, or color hues in editing software and then create algorithms that apply these artsy styles to your images with a quick click!

How to take the perfect selfie?
Lighting and camera angles likely have the most impact! Natural light is soft and diffused and typically photographs best. Cell phones have lighting cases and attachments to bring a similar lighting indoors. Make sure to face the light source, keep your chin down, and the camera up!

MAKE CONNECTIONS!

HOW DOES THIS CONNECT TO STUDENTS?	HOW DOES THIS CONNECT TO CAREERS?	HOW DOES THIS CONNECT TO OUR WORLD?
Digital images are all around us. We use them for work, play and socialization. Students use digital platforms like smartphones and computers to share images and create virtual communities. The memes we view and share every day are digital transmissions of images across several different types of media.	**Theatrical lighting designers** install lighting and operate it during production. They coordinate lighting designs and program light boards. **Graphic designers** create visual concepts using computer software and understand how color is generated by machines to create digital images. **Astronomers** observe visible spectrums of light to identify elements in the universe using telescopes. **Engineers** design, develop, and test lighting equipment. Software engineers develop apps that allow users to send and modify digital images. **Photographers** use various equipment such as filters and extra light sources, to control how light waves are captured in digital cameras to create a photograph.	Taking and sending images allows us to share our lives quickly and openly to large audiences. It builds awareness of events happening all over the word and provides journalists with powerful visual tools. Learning about the visible spectrum and telescopes enables us to explore outer space for signs of life as we know it.

DAY 1

Small Groups (10 minutes):

1. Put students in groups of 2–3 and distribute a camera to each group. You can also have students use a smartphone or tablet instead of a camera.
2. Without mentioning "shutter speed," explain to students that they will now explore an important function of taking a digital image.
3. Distribute Exploring the Digital Camera student capture sheet to each group.
4. Instruct students to operate their cameras or smart device and record all observations as directed.

Whole Group (5 minutes):

1. Discuss the findings of each question from Exploring the Digital Camera student capture sheet.
2. Ask students to share and explain their answer to question 4.
3. Invite students to come to a conclusion about shutter speed, clarify the definition to the class:
   - Shutter speed is the amount of time that the shutter remains open in seconds when taking a photograph in a camera. This speed determines how much light is allowed in. Faster shutter speed = less light. Slower speed = more light.

Small Groups (15 minutes):

1. Transition to the shutter speed activity by providing examples of light motion trail photographs (use the Teacher Resource Sample Long Shutter Photos for examples). With the same group, students will now capture and "draw" their own light motion trails by extending the shutter speed value on their devices to about 5 seconds and using a set of lights.
2. Distribute lights to each small group of students and discuss the setup needed to accomplish the images from Teacher Resource Sample Long Shutter Photos:
   - Dim or turn off the room lights
   - Keep camera or smart device stable (tripod or flat object)
   - If applicable, change the camera setting to Shutter Speed Priority (Tv or S on camera dial)
   - Turn off flash
   - Try out different shutter speed values to capture different effects

   Note to Teacher

   It will be important to have students capture the photos in a room with little light. This will allow longer shutter speed values and a longer "trail" of light.

Follow–Up Questions (10 minutes):

- What is the relationship between shutter speed and brightness?
- How could you share this image with a friend?

DAY 2

Whole Group (5 minutes):

1. Display a high–resolution photograph using a projector or smartboard. Zoom in little– by– little and ask students to share out what they notice. Support their observations by asking the following guiding questions:
   - How do the lines in the image change?
   - How do the colors and shapes change?

   Zoom into the highest magnification the image will allow. Students should be able to see pixels or squares/dots of color, at this point. Explain that a "pixel" is a tiny dot of light and color on a screen. Digital images are comprised of pixels.

2. Explain that in each pixel are three different colored lights (red, green and blue) with varying brightness. These colored lights can dim, brighten, display only one color or several to make another color. Combinations of these pixels create the images you see. This is the similar to how the human eye has three types of cones to see colors. One is sensitive to red, another blue and lastly green. Light waves allow us to see the different colors in the pixels. The wavelengths reflected back determine which color we see. Objects have different colors depending on which parts of the visible spectrum they absorb and which parts of the visible spectrum they reflect.

3. Tell students they are going to be able to collect evidence of how light travels in waves.

4. Pass out the diffraction grating and explain that diffraction grating contains pieces of transparent material onto which hundreds of lines per centimeter have been scratched. As the light passes through these scratches, different wavelengths of light (different colors of light) are bent at different angles, thereby separating the white light into different bands of color.

Small Groups (5 minutes):

1. Distribute a compact disc to each student group. Have them hold the disc with the metallic side up and observe what happens as they spin the disc. The disc acts as a diffraction grating, separating the white light from the classroom lights into various colors. Have the students share within their group what colors they observe.

Small Groups (20 minutes):

1. Give each student group an incandescent light bulb and a fluorescent light bulb. Invite students to light each bulb at the same time and record any differences they observe.

2. Have students hold their diffraction grating up to each light and record the colors they see. It is anticipated that students will notice the incandescent bulb produces a continuous line of color (a continuous spectrum) with violet being the closest color to the bulb. The fluorescent bulb produces a continuous spectrum, but with definite divisions between the colors (violet will be closest to the bulb).

3. Have each student group take a photo of a group member standing in front of each light bulb. Ask students to observe the image and record what they see.
   - Is the person in the photo easy or difficult to see?
   - How do the lights look different in the photo?
   - How does the light look different in–person versus on the camera/device?
   - What changed the appearance of the light?
   - What happens when you use the diffraction grating through the camera lens?
   - How do you think the ranges in wavelengths influenced each photograph?
4. Have students move the subject of the photo so that the light is reflecting on them and not directly behind them. Ask students to turn off the fluorescent bulb for now. Have students take the photo and record any differences.
   - Is the person easier or harder to see than in the last photo? Why do you think this is?
5. Have students repeat the exercise, but this time turning on the fluorescent bulb and turning off the incandescent bulb.
   - How is this photo different than the last?
   - Which photo would you say is better? Why is that?
6. Ask students to manipulate the shutter speed of the device to make it 5 seconds slower and take the same image. How is this image of the lights different than the previous image?
   - How does the subject of the photo look different? What did the shutter speed change about how the image looks?
   - Which type of light, fluorescent or incandescent, transmits better into digital photography? Why do you think that is?
   - Why do you think that light is so important to photography?
   - Taking photographs in direct light sometimes causes the photograph's subject to appear dark or grainy. You might have noticed this when you've taken a selfie in front of a window or source of light—the subject of the photo becomes very hard to see. How would you reframe this image and/or adjust your shutter speed to best capture the subject of the photo?

   Students should conclude that photographs produced with fluorescent lights were only made up a few colors of the visible spectrum. This is supported using the diffraction grating. Students observed choppy, sudden spikes between the wavelengths on the visible spectrum. Photographs produced using incandescent lights are made up of continuous colors of the visible spectrum. Students observed smooth transitions between wavelengths using the diffraction grating.

Whole Group (5 minutes):

1. Summarize with students they observed that light travels in waves. They were able to see this using their diffraction gratings. This helps us understand how an image is captured with a camera. Light waves reflect off of what you are taking a picture of and travel in waves to the lens of a camera. The camera lens focuses and captures the reflected light. When humans view an object, the light travels in waves to meet their eye. Our brains then decode the message to inform us of what we are seeing. Digital devices record light differently than the human eye. Incandescent light that does not shine from behind a subject transmits better in a photographic medium than fluorescent light.

Small Groups (10 minutes):

1. Explain to students that now that we know how to capture and see an image, they will investigate how a digital image is sent. Distribute the following steps or display them (out of order) for students to sequence:
   - A digital image is encoded to a grid of pixels.
   - The grid is encoded into numerical codes, of ones and zeros in combination.
   - Radio waves send images using this series of ones and zeros.
   - Once sent, the digital image is converted back to the grid of pixels.
2. Review the correct sequence with students.
3. Invite students to summarize the advantages and disadvantages of digital transmission and storing of digital images.

TAKE ACTION!

Digital images can be manipulated for different effects. Select one of the following topics and conduct research to explain the relationship between properties of light and digital photography: image filter, facial recognition, image overlay and photo editing.

Facial recognition:
https://www.fbi.gov/file–repository/about–us–cjis–fingerprints_biometrics–biometric–center–of–excellences–face–recognition.pdf/view

Image filters and overlay:
https://thetartan.club.cc.cmu.edu/2016/9/12/scitech/woah–x2

NATIONAL STANDARDS

Next Generation Science Standards

High School

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Obtaining, Evaluating, and Communicating Information Communicate technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).	**PS3.D: Energy in Chemical Processes** Solar cells are human-made devices that likewise capture the sun's energy and produce electrical energy. (secondary) **PS4.A: Wave Properties** Information can be digitized (e.g., a picture stored as the values of an array of pixels); in this form, it can be stored reliably in computer memory and sent over long distances as a series of wave pulses. **PS4.B: Electromagnetic Radiation** Photoelectric materials emit electrons when they absorb light of a high-enough frequency. **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.	Cause and Effect Systems can be designed to cause a desired effect.

EXPLORING DIGITAL IMAGE STUDENT CAPTURE SHEET

If applicable, change the mode on the Camera Dial to Tv or S.

1. Camera: Take one photograph with the setting at 1/500. Take a second photograph with the setting at 1/4. Smart device: Take one photograph on the app's lowest value/setting and one at the highest value/setting.

   What differences do you see in the photographs?

2. Change the setting to 2" (2 seconds) on the camera or the highest value available on the app. Take a few photographs while moving the camera around the room. What do you see and why do you think this occurs?

3. Just having used different settings, what do you think these numbers and fractions represent?

TEACHER RESOURCE SAMPLE LONG SHUTTER PHOTOS