The world is a colorful place when light shines. How many colors can you see in the images shown? How many colors are there? How many colors can you see on a television or computer screen?

**Materials:** (Each of the following is required per group)
- 1 sheet of thick paper with printed pattern
- Tempera paint
- Cups (6 or more)
- Stir sticks
- Paint brush
- Well plates
- Plastic droppers (1 mm size preferred)

**Procedures — Custom Colors**
1. What are the three colors of tempera paint you have?

2. Use two droppers, one for each color, to mix equal amounts (ratio of 1:1) of two colors of paint in a well plate using Fig. 1 and the teacher demonstration.

   ![Figure 1: Technique for mixing an equal ratio of two colors of paint](image)

3. Use the additional sheet of art paper and paint the squares below the color label. Then mix a 1:1 ratio of the colors in a cup to paint the square in the box on the right. Record the color you observe.
   - a. Red + Yellow =  
   - b. Red + Blue =  
   - c. Blue + Yellow =  

4. Mix equal amounts of all three colors a ratio of 1:1:1.
   - a. What color does it make?  
   - b. How many units of volume do you have?  

5. Mix unequal amounts of the primary colors of paint in the empty wells on your plate using Fig. 2.

   ![Figure 2: Technique for mixing an equal ratio of two colors of paint](image)
Development – Custom Colors
1. What are the three primary colors of pigments you started with?

2. Can you mix any other colors to create a primary color?

3. What are the three secondary colors of pigments created by mixing the primary colors at 1:1 ratios?

4. What happens when you mix uneven ratios 2:1 of primary colors?

5. How did you measure the amount of each color of paint?

Assessment – Custom Colors
1. Use your paint supplies and extra cups to mix multiple shades of paint.
2. Change the ratio of each color you mix to fill in the color wheel on an additional sheet*.
3. Match the paint color you create to a colored pencil to fill in the color wheel below.

![Color wheel diagram]

Figure 3: Color wheel creating by mixing different ratios of paint.

4. Create your own custom paint: mix multiple colors together at any ratio.
   a. Write the ratio of paint drops for your color (Red:Yellow:Blue)
   b. Create a name for your color
**Introduction – Light Show**

Watch the teacher demonstration of a prism or spectroscope in sunlight or indoor lights. How do you describe light? Think about what happens when people wear sunglasses?

**Materials:** (Each of the following is required per group)
- Light mixing kit (light bulbs require a lamp)
- Spectroscope
- Visible light power meter
- Colored pencils

**Procedures – Light Show**

1. Become familiar with the spectroscope and use it to view two light sources: the sun and room lights.

![Figure 4: How to use a spectroscope to view the colors of a light bulb.](image)

2. Fill in the colors over the question marks that you see inside the spectroscope near the numbers.

![Figure 5: The colors of sunlight and room lights viewed with a spectroscope.](image)

```
Wavelength in 10^-7 meters

<table>
<thead>
<tr>
<th>7</th>
<th>6</th>
<th>5</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>RED</td>
<td></td>
<td>GREEN</td>
<td></td>
</tr>
</tbody>
</table>
```

3. Become familiar with the light mixing kit by changing the color controls to “white” light.

4. Measure the brightness of your light source with a light meter. Hit the “Range” button on the light meter until a number other than “1.” appears on the screen.
5. Record the reading on the light meter

6. View with a spectroscope what color do you see?

7. Change the brightness of the light by pressing the bottom right yellow button.

8. Record the reading on the light meter

9. View with a spectroscope what colors do you see?

10. Fill in the table below for the different colors of light produced by the kit.

<table>
<thead>
<tr>
<th>Color Produced</th>
<th>Colors Visible in Spectroscope</th>
<th>Light Meter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Green</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blue</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yellow</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cyan (light blue)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Purple</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 1: Light mixing kit color measurements.

Development – Light Show

Spectroscopes measure the color of and light meters measure the intensity.

1. What are the three primary colors of light for your light bulb used to make white light seen in the spectroscope?

2. Are these the same primary colors as the pigments? If not which color has changed?

3. Were the same light colors were used to make less bright white light?

4. Was the light meter reading the same for bright and less bright white?
The light meter measures intensity. Another way to describe intensity is how bright the light is.

5. How bright was red light (data from Table)?

6. How bright was blue light (data from Table)?

7. How bright was purple light (data from Table)?

8. What two colors made purple light?

9. To mix paint we used drops of volume. What unit of measurement do you mix light by?

**Assessment – Light Show**

1. Use a spectroscope to view a picture displayed on your computer monitor (may require web access).

2. Change and record the color for the computer desktop (not Red, Green or Blue).

3. View the computer monitor with a spectroscope. What colors are visible?

4. How many colors of light can you see on the computer monitor with a solid background?

5. How many colors of light can you see when the monitor is viewed with a spectroscope?

6. Set the background color to blue.

7. How many colors of light can you see when the blue monitor is viewed with a spectroscope?

8. What other monitor colors would show as only one color when viewed with a spectroscope?

9. Are the color lines the same brightness?
Procedures – Computer Images

1. Open a computer paint program. (Windows© Start Menu => Accessories => Microsoft Paint©)
2. Open the custom color menu shown in Figure 8.
3. Look in the lower right corner at the colors. What are the three primary colors of these computer images?

![Figure 8: Opening Microsoft Paint and the custom color palette.](image)

4. Adjust the amount of **Red, Green, and Blue**.
5. What is the biggest “amount” of each color you can use?
6. Open the Image:Resize menu.

![Figure 9: Image size control menu.](image)

7. What units can be used to measure the size of the image?
8. Adjust the horizontal and vertical size. Describe in sentences what happens on the screen?

9. Draw an image that is 100 pixels by 100 pixels and choose save as from the “File” menu.

10. What types of image files can you save? Click on the “Save As Type Box”.

11. Save the file as a **256 Color Bitmap** with the name *100x100.bmp*.

12. Open the Image:Resize menu again.

13. Change the dimension unit to Pixel. Make sure the Aspect Ratio box does not have a check.

14. Enter 1280 the horizontal dimension and 800 in the vertical dimension.

15. Describe what happens on the screen? How big is the white area now?

16. Save the file as a **256 Color Bitmap** with the name *1280x800.bmp*.

**Development – Computer Images**

Image files and monitors are 2-dimensional rectangular maps of pixels. A pixel is a solid square of one color. Each pixel has three lights or lenses that control the amount (brightness) of light from each color for that pixel.

![Pixel Array Diagram](image-url)

**Figure 10:** Pixel array for a computer image or monitor.

1. Using the diagram above calculate the number of pixels in the image file *100x100.bmp*.

2. Open Windows Explorer or a similar file browser to view the size of the file.
3. What is the file size for your image?

4. Subtract 54 bytes from the file size.

5. How many pixels are in your image (answer #1)?

6. How many bytes are stored per pixel?

7. Why does each pixel have three bytes? (Think about the number of primary colors.)

8. Calculate the number of pixels in the second image 1280x800.bmp.

9. Calculate the number of bytes to store this image.

10. What is the unit to measure the size of files and computer memory?

11. What is a byte?
**Materials:** (Each of the following is required per group)
- 1 sheet of thick paper with printed pattern
- Scissors
- Hole punch
- 3 book rings
- Stapler
- Markers
- Calculator

**Procedures – Counting**

1. Cut along the dotted lines of the additional sheet of paper with a pattern.
2. Create two sets of numeral tiles (0, 1, 2, 3, 4, 5, 6, 7, 8, and 9) with a hole punched in the top.
3. Create two additional tiles with 0 and 1 on them.
4. Create two tiles with your team or individual logo. Customize your calculator with color.
5. Fold the remaining piece of paper along the solid line to build a calculator using the using the diagram below. Use one digit or set of numerals.

![Figure 12: A manual calculator design with decimal numbers.](image1)

6. How high can your calculator count? 
7. How many numbers can your calculator display? (Zero is a number!) 
8. How many tiles did it take to make the numbers? 
9. If you want to show the result of adding 1+9 how must you change your calculator? 

10. Add another digit or set of numerals to your calculator.

![Figure 13: A manual calculator with two decimal digits and two calculators next to each other.](image2)

11. How high can your calculator count? 
12. How many numbers can your calculator display? (Remember 0.) 
13. How many numerals (number tiles) did it take to make the display?
14. Place two calculators next to each other. How high can the new calculator count? __________

15. How many numbers can two calculators display? (Remember zero.) __________

16. How many numerals (number tiles) did it take to make the display? __________

Development – Counting

We usually use the **decimal** number system in everyday life. The word decimal has the root *dec*-. A *decade* is ten years. Your calculator is built using decimal numbers.

1. How many different numerals does the decimal system have? And what are they?

2. How do you add 1 point to your calculator? Describe your actions in sentences.

3. Do zeros in front of a number change the amount? Are these numbers the same? __________

```
        49   049   0049   000000049
```

4. What additional mathematical step (shown by the arrows) do you perform when you add 9+1, 19+1, or 19 + 11? __________

```
    + 01
   109
+ 119
+ 119
+ 1099
```

Figure 14: Adding decimal numbers.

5. How do you add 1 point to your calculator if the calculator reads “29”? Think about how you carry a “1” into the next digit. Answer in sentences.

```
29
+ 1
```

Figure 15: Adding decimal numbers with your calculator.
6. How do you read a number: the digit on the right (3) is multiplied by 1; the digit in the middle (2) is multiplied by 10; what is the digit on the left (1) multiplied by?

\[1 \times ? + 2 \times 10 + 3 \times 1 = 123\]

7. What would another digit to the left of the number above be multiplied by, the digit 7 in 7123?

8. An exponent is another way of writing a number that means multiply the number by itself. Fill in the next equation.

\[
\begin{align*}
10^2 &= 10 \times 10 = 100 \\
10^3 &= 10 \times 10 \times 10 = 1000 \\
10^4 &= ?
\end{align*}
\]

9. A special case is zero; any number to an exponent of 0 equals 1. Fill in the missing numbers.

\[
\begin{align*}
10^0 &= 1 \\
2^0 &= ? \\
7^0 &= 1 \\
9946528^0 &= ?
\end{align*}
\]
Procedures – Binary Calculator

1. Modify your calculator by removing all the numbers except “0” and “1”. Add a third digit (a set of “0” and “1” tiles).

   ![Binary Calculator Display](image)

   Figure 16: Binary calculator display.

2. How do you add with only “0” and “1” with no other numerals? When you add “1+1” you get “0” plus you have to carry a “1” into the next digit

   \[
   \begin{array}{c}
   00 \\
   + 01 \\
   \hline
   01
   \end{array} \quad \begin{array}{c}
   101 \\
   + 01 \\
   \hline
   10 \\
   \end{array} \quad \begin{array}{c}
   011 \\
   + 001 \\
   \hline
   100
   \end{array}
   \]

3. Start at “000” and count by adding one to your calculator. Fill in the table below.

<table>
<thead>
<tr>
<th>Count</th>
<th>Left Digit</th>
<th>Middle Digit</th>
<th>Right Digit</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

4. How many numbers can you display with 1 digit?
   
   5. How many numbers can you display with 2 digits?
   
   6. How many numbers can you display with 3 digits?
   
   7. Place two calculators next to each other. How many patterns can you make out of four binary digits on a calculator?

   8. How many patterns do you think you can arrange with 8 digits? Show any math calculations you do.
Development – Binary Numbers

1. The word decimal has the prefix *dec*- which stands for 10 as in a *decade* is ten years. How many digits are in a *binary* system and what are they. (Hint: How many wheels do *bicycles* have?)

2. The number $123_{10}$ (the subscript says the number **BASE** is 10 or decimal) can be rewritten using exponents

\[
123_{10} \leftarrow \text{Base 10}
\]

\[
1 \times 10^2 + 2 \times 10^1 + 3 \times 10^0 = 123
\]

100’s Digit 10’s Digit 1’s Digit

\[
100 + 20 + 3 = 123
\]

What is the decimal equivalent value of binary numbers $111_2$ and $101_2$?

\[
111_2 \leftarrow \text{Base 2}
\]

\[
1 \times 2^2 + 1 \times 2^1 + 1 \times 2^0 = 7_{10}
\]

4’s Digit 2’s Digit 1’s Digit

\[
1 \times 2^2 + 0 \times 2^1 + 1 \times 2^0 = ?
\]

4’s Digit 2’s Digit 1’s Digit

3. Can you finish the table below?

<table>
<thead>
<tr>
<th>Binary #</th>
<th>1</th>
<th>10</th>
<th>100</th>
<th>1000</th>
<th>10000</th>
<th>100000</th>
<th>1000000</th>
<th>10000000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decimal #</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2: Binary numbers and their decimal equivalent.

4. Each *binary digit* (either a 1 or a 0) is called a **bit**. Eight bits forms a **byte**. A memory location on a hard drive or flash drive is stored in bytes. How many different values can be stored in one memory byte?

5. If a flash drive has 1024 bytes how many bits are there? __________________________
6. Hexadecimal numbers use base 16 (*hex* - six, *dec* - ten). This means that the numbers 0-9 aren’t enough; we need sixteen symbols not just ten. We use the letters A-F for the other six. Can you fill in the table below?

<table>
<thead>
<tr>
<th>Hexadecimal (base 16)</th>
<th>Decimal (base 10)</th>
<th>Binary (base 2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D</td>
<td></td>
<td></td>
</tr>
<tr>
<td>E</td>
<td></td>
<td></td>
</tr>
<tr>
<td>F</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 3: Hexadecimal number table with decimal and binary equivalent.
**Procedures – Computer calculator (Microsoft Windows 7 Version)**

1. Open a calculator program such as Microsoft Calculator©.

2. Change the view to “Programmer”

![View menu](image1.png)  
![Programmer View](image2.png)

Figure 17: Opening a calculator program in "Programmer" mode.

3. Record your observations next to the letters below of how the screen changes.

![Calculator Program](image3.png)

Figure 18: Calculator program in "Programmer" mode.

a. Describe in sentences how the number buttons changed.

b. Describe in sentences the menus on the left side of the screen.

c. Describe in sentences the display below the calculator display.
4. Use the menu box on the left side of the calculator (labeled as b) in Figure 18) with the options Hex, Dec, Oct, and Bin. Record the changes in the buttons for each option.

5. Click on the “Dec” mode. Type the number 255 into the calculator. Click on the “Hex” mode.

6. What number is displayed on the calculator display?

7. Click on the “Hex” mode. Type the number “AA” into the calculator. Click on the “Dec” mode.

8. What number is displayed on the calculator display?
Development – Computer calculator (Microsoft Windows 7 Version)

1. Answer some of the question from the previous section using the calculator program.
2. Can you finish the table below?

<table>
<thead>
<tr>
<th>Binary #</th>
<th>10</th>
<th>1000</th>
<th>10000000</th>
<th>1010</th>
<th>11111</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decimal #</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 4: Binary numbers to convert to decimal with a calculator.

3. Fill in the table below using the Calculator program?

<table>
<thead>
<tr>
<th>Hexadecimal (base 16)</th>
<th>Decimal (base 10)</th>
<th>Binary (base 2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>F</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AF</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FF</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FFFFFFF</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 5: Hex numbers to convert using a calculator.
Procedures – Save and Edit a Real Webpage (Internet Explorer Version 9.0)

1. Open a well known web page from the internet using Internet Explorer.
2. Click on the tools icon or press the “Ctrl” button and the “S” button at the same time.
3. Save the file to the computer hard drive desktop.

4. Open the HTML document from the hard drive in Internet Explorer (you will have two windows).
5. **Right-click** on the HTML document and “Open with” WordPad or similar text editor.
6. Describe what the webpage (.html file) looks like when opened in WordPad? Write the first three words you can read.

An HTML file has several sections. One is the page **title** that starts with the text `<title>`. Use the Find function press `CTRL + F` to find the text “title”

![Find function in a text editor](image)

**Figure 22:** Using the find function in a text editor.

7. What is the title of this web page?

8. Edit the title to your name.

9. Save the text document.

10. Hit refresh on the web browser window that opened your file.

11. Describe any changes that occurred.

12. Another section of an HTML file is the **background color**. Find lines of text with the word “color:” Write the first three the numbers that follow the word color.

13. What type of number is used to choose the web page color?

14. What color is the webpage background?

Use the Replace function press `CTRL + H` to replace the hexadecimal numbers “FFF” with “000”.
15. Save the text document.
17. Describe the changes that occurred.
Procedures – Edit a Webpage color (Firefox)

1. Open the web page template from the website given by the teacher using Firefox.
2. Click on the view tab at the top toolbar, or press the “Ctrl+U” button at the same time.
3. Save the file to the computer hard drive using any name, you choose. The file should be saved in a folder on the desktop named “IEAWebpage”.

Figure 24: Saving a web page to a computer hard drive.
4. Open the HTML document from the location on the hard drive using WordPad or similar text editor.

Development – Edit a Webpage color

1. There are six white squares in the web page you opened. Change the colors of the squares to reflect the appropriate color written inside the box. In the third box that doesn’t have a color written inside, you are to change the color of the box to whatever color the previous two colors create when mixed. (Hint: Find the name of the color in the HTML file or search for each box based on its name e.g. colorbox1.)

2. Change the entire webpage background to “Light Blue”. What is the line of text you edited? (Hint: Search for “<body style="color: rgb(0, 0, 0); background-color: rgb(0, 0, 0); alink="#000099" link="#000099" vlink="#990099">” within the HML file.)

3. Change the instructions at the top of the page to “Black”. What is the line of text you edited? (Hint: Search for the instructions in the HTML file.)

4. Change of the background of all the tables to “Blue”. What is the line of text you edited? (Hint: Search for “<td style” within the code)

5. Find this line of code in the file: “<table border=5 cellpadding=1 cellspacing=1” . Type 3 sentences describing the lesson you participated in today. (Hint: use the following line of code <h1 style="color: #FF0000; font-size: 20px"> Insert Your Sentences Here </h1>)

6. Change color of text that you just input to color of your choice. What is the line of text you edited? (Hint: <h1 style=”color:textcolor;” is used to control color of text)