



Curricular Guide for a Learning unit in Theatrical Lighting Design

Content Area: Theatre

Unit Title: Lighting Design

Target Course/Grade Level: Grades 9-12

Unit Summary: Stage lighting is an actionable technical and artistic tool for storytelling. In this unit students will be able to identify and describe possible career paths with a background in lighting design and technology as well as begin to develop an understanding of and manipulate the four controllable qualities of light: angle, color, distribution, and movement. In addition, students should be able to describe the basic architecture of a modern computerized lighting control console with an emphasis on understanding: a) patching b) live and blind modes c) writing timed cues and d) saving and loading files.

Approximate Length of Unit: Modify as needed

New York Student Learning Standards:

HS Proficient

- **TH:Cr1.1.HSI**
 - a. Apply basic research to construct ideas about the visual composition of a drama or theater work.
 - b. Explore the effect of technology on design choices.

HS Accomplished

- **TH:Cr1.1.HSII**
 - a. Investigate historical and cultural conventions and their effect on the visual composition of a drama or theater work.
 - b. Understand and apply technology to design solutions for a drama or theater work.

HS Advanced

- **TH:Cr1.1.HSIII**
 - a. Synthesize knowledge from a variety of dramatic forms, theatrical conventions, and technologies to create the visual composition of a drama or theater work.
 - b. Create a complete **design** for a drama or theater work that incorporates **technical elements**.



Curricular Guide for a Learning unit in Theatrical Lighting Design

New Jersey Student Learning Standards:

H.S. Proficient:

- 1.4.12prof.Cr1
 - a. Research to construct ideas about the visual composition of devised or scripted theatre work.
 - b. Explore the impact of technology on design choices in devised or scripted theatre work.
- 1.4.12prof.Cr3 c. Explore technical design choices that support the story and emotional impact of a scripted or devised theatre work.
- 1.4.12prof.Cr2
 - b. Examine the collaborative nature of the actor, director, playwright, and designers, and explore their interdependent roles.
 - c. Explore technical design choices that support the story and emotional impact of a scripted or devised theatre work.
- 1.4.12.prof.Pr4 b. Use technical elements to increase the impact of design for a theatre production.
- 1.4.12.prof.Re8 b. Evaluate the aesthetics of the production elements in a devised or scripted theatre work and their ability to support or extend the storyline.

H.S. Accomplished:

- 1.4.12acc.Cr1 b. Understand and apply technology to design choices for devised or scripted theatre work.
- 1.4.12acc.Cr2 b. Cooperate as a creative team to make informative and analytical choices for devised or scripted theatre work.
- 1.4.12acc.Cr3 c. Re-imagine technical design choices during the course of the rehearsal process to enhance the story and emotional impact of a devised or scripted theatre work.
- 1.4.12acc.Pr4 b. Apply theatrical elements and research to create a design that communicates the concept of a theatre production.
- 1.4.12acc.Re8 b. Construct meaning in a devised or scripted theatre work, considering personal aesthetics and knowledge of production elements while respecting others' interpretations.



Curricular Guide for a Learning unit in Theatrical Lighting Design

New Jersey Student Learning Standards (continued):

H.S. Advanced:

- 1.4.12adv.Cr1 a. Synthesize knowledge from a variety of theatrical conventions and technologies to create the visual composition of devised or scripted theatre work.
- 1.4.12adv.Cr1 b. Create a complete design for devised or scripted theatre work that incorporates multiple elements of technology.
- 1.4.12adv.Cr2 a. Collaborate as a creative team to make informative and analytical choices for devised or scripted theatre work.
- 1.4.12adv.Cr2 b. Collaborate as a creative team to make original artistic choices in devised or scripted theatre work.
- 1.4.12adv.Cr3 c. Originate and construct technical design choices that support the story and emotional impact of a devised or scripted theatre work.
- 1.4.12adv.Pr4 b. Create and justify the selection of technical elements used to develop and build a design that communicates the concept of a drama/theatre production.
- 1.4.12adv.Re8 b. Analyze and evaluate varied aesthetic interpretations of production elements for the same devised or scripted theatre work.

Career Readiness, Life Literacies, and Key Skills:

9.2 CAREER AWARENESS, EXPLORATION, AND PREPARATION

- 9.2.8.B.3 Evaluate communication, collaboration, and leadership skills that can be developed through school, home, work, and extracurricular activities for use in a career.
- 9.2.8.B.4 Evaluate how traditional and nontraditional careers have evolved regionally, nationally, and globally.
- 9.2.12.C.3 Identify transferable career skills and design alternate career plans.
- 9.2.12.C.4 Analyze how economic conditions and societal changes influence employment trends and future education.
- 9.2.12.C.6 Investigate entrepreneurship opportunities as options for career planning and identify the knowledge, skills, abilities, and resources required for owning and managing a business.

9.3 – Career & Technical Education (CTE)

- 9.3.12.AR-PRF.7 Describe how technology and technical support enhance performing arts productions.



Curricular Guide for a Learning unit in Theatrical Lighting Design

Interdisciplinary Connections and Standards:

Social & Emotional

- SEL.PK-12.1.3 - Recognize one's personal traits, strengths, and limitations.
- SEL.PK-12.1.4 - Recognize the importance of self-confidence in handling daily tasks and challenges.
- SEL.PK-12.2.2 - Recognize the skills needed to establish and achieve personal and educational goals.
- SEL.PK-12.2.3 - Identify and apply ways to persevere or overcome barriers through alternative methods to achieve one's goals.
- SEL.PK-12.3.1 - Recognize and identify the thoughts, feelings, and perspectives of others.
- SEL.PK-12.5.2 - Utilize positive communication and social skills to interact effectively with others.

Overall Goals of the Lighting Design Unit:

1. The lighting designer serves as a technical and artistic role in the performing arts industry that includes work in theatre, opera, dance, concert settings, as well as industrial applications; however, more career paths are possible.
2. The lighting designer's main objective is to tell a story through the shaping and manipulation of the four controllable qualities of light (angle, color, distribution, and movement) on a modern computerized lighting control console.
3. Training as a lighting designer can lead to a prolific career not only in the legitimate theatre, but also in film, television, industrial design, etc.
4. A modern computerized lighting control console is used to manipulate the four controllable qualities of light.

Unit Essential Questions:

- What is the role of a lighting designer?
- How can lighting be used as a technical and artistic tool for storytelling?
- What transferable skills and/or careers are available to me as a lighting designer?
- How does a modern computerized lighting control console function as a technical tool for lighting design?



Curricular Guide for a Learning unit in Theatrical Lighting Design

Knowledge and Skills:

Students will know...

- The role of the lighting designer.
- That light is a technical and artistic tool for storytelling.
- The four controllable qualities of light: angle, color, distribution, and movement.
- The basic functions of a modern computerized lighting control console.
- How to manipulate the four controllable qualities of light.

Students will be able to...

- Define the role of the lighting designer in the performing arts industry and beyond.
- Understand light as a technical and artistic tool for storytelling.
- Analyze and manipulate the four controllable qualities of light
- Identify the basic functions of a modern computerized lighting control console.

Assessment:

What evidence will be collected and deemed acceptable to show that students truly “understand”?

- Observation
- Participation in Experiential Activities
- Post-Activity Reflective Discussion

Teacher Resources:

- Taylor, C. (2019). Color and Light: Navigating Color Mixing in the Midst of an LED Revolution, a Handbook for Lighting Designers (pp. 183–186). Quite Specific Media ISBN-13: 978-1935247197



Curricular Guide for a Learning unit in Theatrical Lighting Design

504 Accommodations:

- Provide scaffolded vocabulary and vocabulary lists.
 - Provide extra visual and verbal cues and prompts.
 - Provide adapted/alternate/excerpted versions of the text and/or modified supplementary materials.
 - Provide links to audio files and utilize video clips.
 - Provide graphic organizers and/or checklists.
 - Provide modified rubrics.
 - Provide a copy of teaching notes, especially any key terms, in advance.
 - Allow additional time to complete assignments and/or assessments.
 - Provide shorter writing assignments.
 - Provide sentence starters.
 - Utilize small group instruction.
 - Utilize Think-Pair-Share structure.
 - Check for understanding frequently.
 - Have students restate information.
 - Support auditory presentations with visuals.
 - Weekly home-school communication tools (notebook, daily log, phone calls or email messages).
 - Provide study sheets and teacher outlines prior to assessments.
 - Quiet corner or room to calm down and relax when anxious.
 - Reduction of distractions.
 - Permit answers to be dictated.
 - Hands-on activities.
 - Use of manipulatives.
 - Assign preferential seating.
 - No penalty for spelling errors or sloppy handwriting.
 - Follow a routine/schedule.
 - Provide students with rest breaks.
 - Use verbal and visual cues regarding directions and staying on task.
 - Assist in maintaining an agenda book.
- IEP Accommodations:
- Provide scaffolded vocabulary and vocabulary lists.
 - Differentiate reading levels of texts (e.g., Newsela).
 - Provide adapted/alternate/excerpted versions of the text and/or modified supplementary materials.
 - Provide extra visual and verbal cues and prompts.
 - Provide links to audio files and utilize video clips.
 - Provide graphic organizers and/or checklists.
 - Provide modified rubrics.
 - Provide a copy of teaching notes, especially any key terms, in advance.
 - Provide students with additional information to supplement notes.
 - Modify questioning techniques and provide a reduced number of questions or items on tests.



Curricular Guide for a Learning unit in Theatrical Lighting Design

504 Accommodations (continued):

- Allow additional time to complete assignments and/or assessments.
- Provide shorter writing assignments.
- Provide sentence starters.
- Utilize small group instruction.
- Utilize Think-Pair-Share structure.
- Check for understanding frequently.
- Have students restate information.
- Support auditory presentations with visuals.
- Provide study sheets and teacher outlines prior to assessments.
- Use of manipulatives.
- Have students work with partners or in groups for reading, presentations, assignments, and analyses.
- Assign appropriate roles in collaborative work.
- Assign preferential seating.
- Follow a routine/schedule.

Gifted and Talented Accommodations:

- Differentiate reading levels of texts (e.g., Newsela).
- Offer students additional texts with higher lexile levels.
- Provide more challenging and/or more supplemental readings and/or activities to deepen understanding.
- Allow for independent reading, research, and projects.
- Accelerate or compact the curriculum.
- Offer higher-level thinking questions for deeper analysis.
- Offer more rigorous materials/tasks/prompts.
- Increase number and complexity of sources.
- Assign group research and presentations to teach the class.
- Assign/allow for leadership roles during collaborative work and in other learning activities.

ELL Accommodations:

- Provide extended time.
- Assign preferential seating.
- Assign a peer buddy who the student can work with.
- Check for understanding frequently.
- Provide language feedback often (such as grammar errors, tenses, subject-verb agreements, etc...).
- Have students repeat directions.
- Make vocabulary words available during classwork and exams.
- Use study guides/checklists to organize information.
- Repeat directions.
- Increase one-on-one conferencing.



Curricular Guide for a Learning unit in Theatrical Lighting Design

Gifted and Talented Accommodations (continued):

- Allow students to listen to an audio version of the text.
- Give directions in small, distinct steps.
- Allow copying from paper/book.
- Give students a copy of the class notes.
- Provide written and oral instructions.
- Differentiate reading levels of texts (e.g., Newsela).
- Shorten assignments.
- Read directions aloud to students.
- Give oral clues or prompts.
- Record or type assignments.
- Adapt worksheets/packets.
- Create alternate assignments.
- Have student enter written assignments in criterion, where they can use the planning maps to help get them started and receive feedback after it is submitted.
- Allow students to resubmit assignments.
- Use small group instruction.
- Simplify language.
- Provide scaffolded vocabulary and vocabulary lists.
- Demonstrate concepts possibly through the use of visuals.
- Use manipulatives.
- Emphasize critical information by highlighting it for the student.
- Use graphic organizers.
- Pre-teach or pre-view vocabulary.
- Provide student with a list of prompts or sentence starters that they can use when completing a written assignment.
- Provide audio versions of the textbooks.
- Highlight textbooks/study guides.
- Use supplementary materials.
- Give assistance in note taking
- Use adapted/modified textbooks.
- Allow use of computer/word processor.
- Allow students to answer orally, give extended time (time-and-a-half).
- Allow tests to be given in a separate location (with the ESL teacher).
- Allow additional time to complete assignments and/or assessments.
- Read questions to student to clarify.
- Provide a definition or synonym for words on a test that do not impact the validity of the exam.
- Modify the format of assessments.
- Shorten test length or require only selected test items.
- Create alternative assessments.
- On an exam other than a spelling test, don't take points off for spelling errors.



Lighting Color Lesson 1: **Primary, Secondary and Tertiary Colors**

A 75-minute to 120-minute learning unit to explore Primary, Secondary and Tertiary colors in Light. These concepts are fundamental concepts to be able to use color in light for effective storytelling. This unit is intended for a class session at the High School Level.

Goals (Intended Learning Outcomes):

By the end of this unit, learners will be able to:

1. identify the three primary colors of light.
2. identify the three secondary colors of light.
3. with a lighting console, construct the three secondary colors of light by mixing primary colors.
4. with a lighting console, construct tertiary colors with primaries.

Equipment Needs:

1. *4 - Preferred: Source/4 Lustr2, Lustr3 or ColorSource 50deg or other LED theatrical type ellipsoidal spotlights with Floor Plates OR tungsten type theatrical ellipsoids. If using tungsten equipment, you will also need: dimming equipment, power cabling, and color media as described below.*
2. *Color Media: Primary Colors: Roscolux27, Roscolux80, Roscolux90; Secondary Colors: Lee141, Lee128, Roscolux20*
3. *A White Wall or projection screen.*
4. *The ability to darken the classroom from natural and artificial light.*
5. *4 - Power Adapters: from the theatrical lighting unit to Edison Plug to provide power to the luminaire.*
6. *1 - Theatrical computer control console to operate the lighting equipment, such as an ETC Element Console or an ETC Nomad Puck and a laptop.*
7. *Data cabling to connect the lights to the control console, probably DMX 5 pin cabling. A typical order for these lights in a classroom would be:*
 - a. *4 - 25' DMX 5 pin cables*
 - b. *2 - 50' DMX 5 pin cables*
8. *10-20 – Pieces of black tie line to tie up cable (1/4" cotton rope), each 18" long (optional)*
9. *1 - Roll of Black Gaffer Tape (optional)*

Setup:

1. Project 4 Ellipsoidal Lights onto a White wall or projection screen surface.
2. One colored Red, one colored Blue, one colored Green, and one colored as Tungsten No Color.
3. Arrange the lights so that there is both overlap and places where the light can be seen on its own, like a 3-circle Venn diagram, with BLUE on the top or at 12:00 as on a clock face, RED at 8:00 as on a clock face, GREEN at 4:00 as on a clock face. The fourth light should be projected on the top left corner of the wall, separated from the other lights.



Lighting Color Lesson 1: **Primary, Secondary and Tertiary Colors**

Learner Activities:

1. Daytime Sky to Sunset to Night.

Arrange four lights so that they all are focused to the same place on the white wall. Color them with Primary Red (Roscolux27), Primary Green (Roscolux90), Primary Blue (Roscolux80) and Secondary Amber (Roscolux20). Then:

- a. Write a cue 1, with time 5, on the console that mixes the colors to a light blue daylight sky.
- b. Write a cue 2, with time 20, that mixes the colors to a sunset sky color
- c. Write a cue 3, with time 20, that mixes the colors to a feeling of deep night.
- d. Run the cues in time. Describe what you learned about mixing these colors to create new colors that you could use in your designs.

2. Mixing with Secondary Colors

Now, arrange 3 of the lights onto a person standing in as a model, or a mannequin if you have one, so that they are all on one side of the person. Please the three secondary colors into these three lights, Lee141, Lee128, Roscolux20. Write cues to light the figure with varying mixes of these three colors, responding to the following prompts:

- a. Sunrise
- b. Late Morning
- c. Hot Afternoon
- d. Nighttime
- e. Light from a campfire

Reflect on how these three colors could mix to other colors that could be used in a theatrical play or musical. This kind of mixing is called Additive Color Mixing. If you are using a color-mixing LED light, this kind of mixing is actually what is going on INSIDE the light for every color that you want to mix.

What are advantages and disadvantages to using secondary colors instead of primary colors?

Time Allowances:

30-45 minutes to demonstrate primary, secondary and tertiary colors of light.

30-45 minutes for student activities.

15-20 minutes for viewing breakout room results and discussion.



Lighting Color Lesson 1: Primary, Secondary and Tertiary Colors
Talking points / Facilitator's Guide

Note: Action Items in **RED**
Script Items in **BLACK**

(note, if you are confident on the console, you could pre-write cues for these points as noted, you could also pre-set a console with submasters (like an ETC Element so that each of the four lights is on a separate submaster and just bring lights up and down without writing cues)

[Q 1 Start by showing a No Color “white” light source of light in the corner of the wall.]

1. All light, even what we call “White” light, is made up of colors. When we get many different colors of light mixing together, our brains can interpret that as “white light”.
2. Light is transmitted via a particle/wave called a “Photon”. The Photon vibrates in a certain way, somewhat like the vibration of a string that creates a musical note.
3. Our eyes can detect the wavelength of that vibration, similar to the way that our ears can detect and interpret a musical note. We call the vibration of light waves “Color”.
4. Color **IS** Light; Light **IS** Color.

Primary Colors of Light

[Q 2 Turn off the White Light Source, Turn on the three primary colors, Red, Green and Blue]

5. Here are three colors of Light, Red, Green and Blue
6. They can be seen by themselves or ... mixed together.



Lighting Color Lesson 1: Primary, Secondary and Tertiary Colors

7. When we mix different colors, or wavelengths of light, our brains can interpret that as a new color, even though it is a mix of different colors. See how that happens?

[Cue 3: Turn off Green and Blue, leaving only Red]

8. Here is Red

[Cue 4: Add Blue Light]

9. Here is Blue added in

10. See where they mix together? what color do we get at that place? *[Magenta]*

[Cue 5: Turn off Red Light]

11. Here is Blue alone

[Cue 6: Turn on Green Light]

12. Now see what happens when we add Green.

13. See how they mix to create a new color? What do we call this color? *[Cyan]*

[Cue 7: Turn off Blue Light]

14. Taking away the Blue, here is Green alone

[Cue 8: Turn on Red Light]

15. Now, add Red

16. And we get a surprising color: What do we call this color? *[Amber]*

[Cue 9: Turn on Blue Light]

17. If we add all three colors, Red, Green and Blue, we can get to a version of what our brains call "White Light"



Lighting Color Lesson 1: Primary, Secondary and Tertiary Colors

18. The colors that we started with are called “Primary Colors”. In light, (different than paint*), the primary colors are “Red”, “Green” and “Blue”.

19. Does anyone know what the primary colors are in Paint? **[RED, BLUE, YELLOW]**

20. How about Ink, think of the colors in a printer? **[CYAN, MAGENTA, YELLOW]**

21. In every media, the primary colors are the colors that you can use to mix to all the other colors, so in paint, you can mix Blue and Yellow to make green. But in light, Green is a primary color. You can’t mix Blue and Yellow in Light to arrive at Green.

22. These colors are also called Primary because you can mix them together, as we have done here, to “trick” our brains into seeing colors that aren’t present as a single wavelength of light. When we made Cyan Light, there aren’t any “cyan” vibrating photons present, only blue vibrating photons and green vibrating photons. Our brains interpret that mix of green and blue vibrating photons as cyan vibrating photons just the same.

[IF USING TUNGSTEN GEAR, change the WHITE light in the Corner to Lee141

(Cyan). If using LED GEAR, program the corner light to be L141 in Cue 10.]

[Cue 10: Add Corner Light, turn off Red Light]

23. Here is a light with Cyan vibrating photons. See how it looks the same as the mix of the other two?

24. That is true for the other mixes that we made:

STUDIO SCHOOL OF DESIGN

Lighting Color Lesson 1: Primary, Secondary and Tertiary Colors

[IF USING TUNGSTEN GEAR, change the WHITE light in the Corner to Lee128

(Magenta). If using LED GEAR, program the corner light to be Lee128 in Cue 11.]

[Cue 11: Keep Corner Light and Blue Light, turn off Green Light, Turn on Red Light]

25. Here is Magenta

[IF USING TUNGSTEN GEAR, change the WHITE light in the Corner to Roscolux20

(Amber). If using LED GEAR, program the corner light to be Roscolux20 in Cue 12.]

[Cue 12: Keep Corner Light and Red Light, turn off Blue Light, Turn on Green Light]

26. Here is Amber

[NOW RECUT SHAPES LIKE THE PHOTOGRAPH BELOW SO THAT THE COLORS DON'T TOUCH EACHOTHER, RECOLOR SO THAT MAGENTA (Lee128) IS IN THE BOTTOM LEFT LAMP, CYAN (Lee141) IS IN THE TOP LAMP, AND AMBER (Roscolux20) IS IN THE BOTTOM RIGHT LAMP]

Secondary Colors of Light

[Cue 13 TURN OFF CORNER LIGHT, TURN ON OTHER THREE LIGHTS]





Lighting Color Lesson 1: Primary, Secondary and Tertiary Colors

27. These three colors that we made, **Cyan, Magenta and Amber**, are also special colors in light, like the primary colors. We call **Cyan, Magenta and Amber** **secondary** colors, because you can make our brain *see* them by mixing two **primaries**, more or less equally, together.

28. Here is Amber

[point to amber light on the screen or wall]

29. Here is Cyan

30. Here is Magenta

31. Just like with the Primary Colors, we can mix the secondary colors together to create other colors. However, the colors that you get when you mix secondaries are non-spectral. Why is that?

[because if you have two secondaries, all three primaries are present, therefore it will be a version of white light, or what we can call a “tint” (because that is what you get when you mix all three primaries together). We’ll see more about this in Learning Activity 2.]

32. Here are Magenta and Cyan Mixed together

[OPEN UP THE CUTS TO SHOW MIXING BETWEEN MAGENTA AND CYAN]

33. Together, they create Lavenderish white light.

[OPEN UP THE CUTS TO SHOW MIXING BETWEEN CYAN AND AMBER]

34. Here is Cyan and Amber, see how they mix together to also make a kind of white light?

[OPEN UP THE CUTS TO SHOW MIXING BETWEEN MAGENTA AND CYAN]



Lighting Color Lesson 1: Primary, Secondary and Tertiary Colors

35. Here is Amber and Magenta. How would you describe this mixed light color?
36. Here are all three secondaries mixed.
37. Used this way, they mix to a better looking white, like the primaries, but perhaps these colors are more usable to us in the theater.

[Cue 14] (reduce Magenta intensity a little bit to make the mixes more accurate).

38. In the mid 20th century, one of the pioneering lighting designers who was responsible for so many of the practices that we take for granted, **Tom Skelton**, used these colors to light many of his shows.

Tertiary Colors of Light

39. There are of course more colors of light than Primary and Secondary colors. For instance, Orange, Aqua, Purple are also colors that can correspond to a single wavelength of light.
40. We can mix to these colors by changing *the proportions* of the primary colors. When we mixed the “secondary” colors, we said that they were roughly equal proportion of the two primaries.
41. Let’s now see how to mix “Orange”. Let’s Start with Red Light.

**[Cue 15 – TURN OFF TOP AND BOTTOM RIGHT LIGHT, RECOLOR
BOTTOM LEFT LIGHT WITH Roscolux26 (Red), Recolor BOTTOM RIGHT
LIGHT WITH Roscolux 90 (Green)]**

42. Mix in just a little bit of Green.

[Cue 16 – SLOWLY FADE IN THE GREEN LIGHT]



Lighting Color Lesson 1: Primary, Secondary and Tertiary Colors

43. Before we get to Amber, we start to alter the Red and we can arrive at Orange. These “in-between” colors are called “**Tertiary**”
44. Tertiary Colors, like Primary and Secondary colors are also called “Spectral” colors.
45. Spectral colors appear in the rainbow
46. Spectral colors can all correspond to a single wavelength of light.
47. The world of color and light is very complicated! There are some very interesting relationships between these colors and of course, *colors that we can see and describe that DON'T correspond to a single wavelength, like pink and lavender and steel blue.*
48. Do you have any questions about the concepts that we saw today?

Recommended Reflection Discussion topics:

- a. White light
- b. Primary colors
- c. Secondary colors and Tertiary colors
- d. Mixing different primary colors to create secondary and tertiary colors.
- e. Creating color shifts over time, like a sunset or a shift from warm white to cool white.

Time on the Console: Provide Learners with time on the console to mix colors and challenge themselves to write cues with times. See learner activities from main lesson document.

Wrap-up

49. Thanks! We'll talk more about Lighting Colors in the next unit.



Lighting Color Lesson 2: **The spectrum and lighting color wheel, non-spectral colors and complementary colors of light.**

A 75-minute to 120-minute learning unit to explore the visible lighting spectrum, color spaces and complementary colors in light. This unit is intended for a class session at the High School Level.

Goals (Intended Learning Outcomes):

By the end of this unit, learners will be able to:

1. Draw a spectrum showing the range of visible light for most humans and place primary and secondary colors within the visible spectral area.
2. Draw a color circle showing the relationship of the circle to the visible spectrum graph.
3. Logically locate primary and secondary colors on the color circle.
4. Identify the location of white light within a color circle graph.
5. Identify different pairs of complementary colors.
6. Explain why only a pair of complementary colors can mix to White Light.

Equipment Needs:

1. *White Board and Markers. If possible, preferable to light this white board with a controllable source of light on the console, so that it can be turned on and off as needed during the demonstration.*
2. *4 - Preferred: Source/4 Lustr2, Lustr3 or ColorSource 50deg or other LED theatrical type ellipsoidal spotlights with Floor Plates (note: if using tungsten type theatrical lights, you will also need: dimming equipment, power cabling, and color media as described below).*
3. *Color Media: Primary Colors: Roscolux27, Roscolux80, Roscolux90; Secondary Colors: Lee141, Lee128, Roscolux20*
4. *A White Wall or projection screen.*
5. *The ability to darken the classroom from natural and artificial light.*
6. *4 - Power Adapters: from the theatrical lighting unit to Edison Plug to provide power to the luminaire.*
7. *1 - Theatrical computer control console to operate the lighting equipment, such as an ETC Element Console or an ETC Nomad Puck and a laptop.*
8. *Data cabling to connect the lights to the control console, probably DMX 5 pin cabling. A typical order for these lights in a classroom would be:*
 - c. *4 - 25' DMX 5 pin cables*
 - d. *2 - 50' DMX 5 pin cables*
9. *10-20 – Pieces of Black Tieline pieces to tie up cable (1/4" cotton rope), each 18" long (optional)*
10. *1 - Roll of Black Gaffer Tape (optional)*

Lighting Color Lesson 2: The spectrum and lighting color wheel, non-spectral colors and complementary colors of light.

Setup:

1. A White surface with 3 lights on it, one colored Red, one colored Blue, one colored Green (if using color media, Roscolux27, Roscolux80 and Roscolux90 are good possibilities for these colors, or program color mixing lights to equivalents of these colors).
2. Arrange the lights so that you can turn them on and off at will. Arrange the lights so that there is both overlap and places where the light can be seen on its own, like a 3 circle Venn diagram.
3. A White Board and Markers with a line drawn across the top representing the Visible Spectrum, as shown in figure 1. On the sides can be names as from the first image (Cosmic Rays, Gamma Rays, X-Rays, UV on the left. On the right: Infrared, Microwaves, Radio, Television)

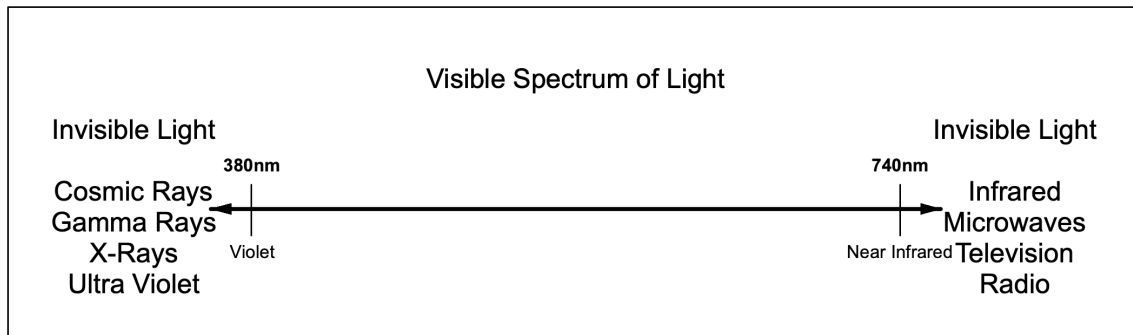


Figure 1: Visible and Invisible forms of Light



Lighting Color Lesson 2:

The spectrum and lighting color wheel, non-spectral colors and complementary colors of light.

Learner Activities:

1. Transitioning through two secondary colors:

Arrange four lights so that they all are focused to the same place on the white wall. Color them with Primary Red (Roscolux27), Primary Green (Roscolux90), Primary Blue (Roscolux80) and Secondary Amber (Roscolux20). Then:

- Write a cue 11 on the console that creates a cyan color mix (using the blue and green lights)
- Write a cue 12 on the console that creates an amber color mix (using the red and green lights)
- Set the time for both cues to 20 seconds.
- “goto” cue 1 and then press go.
- Watch the transition between the cues.
- As written the colors will transition through primary green, which you may not want to see in a show. With the lights that you have, how could you transition through “white” instead of green during the long fade. As a hint, think about creating a transitional cue between cues 11 and 12 (11.5) that accomplishes the way you want the middle of the transition to look, or perhaps manipulate the timings of the cue fades by separating out the up time from the down time (“split fade”), or by delaying the up fade or the down fade in one or both of the cues. To separate out the up and down times on an ETC console, you can type [CUE][x][TIME][y][TIME][z]. The second use of the command time is understood by the console to mean that you are giving the down time a different value from the up time. The [DELAY] command works in a similar way, if you type [DELAY][DELAY] (two times), you will only be delaying the “down” part of the cue.

This is a common problem in theatrical lighting design where we need to design both the cues but also the transition, or movement of the color, between cues.

- On a drawing of the color circle, draw the “color path” of the transitions from above.** If you plot cyan and amber on the color circle and draw a line between them, you don’t quite pass through blue (because of the curve of the circle). Does this line accurately describe what you see in the first version of the color transition?

Now, graph a line that describes what you see in the second transition.

These lines are called “color paths”. They are a useful way to think and communicate about how color moves from one state to another over time.

Time Allowances:

30-45 minutes to demonstrate primary, secondary and tertiary colors of light.

30-45 minutes for student activities.

15-20 minutes for viewing breakout room results and discussion



Lighting Color Lesson 2: The spectrum and lighting color wheel, non-spectral colors and complementary colors of light.

Talking points / Facilitator's Guide:

Note: Action Items in **RED**

Script Items in **BLACK**

(note, if you are confident on the console, you could pre-write cues for these points as noted, you could also pre-set a console with submasters (like an ETC Element so that each of the four lights is on a separate submaster and just bring lights up and down without writing cues)

The Spectrum and the Color Circle

1. Welcome Back everyone!

[Go to White Board, Draw the primary colors, Red, Green and Blue on the spectral line. Connect that to what was discovered yesterday about primary colors.]

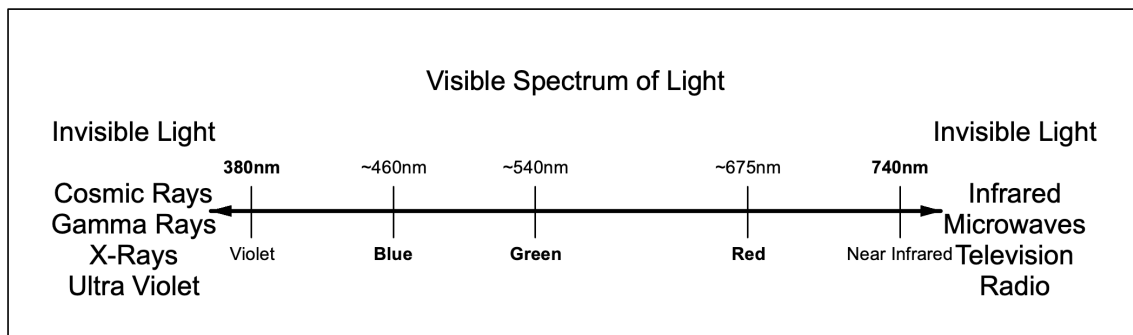


Figure 2: Primary Colors of Light plotted on the Visible Spectrum

2. In the last unit, we looked at primary colors (red, green and blue) and how they can be mixed to make secondary colors (cyan, magenta and amber)

Lighting Color Lesson 2: The spectrum and lighting color wheel, non-spectral colors and complementary colors of light.

3. Here are two of the secondary colors: Cyan and Amber.

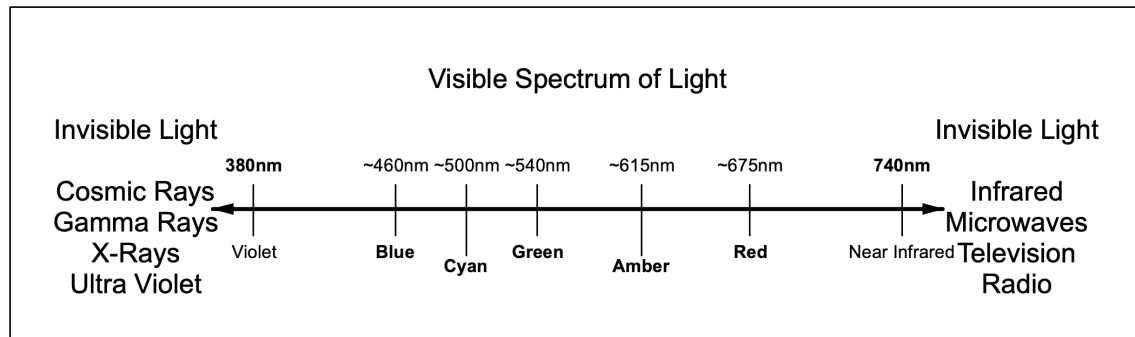


Figure 3: Two of the three secondary colors plotted on the Visible Spectrum

4. And here are some tertiary colors like Aqua, Lime, and Orange

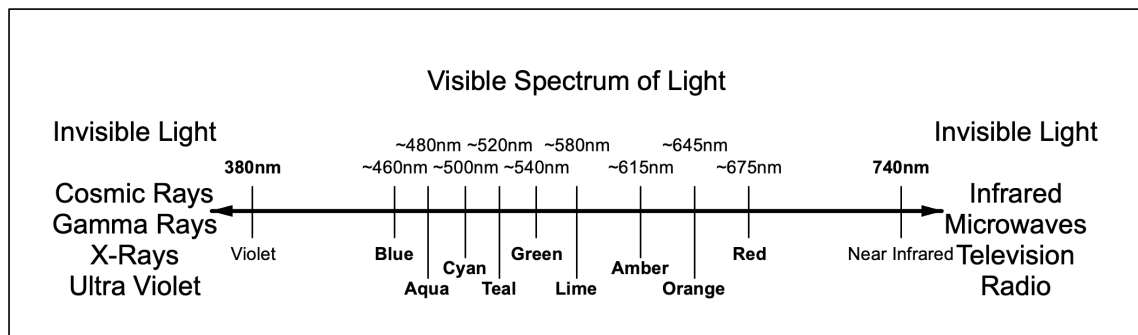


Figure 4: Some Tertiary Colors on the Visible Spectrum

5. Near the end of the day yesterday, we talked about *non-spectral colors*, like **Rose**, or **Lavender**, or **Pale Blue**. These colors don't appear on the spectrum.

Lighting Color Lesson 2: The spectrum and lighting color wheel,
non-spectral colors and complementary colors of light.

6. There is also one more very special color that also doesn't appear in the spectrum, the secondary color: **Magenta**.
7. Yesterday, we said that Magenta was a secondary color that you can get to by mixing Blue light and Red light together.
8. To do that in this graph, we need to bend this spectral line around on itself, to create a circle with this line, to create a two-dimensional graph out of this a one-dimensional spectral line.

Draw a circle connecting the two ends of the visible spectrum so that they meet at 10:00 on a clock.

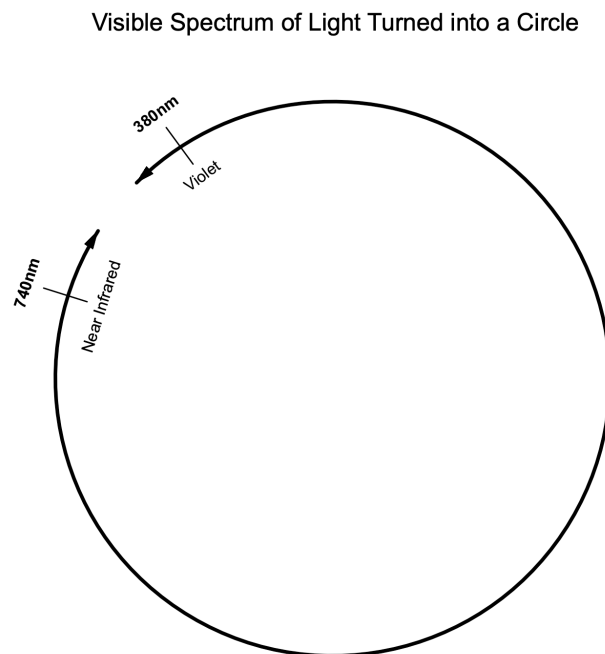


Figure 5: Bending the spectrum into a circular shape

Learning Activity 2: The spectrum and lighting color wheel, non-spectral colors and complementary colors of light.

9. This is the color wheel for light
10. The color circle is a **conceptual diagram** to help us understand what our eyes and brains are doing to process visual information.
11. On the color circle, we can see primary and secondary colors, and we can see how Red and Blue, from the opposite ends of the spectrum, can mix to create a color that we call “Magenta”. Unlike all the other colors on this diagram so far, Magenta does not represent a Single wavelength, but we can *pretend* it does, because it makes talking about color a little bit easier.

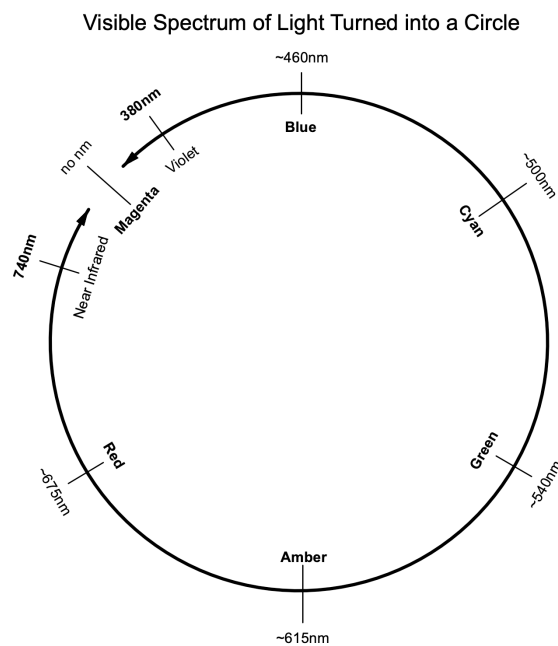


*Figure 6: This allows us to “plot” the color Magenta,
which acts like a secondary color, but is not on the spectrum*

Lighting Color Lesson 2: The spectrum and lighting color wheel, non-spectral colors and complementary colors of light.

White Light

12. In the last unit, we looked at white light and said that it was a mix of the three primary colors.
13. Where is white light represented in the color circle? **[Great, in the center.]**

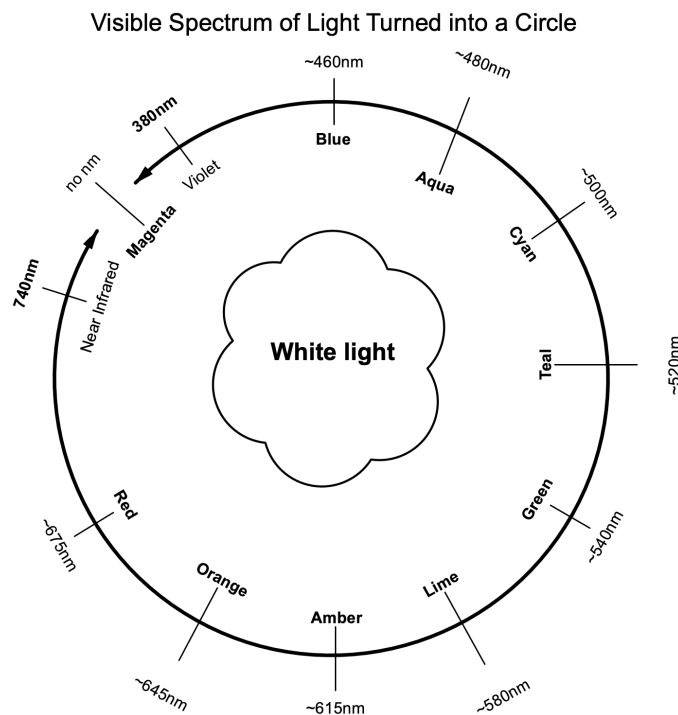


Figure 7: White light can be represented in the center of the color circle

14. White light is in the center, in a kind of cloud of many possible whites.
15. Think about the difference between white light from a household light bulb and the white light from the sun.

Lighting Color Lesson 2: The spectrum and lighting color wheel, non-spectral colors and complementary colors of light.

16. What are other kinds of white light that you can think of? **[Fluorescent light, firelight, moonlight are possible answers.]**
17. Now, think about all the colors in between “White Light” and the “Spectral Colors” that we talked about yesterday. Colors like Pink or Lavender or Pale Green. These colors are called Tints, and they can be plotted in the color circle in the areas between white in the center and the “spectral edge” of the **colorspace**.

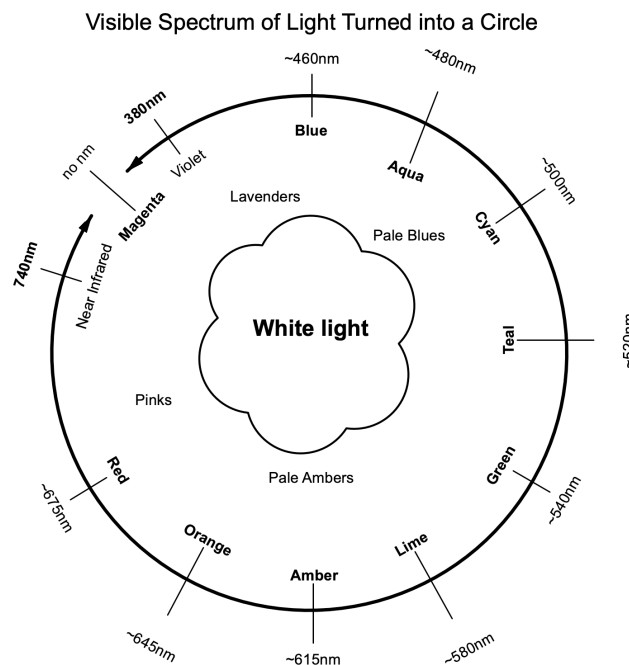


Figure 8: Tints can also be plotted in this circle

18. What is a color space? It is simply a graphical representation of colors showing their relationships.

Lighting Color Lesson 2: The spectrum and lighting color wheel, non-spectral colors and complementary colors of light.

19. One more very interesting thing about the color wheel, which is one kind of **colorspace**. The colors that are opposite each other have a special relationship which we call “Complementary”.

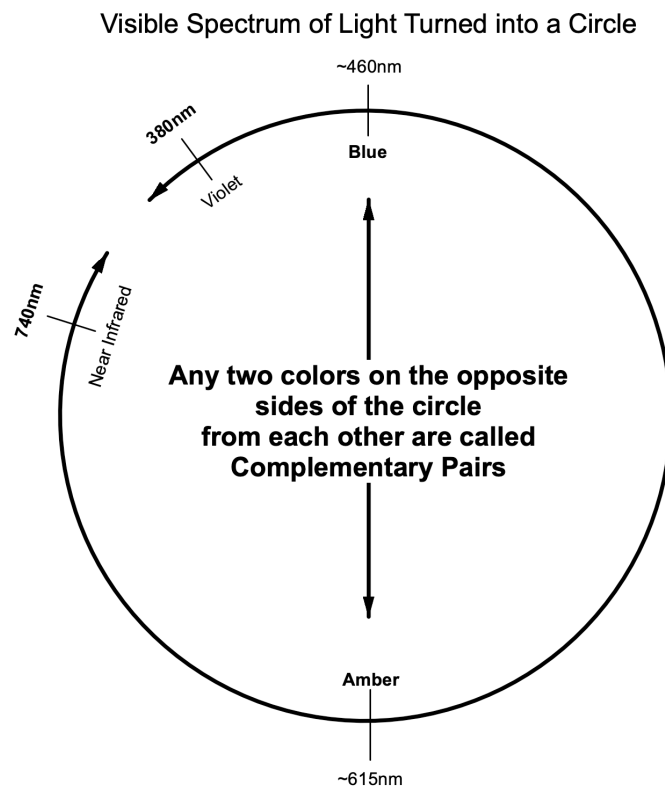


Figure 9: Blue and Amber are a complementary pair

20. Color complements, like blue and yellow or magenta and green are special for a couple of reasons:
21. They are exciting to look at, our brains like them.
22. Any complementary pair can work together to create white light.



**Lighting Color Lesson 2: The spectrum and lighting color wheel,
non-spectral colors and complementary colors of light.**

23. With primary colors, remember we needed **three lights** to mix to white?
24. With a complementary pair, we only need **two lights** to arrive at white.
25. Let's look at how this works.

[Cue 21] Cue with blue light (Roscolux80) facing the wall.

**[Cue 22] Slowly add an amber light (Lee135) (time 20) so that it mostly overlaps the
blue light to arrive at white light**

26. This works because amber already contains both Red and Green light, so with these two
lights, we have all three primary colors and we can make white light!

[Cue 23 fade out all the lights]

27. This also works with any other complementary pair. Let's try it with Red and Cyan.

[Cue 24] Cyan Light on the Wall (Lee141).

[Cue 25] Slowly add Red (Roscolux27) (time 20).

28. In the theater, we use complementary pairs of colors all the time to create a range of colors
on the actors. See how with only these two lights, we can get a whole **range** of colors,
including white?

29. Re-run the blue/amber, but this time, go all the way to only amber, and then back to only
blue through a long slow crossfade, pointing out all of the colors along the way.

30. On the color circle, we can plot this range of colors like this:

Lighting Color Lesson 2: The spectrum and lighting color wheel, non-spectral colors and complementary colors of light.

Visible Spectrum of Light Turned into a Circle

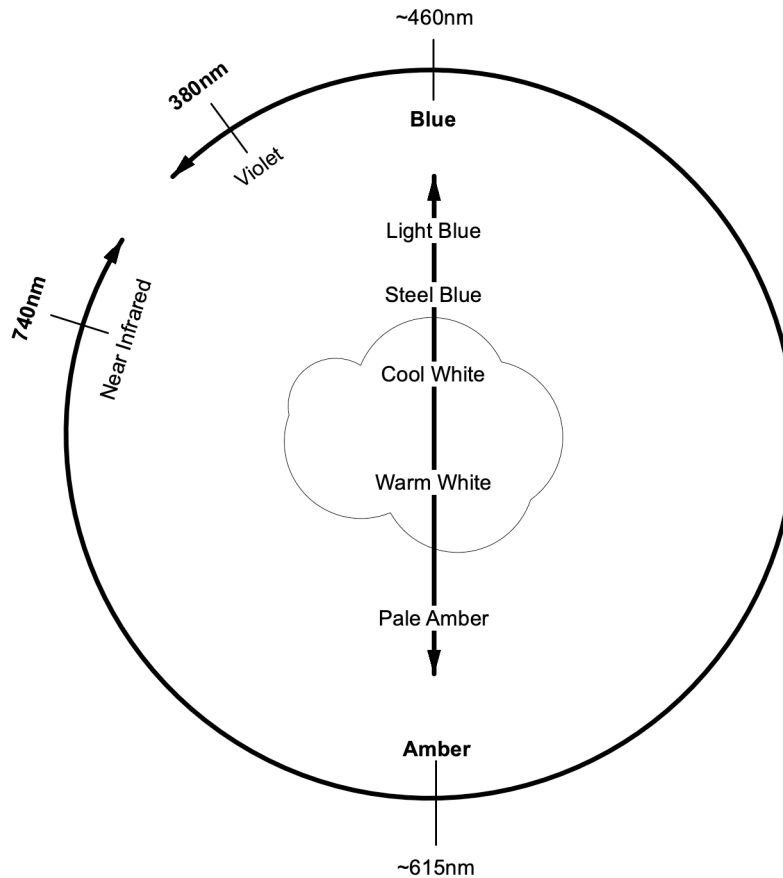


Figure 10: All these possible colors from a pair of lights!

[Draw a line on the white board from Amber to Blue, through the center of the circle. Plot “Light blue, Steel Blue, Cool White, Warm White, Pale Amber” onto the line]

31. That’s a lot of information about color. Today we talked about the spectrum, the color circle and color spaces, the nature of white light and color complements. Any questions or other things that you’d like to talk about?



**Lighting Color Lesson 2: The spectrum and lighting color wheel,
non-spectral colors and complementary colors of light.**

Recommended Reflection Discussion topics:

- a. Pick some other non-spectral colors that you can name and plot them in the color circle graph.
- b. What is the complement of Magenta? **[GREEN]**
- c. Plot out in the color circle all the colors that you could name between Magenta and Green. **[PINK, PALE PINK, PINKY WHITE, NEUTRAL WHITE, GREENY WHITE, PALE GREEN are some possible answers. Now try it with two lights.]**
- d. Is it surprising that to get to PALE PINK, you add GREEN to MAGENTA??

Time on the Console: Provide Learners with time on the console to mix colors and challenge themselves to write cues with times. See learner activities from main lesson document.

Wrap-up

32. Thanks! It was great to talk with you about color today.



Appendix A: An introduction to Mixing color on an ETC Lighting Console

1. If you are using an ETC Lighting Console in your classroom with LED color mixing source, such as ColorSource Ellipsoids or Lustr Ellipsoids instead of Tungsten-based Ellipsoids with Color Media, you can use the Lighting Console to program the colors in the lights.
2. You will have to first find a power source for the lights and connect each light to the console with a DMX-type data cable (these can be daisy-chained so that only one cable eventually plugs into the console).
3. Address each light with a separate channel. Each light takes up multiple channels, so you will need to leave numerical space between the units when you address them. We recommend leaving 20 numbers per fixture, so that the first fixture is addressed with 1, the second on with 21, the third with 41 and so on.
4. Patch the console with the unit types and their addresses to a channel number. On the console, each channel can address a multi-parameter unit such as a color-mixing LED ellipsoidal, so you don't have to leave space as you did with the addresses. Channel 1 can be patched to address 1/1. (The number before the slash refers to a "universe" number, each "universe" is only capable of holding 512 addresses, so on larger shows, multiple "universes" are sometimes necessary. For this demo, you will only need to use one "universe"). Channel 2 can be patched to address 1/21, and so on to cover the four lights in your demonstration.



Appendix A: An introduction to Mixing color on an ETC Lighting Console

5. Once patched, you can set the color of a light by this statement on the “Live” command line:

[1][AT][5][/][2][7][*] In this statement, the [5][/] refers to the Roscolux line of colors, the [2][7] refers to the number Roscolux27.

More resources about programming and setting up ETC consoles can be found online at:

<https://www.etcconnect.com/Support/Tutorials/Element-Video-Learning-Series/Overview.aspx>



Learner Handout for Lighting Color Lesson 2

