Daytime Astronomy

A Scale Model of the Solar System

Middle Grades 5 - 8

Presented By:
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Mission Impossible! Have you ever noticed there are no scale models or drawings of the Solar System....that is both planet size and distances to the same scale. This activity will build that model in the students' mind and in real life as well, should you choose to accept my challenge. Let's take a look at the solar system in scale perspective.

A word about units: For this activity I prefer to measure planet sizes and distances in miles. The scaling for this exercise works out better. If your chart or book uses kilometers...all the better. Have the students create a data table with the distances in kilometers, and then calculate the miles. Multiply all the kilometer readings by .62 and round off for mile reading. Remember in middle school science... "close enough is good enough". Have students round planet sizes to the nearest thousand miles, and planet distances to the nearest million miles. Let's face it, unless we are actually flying a spacecraft to the planet, we don't need all those "insignificant" digits. The measurements on the models, however, will be metric because of the ease of using powers of ten.

First Activity
One millimeter equals one million miles

Part 1 - Paper and Pencil Model: Materials: Metric Rulers (Meter Sticks); Chart of planet size and distances; Adding machine tape (about 4 meters per group), pencils, crayons, tape etc.

The Activity: In the class room we will make a scale model of the solar system, using the scale 1 mm equals 1 million miles. At this scale, the distance from the earth to the sun is 93 million miles, or 93 millimeters. (remember, millimeters are the little tiny units on the metric ruler). The students begin to wonder why they have so much paper. Keep going....
Procedure: Have the students draw a line across the adding matching tape near one end and label it SUN. Now measure 36 mm from the sun. Draw another line and label it MERCURY. Again, measuring from the sun, draw a line at 67 millimeters from the sun and label it VENUS and so on...to PLUTO 3.6 meters...3.6 billion miles from the sun! That’s why the paper is so long. I suggest always measuring from the sun. When the distances get large, remember one meter is 1 billion miles.

How Big are the Sun and Planets? Next, near the line marked sun, have the students estimate the size of the sun. The sun is slightly less than one million miles in diameter, at about 864,000 miles. That makes the sun slightly less than ONE millimeter. A mere dot on the paper. Jupiter at 88,000 miles is 10 times smaller, and the earth at 8,000 miles is 100 times smaller. That’s right, at this scale it is nearly impossible to draw the earth to scale.

What about the Moon? Another challenge is to place the moon in proper orbit around the earth. The distance from the moon to the earth averages about 240,000 miles, or about one quarter million miles. So, once again, the distance from the earth to the moon is less than a quarter of a millimeter at this scale.

This adding machine tape scale model is a pretty good visual. It definitely shows why textbooks don’t have scale drawings in them. It also illustrates quite clearly the difference in spacing between the TERRESTRIAL planets of Mercury, Venus, Earth and Mars, and the GAS GIANTS of Jupiter, Saturn, Uranus, and Neptune. This can lead to an open ended discussion about the nature or creation of the Solar System and the origin of Pluto, and speculation about other objects (planets or planetoids, comets and meteors) orbiting the sun. But there’s more...Read on.
Second Activity
One Millimeter equals one thousand miles.

Part 2: "Playground" Activity: Materials. Cards with Scale Planets, the Model SUN, a One Meter Trundle Wheel, or a 100 meter tape measure (see the physical education teacher), Chalk or other markers, a clear outdoor space of 140 meters or so...a football/soccer field plus end zones plus a little more. I prefer the sidewalk in front of my school building.

The model SUN: Tape or glue several pieces of poster board together and cut out a circle 864 millimeters in diameter. Label it SUN. The sun is about 864 thousand miles in diameter.

The Activity: The Scale is now expanded to 1 millimeter equals 1 thousand miles. We will be walking out a scale model of the Solar System, remember, this time the scale is 1 millimeter equals 1000 miles, or 1 meter equals 1 million miles and therefore 1 kilometer is one billion miles. Select pairs students to be planets. If you are doing other reports, described elsewhere in this packet, this fits right in.

Procedure: Predetermine a location for the SUN. Have the whole class walk to that location. Have preselected students hold the sun so it can be seen as the group walks away into space.

Now the journey (adventure if you like) begins. Walk 36 meters to MERCURY. If you are using a trundle wheel that's 36 clicks...students will enjoy counting the distance aloud. When you arrive, talk a bit about Mercury or better, have students prepared to tell interesting facts...distance, diameter, appearance, and any other special facts. The students selected to be Mercury will stay in this location holding up the card showing the scale size of the planet.

The journey continues... Travel on to VENUS. Have students calculate the distance. Venus is 67 million miles from the sun, and you have already traveled 36 million, so it is 31 more clicks on the trundle wheel. Again discuss briefly some facts about Venus and leave the Venus students and card here.

Go on to EARTH. While at the Earth, have students estimate the distance from the earth to the moon....The actual distance averages less than one quarter million miles, or less than one quarter meter, or about 240 millimeters.

Look back at the model sun from the earth. And yes, it appears to be about the same size as the sun and moon as viewed from the earth. (Never attempt to look at the real sun!)
Now on to MARS. By the time you get to Mars, the students are getting a pretty good idea about distances. If time and distance permit, you might plan a trip to JUPITER. But be sure you have time and space, because you might be surprised by that next step. At Mars you have traveled 140 million miles, the trip to Jupiter will be an additional 342 million miles or 3.5 times farther than already traveled. And that's only Jupiter!

**Back in the classroom...** Talk about the walk through the Solar System. Why didn't we walk all the way to Pluto? Hold up a rolled up adding machine tape that was prepared earlier. Start unrolling from the sun, and say we traveled from the sun to Mercury, Venus, Earth and Mars...Our next stop would have been Jupiter, three and a half time farther away, then Saturn nearly twice as far again and so on. Try to indicate to the students some landmark in your town that is 3,500 meters away or 3.5 kilometers, or more than 2 miles away!!

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**Third Activity**

**One millimeter equals 1000 miles...continued...**

**Part 3: Now, let's go all the way!** On your own, or working with a selected small group of students, measure the distances to all the planets along the sidewalk. Yes, you need more than two miles distance. I went around some corners. You definitely need a trundle wheel here, or I used a bicycle distance computer. Start at the SUN and measure out all the distances as in Part 2. This time write on the sidewalk with chalk the names of the planets and draw circles (or dots) that represent the size of the planets. I think this is pretty impressive! Its fun to have students come in and tell you they saw Saturn, Neptune or Uranus while walking to school or going for a bike ride to the store! Its fun to have them tell their parents about this activity, and this is the kind of activity they will go home and talk about to their parents.

When the students see the vast distances in the solar system and the small sizes of the planets...you might stress the point **"There is a lot of space in space"**. It almost seems like a miracle that we can even see the other planets at all. And its easy to see why Pluto is the unknown frontier.
Appendix...

Other interesting Stuff I Wanted to share with you but knew I wouldn’t have time...

Open ended discussions. Always interesting when centered on space exploration and travel. It took three days to go to the moon in the days of the Apollo missions. In the days of the unmanned Voyager Missions to the outer planets it took about 2 years to go to Jupiter another year for Saturn, six more to reach Uranus and more than 12 years to complete the photo mission to Neptune. A future manned mission to Mars will take three years round trip. What about the problems of manned missions to other planets. Would you go away on a very dangerous trip for years in a spacecraft?

Other Activities - Planet Reports: Divide students into groups of 2 or 3. Each group researches a planet. Make a scale drawing, make a three dimensional model, and write a report of some specified length maybe about 2 pages. This gives the students ownership in a planet, and they become experts. Each group then shares information with the rest of the class. Have each student in the class fill out a data sheet for the planets as the reports are given. I like to be quite structured, but suit your own style. Be creative. Use traditional books and library research as well as internet and other electronic sources.

Other interesting Facts: Have you ever noticed that the sun and the moon appear the same size as viewed from the earth? How can this be? After all the moon is only about 2000 miles in diameter while the sun is over 860,000 miles in diameter. Well the moon is only a quarter of a million miles away while the sun is almost 100 million miles away. So, in gross terms (again close enough is good enough) the sun is about 400 times bigger than the moon, and coincidently is 400 times farther away. So from our viewpoint here on earth they appear the same size. Cool! This results in "Total Solar Eclipses" If the moon were smaller or further away this awesome phenomena would not happen!! Pretty interesting.

Another cool idea: While walking out the model solar system in Part 2, have an extra Moon card with a 2 mm hole in it. While at the earth location, hold the card 240 mm from your eye, and look at the Model Sun through the hole... How do the sizes compare? (Repeating: Never attempt to look at the real sun.)
**Exercise in big numbers.** Since the metric system is in powers of ten just as our number system is it should be easy to understand. However, students often confuse thousands, millions, and billions. To me is important for students to understand that each is a thousand times greater than the other. This will help in understanding other big number concepts, like the age of the earth. Here is some big number background you might find helpful.

<table>
<thead>
<tr>
<th>For Part 1 scale selected is</th>
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</thead>
<tbody>
<tr>
<td>1 millimeter = 1 million miles.</td>
</tr>
<tr>
<td>So... 1000 millimeters = 1000 million miles</td>
</tr>
<tr>
<td>then 1 meter = 1 billion miles</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>In Part 2 and 3....</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 mm = 1 thousand miles</td>
</tr>
<tr>
<td>so now 1 meter = 1 million miles</td>
</tr>
<tr>
<td>and 1 kilometer = 1 billion miles</td>
</tr>
<tr>
<td>for this expanded scale.</td>
</tr>
</tbody>
</table>

Confused yet? Work with it...you'll get it. It is helpful to think of millions as thousands of thousands, and billions as thousands of millions. Remember to relate units by $10^3$, $10^6$, and $10^9$, always adding three zeros at a time.

**Why Are There Seven Days in the Week?** There are seven days in the week because there are seven objects in the sky that were known to the ancients not to be stars. Stars are fixed in their patterns, while the planets were called wanderers because they move through the star field over time. But why seven? Aren’t there nine planets? True, but Uranus, Neptune and Pluto were not discovered until modern times after the invention of the telescope. Now we are down to six planets, but the earth doesn’t count...but the sun and the moon do. So here we go....

Sunday is SUN day
Monday is MOON day
Tuesday is MARS day Martes in Spanish the God of War
Wednesday is WODEN’S day for the Norse King of Gods; Mercury is Roman.
Thursday is THOR’S day for Thor the Norse “Jupiter”, King of the Gods.
Friday belongs to VENUS for Goddess of Love and Beauty
Saturday is SATURN’s day God of the Harvest and Father of Jupiter.
These are the SEVEN objects known to the ancients that moved about in the sky.
The English words we use today come to us from many languages and legends.

**What about this BLUE MOON thing?** It takes 29 1/2 days for the moon to revolve around the earth, or go from one full moon to the next. Since there are 30 or 31 days in most months it is possible to have two full moons in a month. If this occurs the second full moon in one month is called a Blue Moon. The moon is NOT blue, but this event doesn’t happen very often so perhaps that’s from where the expression “Once in a Blue Moon” originates. So, what’s going on now? Well, since February has only 28 days, its possible to not have a full moon in February, and if timing is just right, January and March will have two full moons, or two Blue Moons! That is occurring right now in 1999. I think it is neat to point out to the students the rarity of such events. The last time this happened was 1915, and it will not happen again until 2018. Your 12 year old students will be 31 years old. Ask them to remember you in 2018 when they hear about this happening again.
Keep It Simple - Doorstep Astronomy: Since most astronomy viewing is done at night when the students are home, I like to have students look at simple things they can easily find...like the "Blue Moon", or Venus, or even Jupiter when they are really easy to spot. Just ask the students to step out of doors, look up and see something obvious, and then go on doing whatever kids do most of the time. Students and adults are easily frustrated trying to locate constellations etc. without help. If you want to do more complicated viewing, plan a trip to a local planetarium or a "star gazing party" for students and their parents. This can be lead by you or ask a local expert to volunteer to lead your group.

In Conclusion: The study of space is interesting for most students. It stimulates imaginations plus, students long remember activities in which they participate. This Solar System activity is really neat, and well worth the time to set up. It reinforces the planets of the solar system, their order and size relationship.

What about Proficiency Objectives? This activity links Ninth Grade Ohio Proficiency Test Outcomes in math # 1, 3, 6, 7, 8, 12 and science # 1, 2, 3, 4, 6, and 17.

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The Solar System

Sizes to a Relative Scale

Distances to Another Relative Scale
Planets to scale 1 millimeter equals 1000 miles.

- Mercury
- Venus
- Earth
- Moon
- Mars
- Jupiter
- Uranus
- Neptune
- Saturn
- Pluto
More Stuff... One could Really Get Carried Away With the Seemingly Unlimited Available Resources!!!

WEBSITES:

Search your websites...keywords - astronomy - or - planets - this cyberworld goes on and on and on and on and on etc. etc. etc. etc...

NSSDC Photo Gallery of planetary pictures...Great Pictures of the Planets...
http://nssdc.gsfc.nasa.gov/photo_gallery/photogallery.htm

Comparison of Planet and Moon Sizes (Cool) Photo Atlas of the Solar System

Pictures of all the Planets...Neat Comparisons.
http://seds.lpl.arizona.edu/nineplanets/nineplanets/nineplanets/html

Astronomy Magazine: Very User Friendly Monthly overview of sky events and observations.
www.astronomy.com

Where to Order:

Trundle Wheel: #68936 $26.65 Science Kit & Boreal Labs.
777 East Park Drive
Tonawanda, NY 14150-6784
1-800-828-7777

Calendars:

Hansen Planetarium Publications
Wonders of the Universe Calendar
Useful all year...and great pictures.
1845 South 300 West, #A
Salt Lake City, UT 84115-1804
1-801-483-5400

Sky Calendar
Sky Events Described and Mapped
$9.00 per year - starting anytime
Abrams Planetarium
Michigan State University
East Lansing, MI 48824
Bibliography
A Short List...Solar System

The number of books out there is amazing. I like to keep it simple. Nice pictures and not too many words. I like museum “Gift Shops” as a source of useful and age appropriate materials.

Books:

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Blue Monday and Friday The Thirteenth
Clairon Books - New York
1986

Hertzberg, Hendrik
One Million
Times Books - Random House
1993

Jay M. Pasachoff, et al
A Field Guide to the Stars and Planets
(Peterson Field Guides)
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1998

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The Magic School Bus Lost in the Solar System
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1992

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1998
More Information... Sometimes I Just Can’t Help Myself.

So What About This Counterclockwiseness Thing? Do you know which way the earth rotates? If you were able to go into space and view the earth from above the north pole it would appear to rotate counterclockwise...opposite the direction of the hands on a clock! (Duh)

In fact, if you could continue into a journey into space and view the whole solar system from above the north pole, the earth goes around the sun (revolves) counter clockwise, as to all the planets. Yes, even the moon revolves counterclockwise around the earth.

There seems to be a pattern here. All the planets revolve around the sun in a counterclockwise direction (as viewed from above the north pole) and most of the planets rotate counterclockwise on their axes, AND most of the satellites of the planets revolve counterclockwise around their respective planets. You figured it out, as always, there are exceptions. Venus rotates clockwise (retrograde) to all the other planets. And a few satellites of the major planets revolve retrograde too. Now you know what retrograde means... (backward to the norm). Everything in the solar system tends to move in a counter clockwise pattern...and that's the way it is.

How can I observe this counterclockwise pattern? Well, the sun rises in the east and sets in the west. If you look at the motion of the sun during the day it appears to move in a clockwise motion through the sky. So do the stars. Of course the sun and stars are fixed in their positions, so it must be the earth that is rotating. And it is rotating COUNTERCLOCKWISE under the sun. We are on the counterclockwise rotating earth watching the sun appear move clockwise overhead. (Yeah, I know. All this would be backward in the southern hemisphere.)

The moon too is revolving counterclockwise around the earth. This is fun to observe and an good exercise for your students. Look up the date of the new moon. Observe the moon about one hour after sunset nightly for about two weeks. The moon appears higher and higher in the sky each night. Clearly, the moon is moving around the earth and you can see this counterclockwise movement from night to night. Do this early in the fall or late spring, when there is a chance for clear skies on successive evenings. This loses its effectiveness real fast if it is cloudy! Try it for yourself. It really helps to understand the motions of objects in space. The same can be done for the planets on a higher level, and with more data. Good viewing.
Have you seen brilliant Venus shining in the early evening sky. If you are a sky watcher, you have also noticed Jupiter reigning over the evening sky all winter.

Well, all through February they are drawing closer together until on the evening of February 22 and 23 they will be less than one degree apart. That's very close in viewing terms, but remember, Venus is about 133 million miles from earth while Jupiter is more than four times farther behind it at a staggering 540 million miles...yes more than a half a Billion miles away!

To add to your viewing pleasure, the moon will slide through this picture beginning with the new moon of February 16. I hope the skies are clear and you can enjoy this view and amaze your friends and family with your new found knowledge.

More than you really wanted to know...By the way, Saturn is higher in the sky slightly above all this, and the moon will glide past Saturn on February 20.

AND, Mars is visible in the morning sky. Brilliant "red" just about due south just before dawn. The moon will glide past Mars on the mornings of March 6 and 7.

You too can become an expert in following the stars and planets. Get a good calendar, such as the Hansen Planetarium calendar, and/or Astronomy Magazine (or website) and with a little practice, and good clear dark viewing skies, you will be pleased with your abilities.

Learning constellations requires a little more effort. Visit planetariums and have experts point them out. Or attend star gazing events that are often sponsored by local groups or metro parks. Then a good (but simple) star guide will be helpful. You know those circular "Star Finders" and constellation guides. Remember, constellations and stars are FIXED in their positions and change only on a yearly basis as the earth revolves around the sun. The constellations are always the same for the same month each year. The Planets, as the Greeks noticed, are wanderers. Their positions change in the starfield through time. That is why is helpful to have a calendar to check the positions of the planets.

I have enjoyed putting this project together. I hope you have benefited in some way. I wanted to keep it simple, so I hope I have not offended your intelligence. I am open to suggestions, criticisms, and accolades.

Thank you for attending Daytime Astronomy.
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