**Physics 109**  
**Physics in the Arts**  
**Fall 2001**

**Study Guide for 3rd exam, December 12th, 2001**

**Location:**

**Exam Material:** The exam will cover textbook Part II: Light, p. 141 - 268, the homeworks 8-13, the lab experiments, Reflection, Refraction, Lenses, Magnification, Photography, Additive and Subtractive Color Mixing, and study questions below. However, studying the problems in the textbook (if you have it) is useful.

**Bring a calculator to the exam.**

You may not use any notes.

The format of the exam will be similar to the previous ones.

You will be given the formulas and diagrams below, but you have to know where they apply and how to use them.

The cover page of the exam will give the following information:

\[
\frac{1}{f} = \frac{1}{f'} + \frac{1}{f_i}
\]

\[
M = \frac{h_i}{h_o} = \frac{i}{o}
\]

\[
\text{Diopter} = \frac{1}{f(m)}
\]

\[
f' = \frac{f}{D}
\]

**T**

<table>
<thead>
<tr>
<th>Exposure Time</th>
<th>1</th>
<th>1/2</th>
<th>1/4</th>
<th>1/8</th>
<th>1/15</th>
<th>1/30</th>
<th>1/60</th>
<th>1/125</th>
<th>1/250</th>
<th>1/500</th>
<th>1/1000</th>
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**Study Questions:**

1. A lens has a focal length of 10 cm. You place an object 50 cm from the lens. Where is the image (where should I put the screen or the film)? How large is the image compared to the object. If you place the object 5 cm from the lens where is the image?

2. Show the three easy axes from the top of the object through the lens. X marks the focal length of the lens. Show the image.

3. A slide projector is used to project a 2 cm slide on a screen 5 m away. The image on the screen is 2 m high. What is the focal length of the projector lens?

4. Normal eyes, with the eye muscles relaxed, will focus at infinity (objects far away in focus on the retina). Near sighted people with their eye muscles relaxed see objects (for example) 50 cm away well in focus, but not objects farther away. To look at objects farther away they need to wear glasses. The glasses are lenses forming a virtual image of far away objects. The image must be 50 cm from the eye: it is this image that their eyes look at.
   a) What must the focal length of the glasses be? (Hint: use the lens formula? what is the desired image distance? For what object distance o?)
   b) Are the glasses converging or diverging lenses? (Note: by straining the eye muscles, they can only make the focal length of the eye lenses shorter than in relaxed eyes, but not longer: that is why near sighted people cannot see in focus beyond a certain distance, called the "far point" of the eye. By tightening the eye muscles they can focus on nearby objects up to a point, called the "near point" of the eye.
   c) Convert the focal length into diopters.

5. Most 35 mm slide projectors have lenses with a focal length f = 5 cm. The f# of a good projector is about f/2.
   a) If the screen is 3 m from the lens, how far is the slide from the lens? How large is the picture on the screen if the slide is the usual 35 mm x 24 mm?
   b) How large is the diameter of the lens aperture? Is an f/2 projector lens always better than an f/4 projector lens? Explain.

6. A photograph taken with 1/60 s and f/16 gives the proper exposure. What f# is need, if the exposure time is changed to 1/125 s?

7. A photograph taken with 1/60 s and f/11 on ISO 100 film gives the proper exposure. What f# is needed if the film is changed to ISO 400 and the shutter speed is kept the same?

8. A photograph taken with 1/60 s, f/11 on ISO 200 film gives the proper exposure. What f# is needed if the film is changed to ISO 400 and the shutter speed is changed to 1/30 s?

9. Visible light ranges in wavelength from 400 to 700 ? in what units are these numbers?

10. About what wavelength does spectral red correspond to? Green? Blue?

11. Draw plots of the relative sensitivity of the three types of color receptors, showing how the color sensitivity of each changes with wavelength.

12. What are the eye color sensors called?

13. Do the green sensors respond to green light only? Explain.

14. The transmission curve of a filter tells you what fraction of the light of a particular wavelength the filter transmits. The number 1 on the graph means all the light of that wavelength passes through the filter. 0.5 means half of the light passes, 0 means no light goes through at that wavelength. What color is the light from filter A? From filter B?
15. Subtractive mixing. What color do you see on the screen?


17. Answer problems 14, 15 and 16 using filters C and D below.
18. Answer problems 14, 15 and 16 using filters E and F.

19. Answer problems 14, 15 and 16 using filters G and H.

20. Show where the complementary of the marked colors are on the triangle. What colors are they? Hint: first locate the "white point."

21. What hue is each of the following combinations of primary colors?

- \(0.3R + 0.1G + 0.6B = ?\)
- \(0.2R + 0.2G + 0.2B = ?\)
- \(0.1R + 0.5G + 0.4B = ?\)
- \(0.2R + 0.2G + 0.1B = ?\)

22. If you chose as primary colors blue red and yellow instead of green, what hues could you reproduce by adding these three? What hues could you not reproduce? (E.g. could you make the purples, cyan, orange, white?)