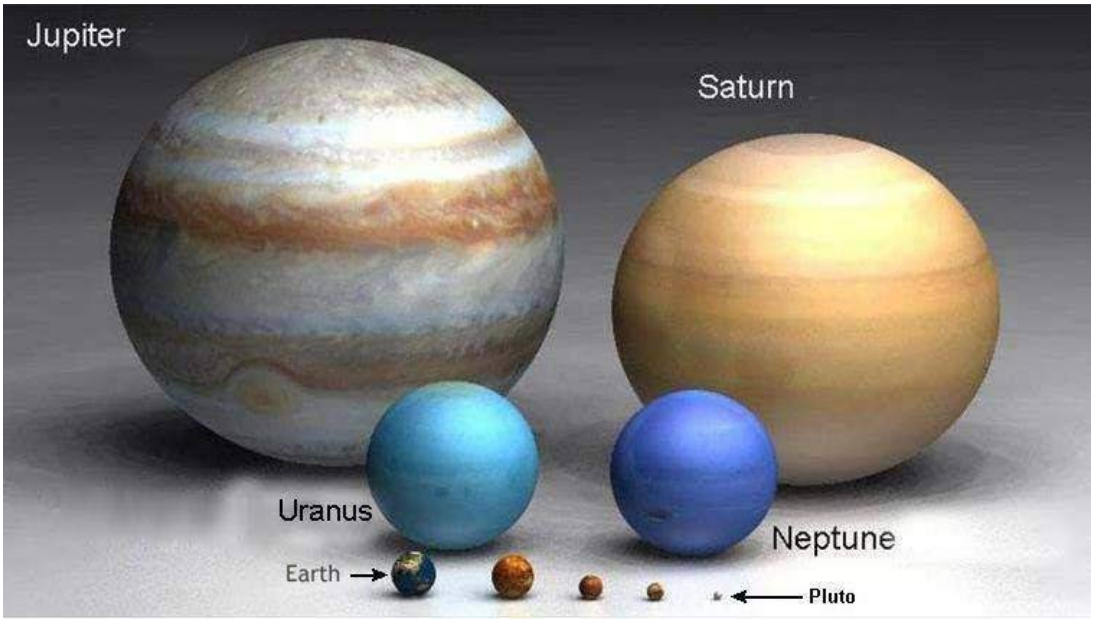
Mass Relations Exercise



Introduction

Can you picture the dimensions of the Solar System? Some of you probably can, especially if you have ever done a scale exercise before.

Those of you who do understand the vastness of our Solar System probably know that the measurements of our universe are tremendously amazing, yet terribly difficult to realize, or to show when there is such a grand scale.

There are several exercises out there creating relatable distance experiments that one could participate in to fully comprehend and appreciate the immensity of our Solar System, but we are going to do something a little different. We are going to *feel* the difference, and we will do so with something that is easily attainable and relatable: water.

Since our planet is 3/4ths covered in water, and most of us in our lives have measured out a teaspoon or held a gallon of water, we already know how they feel in relation to one another.

This exercise is broken up into two parts. The first part requires that you take your best guess! We are going to approximate what we think the masses would be if water was used as our measuring scale. The second is part is actually calculating. You will be able to measure out the actual masses if water really was the scale and be able to see how close your original guesses were!

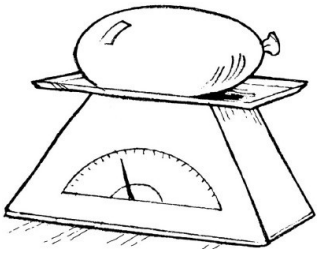
*Note: There will be an answer key provided at the end of the exercise.

Part One:

So what do you think? To keep it simple, we first need to come up with the scale. The easiest way to start is to use us, Earth, as a constant. For simplicity's sake let's give the mass of Earth the measurement of: **1 teaspoon of water.**

Now that we have that figure, take a guess about the masses of other objects in the Solar System! Use your best judgment with what you know about the mass of water. To help, try out! Grab a teaspoon of water, or a cup, or a gallon and *feel* the difference.

To keep this in a "relatable" scale, it is best to guess using teaspoons, tablespoons, cups, or gallons. The reason why we want to stop at gallons is because we can physically hold it, it's not too heavy, and if we were to go any heavier it would be harder to imagine holding (for instance, we don't want to use tubs of water, we're not trying to be Hercules here!).



To help, it is good to know liquid conversions beforehand if you don't already.

Conversions:

3 teaspoons = 1 tablespoon

16 tablespoons = 1 cup

16 cups = 1 gallon

Also, here are some fun facts to think about as you are making your guesses. Think about how these facts might influence your guesses, if the Earth mass was represented by 1 teaspoon.

- Most of those jugs of water you see at doctors or dentists offices hold about 5 gallons of water.
- A Jacuzzi tub tends to hold anywhere from 50-70 gallons of water, depending on the size!
- A small fire engine truck tends to hold up to 500 gallons of water!

- The average family of four can use 400 gallons of water every day.

Your Best Guess of Solar System Masses, if Earth's Mass is Represented by 1 Teaspoon of Water:

Sun: _____

Mercury: _____

Venus: _____

Earth: _____ ***1 Teaspoon*** _____

Mars: _____

Jupiter: _____

Saturn: _____

Uranus: _____

Neptune: _____

Part Two:

This next part involves taking the masses of our planets and converting them to a scale that we can more easily understand and relate to.

Since most numbers won't look as standard as "1 teaspoon," like our scale for Earth, we are going to calculate what each planet would be in gallons, cups, tablespoons, and teaspoons, and then decide which figure is best to use for our end result. Sounds daunting, but after calculating one of the figures, it's just simple mathematics to find the remaining.

Procedure:

*Note: It is best to keep all of your calculations and results in a table, which will be provided for you.

1. Step One: Set up a proportion. We do this because we are converting a mass of a planet into a mass of a liquid; we are creating the scale.

   To figure out how many Earth masses each celestial body is, we first think about how one might go about setting up a standard proportion. What do we know? We know that we typically use Earth as our standard scale. For example, if we wanted to find out how many Earth's would fit inside of Jupiter, or even our Sun, the first thing we would start off with is the mass of our Earth. We would then take the mass of the celestial body we want to find the proportion of, and divide it by the mass of Earth. It's that easy!

   Divide the mass of each object by the mass of Earth and record the results in your table under section entitled: "# of Earth Masses."

2. Step Two: Choose which measurement amount you would like to use first. We will call this first measurement your *base* calculator choice, either: gallons, cups, tablespoons, or teaspoons. You can start with any of them but, it is easiest to start with what you *already* know.
   *Hint: What is the first measurement that was provided for you?

3. Step Three: Start converting! Use what you know about liquid conversions and set up proportions to calculate the mass of each celestial body. Remember, we are only working on your *base* right now.

   To set up a proportion the easiest method would be to once again start with what we know or what we have already filled out. We already have the column completed entitled, "# of Earth Masses" so this is what will help us set up our proportions. For example, lets say we we decided in Step 2 that we wanted to first figure out all the measurements in teaspoons, and for simplicity's sake we choose to start with Venus, what would we do first? Well since we know Earth equals 1, we would put that on the bottom, and on top we would want to put the planet that we are trying to figure out. It should look something like this:

   $$\frac{\text{\# of Earth Masses for Venus}}{1}$$

   The second half of the proportion is what you're multiplying, and since we are using an easy number, like 1, the calculations will be quite simple. So on the top half of the second part of the proportion we would use a variable such as "x," and on the bottom put our base of 1 teaspoon for Earth. Simple!

   $$\frac{\text{\# of Earth Masses for Venus}}{1} * \frac{\text{"x" teaspoons}}{1 \text{ teaspoon}}$$

   Starting to make sense? If not, this next step will come in handy!

4. Step Four: Once you have filled out your first *base* column, confer with your neighbors! This is what we call Peer Review. Astronomers do this to get a second set of opinions and also to double check results. If you and your neighbor have different calculations, talk about it. See if you are all on the same page, and if not, help each other out!

5. Step Five: Once you feel confident that you have successfully calculated the first column, figure out the remaining masses for your other methods of measurement. To do this, you will take your results from your base calculations and use them to calculate the rest.

   To do this section you are going to use the conversions mentioned in Part One of the assignment. Think about mathematics. For example, if you already know that the mass of Earth is 1 Teaspoon, to find out how many Tablespoons the mass would be, you would deduce that because 3 Teaspoons = 1 Tablespoon, Earth would be 1/3, or 0.33 of a Tablespoon.

   *Hint: Multiplication and Division are your friends in this section.

6. Step Six: Once your table is complete, see how your results from this table compare to your original guesses! How close were you? How far off? Were you surprised by your results? Compare with your friends and peers!

Optional Homework/Take Home Assignment

Now that you've examined our Solar System, explore further! There are over 1,000 extrasolar planets (or exoplanets) documented to date. Choose your own that you would like to look at!

Homework Assignment:

Pick up to 5 different exoplanets using the Extrasolar Planets Encyclopedia link provided:

http://www.planetarybiology.com/exoexplorer_planets/

Follow the same guidelines you have been provided for this assignment; document your results. Share with your friends and peers! Find anything interesting? Are the measurements you calculated similar to planets in our own Solar System? Which exoplanet did you find the most unusual or different, why?