Vision: How does your eye work?
Student Advanced Version

In this lab, we will explore some of the capabilities and limitations of the eye. We will look at the extent of peripheral vision, the size of the blind spot, depth perception, and color vision.

Part 1 - Peripheral Vision, Blind Spot, and Depth Perception

Key Concepts:

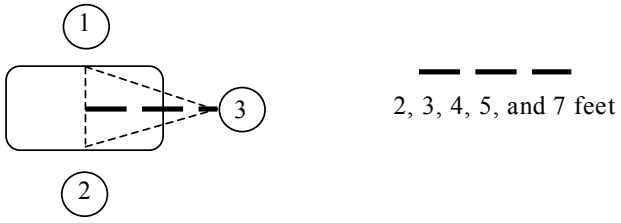
- Sight is one of the five senses that we rely upon to observe the world.
- The eyes are adaptable and versatile organs that help us perform our everyday duties. They detect light and send signals along the optic nerve to the brain to process the images we see.
- **Peripheral vision** is the ability to see the fringe or edge of your vision when you focus straight ahead.
- The **blind spot** is a small area on the back of the eye where the optic nerve enters the eyeball that is not sensitive to light. This creates a gap in your vision. The brain "fills" in the blind spot by combining the images from the left and right eyes so you are unaware you something is missing form your field of vision.
- **Depth perception** is ability to see the world in three dimensions. Depth perception is important for us to determine how far an object is away from us. When we are walking, we need to make sure that we perceive an object's distance from us correctly so we won't walk into them.

I. Peripheral Vision:

In this portion of the lab, we will try to measure how far one's peripheral vision extends.

Procedure:

1. Have the two people testing their eyes sit across from each other (about 3-4 feet apart) and the third person stand an equal distance from both (as diagrammed below).
2. Each of the two sitting people should cover the eye that's further from the third person (one person covers their left eye and the other covers their right). The two people sitting down are allowed only to look straight at each other.
3. The third person will then stand 2 feet to the side of the two people sitting, hold up different numbers of fingers and ask each person sitting down to identify the number of fingers. Repeat this three times and record the number answered correctly in table on the next page.



4. Repeat for a distance of 4 and 6 feet away from seated students.

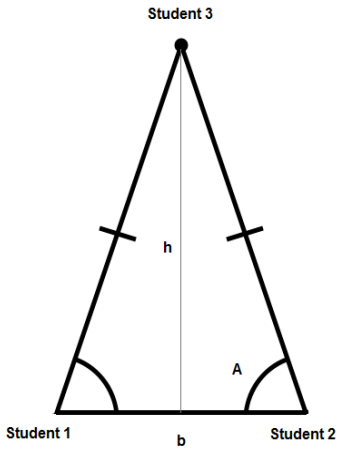
5. Switch roles until everyone in the group has tested their peripheral vision.

Number Correct

	2 foot		4 feet		6 feet	
	Left	**Right**	**Left**	**Right**	**Left**	**Right**
Trial 1						
Trial 2						
Trial 3						

Q1. About how big is your peripheral vision? Think about a clock, with your nose facing 12:00.

Q2. Convert this into an angle measurement (A). Assume that the distance between the two seated people is the base of an isosceles triangle and the distance from each seated person to the standing person is equal.



h – distance to seated person (2, 4 or 6 feet)
b – distance between seated people (3-4 feet)
$\tan(A) = h / (b/2)$
$\tan^{-1}(\tan(A)) = \tan^{-1}(h/(b/2))$
$A = \tan^{-1}(h/(b/2))$

Q3. Peripheral vision in humans, especially in distinguishing color and shape, is weaker compared to animals. What is a possible reason for this? (Think about the location of receptor cells on the retina).

II. The Blind Spot (groups of 3):

In this portion of the lab, we will measure the diameter of an individual's blind spot.

Procedure:

1. Make a tester by marking + on the far right side of a piece of notebook paper.
2. Stand with your back to a wall, with your head touching the wall.
3. Have someone hold the tester 500 mm (0.5 m or 50 cm) in front of your eye (place the + between your eyes, with the paper extending to the left).
4. Close your right eye and look at the + with your left eye.
5. Place a pencil eraser or bright object on the far left side of the tester.
6. Slowly move the pencil eraser to the right.
7. When the eraser disappears, mark this location on the tester. Call this point "A."
8. Continue moving the eraser to the right until it reappears. Mark this location on the tester. Call this point "B."
9. Repeat the procedure until you are confident that they are accurate.
10. Measure the distance between where the eraser disappeared and reappeared (A to B).

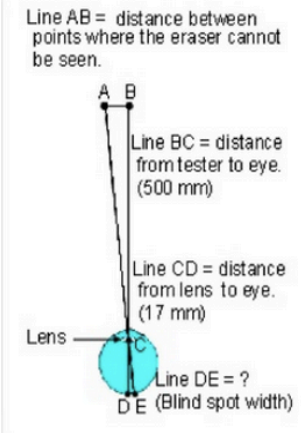
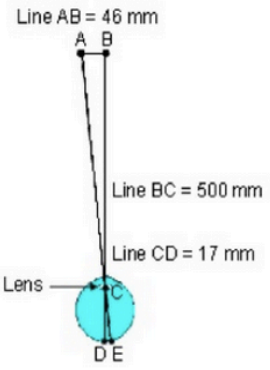
Distance from A to B

Left Eye	Right Eye
Average distance:	Average distance:

Q4. Calculate the diameter of your blind spot.

To calculate the width of your blind spot on your retina, let's assume that 1) the back of your eye is flat and 2) the distance from the lens of your eye to the retina is 17 mm. We will ignore the distance from the cornea to the lens. With the simple geometry of similar triangles, we can calculate the size of the blind spot because triangle ABC is similar to triangle CDE. So, the proportions of the lines will be similar.

Follow this example:

Set up	Example	Calculations
		$\frac{17}{500} = \frac{DE}{AB}$ $\frac{17}{500} = \frac{DE}{46}$; $DE = (46)\frac{17}{500}$; $DE = \frac{782}{500} = 1.56$

Q5. Where was the blind spot relative to your peripheral vision? (Think about the clock and where the blind spot is on the clock).

Q6. What is the diameter of your blind spot? Is it larger or smaller than you would expect?

Q7. What are scotomas?

Q8. Why do we not normally notice our blind spot when we have both eyes open?

III. Depth Perception:

In this portion of the lab, we will explore how depth perception changes when you are using one eye compared to two eyes and when the perceived object is at variable distances from you.

Procedure:

1. Sit at a table with your partner.
2. Put a cup in front of your partner. The cup should be about two feet away from him/her.
3. Have your partner CLOSE one eye. Hold a penny/button in the air about 1.5 ft. above the table.
4. Move the penny/button around slowly. Ask your partner to say "Drop it!" when he or she thinks the penny will drop into the cup. When your partner says "Drop it," drop the penny and see if it makes it into the cup. Repeat this 5 times, changing the position of the cup by moving the cup left and right. Record the number (out of 5) that made it into the cup. 5. Try it again when your partner uses both eyes.
6. Try it again with the cup farther away (~ 3 feet) from your partner (with one eye open and both eyes open)
7. Try it again with the cup closer (~ 1 foot) to your partner (both with one eye open and both eyes open).
8. Change roles and repeat.

Distance: Cup to Guesser	One Eye Open (coins in cup)	Both Eyes Open (coins in cup)
1 foot		
2 feet		
3 feet		

Q9. At what distance did you get the most pennies/buttons in the cup (i.e., you had the best depth perception)?

Q10. Is there improvement with the cup is closer to the subject? Why or why not?

Q11. Is there improvement of depth perception with two eyes open? If so, explain why.

Part 2 – Color Vision

Key Concepts:

- **Color Vision**: We are able to see colors when there is sufficient light, but when the light intensity is too low, we can only make out dark and light shapes.
- On the inside of your eyes there are blue, red, and green **cone cells**. These cells are sensitive to each of those three colors. When light of different wavelengths enters the retina, the color of an object is detected by a mixture of these cones cells.
- An **afterimage** is what you see if one type of cone is over stimulated by staring at a single color. It becomes fatigued, so if you stare at a red poster for a long time then quickly look at a white background, the fatigued cones will not work very well. This causes an afterimage to appear.
- Our brain responds to moving images by anticipating motion to continue in the same direction. Since we anticipate the motion of objects, we can sometimes observe patterns that are not truly there. These are optical illusions.
- Face recognition is a very important part of our visual perception. Therefore, our brain responds strongly to images involving human faces, sometimes distorting our perception in interesting ways.

Instructions: Open your computer and find the four Vision stations: Color Vision, Afterimages, Swirling Ring, and Hollow Face. Follow the instructions for each individual station. Fill in the tables below and then answer the questions at the end of this section.

I. Color Vision: In this station, you will look at five different color images that have colored numbers on them.

Fill in the table below with your guess for the number inside the circle for the five intensities of images on the website. Then place the mouse cursor over each image to reveal the actual number and record this number in the table.

	10% Intensity	**15% Intensity**	**20% Intensity**	**25% Intensity**	**30% Intensity**
Guess					
Actual					

Q12. At what intensity could you begin to see the colored numbers? Explain what you saw in terms of the types of photoreceptors in the retina.

Q13. What is the retina and where in the eye is it located?

Q14. Name the two types of photoreceptors in the retina and describe what they do.

Q15. What is photoreception?

II. Afterimages: Follow the instructions on this station to observe an afterimage.

Q16. What were the colors in the afterimage behind each colored square?

Q17. What are opsins and how do they work?

Q18. Use bleaching to explain the after image.

Q19. What is the wavelength of the visible spectrum?

Q20. Arrange the following in increasing order of maximum wavelength absorbed – red cones, green cones, and blue cones.

III. Swirling Ring Illusion: In this optical illusion, there is a ring with randomly blinking dots that has a very interesting behavior. Follow the directions for this station to observe this optical illusion.
Q21. Describe what you saw in this illusion.

IV. Hollow Face Illusion: Follow the instructions in this station to observe the Hollow Face Illusion (provided by Professor Richard Gregory). Then, look at the hollow mask presentation to see the Hollow Face Illusion.
Q22. Describe what you saw in this illusion.

References

Depth Perception and Blind Spot:
1. http://faculty.washington.edu/chudler/blindspot.html
2. Cassin, B. and Solomon, S. *Dictionary of Eye Terminology*. Gainsville, Florida: Triad Publishing Company, 1990.
3. http://www.britannica.com/EBchecked/topic/69390/blind-spot
Color Vision
1. http://faculty.washington.edu/chudler/chvision.html