ASSIGNMENT SUMMARY
This exercise is intended to reinforce your understanding of the color concepts presented in LS-5-21 Color and TM-30-20 IES Method for Evaluating Light Source Color Rendition, and the related information covered during the class lectures that support this material.

LEARNING OBJECTIVES
- Attain working familiarity with the colorimetric concepts that are most relevant to lighting design and applied illuminating engineering, by:
  - Recalling human color perception phenomena
  - Explaining key aspects of CIE colorimetry, including color matching functions (CMFs), chromaticity, Correlated Color Temperature (CCT), and Duv
  - Explaining the basic concepts that underlie the evaluation of color rendering quality, as exemplified with TM-30-20
  - Classifying color rendering quality using measures from TM-30-20
  - Interpreting colorimetric data that appears on lighting equipment data sheets
- Infer the limits of the colorimetric concepts that we have covered, recognizing that the foundational topics studied are a baseline that invites deeper study.

LEARNING OUTCOME MAPPING

<table>
<thead>
<tr>
<th>Course Learning Outcome</th>
<th>ABET Student Learning Outcome</th>
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<tbody>
<tr>
<td>7. Interpret data about color quality in lighting, including chromaticity, CCT, and color rendering.</td>
<td>7. An ability to acquire and apply new knowledge as needed, using appropriate learning strategies.</td>
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READING
Read IES LS-5-20 Color and IES TM-30-20 IES Method for Evaluating Light Source Color Rendition. Chapter 8 Color, from Designing with Light by Jason Livingston is another suitable reference for some of the material covered.

QUESTIONS
Questions related to Chromaticity
1. Create a flowchart from left to right that uses spectral plots to illustrate the concepts listed below. Absolute precision in the shape of the curves is not expected; drawing by hand is perfectly fine. Use annotations if needed to illustrate your understanding of the concepts. Take care to label the axes properly.
   a. SPD of D65 (a mathematical model of daylight), that is “light color”.
   b. Spectral reflectance of a typical carrot, that is “object color”.

c. Representation of the spectrally modified daylight after it has reflected from the carrot, that is “practical color”.

d. Representations of the color matching functions (CMFs) that are used to compute chromaticity.

e. Representations of the figures that can be used to compute tristimulus values denoted as X, Y, and Z.

f. Write the equations used to convert from tri-stimulus values to chromaticity coordinates.

2. Sketch a CIE (x, y) chromaticity diagram. Label the axes. Label the spectrum locus and add a few wavelengths for orientation. Label the purple line and indicate the wavelengths at each end. Draw and label the blackbody (Planckian) locus and mark the approximate location of a few CCTs. A hand drawing is perfect adequate but take care to be neat.

3. What is metamerism?

4. Explain the concept of “chromaticity difference”? Why is it relevant to applied lighting?

5. Explain the concept of “chromaticity stability”. Why is it relevant to applied lighting?

Questions related to Correlated Color Temperature (CCT)


7. What are the quantity and unit used to characterize correlated color temperature? (Hint: “quantity” and “unit” are two separate questions. By way of analogy, length is a quantity, meter is a unit).

8. List three standard CCTs that are available for common lamps (Hint: These correspond to ANSI quadrangles).

9. Is the amber light of a candle flame visually warmer or visually cooler than the blue light of the sky? Substantiate your answer.

10. Does the amber light of a candle flame have a higher or lower color temperature than the blue light of the sky? Substantiate your answer.

Relating Chromaticity to Correlated Color Temperature

11. If a light source has a positive $D_{uv}$, it is likely to be tinted what color?

12. Explain why a pair of chromaticity coordinates can be used to communicate identical information as CCT plus $D_{uv}$. Why do most specifiers prefer CCT plus $D_{uv}$?

Color Rendering

13. What does the CIE CRI (a.k.a., $R_a$) tell us about a light source?

14. List at least three attributes of light source color-rendering performance for which CIE CRI does not provide guidance.

15. Is it true or false that a light source with a higher CRI will always be preferred on one with a lower CRI?

16. It is false to say that two light sources have the same CRI, then they must render colors in the same way. Explain why that statement is false.

17. List a few reasons why the IES TM-30-20 method for evaluating light source color rendition is an improvement over the CIE CRI method.

18. Download the IES TM-30-20 Excel calculator that performs the TM-30-20 calculations. Spend some time exploring the spreadsheet. Pick a source from the light-source library and print out the full-page TM-30-20 report.

19. For the source that you selected in the prior question, indicate the TM-30-20 Annex E categories for preference (P), vividness (V), and fidelity (F).
Other Questions about Color and Light
20. Consider a Red Delicious apple that is illuminated by a broad-band light source such as daylight. Does the Red Delicious apple appear red because it reflects or absorbs red light? Explain your answer.
21. Explain additive color mixing.
22. Explain subtractive color mixing.
23. Conceptually, what is physiological mechanism that enables chromatic adaptation? Said another way, how does the human visual system chromatically adapt?
24. What is the Helmholtz-Kohlrausch effect?

Interpretation of Colorimetric Data from a Spec Sheet

SUBMISSION FORMAT
Upload your answers to Canvas in a single document. It is okay to write your answers by hand. However, please write clearly and ensure that your submission has a professional appearance and is easily legible—that is, clear writing, high contrast. If you scan and covert to PDF, made sure that the scan is high quality.