General- Physics-2 Q4 Week-5

Fundamental Physics I (University of the Philippines System)

DEPARTMENT OF EDUCATION
SCHOOLS DIVISION OF NEGROS ORIENTAL
REGION VII
Kagawasan Ave., Daro, Dumaguete City, Negros Oriental

APPLICATION OF IMAGE FORMATION

for GENERAL PHYSICS 2/ Grade 12/ Quarter 4/ Week 5

SELF-LEARNING KIT

FOREWORD

This Self-Learning Kit will serve as guide in the application of the principles of geometric optics in discussing image formation by the eye and correction of common vision defects.

The principle of image formation has various applications. Some of these applications enable the viewing of objects that are unperceivable to the unaided eye. These applications make accurate use of the principles of geometric optics, which you learned in the previous self-learning kit. Image formation, as you have learned, depends on the reflection and refraction of light using mirrors and lenses, respectively.

Moreover, this kit provides different activities which are useful in understanding how the property of refraction of light principle is utilized to life's different situations.

So, explore and enjoy doing the activities and be ready to be equipped how vision defects are being corrected.

OBJECTIVES

At the end of this self-learning kit, you will be able to:

K: understand the basic physics of how images are formed by the human eye;

S: apply the principles of geometric optics to discuss image formation by the eye, and correction of common vision defects; and

A: recognize the importance of identifying lenses in the correction of common vision defects.

LEARNING COMPETENCY

Apply the principles of geometric optics to discuss image formation by the eye, and correction of common vision defects **(STEM_GP12OPTIVd-28).**

I. WHAT HAPPENED
PRE-ACTIVITY:

Connecting Concepts

Lenses are used everyday, may it be at work or at home. It serves as an aid to the eye to see a clearer and better view of the world. As a review, can you tell how lenses able to do this? How are lenses related to light?

Activity 1. Physics in a Glass

***Objective*:** To observe the size of the arrow as seen on the screen.

Materials:

- Magnifying glass/glass of water
- Bond paper (screen)
- A marker

Procedure:

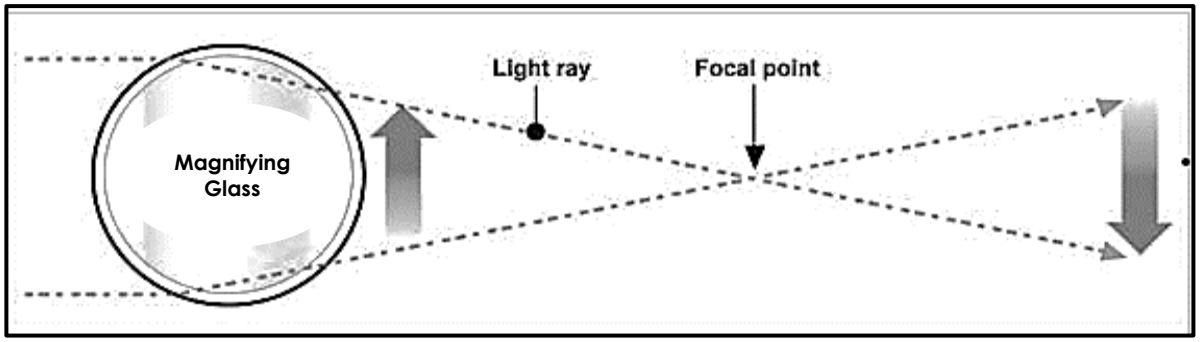
1. Get a magnifying glass/glass of water.
2. Draw a horizontal arrow on a notecard.
3. Put the note card behind the magnifying glass/glass of water and slowly move the note card back and forth. Look into the screen and observe the arrow. What appears to happen to it?

4. Put a white paper as the screen. Slowly move the notecard closer or farther from the magnifying glass/glass of water.
5. Write your observations on your notebook/Activity Sheet.

II. WHAT I NEED TO KNOW
DISCUSSION

Geometric Optics: Lenses and Vision Correction

In the activity you have just performed, you have just demonstrated a concept in physics which is bending of light, **refraction.** When the arrow is moved to a particular distance behind the magnifying glass, it looks like it reversed itself. When light passes from one material to another, it can bend or refract. When light goes through a magnifying glass/glass of water, the light bends toward the center. Where the light all comes together is called the ***focal point,*** but beyond the focal point the image appears to reverse because the light rays that were bent pass each other and the light that was on the right side is now on the left and the left on the right, which makes the arrow appear to be reversed. The diagram explains this better.



Adapted from www.physicscentral.com/experiment/physicsathome/reversing-arrow

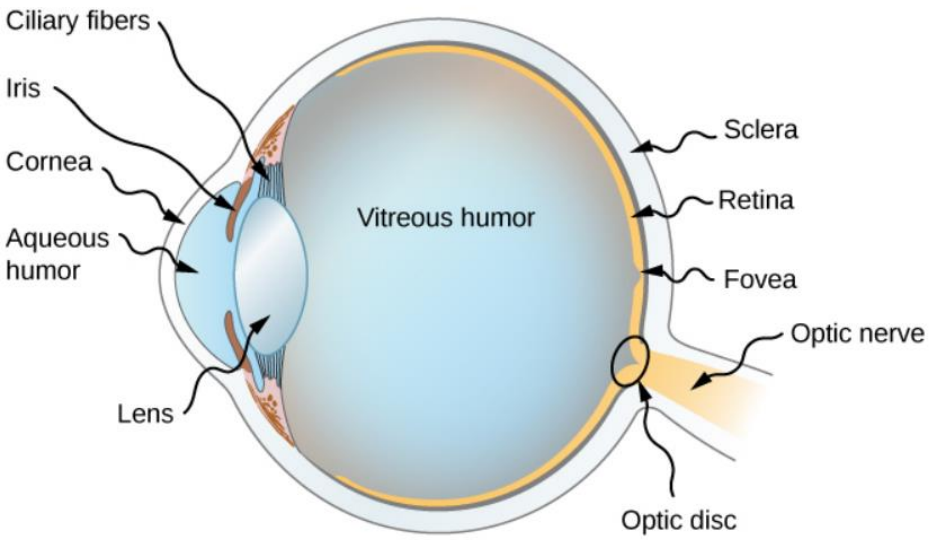
Figure 1. Images formed by lenses

Physics of the Eye

The eye is remarkable in how it forms images and in the richness of detail and color it can detect. However, our eyes often need some correction to reach what is called "normal" vision. Actually, normal vision should be called "ideal" vision because nearly one-half of the human population requires some sort of eyesight correction, so requiring glasses is by no means "abnormal."

Figure 1 below shows the basic anatomy of the eye. The cornea and lens form a system that, to a good approximation, acts as a single thin lens. For clear vision, a real image must be projected onto the light-sensitive retina, which lies a fixed distance from the lens. The flexible lens of the eye allows it to adjust the radius of curvature of the lens to produce an image on the retina for objects at different distances. The center of the image falls on the fovea,

which has the greatest density of light receptors and the greatest acuity (sharpness) in the visual field. The variable opening (i.e., the pupil) of the eye, along with chemical adaptation, allows the eye to detect light intensities from the lowest observable to 10^{10} times greater (without damage). This is an incredible range of detection. Processing of visual nerve impulses begins with interconnections in the retina and continues in the brain. The optic nerve conveys the signals received by the eye to the brain.



Adapted from https://openstax.org/books/university-physics-volume-3/pages/2-5-the-eye

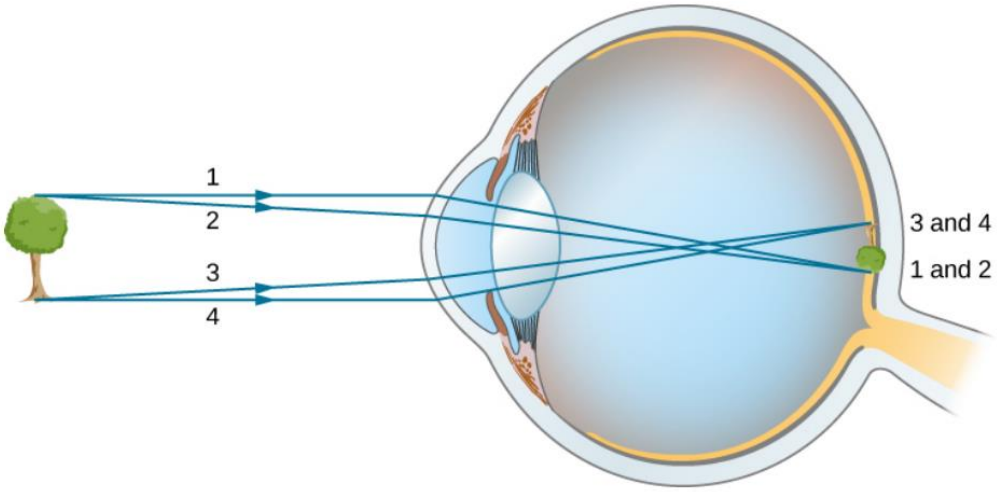
Figure 2. The cornea and lens of the eye act together to form a real image on the light-sensing retina, which has its densest concentration of receptors in the fovea and a blind spot over the optic nerve. The radius of curvature of the lens of an eye is adjustable to form an image on the retina for different object distances. Layers of tissues with varying indices of refraction in the lens are shown here. However, they have been omitted from other pictures for clarity.

The indices of refraction in the eye are crucial to its ability to form images. Table 1 lists the indices of refraction relevant to the eye. The biggest change in the index of refraction, which is where the light rays are most bent, occurs at the air-cornea interface rather than at the aqueous humor-lens interface. The ray diagram in Figure 3 shows image formation by the cornea and lens of the eye. The cornea, which is itself a converging lens with a focal length of approximately 2.3 cm, provides most of the focusing power of the eye. The lens, which is a converging lens with a focal length of about 6.4 cm, provides the finer focus needed to produce a clear image on the retina. The cornea and lens can be treated as a single thin lens, even though the light rays pass through several layers of material (such as cornea, aqueous humor, several layers in the lens, and vitreous humor), changing direction at each interface. The image formed is much like the one produced by a single convex lens (i.e., a real, inverted image). Although images formed in the eye are inverted, the brain inverts them once more to make them seem upright.

Table 1. Refractive Indices Relevant to the Eye

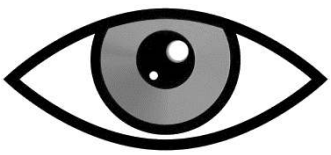
Material	Index of Refraction
Water	1.33
Air	1.0
Cornea	1.38
Aqueous humor	1.34
Lens	1.41*
Vitreous humor	1.34

Refractive Indices Relevant to the Eye *This is an average value. The actual index of refraction varies throughout the lens and is greatest in center of the lens.



Adapted from https://openstax.org/books/university-physics-volume-3/pages/2-5-the-eye

Figure 3. In the human eye, an image forms on the retina. Rays from the top and bottom of the object are traced to show how a real, inverted image is produced on the retina. The distance to the object is not to scale.



VISION CORRECTION

The need for some type of vision correction is very common. Common vision defects are easy to understand, and some are simple to correct. Figure 4 illustrates two common vision defects. ***Nearsightedness*, or *myopia***, is the inability to see distant objects clearly while close objects are clear. The eye over converges the nearly parallel rays from a distant object, and the rays cross in front of the retina. More divergent rays from a close object are converged on the retina for a clear image. The distance to the farthest object that can be seen clearly is called the *far point* of the eye (normally infinity). ***Farsightedness*, or *hyperopia*,** is the inability to see close objects clearly

while distant objects may be clear. A farsighted eye does not converge sufficient rays from a close object to make the rays meet on the retina. Less diverging rays from a distant object can be converged for a clear image. The distance to the closest object that can be seen clearly is called the *near point* of the eye (normally 25 cm).

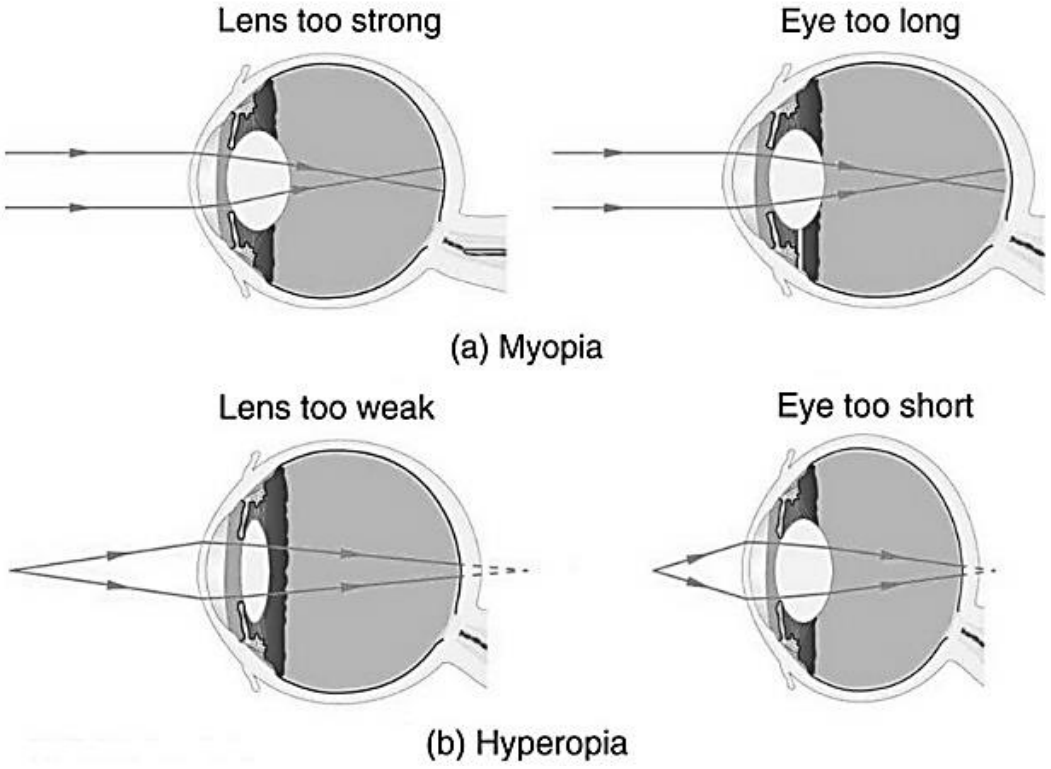


Figure 4. (a) The nearsighted (myopic) eye converges rays from a distant object in front of the retina; thus, they are diverging when they strike the retina, producing a blurry image. This can be caused by the lens of the eye being too powerful or the length of the eye being too great. (b) The farsighted (hyperopic) eye is unable to converge the rays from a close object by the time they strike the retina, producing blurry close vision. This can be caused by insufficient power in the lens or by the eye being too short.

Since the *nearsighted eye* over converges light rays, the correction for nearsightedness is to place a ***diverging spectacle lens*** in front of the eye. This reduces the power of an eye that is too powerful. Another way of thinking about this is that a diverging spectacle lens produces a case 3 image, which is closer to the eye than the object (see Figure 5). To determine the spectacle power needed for correction, you must know the person's far point—that is, you must know the greatest distance at which the person can see clearly. Then the image produced by a spectacle lens must be at this distance or closer for the near-sighted person to be able to see it clearly. It is worth noting that wearing glasses does not change the eye in any way. The *eyeglass lens* is simply used to create an image of the object at a distance where the near-sighted person can see it clearly. Whereas someone not wearing glasses can see clearly *objects* that fall between their near point and their far point, someone wearing glasses can see *images* that fall between their near point and their far point.

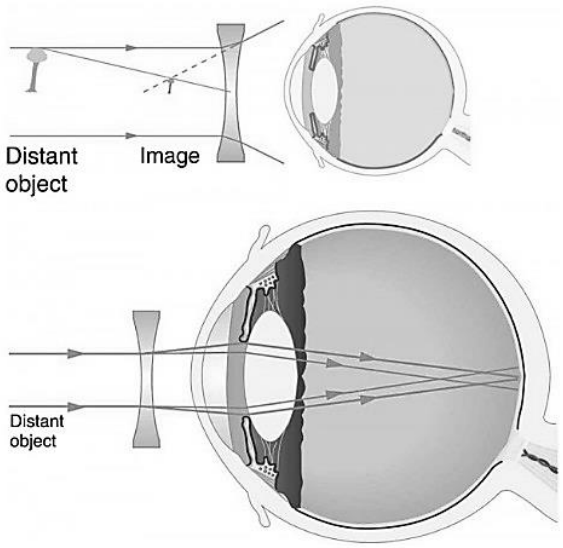


Figure 5. Correction of near sightedness requires a diverging lens that compensates for the over convergence by the eye. The diverging lens produces an image closer to the eye than the object, so that the near-sighted person can see it clearly.

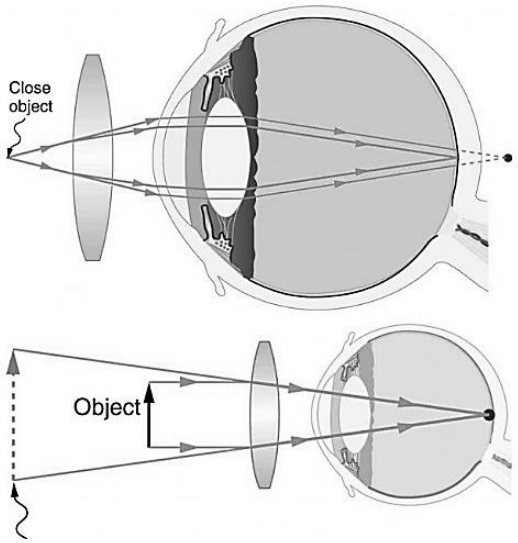


Figure 6. Correction of farsightedness uses a converging lens that compensates for the under convergence by the eye. The converging lens produces an image farther from the eye than the object, so that the farsighted person can see it clearly.

The *farsighted eye* under converges light rays, the correction for farsightedness is to place a ***converging spectacle lens*** in front of the eye. This increases the power of an eye that is too weak. Another way of thinking about this is that a converging spectacle lens produces a case 2 image, which is farther from the eye than the object (see Figure 6). To determine the spectacle power needed for correction, you must know the person's near point—that is, you must know the smallest distance at which the

person can see clearly. Then the image produced by a spectacle lens must be at this distance or farther for the farsighted person to be able to see it clearly.

Corrective lenses are prescribed based on the lens power required to correct the respective eye defect. The lens power of a corrective lens is computed as follows:

$$lens\ power = \frac{1}{f}$$

Lens power is measured in diopters (m^{-1}).

Example 1:

Joey, a nearsighted person, cannot distinctly see objects that are beyond 80 cm from his eyes. What should be the power of the corrective lenses so that he can see distant objects clearly?

Solution:

The image formed must be on the same side of the lens as the distant object (virtual). Thus, you have

$$q = 80\ cm$$

Furthermore, it must be nearer to the lens than the object (diverging lens). As the object is at great distance, p must be very latge enough to make $\frac{1}{p}$ practically zero. Then, you have

$$\frac{1}{p} + \frac{1}{q} = \frac{1}{f}$$

$$0 - \frac{1}{80} = \frac{1}{f}$$

$$f = -80cm = -0.80\ cm$$

The lens power is

$$lens\ power = \frac{1}{f} = \frac{1}{-0.80\ m} \approx \mathbf{-1.25\ diopters}$$

The corrective lens must have a lens power of approximately -1.25 diopters

Example 2:

Rita, a farsighted person, cannot clearly see objects closer to her eyes than 75 cm. What should be the power of the corrective lens that will enable her to read texts at a distance of 25 cm?

Solution:

The image formed must be on the same side of the lens as the distant object (virtual), This means that

$$q = -75\ cm$$

Also, it must be farther from the lens than the texts she would read (converging lens). Thus, you have

$$\frac{1}{f} = \frac{1}{25} - \frac{1}{75}$$

$$f \approx 37.5\ cm \approx 0.375\ m$$

The lens power is

$$lens\ power = \frac{1}{f} \approx \frac{1}{0.375\ m} \approx \mathbf{2.67\ diopters}$$

The corrective lens must have a lens power of approximately 2.67 diopters.

Another common vision defect is ***astigmatism***, an unevenness or asymmetry in the focus of the eye. For example, rays passing through a vertical region of the eye may focus closer than rays passing through a horizontal region, resulting in the image appearing elongated. This is mostly due to irregularities in the shape of the cornea but can also be due to lens irregularities or unevenness in the retina. Because of these irregularities, different parts of the lens system produce images at different locations. The eye-brain system can compensate for some of these irregularities, but they generally manifest themselves as less distinct vision or sharper images along certain axes. Figure 7 shows

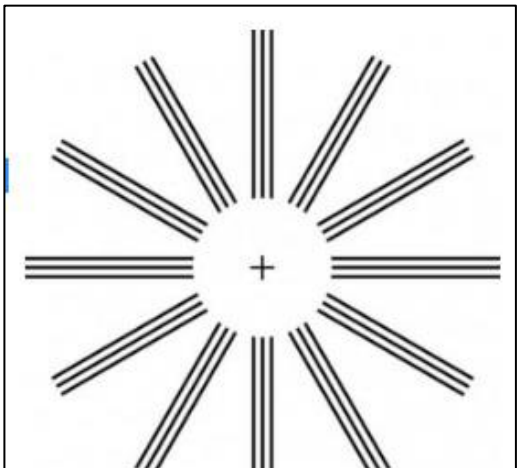


Figure 7. This chart can detect astigmatism, unevenness in the focus of the eye. Check each of your eyes separately by looking at the center cross (without spectacles if you wear them). If lines along some axes appear darker or clearer than others, you have an astigmatism.

a chart used to detect astigmatism. Astigmatism can be at least partially corrected with a spectacle having the opposite irregularity of the eye. If an eyeglass prescription has a cylindrical correction, it is there to correct astigmatism. The normal corrections for short- or farsightedness are spherical corrections, uniform along all axes.

Performance Task:

Directions: Do what is asked below. After which, submit your video to your subject teacher.

You are an ophthalmologist at an eye clinic. Two patients with vision problems came to you for help. You decided to further explain to them their vision problems and how these can be resolved using prescription glasses. One of the patients is farsighted, and the other has astigmatism. The usefulness of your advice or prescription will be evaluated by the head of the ophthalmology department who requires your interaction with the patients to be recorded in video. The evaluation will depend on the following: the use of accurate concepts to explain their conditions, the use of appropriate visual aids during the consultation sessions, the use of patient-appropriate language, and the ability to encourage them to use prescription glasses.

III. WHAT I HAVE LEARNED EVALUATION/POST-TEST

A. MULTIPLE CHOICE: Choose the letter of the correct answer. Write it on your notebook/Answer Sheet.

1. Which of the following statements is NOT correct about myopia?
   a. The vision may be corrected with the help of concavelens.
   b. It is also known as nearsightedness.
   c. In the affected eye, the image of distant object is formed beyond the retina.
   d. The person affected by it cannot see beyond few meters.
2. Nearsightedness is termed as
   a. Hypermetropia b. Myopia c. Presbyopia d. Astigmatism
3. In which light produces image focus in front of the retina?
   a. Presbyopia b. Hyperopia c. Hypertropia d. Myopia
4. What does regulate the amount of light entering through the eye?
   a. Iris b. Lens c. Cornea d. Ciliary Muscles

5. A person suffering from short-sightedness has _____.
   a. An eyeball that is too long and needs a convex lens to focus distant objects.
   b. An eyeball that is too long and needs a concave lens to focus distant objects.
   c. An eyeball that is too short and needs a convex lens to focus near objects.
   d. An eyeball that is too short and needs a concave lens to focus near objects.

B. You are a Doctor because?...

According to the news published by the Manila Times (February 9, 2021), Filipinos are also affected by poor eyesight. It was stated that 332,150 people are already bilaterally blind and almost 2.1 million are in bilateral low vision.

Tasks to do:

1. If you are given a chance to become an ophthalmologist, what kind of lenses are you going to give to correct the eye defects of myopic and hyperopic individual? (State your answer in a form of prescription like a doctor. Paste your output in ½ index card.)
2. What are the advices that you can give to your patients who are partially and fully affected by astigmatism, myopia, and hyperopia? (Provide at least 5 tips with specific food and habit to be developed to avoid eye defects.). Write your answer on your notebook.

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SYNOPSIS AND ABOUT THE AUTHOR

Images are formed by optical media by means of the reflection and refraction of light. These media are used in different applications such as in correcting vision defects and viewing very small or very distant bodies.

Eyes that lack sufficient ability to vary their focus require the use of corrective lenses. Farsighted (hyperopic) persons can only distinctly see objects that are far from the eye. Nearsighted (myopic) persons can only distinctly see objects that are close to the eye. On the other hand, astigmatism is an unevenness or asymmetry in the focus of the eye.

ANSWER KEY

Pre-Test:
Answers of students may vary depending on the result of their observations.

Post-test:
A.
1. c
2. b
3. d
4. a
5. b

B.
Answers of students may vary.

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