Chapter 1

Scaled Solar System Model

Research Question

Is it practical to build a single scaled model solar system that would be suitable for teaching elementary school children about the relative sizes of planets and their distances from the Sun?

Guidelines

For this exercise you will hand in a completed Table 1.1, plus written answers to the questions asked at the end of this paper.

Procedure

When making a scaled model, one shrinks **all** dimensions by the same multiplying factor. This factor is called a **conversion ratio**. Apply this conversion ratio to all the sizes and distances in the solar system (Table 1.1). Remember to carry the units through all your equations.

If you do not know Kepler's laws, then you may assume that a planet's **semi-major axis** is the average distance from the Sun to the planet.

1. Choose a single object in the solar system.
2. Choose a common household object to represent this object's size in the model.
3. Divide the size of the household object by the size of its solar system object to determine the conversion ratio.

4. Apply the conversion ratio to the whole solar system. Fill in the blanks in Table 1.1.
5. Look at the resulting sizes and distances, and choose an object of about the same size to fill in the final column in Table 1.1.

Example

Suppose I choose the Earth as my starting solar system object, and a dime as my model object. A dime has a radius of about 1 cm. Therefore,

$$\begin{aligned} \text{Conversion factor} &= \frac{1 \; \textit{cm model units}}{6,378 \; \textit{km true units}} && (1.1) \\ &= 1.568 \times 10^{-4} \; \frac{\textit{cm model units}}{\textit{km true units}} && (1.2) \end{aligned}$$

Note that the units of the conversion factor will only work when converting from (true) km to (model) cm. Let's apply this conversion factor to see how large Mars is:

$$\begin{aligned} \text{Mars model in cm} &= \text{Mars true in km} \times \text{conversion factor} && (1.3) \\ &= 3.397 \times 10^{3} \; \textit{km true units} \;\times\; 1.568 \times 10^{-4} \; \frac{\textit{cm model units}}{\textit{km true units}} && (1.4) \\ &= 0.5326 \; \textit{cm model units} \; \frac{\textit{km true units}}{\textit{km true units}} && (1.5) \\ &= 0.5326 \; \textit{cm model units} && (1.6) \end{aligned}$$

In the above set of equations, the units of *km true units* in both the numerator and denominator reduce to the value "1", and we are left with the model units of cm. We conclude that the size of Mars in our model is 0.533 cm, and fill this value in Table 1.1. An object of about 0.5 cm in radius might be a shirt button.

Questions

1. (Data & calculations) Complete Table 1.1. Show a complete calculation for one row of the Table, carrying the units through in your equations.
2. (Conclusions) How do planetary sizes and distances compare with each other? Does the result surprise or impress you in any way?
3. (Assumptions) Is it easy to find representative objects for all sizes and distances?
4. (Goal) Is it possible to communicate effectively both the relative sizes AND distances to an elementary school child, or do you think that information on one is sacrificed in order to communicate information on the other? Why?

5. (Goal) Do you think your whole model would be helpful to a child, or only parts of it, or none of it? Why?
6. (Procedure) Could you suggest an alternate goal that would be easier to achieve and more pedagogically sound?
7. (Perspective) There are lots of other solar system models at museums and planetariums. Find out about one of these (the internet is probably easiest) and state what the size of this model is, and how it compares with your own.

Object	True semi-major axis (km)	True Radius (km)	Model Semi-major Axis (cm)	Model Radius (cm)	Model Object (axis)	Model Object (radius)
Sun	N/A	1.392×10^6				
Mercury	5.791×10^7	2.440×10^3				
Venus	1.082×10^8	6.052×10^3				
Earth	1.496×10^8	6.378×10^3				
Mars	2.279×10^8	3.397×10^3				
Jupiter	7.783×10^8	7.149×10^4				
Saturn	1.429×10^9	6.027×10^4				
Uranus	2.875×10^9	2.556×10^4				
Neptune	4.504×10^9	2.476×10^4				
Pluto	5.916×10^9	1.195×10^3				

Table 1.1: Sizes and distances of the major objects in our solar system.