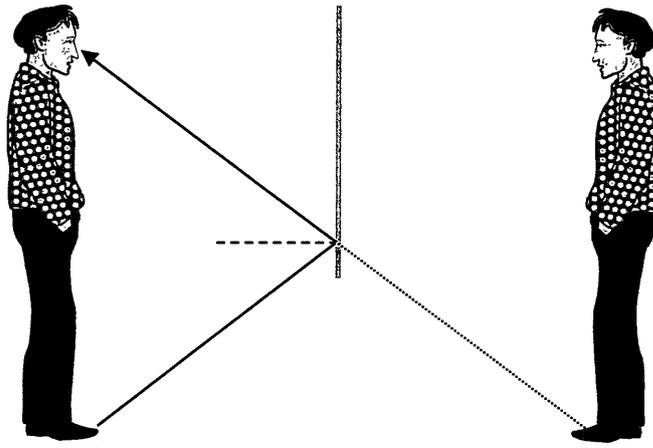
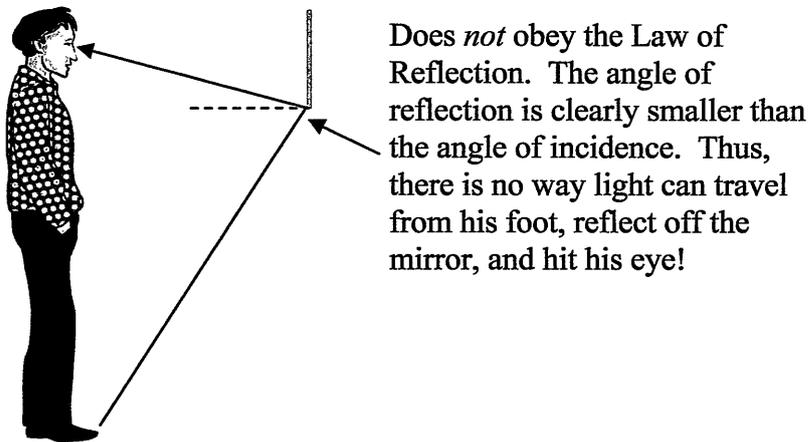


SOLUTIONS TO THE MODULE #15 STUDY GUIDE

1. a. Electromagnetic wave – A transverse wave composed of an oscillating electric field and a magnetic field that oscillates perpendicular to the electric field
- b. The Law of Reflection – The angle of reflection equals the angle of incidence.
2. The wave theory of light views light as two transverse waves, one made of an oscillating magnetic field and the other an oscillating electric field. The particle theory of light views a ray of light as a beam of individual particles called photons. The quantum-mechanical theory says that light is both a particle and a wave. It is made up of individual packets that behave like particles, but the packet is actually made up of a wave.
3. Light waves oscillate a magnetic field and an electric field. Each one oscillates perpendicular to the other, as well as perpendicular to the direction of travel.
4. Einstein's Special Theory of Relativity says that nothing with mass can travel faster than the speed of light.
5. Unlike sound, light travels slower in liquids than gases. Thus, the light's speed increased once it left the water.
6. The acronym ROY G. BIV allows us to remember the relative size of the colors' wavelengths. Red is longest and violet is shortest. Thus, in terms of increasing wavelength, the colors are: violet, green, yellow, and orange.
7. Wavelength and frequency are inversely proportional. Thus, in terms of increasing frequency, it is the reverse of the previous order: orange, yellow, green, and violet.
8. Radio waves have wavelengths longer than visible light while X-rays have shorter wavelengths. This comes from Figure 15.3. Just like the visible light colors, you need not memorize any values for the wavelengths, but of the major categories in the figure, you need to know their relative wavelengths. Since frequency and wavelength are inversely proportional, radio waves have lower frequencies than visible light, while X-rays have higher frequencies.
9. Infrared light is not visible. Thus, even though human bodies constantly emit infrared light, we cannot see that happening. There are special devices you can get that do, indeed, detect the infrared light that the human body emits. This allows you to see living organisms and other hot objects, even in the darkest of nights.
10. By the Law of Reflection, the reflected light also makes a 15 degree angle relative to that line.
11. Yes. Remember, to see a part of his body, light must be able to travel from that part of his body, reflect off the mirror, and hit his eye. His brain will then extend that line backwards, forming an image in the mirror. The only constraint is that the light that strikes the mirror must obey the Law of Reflection:



Had the mirror been much smaller, there would have been no way light could travel from his foot and hit his eyes and also obey the Law of Reflection:



12. The light ray can be reflected or refracted.

13. When light travels from a substance in which it moves quickly to a substance in which it moves slowly, the light bends towards the perpendicular. Since light moves faster in air than in glass, the light will bend towards the perpendicular line.

14. In order for you to see the objects underwater, light must travel from the object to your eyes. Thus, the light must travel out of the water and into the air. When light travels from water to air, it bends. This causes your mind to form a false image of the object in a slightly different location.

15. There must be water droplets suspended in the air, the sun must be shining on them from behind you, and the sun must be at a certain angle (or height in the sky). The water droplets cause the refraction. In order to separate the colors enough to see them, however, the light must be refracted, reflected, and refracted again (see Figure 15.6). To do that, light must enter the water droplet on the side from which you are viewing it.

16. A converging lens causes light rays to bend so that they converge to a single point. Diverging lenses cause light rays to bend away from each other.

17. The function of a lens depends on its shape. Lens (a) is a converging lens and lens (b) is a diverging lens.

18. The eye focuses light by changing the shape of its lens. A camera focuses light by moving the position of the lens. The eye's method is faster and much more precise.

19. If your red cone cells no longer worked, your brain would think that you never saw red light. When the white light reflected off of the paper and hit your eyes, then, your green cone cells would send signals to your brain, as would your blue cone cells. As a result, the white paper would appear to be blue-green or cyan. If you looked at a red piece of paper, it is red because it only reflects red light. Thus, it would send only red light to your eyes. You cannot see red light, however, so the red paper would appear to be black. In actual fact, it would probably appear gray, because the other cells in your eyes (rods) detect the presence of light without detecting color. Thus, your brain would receive signals from the rods telling it that light was there, but there would be no cone cell signals to indicate the color. The brain would be a bit confused, but it would probably form a grayish image, as if you were seeing only in black and white.

20. In order to look violet, it must absorb all colors except violet. Thus, it absorbs red, yellow, orange, green, blue, and indigo light.

21. Since cyan absorbs all colors except blue and green, it will absorb any red light shone on it. As a result, no light will make it to your eyes. In red light, then, the paper would look black. When you shined green light on it, the green light would be reflected. There would be no blue to mix with it, though. In green light, the paper would look green.