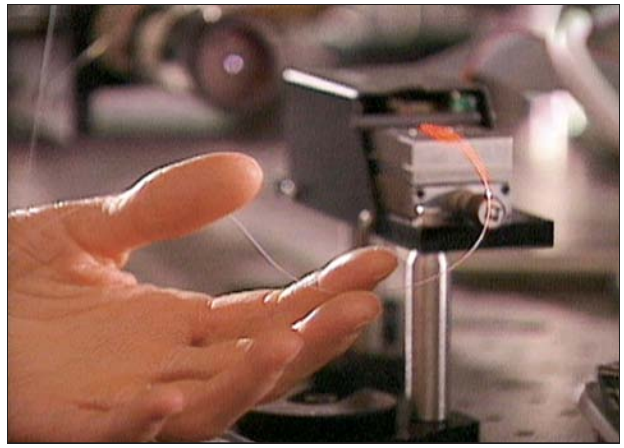
MOVIE GUIDE

MOVIE NUMBER 5003

Communication at the Speed of Light

The Movie:



Tiny glass filaments carry so much information that all the books ever written could be transmitted over a single fiber optic cable in a few seconds. Featured: Kelvin Heard, engineering manager, Pacific Bell; Christina Gabriel, researcher, AT&T Bell Laboratories; Norman Whitaker, electrical engineer, AT&T Bell Laboratories. *(Movie length: 1:44)*

Background:

Around 170 years ago, an American painter named Samuel Morse developed a means of reliably and easily sending information across a great distance. This “distance writer” (“telegraph”) was the beginning of a telecommunications industry that is as ubiquitous in the developed world as air itself. Telephones, radio, television—by 1950 we had come to live in a sea of mass and personal communication.

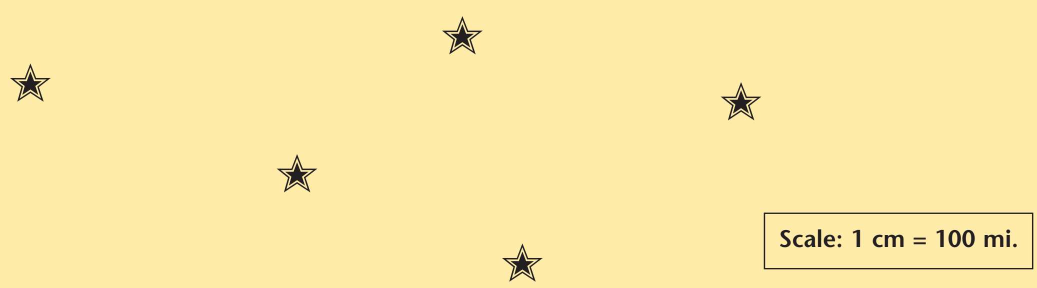
Then two new developments conspired to change everything once again—the technology for converting any form of information into a string of 0’s and 1’s, and the invention of fiber optic cable, capable of carrying those 0’s and 1’s from one place to another at a near-infinite rate.

Curriculum Connections:

Networks

1

Find the shortest amount of optical fiber cable necessary to connect these five locations. (Note that you do not have to connect each city directly to every other city.)



Scientific Notation

2

A telephone company is using fiber optic cable to transmit information at the rate of 600 million bits (zeros and ones) per second. The human voice can be translated into a signal of approximately 60,000 bits per second. Convert both numbers into scientific notation to find out how many conversations the fiber optic cable can carry at the same time.

Percents

3

Light traveling down a fiber optic cable loses only a small percentage of its intensity for each kilometer of travel. Typically, after a kilometer of cable, the light will have as much as 92% of its original intensity. After another kilometer of cable, it will have 92% of that intensity (which is 92% of 92% of the original intensity).

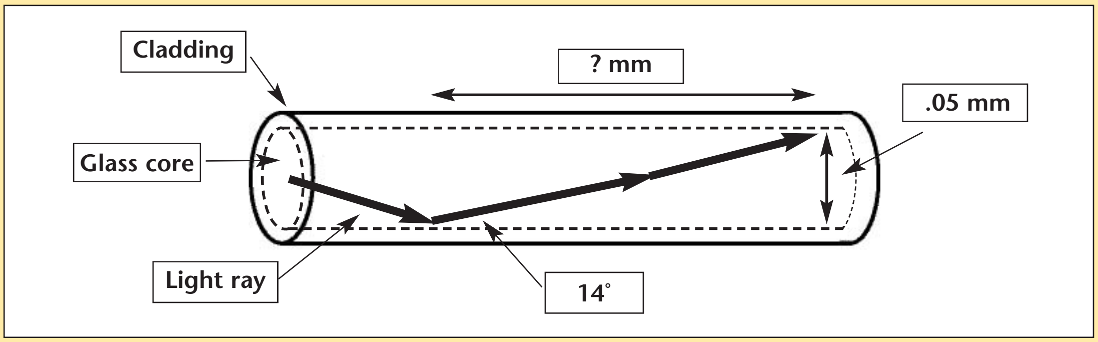
If the intensity of light at the beginning of a cable is 1,000 units, what will its intensity be after 1 kilometer? 2 kilometers? 5 kilometers? 10 kilometers?

Trigonometry

4

As light travels along in a fiber optic cable, it "bounces" off the sides of the glass core of the cable, reflected by the material in which the glass is wrapped (called "cladding").

The highest angle at which light will "bounce" is 14°. For light which bounces at that angle, how far will it travel down the cable between bounces?



Algebra (variables, expressions)

5

If you send a signal over a fiber optic cable to another computer and get a response, the response time, $t_{response}$, depends on three things:

a) the distance between you and the computer, L

b) the velocity of light traveling through the cable, v

c) the amount of time it takes the other computer to process your signal, $t_{processing}$

The equation for the response time is this:

$$t_{response} = t_{processing} + \frac{2L}{v}$$

Note that the velocity of light in fiber optic cable, v, is about 200,000,000 meters/second.

1. Calculate $t_{response}$ for the given values of L and $t_{processing}$:

L	$t_{processing}$	$t_{response}$
500,000 meters	0.013 seconds	
8,000,000 meters	0.005 seconds	
2,000 meters	0.002 seconds	
20,000,000 meters	0.04 seconds	

To: A. B.
From: T. W.

Alex,

I really appreciate your willingness to take some time out of your busy schedule to help me out on this fiber optic problem.

Below is the data that we've collected on efficiency of light transmission through four different brands of optical fibers.

As you can see, in all cases the lab people measured the intensity of light that came through for various lengths of the fiber.

The trouble is that the data is coming from different sources, so they didn't all start with the same light intensity, which makes it harder to compare the fibers.

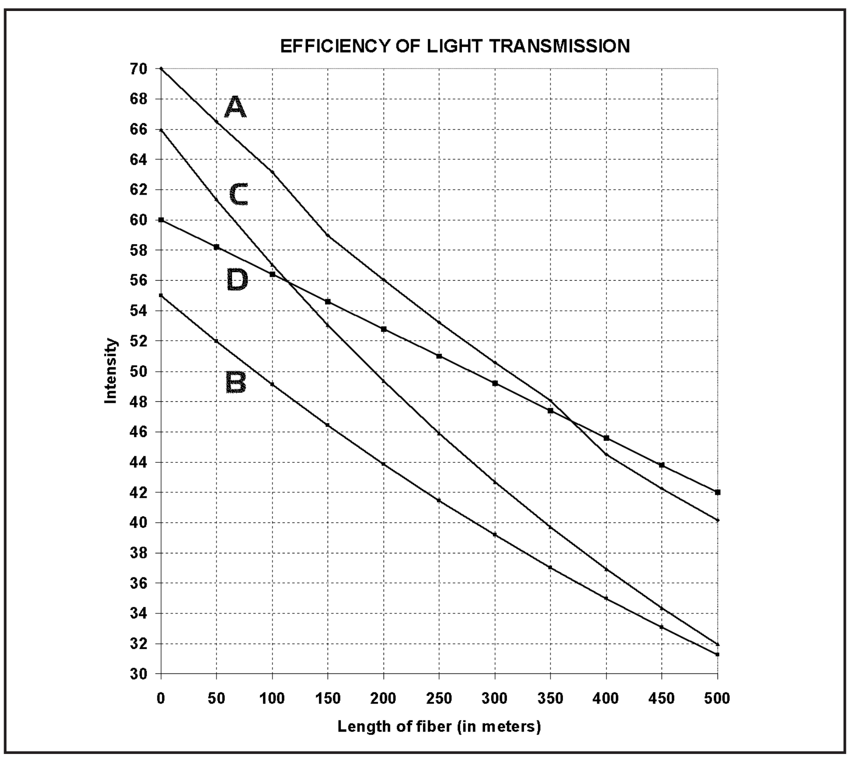
Also, in at least one of these cases, my researcher told me that he thought they just made up the data to make their fiber look good. But he didn't say which one and he's off on a three-week vacation in Samoa (without his cell phone!).

It will be a miracle if you can do anything with this but I'm glad you will try.

The main thing I need to know is which brand of fiber is the best at transmitting light and seems to be the most reliable in its manufacturing process.

I'll be happy to pay your outrageously high consultant fee if you can give me these answers.

Best, Tom



P.S. For the fiber you recommend, I also need to know its efficiency at transmitting light over a 1,000-meter distance. I'm <u>sure</u> *that's* impossible, but if you can somehow figure it out from this data I'll double your fee.

Teaching Guidelines: "Fiber"
Math Topics: Algebra (exponential function)

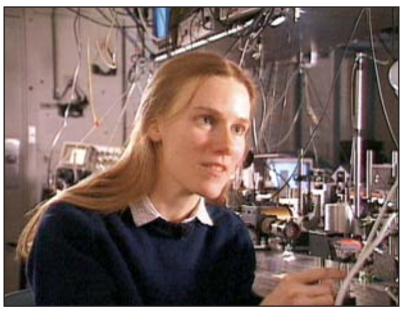
Distribute the handout and discuss it. Make sure that students understand what is represented by the four lines on the graph: how much light is transmitted through a fiber for varying distances.

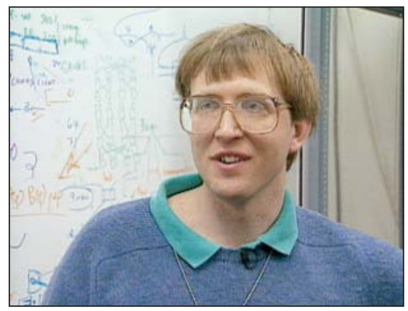
Tell students you want them to try to determine, if possible, the equation for each of the graphs given, and make their recommendation as to the best fiber based on those equations.

Students should find that the equations for graphs B and C are both exponential. The equation for graph D is linear, and the equation for graph A will be very hard to determine.

Based on this it is likely that the data for fiber D is falsified. Of the remaining fibers, both A and C have the better transmission efficiencies (determined by taking the ratio of the output after 500 meters to the input light intensity). Fiber A, though, seems to have some inconsistencies as indicated by the non-smooth nature of the curve; therefore fiber C is the best choice.

To find the projected intensity at 1,000 meters, students can solve the equation they generated. However, once they recognize that the curve is exponential they may realize that by the nature of the exponential function, the intensity will drop by the same ratio over the second 500 meters as it did over the first. Thus the efficiency of transmission at 1,000 meters is the square of the efficiency of transmission at 500 meters.





If you enjoyed this Futures Channel Movie, you will probably also like these:

Communications Satellites, #5004	A system of satellites that orbit the Earth at various distances make it possible to communicate from anywhere, to anywhere.
The Bose Speaker, #1017	"You can never do anything better unless it is different," according to Dr. Amar Bose, who uses the rules of mathematics to achieve superior sound quality in his Bose radio and speakers.
Solar Cells, #1015	Photovoltaic cells generate electrical current directly from sunlight.