Vision is the act of seeing; vision involves the transmission of the physical properties of an object from an object, through the eye, and (via action potentials) to the brain.

When something interferes with the proper reception or transmission of these visual stimuli, the electrical impulses are either not received or not recorded properly and a visual problem exists. If the eyeball itself is too long or too short, or if the lens is improperly shaped, or if the ciliary muscles do not contract as they should, a person will not see clearly.

What we see and how we see it are not always just a matter of physics. We know, for instance, that victims of war and other physical and mental terrors may develop a psychological blindness in the absence of any apparent physical abnormality. We also know that sometimes a refractive lens might be mechanically correct but that practically or psychologically it is not the right lens for the person being tested. For these reasons we can say that vision testing today is both an art and a science.

In this lesson we will examine some of the physiological aspects of vision. It should be mentioned that anomalies tested for here do not indicate the overall "health" of the eye. (Example: A person may be quite nearsighted while still having eyes that are physically strong, disease-free, and showing no signs of degeneration.)

It should be remembered, that tests performed in this laboratory lack both the precision and the accuracy you would find in the professional laboratory of an optometrist or ophthalmologist. If after completing these tests you feel you have a vision problem, consult an appropriate health care professional.

As you go through these tests, record your results on the data sheet.

A. Visual Acuity

Visual acuity is a measure of the resolving power of the eye. The normal human eye can differentiate at a distance of 10 m two points that are 1 m apart. This is because of the retinal cones. If two photoexcited cones are separated by at least one nonexcited cone, the human brain can differentiate between the points of excitement. A person with less than "normal" visual acuity has some aberration that causes the excitation of all cones in a particular area. Pinpoints of light are not recognized as distinct. Thus, separate points are not recognized as separate and the images appear blurred. The Snellen chart, named for Dutch ophthalmologist Herman Snellen (1834-1908), is a standard chart used for testing visual acuity. One problem with the Snellen test is that it tests ONLY for distance visual acuity. In other words, Snellen tests for myopia. The Snellen test does not test directly for hyperopia, and a person with simple moderate hyperopia might not be detected at all on the Snellen test. This person might well have a Snellen score of 20 / 20. Another person might be extremely farsighted and test out at 20/200 on the Snellen chart- not because the person is unable to focus "that far away" but rather because the person is unable to focus "that close!"

In addition to hyperopia, the Snellen chart also does not test for either astigmatism or presbyopia. Hyperopia, astigmatism, and presbyopia are essentially symptomless and present definite problems for vision-screening experts, particularly those screening the vision of young children. Additionally, the Snellen test does not test for amblyopia (lazy eye) or any eye disease. Amblyopia exanopsia is the term commonly used for the inability to control the movements of one or both eyes. To avoid diplopia (double vision), vision in the amblyotic or "lazy" eye often becomes dim or suppressed. If not detected in the preschooler, optical muscles do not strengthen properly and vision may be permanently lost in the affected eye. In school screenings about 80% of the referred vision problems are simple nearsightedness, even though in the general population about 60% of all people are hyperopic. (Very young children tend to be farsighted.) It is generally considered to be more difficult to function in a society with myopia than with hyperopia.
Figure 1 Snellen eye chart. This chart determines acuity at a distance of 20 feet. By determining the last accurate line, one can determine their acuity. If one is 20/20, they have “normal” acuity (emmetropia). If one reads accurately at 20 feet what the “normal” eye can read at 40 feet, they are 20/40.


Write your results for each eye on the data sheet.

**B. Correcting Vision**

Figure 2 Images of normal (Emmetropia), near-sighted (Myopia), and far-sighted (Hyperopia) eyes. Lenses are applied to correct the focal point.

Compare the images of the eyes. On the data sheet, write comments on the location of the focal point for myopia and hyperopia. In addition, explain how lenses correct the focal points.
Several glass lenses have been placed in a tray with some reading material. The lenses are a concave (or convex) shaped. Try reading the material with the lenses a few inches above it. Comment on your observations. Try focusing light rays through the lenses. Comment on your observations. Relate your observations to figure 2 and discuss what lenses can be used to correct myopia and hyperopia and why. NOTE: if you wear glasses, make the same observations with your lenses.

C. Astigmatism

Astigmatism is a condition caused by an uneven curvature of one of the rounded surfaces of the eye. Usually the lens is the part with the aberration; however, the cornea may also be afflicted with uneven curvature. (A misshaped retina will cause astigmatic vision, but this condition is not usually classified as true astigmatism.) Because of the uneven curvature, lines in one or more planes will be out of focus. In other words, the light rays striking one plane (or portion of a plane) will not be bent proportionately the same as light rays striking another plane (or portion of a plane). Astigmatism can be simple (affecting only one meridian of the eye), compound (involving both horizontal and vertical curvatures of the eye), index (resulting from refractive indices inequalities indifferent parts of the lens), or mixed (causing one meridian to be hyperopic and the other myopic).

For this test, go to http://www.prokerala.com/health/eye-care/eye-test/ and follow directions for Astigmatism Test.

Write your results for each eye on the data sheet. http://www.acuvue.ie/astigmatism has some examples that help.

D. Near Point Determination

Near point determination is a test to measure the elasticity of the lens. Specifically, as you focus on closer objects, your lens must become more spherical than when you focus on more distant objects. The ability of the lens to accommodate this increased convexity decreases with age, and a condition known as presbyopia - meaning old eye- develops. (Presbyopia is not limited to older people. Optometrists today tell us that presbyopia is not the best term to use, especially since more and more children are being diagnosed with this condition. This may be due to an increased awareness of the problem rather than to an actual increase in presbyopia.) Near point is the measurement from the eye to the closest distance at which the subject can focus sharply.

For this test, test each eye separately and write results on the data sheet. Take the test sheet (plan sheet of paper with “Click for the title” written on it). Start with the test paper at an arm’s length from your eye. Slowly move the paper toward your eye. When the image begins to blur, have your partner measure the distance from your eye to the paper. This is your near point. Record this data on your data sheet.

Table 1 Average near points for different ages

<table>
<thead>
<tr>
<th>Years</th>
<th>Distance (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>7.0 – 7.5</td>
</tr>
<tr>
<td>20</td>
<td>9.0 – 10.0</td>
</tr>
<tr>
<td>30</td>
<td>11.5 – 13.0</td>
</tr>
<tr>
<td>40</td>
<td>17.2 – 20.0</td>
</tr>
<tr>
<td>50</td>
<td>45.0 – 52.5</td>
</tr>
<tr>
<td>60</td>
<td>89.3 – 90.0</td>
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</tbody>
</table>
E. Color Blindness
Color blindness, which can be any of several sex-linked hereditary conditions, is due to one or more defects in retinal cones. Recall that cones are responsible for color vision. Protanopia exists if red cones are lacking. Individuals with this condition tend to see blue-greens and purplish reds as grays. Deuteranopia exists when green cones are lacking. Such individuals see greens and purple reds as gray. People with either of these conditions have red-green color blindness and have varying degrees of difficulty in differentiating between the reds and the greens. Red-green color blindness is technically called daltonism (after the English chemist, John Dalton, 1766-1844). In addition, yellow weakness, blue weakness, and total color blindness exist. It also seems that some persons have a mild color loss. These people can distinguish the entire color spectrum, given sufficient time, light, and concentration. However, their color acuity does not seem to be as sharp as that of the general population. These individuals seem to have fewer, though equally efficient, cones than do other people. Color blindness can best be tested with the Ishihara or Stilling color test plates.

For this test, go to http://www.prokerala.com/health/eye-care/eye-test/ and follow directions for Color Blindness Test.

Write your results for each eye on the data sheet.

F. Blind Spot Determination
The blind spot determination test verifies that there are no photoreceptors in the optic disk. This is the point where the retinal nerve fibers leave the eye.

For this test, test each eye separately and write results on the data sheet. Take the test sheet (plan strip of paper with + and - on it). Start with the test paper at an arm’s length from your eye. Keep your left eye closed, and use your right eye to focus on the dot. The dot should be directly in front of your open eye and the cross is to the outside. Slowly move the paper directly toward your face until the cross disappears. Measure the distance (cm) where it disappears and re-appears. Repeat this experiment with the right eye closed and the left eye open. Record your results on your data sheet. Discuss this phenomenon with your partner.

G. Pupillary Light Reflex
The pupillary light reflex demonstrates how quickly the pupil of the eye changes size in response to the amount of incoming light (see figure 3).

Test this by holding one eye closed for at least one minute and then release the eye suddenly in the presence of a bright light. As you do this, have your partner observe the changes in your pupil size. Repeat this experiment with the other eye and have your partner note any differences in the reflex between one eye and the other eye. Record your results.

Figure 3 Pupillary Light Reflex
Figure 4 Pupillary Distance Reflex
H. Pupillary Distance Reflex
The pupillary distance reflex is based on the need for more light to enter the eye to view more distant objects. Thus, to view these far objects, the pupil will be larger (see figure 4).

Test this reflex by concentrating on a close object (magazine article) for at least one minute. Suddenly switch your vision to a predetermined distant object at least 20 ft away and illuminated with the same light intensity as your nearby object. Have your partner observe changes in your pupils. This test can be done with each eye separately and with both eyes together. Be certain to rest your eyes between tests so that ocular fatigue does not influence your pupillary reflexes. Record your results on your data sheet.

I. Peripheral Vision
Peripheral vision is the name given to your "sideways" vision. Some people develop "tunnel vision" which is an inability to see lateral objects or events. If your peripheral vision is good, while looking straight ahead you should be able to see approximately 90 degrees to either side of your head. In other words, with your arms outstretched to the side and with both eyes open and focusing on a distant object, you should be able to discern the fingertips of both hands. Were your nose not in the way, each eye should actually have a range of vision of about 180 degrees. Although rather complicated machines for performing peripheral vision tests without human error do exist, you can use one laboratory method to help you understand your own visual range.

Test each eye separately. Sit in a somewhat darkened area and concentrate on a distant object directly in your line of vision. Have your partner slowly move his or her finger or a piece of white chalk around your head from the rear, maintaining a radius of about 45cm. Stop your partner as soon as you see the finger or chalk. Measure the angle from the point of your forward vision. Record your results for each eye on your data sheet.

J. Eye Dominance
Eye dominance is the term used to describe whether you are "left-eyed" or "right-eyed." Although you may seem to see equally well with both eyes, your vision in one eye is probably dominant over your vision in the other eye. Being right- or left-eyed is totally independent from being right- or left-handed!

Test for eye dominance by focusing both eyes on an object somewhere across the room. Now, with your thumb or index finger, quickly point to that object. Hold your hand still and look at the object with each eye separately. With one eye your finger should appear to be directly on the object. With the other eye your finger will be approximately 3 degrees to one side or the other of the object. Whichever eye is open when your finger seems to be on the object is your dominant eye. Record your results on your data sheet.
K. After-Image
Test the effects of focusing on an image for a period of time. Obtain a white sheet of paper with a colored dot on it. Predict what will happen when you stare at the image for 30 seconds. Focus on the colored sticker for 30 seconds while your partner times you. When your partner indicates that the time is up, shift your gaze to a plain white section on the same sheet of paper. Record what you see.

Repeat procedure two more times, using two other colored stickers.