MOVIE GUIDE

MOVIES NUMBER 3005-06

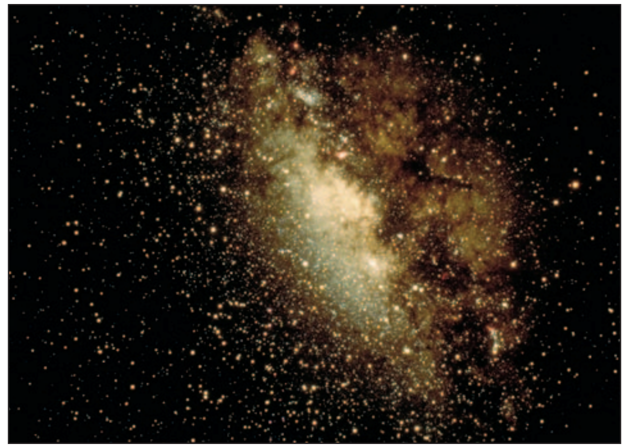
Eyes on the Universe PARTS 1 & 2

The Movies:

Part 1: Looking Into Time—Astronomers think of telescopes as "bigger eyes" that allow them to look, not only deep into space, but back into time. *(Movie length: 3:29)*

Part 2: Planetary Systems—New telescopes will soon allow astronomers to study the planetary systems of other stars and compare them to our own Solar System. *(Movie length: 3:03)*

Featured: Don McCarthy, astronomer, Kitt Peak Observatory; Roger Angel, Astronomer, Kitt Peak Observatory.



Background:

The primary activity of a scientist is to observe, and scientists understand well that careful observation leads to discoveries and new understandings. Nowhere is this more evident than in the telescope. Galileo shook the world by observing that Jupiter has moons which orbit that planet; the realization that there were heavenly bodies which did not orbit the Earth was the beginning of our understanding of our planet's place in the cosmos. In the early 20th century, Edward Hubble's observations showed us that the universe is far more vast than anyone had conceived of—and what's more, is still expanding. More recently, observations of the sunspot activity of other stars is helping us to better understand climate patterns on earth.

Though it has seemed extremely probable that there must be planets orbiting at least some of the billions of stars in the universe, there was no proof of it until quite recently. And even then, the proof is not that we saw such planets—rather we saw the very faint effects that they have on the stars around which they orbit. Still, that in itself was an amazing feat of observation and scientific thinking, and as new and better observing instruments allow us to see farther and more clearly, there's no doubt that there are many more discoveries to come.

Curriculum Connections:

Algebra

1

Light that arrives at a telescope from a distant star left that star at some time in the past, usually many years ago. Often, astronomers are able to make a good guess as to the distance (*d*) from a star to the Earth. They can then compute the year in which the light left that star (*y*) with this equation:

$$y = y_{current} - d/c$$

where

$y_{current}$ = the current year
d = the distance to the star
c = the speed of light: 186,000 miles per second, or 3×10^5 kilometers per second

a) If light arrives at a telescope in the year 2004 from an object which is 3×10^{15} kilometers away, in what year did it leave that object?

b) If light left an object in the year 1,000 AD, and arrived at Earth in the year 2,000 AD, how far away was that object?

Scientific Notation, Measurement (conversion) 2

Determine the time it would take to travel to each destination by the given means of transportation:

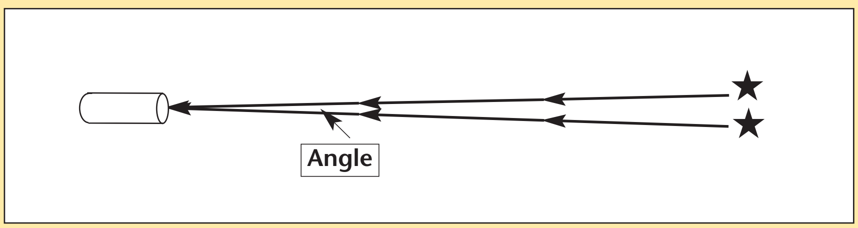
Destination	Distance from Earth (meters)	Speed of travel (meters/second)	Time of travel (years)
The Moon	3.84×10^{8}	walking, 2 meters/sec	?
Mars*	5.6×10^{10}	bicycle, 8 meters/sec	?
Jupiter*	5.9×10^{11}	automobile, 30 meters/sec	?
Pluto*	4.3×10^{12}	train, 50 meters/sec	?
Alpha Centauri (the nearest star)	4.07×10^{16}	propellor plane, 80 meters/sec	?
Sirius (brightest star in the night sky)	8.23×10^{16}	jet plane, 150 meters/sec	?
Center of the Milky Way Galaxy	2.36×10^{20}	Space Shuttle, 8,000 meters/sec	?
Andromeda Galaxy	2.08×10^{22}	Light ray, 3 x 108 meters/sec	?

*At closest approach to Earth.

Circles (angles), Trigonometry 3

If two objects in space, such as two stars, are too close to each other, they will look like only one object in a telescope. How far apart do the objects have to be before a telescope can see them as two objects? That depends on the size of the telescope and how perfect the mirror is, as well as other factors such as ground vibrations or disturbances in the atmosphere above the telescope. (This is part of the reason that the Hubble Telescope was placed in orbit around the Earth, outside the atmosphere and where there are no vibrations.)

The separation that two objects must have to be seen as distinct is actually an angle, not a distance. See the diagram below:

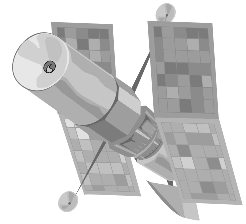


For the Hubble Telescope, orbiting the Earth, the angle between rays of light coming from two separate objects can be as small as .046 arc-seconds (1 arc-second is 1/3600 of a degree).

If the Hubble Telescope were to look for a planet circling Alpha Centauri, 4.3 light years away, how far from the sun would the planet have to be in order to be seen?

Circles 4

Large telescope mirrors do more than magnify what you are looking at—they also collect light from a distant object and focus it onto one spot, making dim objects easier to see. The larger the mirror, the more light is collected. Two of the largest telescopes on Earth are the 100-inch diameter telescope on Mount Wilson and the 200-inch diameter telescope on Mount Palomar, both in California. Find the areas of both mirrors. How much more light is gathered by the 200-inch telescope than by the 100-inch telescope?



From: Chief Astronomer
To: Mirror Design Team
Regarding: Telescope #2

Here are the specifications for the mirror for telescope #2, which we are hoping to have up and running within 18 months:

1) Light-gathering power: Telescope #2 should have twice the light-gathering power of telescope #1, which, as you know, has a 3-meter diameter. Knowing this will enable you to determine the diameter of the main mirror for telescope #2.

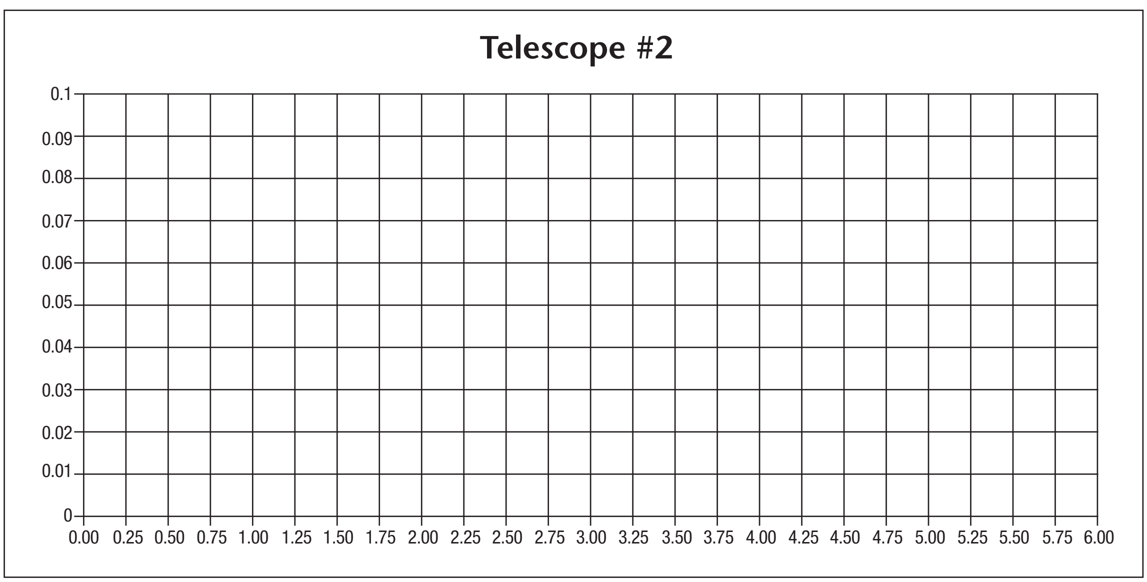
2) Focal Length: Telescope #2 should have a focal length of 8 meters.

Based on this data, please sketch the cross-sectional curve of the mirror for telescope #2 below. Be sure to state the value of the depth and radius of the new mirror.

Then determine the specific equation which describes that curve, in quadratic function format *($y = ax^2 + bx + c$)*.

I need this right away.

Ed



Teaching Guidelines: Telescope #2
Math Topics: Algebra (quadratic equations and functions)

This project should be done by students working individually or in teams of two.

Distribute the handout and discuss it. Ensure that students understand the questions they are being asked to answer.

To determine the diameter, students will need to realize that in order for telescope #2 to have twice the light-gathering power of telescope #1, it will need to have twice the area:

Area of telescope #1 = 7.06 square meters (radius is 1.5 meters).

The area of telescope #2 must be 14.12 square meters, which gives a radius of 2.12 meters, or diameter of 4.24 meters. As an alternative approach, for the area of #2 to be twice the area of #1, then the diameter of #2 must be equal to the diameter of #1 multiplied by the square root of 2 (1.414…), which gives the same result.

In order to graph the curve, students will need to know the value of the coefficent, *a*. They should have learned that, for a parabola, this equation holds true:

$\boldsymbol{F} = 1/(4a)$, where $\boldsymbol{F}$ is the focal length of the parabola.

Using a focal length of 8 meters in this equation gives a value for *a* of .03125 meters.

To graph the parabola, students should place the vertex at (2.12,0), and use the vertex form of the parabola equation:

$$(y - 0) = .03125(x - 2.12)^2$$

which simplifies to

$$y = .03125x^2 - 0.1325x + .14045$$

Thus the y intercept is +.14045.

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

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.
Space Weather, #3004	With solar flares 200,000 miles across releasing the equivalent of all the energy ever produced on the Earth at one time, space weather forecasters will become an important feature on the future news.
Life Under the Ocean, #2004	A marine biologist studies the jellyfish-like animals living at 3,000 feet, where it is cold, dark and quiet.