

Eye See

Around the Bend

Light bends, or refracts, when it passes from one material to another. Refraction is what makes a straw appear "broken" at the point where it passes from air into a clear liquid, and makes people appear short and stocky when they stand in a pool. Scientists rate the amount light bends in different substances as the Index of Refraction of the substance. The higher the number, the more light bends as it passes through.

Air	1.003
Water	1.33
Plastic (polystyrene)	1.49
Window Glass	1.51
Crystal	1.62
Diamond	2.42



The Great Debate

Is Light a Wave?

Holland, 1690

Christian Huygens (pronounced high jens) was a Dutch physicist who laid the foundations of wave theory of light, which explained reflection and refraction. In his book, *Treatise on Light*, he said:

"If, in addition, light takes time for its passage . . . it will follow that this movement, impressed on the intervening matter, is successive, and consequently it spreads, as sound does, by spherical surfaces and waves, for I call them waves from their resemblance to those which are seen to be formed in water when a stone is thrown into it, and which present a successive spreading as circles, though these arise from another cause, and are only on a flat surface!"

Or a Particle?

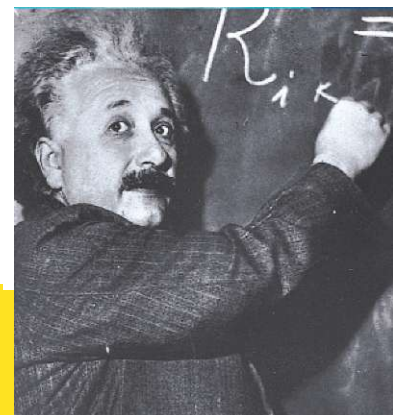
Switzerland, 1921

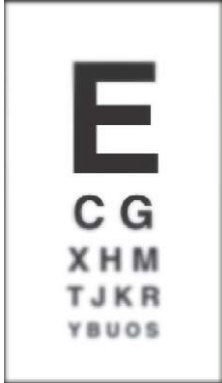
Albert Einstein didn't agree with Huygens' ideas on light as a wave. "[The wave theory] is not able to explain certain fundamental

properties of the phenomena of light. Why is the occurrence of a certain photochemical reaction only dependent on the color, but not on the intensity of light? Why are short-wave rays in general more effective than long-wave rays?... The undulation theory in today's version gives no answer to these questions.."

Einstein later defines the photoelectric effect. It depends on light traveling as packets of energy, called photons, to describe how light can create a current when it strikes a light-sensitive metal.

The answer? Light behaves as both a wave and a particle, but it is best understood as being composed of packets of energy called photons.





Bringing It Into Focus

When an eye doctor rates your vision as 20/20, that means from a distance of 20 feet (6 m), the bottom line of a typical eye chart is clearly in focus, and looks to be 20 feet away. A rating of 20/40 means that at 20 feet, the chart looks to be 40 feet (12 m) away. Many people with vision above 20/40 require eyeglasses, at least for seeing distances.

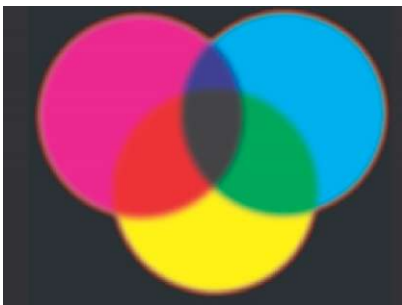
This means that a person with 20/200 vision would have to move up to 20 feet to see a letter a person with "perfect" 20/20 vision could see at 200 feet! Of course, many eye charts in doctors offices are adjusted so the patient does not need to stand at 20 feet to be tested.

Color Combos

Combining Light Colors: Red, blue, and green lights are known as the primary colors. When all three are mixed, they make white light.



Combining Pigment Colors: When red, blue, and green pigments are combined, they have an additive effect that produces other colors. All three together make black.



Need for Speed

If you could travel at the speed of light, here's how long it would take you to get to different places in the universe:

Los Angeles to New York	.0016 seconds
Around the Equator	.133 seconds
Venus	2.5 minutes
Mars	4.1 minutes
Center of the Milky Way	30,000 years
Most distant galaxy	13-15 billion years

From a Distance

Nearsighted vision means that only "near" objects are in focus. This happens if your eyeball is too long, making images focus before they hit your retina. Concave lenses (right) correct this by causing light rays to spread out, projecting the image farther back in your eye.

Farsighted people see distant objects fine, but close-up objects may be blurry. This happens if your eyeball is too short, and images come into focus behind the retina. Convex lenses help light rays come together before entering your eyes, shortening the focal length and bringing the image into focus on the retina.



Activity

ANOTHER GREAT DEBATE Now you know how to correct the vision of someone who is nearsighted or farsighted. But what if someone is both? Some people have an astigmatism that makes one eye see differently than the other. Do some research on an invention Benjamin Franklin made to correct this problem. How does his invention work? Pretend you live in the late 1700s, Franklin's time. Write him a letter explaining why his invention is helpful and suggesting another eye-related invention he could create.