**Science TEKS**

(8.3) **Scientific processes.** The student uses critical thinking and scientific problem solving to make informed decisions.

 (C) represent the natural world using models and identify their limitations;

(8.13) **Science concepts.** The student knows characteristics of the universe.

 (B) explain the use of light years to describe distances in the universe.

(Ast.2.B, Ast.7.A)

### Materials

Advanced Preparation:

* Obtain the video or CD “Powers of Ten” <http://www.powersof10.com/>
* Prepare scale models on register tape.
* Glue together two halves of a lentil.
* Prepare transparencies/load Powerpoint

For whole class demonstrations:

* “Powers of Ten” video or CD
* “How Far is a Light Year” Powerpoint (© University of Texas, 2009)
* 18” (45cm, .45m) diameter balloon
* Assorted small objects such as marbles, beans, toy balls or Styrofoam spheres, etc.
* Two halves of a lentil glued together (4mm, .004m)
* Meter sticks or tapes.
* Pencil, marker, tape.
* Cash Register tapes marked with scale of 50 meters.

For each student group of 4 students:

* One roll of cash register tape
* Meter stick or tape
* Pencils, markers, tape, scissors (teacher can cut for students if needed)

**ENGAGE**

*This part of the lesson is designed for* ***whole group instruction****.*

1. Tell students that they will learn about how astronomers use a unit that may be new to them, and is used to measure the universe.
2. Ask students to take notes during the video, especially noting the largest, smallest distances, and how a light year is represented.
3. Play the video or CD or “Powers of Ten.” (~ 10 min.)
4. At the conclusion of the video remind students that they saw a range of 1040 meters view of the universe down to the proton of an atom. Write a “1” with 40 zeros on the board or show powerpoint. Ask students how to represent the numeral with Scientific Notation.

Facilitation Questions – Engage Phase

1. What was the largest distance in “Powers of Ten?”

 *1 X 1024 meters, or 100 million light years. It was the edge of the known universe.*

1. What was the smallest distance in “Powers of Ten?” *1 X 10-16 meters, or 0.000001 angstroms. It was the proton inside a hydrogen atom.*
2. What was the distance of a light year?  *1 X 1016 meters or 10,000,000,000,000,000 meters.*
3. How long did it take for light to cross half of our moon’s orbit?

*1 second.*

# **EXPLORE**

This part of the lesson is designed for **whole group instruction and for groups of 4 students**.

#### A. Find Earth/Sun Objects to Scale

1. Place various objects (marbles, balls, candies, beans, and the lentil) on tables.
2. Show students an 18” (45 cm, 0.45 m) diameter balloon and tell them that in this model the balloon will be the Sun.
3. Use facilitation questions and ask students to find the object(s) that would represent Earth, and evaluate the model.
4. Explain that the model shows the **ratio** of the Sun’s and Earth’s diameters.
5. Ask students what the **ratio** would be, and use “Finding the Earth/Sun Diameter Ratio” transparency to demonstrate finding the ratio.
6. Show Powerpoint Slides to illustrate calculating the ratio of the Sun/Earth diameter.

#### B. Find the Ratio of Sun/Earth Distances

1. Tell students that for the next part of the lesson they will work in groups to create a model of the distance from the Earth to the Sun. Could they create a model using the same objects they used in the previous activity?
2. Question students (using facilitation questions) to guide them to use the same ratio for distance between the Earth and Sun, as for the Earth/Sun diameters.
3. Tell students that the actual distance from the Earth to the Sun is 152,000,000,000 meters or 1.5 X 1011 meters.
4. Show the “Finding the Earth/Sun Distance Ratio” transparency and the Powerpoint slides to illustrate calculating the distance for the scale model of the Earth/Sun distance that they will create. Guide with facilitation questions.
5. Have students work in groups to measure and cut portions of the 50 meter scale using cash register tape.
6. Guide students to construct one model (in the hallway or outdoors) that joins all sections for a 50 m tape with “Sun” and “Earth” marked. Be sure to draw Sun and Earth to scale.
7. Discuss the strengths and weaknesses of the model, including differences in scale, materials, size, etc.

Facilitation Questions – Explore Phase

A. Find Earth/Sun Objects to Scale

1. If the Sun was this size, then what object in the room would be the Earth? *The lentil.*
2. What are some of the strengths of this model of the Sun and Earth? *The sizes are proportional, meaning that if the Sun really were the size of the balloon, the Earth would be the size of a lentil; we can fit this model into the classroom; real objects make it easier to understand the relative sizes; accept other reasonable evaluations of the strength of the model.*
3. What are some of the weaknesses of this model of the Sun and the Earth?  *The Sun and Earth are not actually that size; the Sun is not a balloon and Earth is not a lentil; the Earth and Sun are changing and dynamic systems; accept other reasonable evaluations of the weakness of the model.*
4. If the Earth’s diameter is approximately 1.3 X 107 meters, and the Sun’s diameter is 1.4 X 109 meters, what is the Earth to Sun diameter ratio? *The ratio is 1:108*

####  B. Find the Ratio of Sun/Earth Distances

1. If the Earth were the size of a lentil, and the Sun a large balloon, how would you decide what the distance between the two objects was? If you were going to make a model of the distance from the Earth to the Sun and you wanted to use the same scale as in the previous activity, what would the ratio be? *The ratio would still be 1:108; use cross-multiplication of the ratios*
2. Knowing that the distance from the Earth to the Sun is 1.5 X 1011 meters, what would the distance have to be if we used the ball and lentil? *If the Sun was a 45 cm balloon and the lentil was the Earth, then the distance between them would be 48 meters, or about 50 meters.*

**TEACHER’S NOTES:** A light year is the distance that light travels in a year. There is nothing that can travel faster than, or even as fast as, electromagnetic energy.

We say “light” even though we really mean all kinds of electromagnetic energy such as radio waves, microwaves, x-rays, UV, and infrared light. People tend to think of “light” as only the part of the spectrum we can see, but it actually includes lots of energy we can’t see. All parts of the electromagnetic spectrum travel at about **300,000,000 m/s** or **3 X 108 meters/second**.

Mathematics Note – The eighth grade math TEKS do not support students being able to find ratios using scientific notation. BUT, students can do the calculations if they use calculators, and the TEKS do support dilation of figures and ratios.

## EXPLAIN

The Explain portion of the lesson is directed by the teacher to allow the students to formalize their understanding of the TEKS addressed in the lesson.

***Finding the Distance of a Light Year***

1. Ask students if they can guess what the fastest speed in the universe is.
2. Tell students that a *light year* is the **distance** that light travels in one year. We know the speed of light is 300,000,000 or 3 X 108 m/s, so if we know how many seconds are in a year, we could find out how many meters a light year is.
3. Use facilitation question to calculate the **distance that light travels in a year**. Show Powerpoint slides.
4. Tell students that it takes light approximately 8 minutes to travel from the Sun to the Earth. That means that if we see something happen on the Sun (a solar flare for instance) it happened 8 minutes earlier. When astronomers (or students) look at a distant object, such as a nebula that is 65 million light years away, they are actually looking back in time.

Facilitation Questions – Explain Phase

1. What is the fastest speed in the universe?

*Accept all answers and then tell students it is 3 X 108 meters/second, the speed of light.*

1. How many seconds in a year?

*Multiply 60 seconds X 60 minutes X 24 hours X 365.25 days to equal 31,557,000 or 3.15 X 107 seconds.*

1. How far does light travel in a year?

*3 X 108 m/s (3.15 X 107 s) = 9.5 X 1015 meters*

**ELABORATE**

*The Elaborate portion of the lesson provides an opportunity for the student to apply the concepts of the TEKS within a new situation. This part of the lesson is designed for* ***groups of 4 students****.*

***Comparing the Scale of the Solar System Model to a Light Year***

1. In the earlier model of the solar system the distance between the Earth and the Sun was represented by 48 meters.
2. Use Facilitate questions to help students discover the size of a light year using the same scale used in the “Explore” section. (See Powerpoint)
3. Since the previous scale is impossible to represent, what would be a scale that we could use? Guide students to using a 50 m scale so as to make it comparable to the last scale model of the Earth/Sun distance. (Besides having already made the scale!)
4. Use facilitation questions to guide students to find the sizes and relative distance of the Earth and Sun on the new scale model. (See Powerpoint)
5. Guide students to changing the SCALE of the model to fit the 50m tape already created.
6. Go back outdoors or to the hallway and mark the position of the Sun and Earth on the scale and indicate the relative sizes. (See Handouts/Transparencies) Have students hold up fingernail to demo 1 mm distance.
7. Discuss some of the strengths and weaknesses of the model.

Facilitation Questions – Elaborate Phase

1. If we used the same scale as we used previously, how much cash register tape would it take to represent a light year?

*If the same scale were used, it would take 3,100,000 or 3.1 X 106 meters.*

1. Would we be able to create this model on campus? In Austin? In Texas?

*No, at ~ 1.3 X 106 meters at its widest point, Texas would not even hold the model at that scale.*

1. What would be a good scale to use and why?

*Using a 50 m scale would let us compare the light year scale to the Sun/Earth distance scale.*

1. What would the distance from the Earth to the Sun be on this new scale? *The distance would be 0.00075 or 7.5 X 10-4 meters (0.8 mm or approximately 1 mm, the thickness of a fingernail.)*
2. At this scale, what would be the size of the Earth and the Sun?

*The Sun would be 0.000007 or 7 X 10-6 meters, approximately the size of*

*a part of the DNA molecule in “Powers of Ten.” The Earth would be 0.000000065 or ~ 7 X 10-8 meters, approximately the size of the CH3 molecule in the video!*

### EVALUATE

*The Evaluate portion of the lesson provides the student with an opportunity to demonstrate his or her understanding of the TEKS addressed in the lesson.*

***TAKS Format Questions***

1. A light year is used to measure
2. time
3. distance
4. speed
5. energy
6. Approximately how far does light travel in one year?

(1 X 1016 meters, or 10,000,000,000,000,000 meters)

3. A light year is the appropriate unit to measure

A. The time it takes light to travel from the Sun to the Earth

B. The time it takes light to travel from the Sun to Sirius

C. The distance between the Sun and Earth

D. The distance between the Sun and Sirius

**Alternative Assessments**

If you could create a model of a light year where 1 meter = 1 cm, what would the size of the model be? What would the size of the Sun and the Earth be?

Create a foldable that illustrates the scale of our solar system and the scale of our Sun/Earth within a light year.

**Finding the Earth/Sun Diameter Ratio**

![MP00133_[1]]()

**The Earth’s diameter is**

**12,756,000 meters or ~ 1.3 X 107 meters**

![j0083171[1]]()

 **The Sun’s diameter is**

 **1,400,000,000 meters or**

 **~ 1.4 X 109 meters**

**The ratio of the Earth/Sun diameter is**

 **1.3 X 107 m : 1.4 X 109 m**

**Simplify the ratio...**

**1.3 X 107 m : 1 m**

**1.4 X 109 m : 108m**

**Earth to Sun Diameter ratio is 1 : 108**

**Finding the Earth/Sun Distance**

![j0141155[1]]()**The distance from the Earth**![j0083547[1]]() **to the Sun**

 **is 1.5 X 1011 meters**

**In our model 0.45 m (the diameter of the balloon) = 1.4 X 109 m (actual diameter of the sun)**

**SO**

**The ratio of the diameter of the balloon to the actual diameter of the Sun, is the same as the ratio of the distance on our model is to the actual distance.**

|  |  |  |
| --- | --- | --- |
| Sun Diameter |  | Sun to Earth Distance |
|
| Model | .45 m | = | X | Model |
| Actual | 1.4 x 109 m | 1.5 x 1011 m | Actual |

X = 4.8 x 101 meters

**The distance from the Earth to the Sun in our model is 48 meters, or about 50 m**

**On the Graphing Calculator…**

* **Turn on and press “Mode”**
* **At the top row are the words:**

**Normal Sci Eng**

**And the “Normal” is highlighted in black**

* **Arrow right to “Sci” until it is highlighted, and press “Enter”**
* **Quit (2nd Mode), and now all of your calculations are in Scientific Notation (Powers of Ten)**

**How Many Seconds are in a Year?**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 60 s | 60 min | 24 hr | 365.25 days | = 3.2 x 107 s |
| 1 min | 1 hr | 1 day | 1 yr | 1 yr |

**So How Far is a Light Year?**

**Multiply the Speed of light (m/s)**

**by the number of seconds per year (s/yr)**

**to find the number of m/yr**

**3 x 108 m/s X 3.2 x 107 s/yr =**

**On the graphing calculator, you can enter**

**“3 2nd LOG 8 ) X 3.2 2nd LOG 7 ) Enter”**

**and your calculation will be**

**9.5 x 1015 m/yr**

**Or 9,500,000,000,000,000 meters**