# Scale models

How do we figure out how big to make the balls and distances in our model, to keep it accurate? We need to start by choosing one model object's size and compare it to the real object. This will determine the other sizes for our model.

$$d_{blue,real} = 3.0\,cm$$

$$d_{blue,model} = 1.5\,cm$$

We need to measure the diameter of the real red ball and the distance between the real blue ball and real red ball to figure out how big to make these sizes in our model.

$$d_{red,real} = 1.0\,cm$$

$$D_{blue\ to\ red,real} = 12\,cm$$

Now we can calculate the sizes we need for our model.

$$\frac{d_{red,model}}{d_{red,real}} = \frac{d_{blue,model}}{d_{blue,real}}$$

$$d_{red,model} = \frac{d_{blue,model}}{d_{blue,real}} d_{red,real}$$

$$d_{red,model} = \frac{1.5\,cm}{3.0\,cm} 1.0\,cm$$

$$d_{red,model} = 0.50\,cm$$

The ratio (fraction) of the model red ball to the real red ball is the same as the ratio of the model blue ball to the real blue ball.

We solve for the diameter of the model red ball, and then insert values to find the diameter we need for the red ball in our model.

$$D_{blue\ to\ red,model} = \frac{d_{blue,model}}{d_{blue,real}} d_{blue\ to\ red,real}$$

$$D_{blue\ to\ red,model} = \frac{1.5\,cm}{3.0\,cm} 12\,cm$$

$$D_{blue\ to\ red,model} = 6.0\,cm$$

We can find the Distance between the blue and red balls in our model the same way. This was easy, since we could just use a very similar equation. Once we set the scale using the blue model ball compared to the blue real ball, we have the scale for anything in the model compared to the real system. If we had nine balls, all different distances apart, we could use the same scale to find the correct sizes and distances in our model.

Now, let's build a scale model of our Solar system.

Let's assume that in our model, the sun is the size of a bowling ball. Comparing the size of a bowling ball will allow us to calculate the other relative distances in our scale model.

$$d_{sun,real} = 1.4 \times 10^{9}\,m$$

$$d_{sun,model} = 2.2 \times 10^{-1}\,m$$

Deciding to use a bowling ball, with a diameter of about 22 cm (2.2 x 10-1 m) sets the scale for our scale model.

$$d_{earth,real} = 1.3 \times 10^{7}\,m$$

$$D_{sun\ to\ earth,real} = 1.5 \times 10^{11}\,m$$

We also need to know the other real distances involved. Now we can use the scale set by the bowling ball to find the diameter of our model earth and how far away from our model sun to place it.

$$d_{earth,model} = \frac{d_{sun,model}}{d_{sun,real}} d_{earth,real}$$

$$d_{earth,model} = \frac{2.2 \times 10^{-1} m}{1.4 \times 10^{9} m} 1.3 \times 10^{7} m$$

$$d_{earth,model} = 2.0 \times 10^{-3} m$$

Using the scale set by the bowling ball compared to the real size of the Sun, we calculated the size of Earth in our model. In our model, Earth is the size of a small bead, a couple of millimeters in diameter.

$$D_{sun\,to\,earth,model} = \frac{d_{sun,model}}{d_{sun,real}} d_{sun\,to\,earth,real}$$

$$D_{sun\,to\,earth,model} = \frac{2.2 \times 10^{-1} m}{1.4 \times 10^{9} m} 1.5 \times 10^{11} m$$

$$D_{sun\,to\,earth,model} = 24\, m$$

We can use the same formula to find out how far apart the bead would be from the bowling ball in our model. Here, we calculate that the distance in our model would be 24 meters.

Now, if the true distance to the nearest star,  Alpha Centauri, is 4.0 x 1016 m, how far away would it be in our model?

$$d_{sun,real} = 1.4 \times 10^{9} m$$

$$d_{sun,model} = 2.2 \times 10^{-1} m$$

$$d_{earth,real} = 1.3 \times 10^{7} m$$

$$D_{sun\,to\,earth,real} = 1.5 \times 10^{11} m$$

$$d_{earth,model} = \frac{d_{sun,model}}{d_{sun,real}} d_{earth,real}$$

$$d_{earth,model} = \frac{2.2 \times 10^{-1} m}{1.4 \times 10^{9} m} 1.3 \times 10^{7} m$$

$$d_{earth,model} = 2.0 \times 10^{-3} m$$

$$D_{sun\,to\,earth,model} = \frac{d_{sun,model}}{d_{sun,real}} d_{sun\,to\,earth,real}$$

$$D_{sun\,to\,earth,model} = \frac{2.2 \times 10^{-1} m}{1.4 \times 10^{9} m} 1.5 \times 10^{11} m$$

$$D_{sun\,to\,earth,model} = 24 m$$