SOLAR SYSTEM SIZE SCALES OR "WALKING TO THE PLANETS" LAB EXERCISE

JASON KENDALL, WILLIAM PATERSON UNIVERSITY

1. Overview and Setup

Purpose: To demonstrate the distance scale between the planets and to the next star, as well as show the extent of human space exploration.

Method: Build a scale model solar system on a football field.

- You'll need a tape measure.
- You'll need to estimate distances to nearby townships and major nearby landmarks.
- You'll need a football field or something else where you can walk in a straight line for at least 100 yards or meters.
- Active and working internet connection.
- Your model must be built outdoors, so it can't be raining.
- Football field will be helpful because of the known demarcations of the lines.
- Materials: long tape measure or meter sticks. Surveyor marking flags or other marker of some kind.
- If you're submitting it online, then take pictures of your model along with your work.

Goals: This is basically a liberal art of astronomy. This lab hopes to give the student a much deeper perspective of distance and sizes.

2. Rough Scales

(1) Just to start with, how many miles does a typical car go before it completely falls apart?

(2) Roughly how much time does it take to do that, on average?

(3) How many cars would you go through if you drove to the Sun at a distance of 93,000,000 miles?

(4) How many years would that take?

(5) The distance between the Earth and Sun is 93,000,000 miles, and the size of Earth is about 8000 miles. Imagine that the 93,000,000 miles was scaled to 30 inches. Exactly how big would Earth be on this size scale? How big would the Sun be?

3. Real Distances to Real Objects

From here on out, all numbers larger than 1000 must be put into powers-of-ten notation, keeping only the first three digits (rounding the last), and the power. Thus, if your calculator says something is 12,895,558,547,884.56, that's not what you would write. You would write 1.29×10^{13}.

Open up your textbook to the appendix and find the bulk size scales of the planets. You are looking for the average distances between each of the planets and the Sun. Note that 10 kilometers is 6.2 miles. Also note that a parsec is 206,265 AU. Also, note that there are only three nations in the world that still use miles/feet/inches/pounds: the USA, Liberia and Burma. Therefore, this is the last time you'll see miles in this class. So, just for your edification, 93,000,000 miles equals 150,000,000 kilometers (km).

Average Distances in various units from the Sun:

Object	Kilometers	Astronomical Units	parsecs
Mercury			
Venus			
Earth	1.50×10^8 km	1 AU	4.85×10^{-6} pc
Mars			
Jupiter			
Saturn			
Uranus			
Neptune			
Pluto			
Proxima Centauri			
Sirius			

Here are two helpful web links for the data above.

https://www.google.com/#q=convert+40+AU+to+km

https://www.google.com/#q=convert+9+parsecs+to+km

4. Where is the Voyager 2 Spacecraft?

Now go to http://voyager.jpl.nasa.gov. Find the current distance of Voyager 2 from the Sun in

(1) Kilometers

(2) Astronomical Units

If the current speed of Voyager 2 is 3.6 Astronomical Units per year...

(1) How fast is Voyager 2 going in kilometers per second?

(2) How fast is Voyager 2 going in miles per second?

Given Voyager 2's speed, how long will it take for it to go

(1) From our campus to New York City?

(2) From our campus to Los Angeles?

(3) To the Moon?

(4) 100 more Astronomical Units?

(5) Voyager 2 is going roughly in the direction of Sirius, which is 8.6 light-years away. How long will it take to get that far?

5. Building the Model

Before we go outside, we need to make some conversions. First, let's scale it down so that one Astronomical Unit is equal to 2 feet, 6 inches or 76.2 centimeters. Multiply it all out. Just do either feet/inches or meters/centimeters depending on which kind of measuring sticks you'll be using outdoors. When you're done, take this outdoors and mark it out with the surveyor flags on the football field! The instructor will check your calculations with a tape measure which has all the markings for all the planets. You'll be graded on how close you get to those markings.

Object	Average Distance in AU from the Sun	Convert to feet and inches	Convert to cm or meters
Mercury			
Venus			
Earth	1	2 feet, 6 inches	76.2 cm or 0.762 m
Mars			
Jupiter			
Saturn			
Uranus			
Neptune			
Pluto			
Voyager 2			
Sirius			

How far away is Sirius in this model, and what is a landmark for that location?

6. Converting Units

Here's a helper for you.

$$\frac{3.2 \text{ AU} \left| 0.762 \text{ m} \right.}{\left| \ 1 \text{ AU} \right.} = 2.44 \text{ m}$$

A different mix-up...

$$\frac{11.1 \text{ AU} \left| 2 \text{ feet} + 6 \text{ inches} \right.}{\left| \ 1 \text{ AU} \right.} = \frac{11.1 \text{ AU} \left| 2 \text{ feet} + \left(6 \text{ inches} \times \left(\frac{1 \text{ foot}}{12 \text{ inches}} \right) \right) \right.}{\left| \ 1 \text{ AU} \right.} = \ldots$$

$$\frac{11.1 \text{ AU} \left| 2 \text{ feet} + 0.5 \text{ feet} \right.}{\left| \ 1 \text{ AU} \right.} = 11 \times 2.5 \text{ feet} = 27.75 \text{ feet} = 27 \text{ feet and } 9 \text{ inches}$$

This is as good a reason as any to use metric system...

7. Teacher's Notes

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Method: Build a scale model solar system on a football field.

Goals: This is basically a liberal art of astronomy. This lab hopes to give the student a much deeper perspective of distance and sizes. As you discuss this topic, try to impress upon them how long it would take to cover some portion of the distances they are measuring. The real take-home of the exercise is to get that sense. The numbers are there for pedagogy, but it's the long-term pacing out of steps and lengths, accurately measuring the long distances, and taking the time to do it, which will impress upon them the actual size scales involved.

- You'll need a 100-foot tape measure with the distances of all the planets marked out on it.
- You'll need to estimate distances to nearby townships and major nearby landmarks.
- You'll need a football field or something else where the students can walk in a straight line for 100 yards. If you choose to do the exercise in meters, then everything will need to be scaled accordingly.
- Active and working internet connection. Either on lab computers or student's internet-ready devices.
- Evaluation will be done outdoors, so it can't be raining.
- Football field will be helpful because of the known demarcations of the lines.
- Materials: 100 foot tape measure, Surveyor marking flags. These are cheap at any home-improvement store, Numerous meter sticks or yard sticks.
- The students should not use a tape measure, even though it would make things easier. The goal is to feel the distance, and not much else does that like laying down a yardstick to the various distances.

Astronomy Liaison Coordinator, Department of Physics, William Paterson University, Wayne, NJ 07470, http://www.wpunj.edu/cosh/departments/physics/faculty/Kendall.dot, kendallj@wpunj.edu