

LAB 7: HUMAN EYE, A BIOPHYSICS LABORATORY

During this laboratory session, students will

- ✓1 apply the skills and knowledge they acquired in Geometric labs I and II to Biophysics,
- ✓2 create a very simple eye model,
- ✓3 work on a PASCO eye model,
- ✓4 view the eye accommodation in different manners,
- ✓5 study myopia,
- ✓6 study hyperopia.

Student Learning Outcome: Successful students will

- ✓1 understand the optical system of the human eye,



- ✓2 understand some reasons why the radii of human eye lenses are not the same,
- ✓3 know how to identify whether an image is real or virtual.

INTRODUCTION

This experiment focuses on the human ocular system. The diagram of human eye, which you can find easily in the web, shows that the human eye has two lenses. The first is the fixed-focal length cornea that looks like a plano-convex lens. It brings the objects at the far point (ideally infinitely far away) to a focus on the retina when the second lens is relaxed. The second, which we call the crystalline lens or simply eye lens, is biconvex and adjusts so that we can focus on objects between our far point (ideally infinity) and our near point (ideally around 20–25 cm from the cornea).

Using a PASCO eye model, you will study the formation of images on the retina of the eye and the eye accommodation. In addition, you will also learn about certain eye diseases, such as farsightedness or hyperopia and nearsightedness or myopia. This is just a small portion of what can be learned about the eye using Physics.

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Activity #1: Homemade eye model

Build your eye model following the instructor demo that he gave during his in-class introduction. Then answer to the following questions.

1. Identify the elements of the eye that the biconvex lens, the screen, and the object (hand) respectively represent.
2. What is missing in this homemade model?
3. How is the image on the screen, is it upright or inverted, real or virtual?
4. What happens to the neatness of the image when we move the object closer to the lens? Same question when we move the object away from the lens?
5. Does d_o or d_i remain constant when the eye switches the attention from one location to another one? Which one changes? Why?
6. According to your answer for question #5 and the thin lens equation, what can we say about the focal length of the eye lens?
7. Using the thin lens equation, find the focal length of eye lenses that forms images at the retina if it is looking at an object 6.00 m away. Same question if looking at an object 16.00 m away. What is the percent difference of "f"? (Use the distance between the retina and the eye lens you found for the

preliminary work.)

8. According to the lens makers' equation, what parameters of the eye lens does the brain change to accommodate the focal length?

Activity #2: Accommodation

We will use the PASCO eye model from this activity on (activities #2–#5). In this model, the corneal lens, which was missing in the homemade human eye, and crystalline lens together act like a single convergent lens. This model contains a pupil as an option. Rays from an object that enter the eye through the pupil pass through that lens system and form an inverted, real image on the retina.

1. Insert the retina (white screen) in the middle slot, which is marked NORMAL, and the +400-mm lens in the SEPTUM slot. Then put your cell phone in front of the eye model, about 50 cm from the cornea—no flash light, however, make sure that your cell phone screen is shining. Adjust the position of the cell phone so that the image would be well-focused. Record that position for future use.
2. Move the cell phone up and down, left and right. Describe how the image is affected by these motions.
3. Move your phone back and forth. Describe how that affects the image.
4. Remove the 400-mm lens and prepare the adjustable focus lens according to PASCO direction if available or using the following direction:
 - First, using the syringe and needle, fill the adjustable focus lens with water.
 - Also, fill the syringe about 3/4 way with water.
 - Then attach one end of the plastic tubing to the syringe.
 - Then push slightly the piston in until the tube is filled with water.
 - Connect the tube to the adjustable lens. Slightly pull out or pull in the

piston to chase away any air bubble.

5. Insert the prepared lens into the SEPTUM slot. Keep in mind that this is the eye lens, so it should be in the eyeball. It is not meant to be put in front of cornea to play the role of a correcting glass.
6. Put your cell phone screen about 25 cm from the retina. You should be able to see a very blurry image. Then start playing gently with the syringe piston to create the clearest image. Did you increase or decrease the power of the lens?
7. This time, put the cell phone at about 50 cm from the retina. Again, play carefully with the piston to get the clearest image. Did you increase or decrease the power of the lens?
8. Do you have some rational to your answers to #6 and #7? Explain in few words.

Activity #3: Asymmetry of the eye lens and accommodation tuning

1. Use the relevant geometrical/physical/optical characteristics of the human eye you found in the preliminary work to fill the following two charts. Assume that the eye lens follows the lens makers' equation you found in the preliminary work. R_1 is the anterior radius through which the incoming rays enter (R_2 is the posterior radius). You may use Excel.

| | | | | | | | |
|------------|-----|-----|-----|-----|-----|-----|----|
| R_1 (cm) | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| R_2 (cm) | 4.0 | 4.5 | 5.0 | 5.5 | 6.0 | 6.5 | 7 |
| f (cm) | | | | | | | |

| | | | | | | | |
|------------|-----|-----|-----|-----|-----|------|-----|
| R_1 (cm) | 8.0 | 8.5 | 9.0 | 9.5 | 10 | 10.5 | 11 |
| R_2 (cm) | 6.0 | 6.0 | 6.0 | 6.0 | 6.0 | 6.0 | 6.0 |
| f (cm) | | | | | | | |

- How would the chart support the idea that the fine-tuning of the accommodation is done through the contraction/relaxation of the anterior capsule, whereas the rough tuning is done via the posterior capsule?
- Which one of the capsules would be involved more for near vision? Which one for far vision? Why?

Activity #4: Common eye diseases

1. Farsightedness or hyperopia:

- Put the most powerful converging lens available to you (very likely a 62-mm lens) in the SEPTUM slot and retina in its NORMAL position. This is to assimilate a near vision.
- Adjust the position of the cell phone in order to get a clear image.
- Move the retina to the forward slot. The eyeball is then shorter, which creates a hyperopia condition. Needless to mention the image is blurry (out of focus). This resembles to a farsighted person looking at a near object (or reading something).
- Insert the round pupil in slot A. What do you notice? Why would reducing the size of the pupil make the image clearer? When would a farsighted person see better when reading: in bright or in dim light?
- Remove the pupil. Then find a lens that corrects the hyperopia the best. What is its power?

2. Myopia:

- Find the least powerful lens available to you (very likely a 400 mm). It will allow us to assimilate a far vision.
- Follow the different steps in #1) keeping in mind that we are now working on the far vision—you should move the retina to the back slot to lengthen the eyeball.

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