CS 178 – Digital Photography
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Final Exam Review Solutions

Part 1: True or False. Write T or F beside each question.

1. If the reflectance spectrum of an object is nonzero for some wavelengths that the illumination spectrum is nonzero, the object will definitely reflect some light.

True. *For any wavelengths that are nonzero in both spectral power distributions, light will be reflected.*

2. Magenta is on the locus of spectral colors because it is derived from a combination of two pure wavelengths.

False. *Because there is no single wavelength that induces the perception of magenta (which requires activating our rho and beta receptors more so than our gamma receptor), magenta does not lie on the locus of spectral colors.*

3. If you illuminate an object with a monochromatic light source, then regardless of the original color of the object, it will either appear to be the same chromaticity as the light source, or black.

True. *If the light source is a pure wavelength, then only that wavelength will be reflected off of any object, regardless of the object's reflectance spectrum. If the object does not reflect that wavelength, it will appear black; otherwise it will appear to have the same chromaticity as the light source.*

4. There are some pure wavelengths that humans are responsive to but that are not in a rainbow.

False. *A rainbow contains all visible wavelengths.*

5. In Maxwell's color matching experiment, matching a color with a negative value for one of the primaries means the color is outside the gamut defined by those primaries.

True. *Say the R response to the test stimulus is negative. That means that even a color created from no R and any G and B values (e.g. a triplet of the form (0, G, B)), cannot match the test stimulus. A negative value for R means that if you create a new test stimulus by adding the magnitude of R to the original test stimulus, you can now match the new test stimulus with a triple of the form (0, G, B). Therefore, the original color was outside the gamut of those primaries.*

6. Chromaticity diagrams factor out saturation and leave only hue and value.

False. *Chromaticity diagrams factor out value and leave only hue and saturation. One way to know this is false is to recall that there is only one "white" in chromaticity diagrams.*

7. It is a clear day. White balance temperature for the midday sun is roughly 5200K. If we want to take a picture in a shady area where there is no direct sunlight, we should set the white balance temperature to something lower than 5200K.

False. *In the shady area, the only illumination is from the sky, which is blue. Since the source of illumination is blue, we have to compensate for that by saying that the scene is actually illuminated by something hotter (more blue) than 5200K.*

8. Blue light contributes more than green light to luminance because blue light is a shorter wavelength, and thus has more energy.

False. *Humans are most sensitive to green light, which is why color spaces that have a luminance channel weight the green value the most in computing luminance.*

9. When bouncing a floodlight off a uniform white reflector card to produce a fill light, if you move the card closer to your subject, the subject will become more brightly illuminated.

True. *Imagine the card as a collection of finely spaced point light sources, each radiating light across the hemisphere above that point (since the card is diffuse). Now consider a patch on a the subject. As you move the card towards the subject, that patch will subtend a larger fraction of the solid angle leaving each point on the card. Thus, the patch will receive more light.*

10. JPEG's compression strategy is to compress the luminance information more than the chrominance because humans are less sensitive to luminance information.

False. *Humans are less sensitive to chrominance information, so JPEG's compression strategy is the compress that the most, not luminance information.*

Part 2: Multiple Choice

1. At your favorite band's concert, after settling for a few shots of the whole band, you decide to focus on color as a pictorial element. Differently colored lights are shining on the lead singer and guitar player depending on the mood of the song. If both performers are wearing all blue, what color can the lights be so that they appear to be wearing black, while the red guitar in the scene appears non-black? Assume most of the energy in the materials' reflectance spectrum is focused around the blue and red wavelengths, respectively. Circle the best answer.
(a) Blue lights would work.
(b) Purple lights would work.
(c) White lights would work.
(d) Red lights would work.
(e) No available lighting can possibly work, so you'll do it later in Photoshop.

The stimulus that enters our eye is the wavelength-by-wavelength product of the reflectance spectrum of the object and the spectral power distribution of the light source; We want that product to be zero for everything but the guitar. If the reflectance spectrum of the performers' clothes is centered around blue, then only red lights could make the performers' clothes appear black.

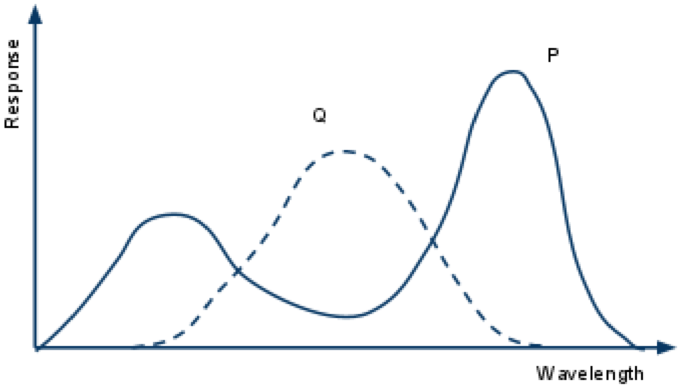
2. A streetlight has a uniform luminous intensity of 8 lumens/sr over its whole cone of light, and the cone is pointed directly downward. If the light subtends 3 steradians, how much total power will fall on the road 5 meters below? Assume the road is larger than the lit area created by the streetlight.
(a) 5 lumens.
(b) 8 lumens.
(c) 24 lumens.
(d) 40 lumens.

*Since all the power form the light is falling on the road, the total power here = radiant intensity [lumens/sr] * steradians subtended = 8 * 3 = 24. The distance to the road is irrelevant in this case.*

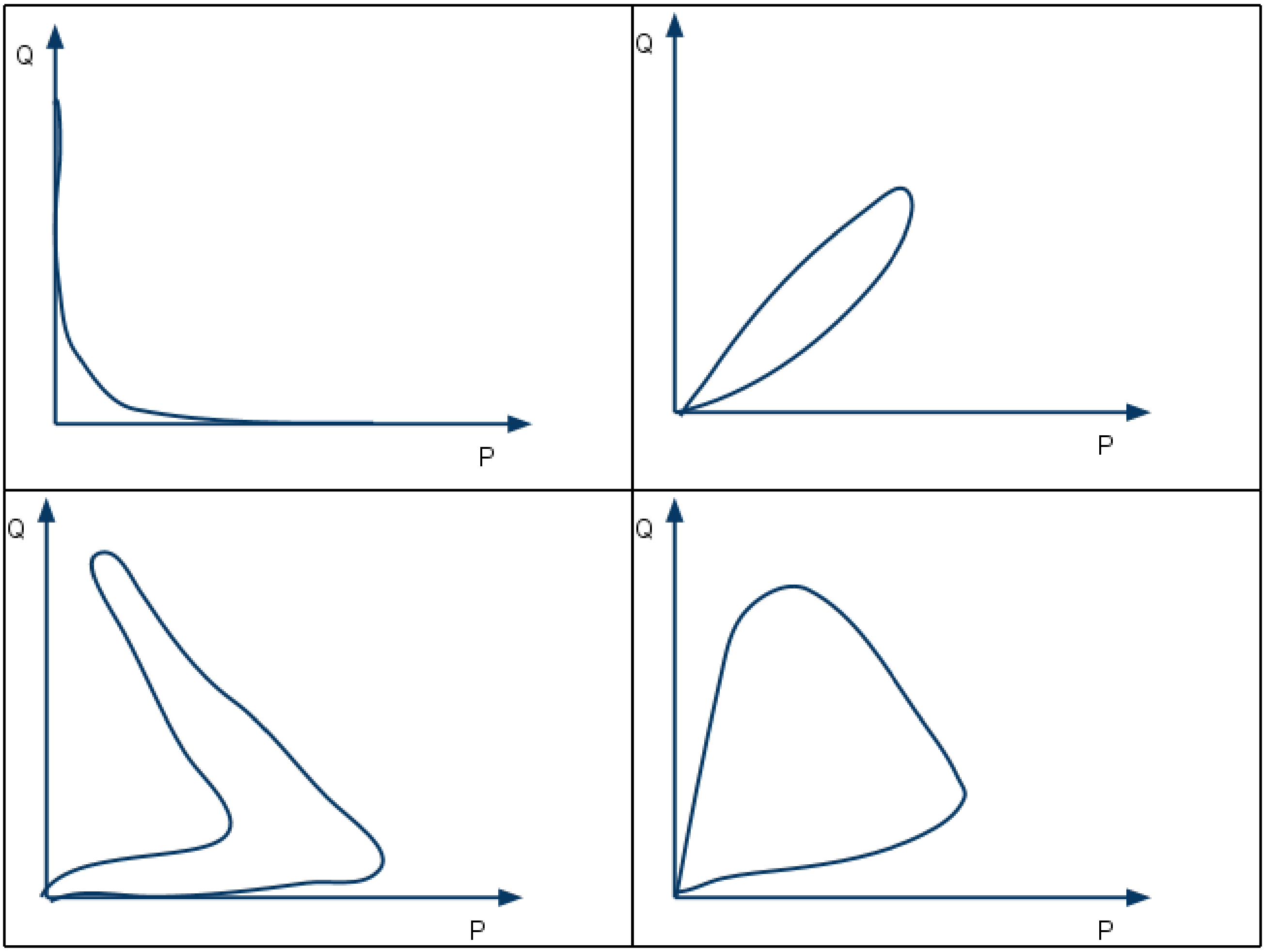
3. If you are taking a picture of the sunset where the scene is mostly red but the camera assumes that the average color of the scene is grey, the picture will come out more ______ than what you see. Circle the best answer.
(a) red
(b) yellow
(c) green
(d) cyan
(e) magenta

Since the camera thinks the scene is too red and it wants to shift that towards grey, it will lower reds and boost up greens and blues. Therefore the picture will come out more cyan (G+B).

4. Imagine a (rather strange) dichromat whose spectral response curves look like this:



What would the spectral locus of perceivable colors look like? Circle the most plausible graph from among the following:



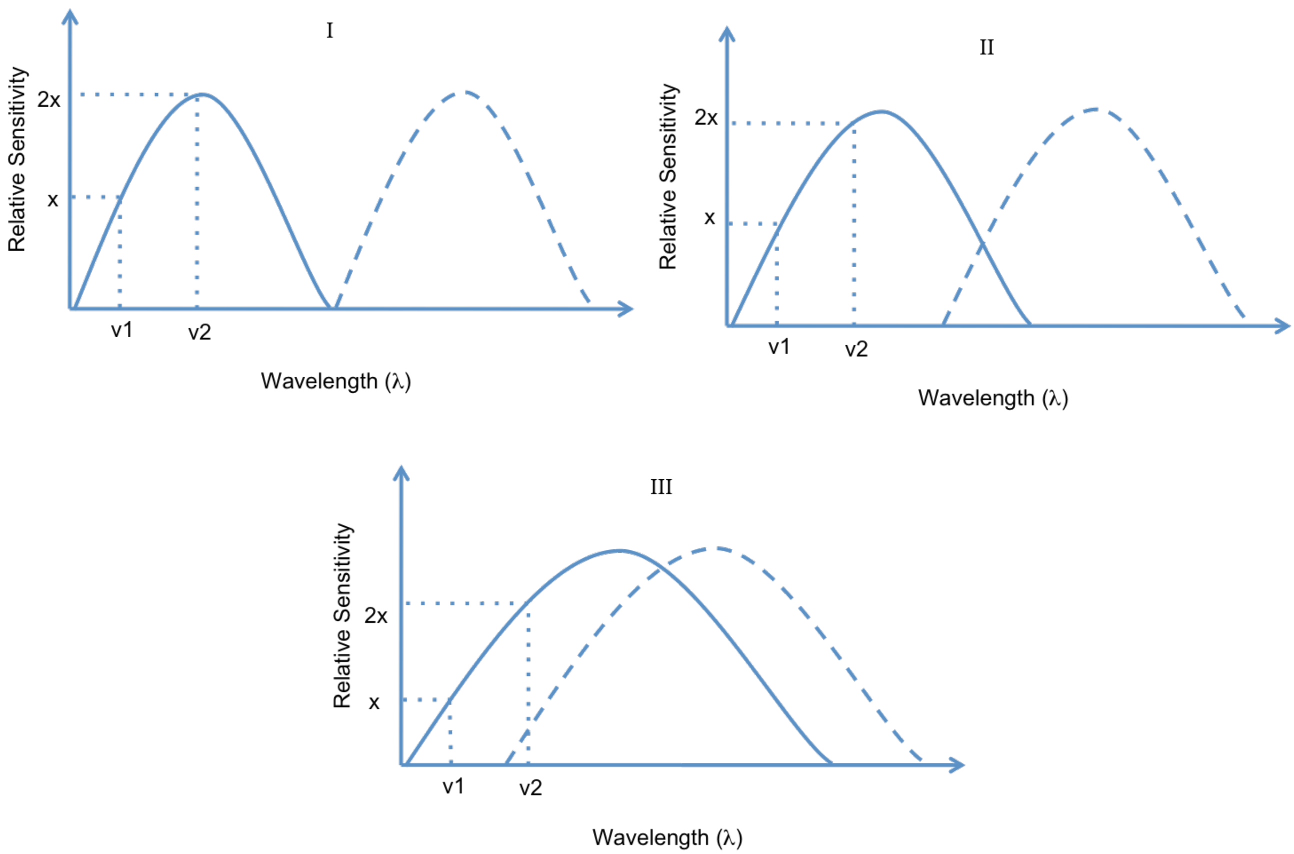
The answer should be the curve in the lower left. Tracing the responses from the shortest wavelength, notice that P increases first with Q remain quite low. Then as P decreases, Q increases. This eliminates the top two curves. After Q peaks, P actually goes up, so the answer is, again, the curve in the lower left.

5. It is possible to design a light that appears red and a filter that appears green, such that if you shine the red light through the green filter, the resulting light appears ___. (Circle all that apply.)

(a) Red
(b) Yellow
(c) Green
(d) Brown
(e) Cyan
(f) Black (nothing gets through)

All answers are possible. In designing the spectral power distributions (SPDs) of the light and the filter, it is possible for the result of multiplying the two SPDs wavelength-by-wavelength to be any of the above colors, even while they appear red and green to us, respectively. Choice (e) may be the most surprising, but even cyan is possible. Consider a light source that has a huge amount of pure red and a much smaller amount of pure cyan; it will certainly appear red. Now consider a filter that lets in all wavelengths between cyan and yellow; it will appear green. But when we shine this light through this filter, the only wavelength in which they're both nonzero is cyan, so cyan light will get through.

6. The figure shows the spectral response curves of three different organisms. These organisms first look at a source that emits light of wavelength v1 and then at a source that emits light of wavelength v2 but at half the intensity of the first source. Which of the organisms can distinguish between the two sources of light? Circle the best answer (a-f).



(a) I only
(b) I & II
(c) II only
(d) III only
(e) All three
(f) None of the above

For organisms I and II, both sources produce the same reaction in the organisms' receptor. Since the second source is only half the intensity of the first, they will both intersect at the same point on the relative sensitivity axis. With organism III however, the second source intersects with both receptors and this will cause a difference in response compare to the first source. So organism III is able to distinguish between the sources.

7. You're taking a photo of a friend who is 10 feet away, lit only by your on-camera flash. If she walks to 40 feet away, what could you do so that your friend appears the same brightness as before, assuming you keep the rest of your settings constant? Assume all settings are available, and circle all that apply.

(a) Increase flash power by 2x
(b) Increase flash power by 4x
(c) Increase flash power by 16x
(d) Decrease your f-number by 2x
(e) Decrease your f-number by 4x
(f) Decrease your f-number by 16x
(g) Increase your ISO by 2x
(h) Increase your ISO by 4x
(i) Increase your ISO by 16x
(j) You don't need to change anything -- she will already appear the same brightness

The amount of light hitting your subject decreases with distance squared, so at 40 feet your friend will be receiving 1/16th the light compared to at 10 feet. To compensate, you could use 16x as much flash power, increase your ISO by 16x, or let in 16x as much light by decreasing your f-number by 4x (thereby increasing the area of the lens opening by 16x).

8. Fresnel lenses are useful because (circle all that apply)

(a) They are good for focusing light.
(b) They are good for capturing images because of their focusing ability.
(c) They have the same refractive power as thicker lenses.
(d) They allow you to make lenses that are smaller in diameter.

Fresnel lenses were designed to focus light like a high power lens without being as thick. Slides 36 and 37 of the Light and Reflection lecture has figures and talks about the properties of Fresnel lenses.

9. What assumption underlies panoramic mosaicing?

(a) rotation about the center of the camera body
(b) rotation about the center of projection
(c) translation in the xy plane, assuming the z axis points in the direction of the lens
(d) translation in the xz plane, assuming the z axis points in the direction of the lens

The center of projection, a.k.a center of perspective is the point where the lines of sight viewed by the camera converge. In the cylindrical panoramas applet on the class webpage, this point is represented by a red ball at the center of the 3D view. In an idealized thin lens, the center of projection is in the middle of the lens. If you rotate your camera around the tripod screw, or any other point except the correct center of perspective, then objects close to the camera will shift position relative to their backgrounds from image to image in the sequence.