

MODELING A CONSTELLATION IN TWO AND THREE DIMENSIONS

grades 4–6

Objectives

Thinking and acting like a scientist: By building an accurate three-dimensional model of a constellation, students will practice the kinds of scientific thinking that go into making predictions and creating models.

Math skills: Students will learn about scale, perspective and distance by building a three-dimensional model of something they usually perceive as two-dimensional.

Introduction

One of the things that scientists do is to build descriptions and understandings of the way the world around us works that allow us to make useful predictions. These descriptions are called “models”. Models can take many forms. Some models are mathematical formulas, like those used to calculate acceleration or velocity. Some models are graphic descriptions of how the pieces of something are arranged or how they interact, such as the various models for atoms. Other models take the form of small scale versions or physical constructions that approximate some, but not all, of the elements of the original object or event.

Astronomers use models all the time to study the planets and the stars. That is because almost everything that astronomers are interested in is located far from Earth. Our view from Earth can make the universe seem like a two dimensional dome over the planet. In order to get a sense of how objects we observe from Earth fit together in three dimensions, astronomers build models of the universe.

In this activity, students will start with something familiar — the well-known constellation, Orion — and look at it in the way that an astronomer would look at it. They will start out by modeling the constellation as it looks from Earth by making a two-dimensional picture. Then they will reconsider their models as scientists, reconstructing them in three dimensions to reflect the actual relationships that scientists observe between the stars that make up the picture.

This lesson consists of both hands-on and computer-assisted activities. Students will use the Museum’s Digital Universe software to visualize and “explore” the constellations in three dimensions. They will use pen and paper, rulers and scissors and cardboard and aluminum foil to build their own three-dimensional constellations. After observing a two-dimensional “night sky view” of Orion, students will construct a two-dimensional model. Using the Digital Universe, students will then “fly” out to Orion, attempting to observe and note the spatial relationships between stars in the constellation in *three* dimensions. Students will then adjust their constellation models to incorporate a third dimension based on their observations. Finally, students will fly around to a side-view of Orion and check their three-dimensional model against the “real” stars.

Requirement

The American Museum of Natural History's "Digital Universe" program, including the Partiview software and Milky Way Atlas data set. The software can be downloaded at <http://www.haydenplanetarium.org/hp/vo/du/index.html>.

Additional Materials

Ruler

Pen and paper

Sheet of cardboard (approx. 2 x 2 feet)

Scissors

Spools of thread, dental floss or other lightweight string

Paper clips (10 –20)

Aluminum foil (6-8 feet for stars)

LCD projector (optional)

Supplemental configuration file to Partiview 3-D_Constellation_Modeling and related data sets

Individual computers running Digital Universe software and configuration files (optional)

LCD projector (optional)

Additional Resources for Educators

Other astronomy activities are available in the "Resources for Learning" section of the American Museum of Natural History Website:
<http://www.amnh.org/education/resources/index.html>.

Procedure

Part One: Introducing the Constellations

1] Show the class a Digital Universe rendering of the night sky with the constellation data set and labels turned on. Run the **Milky Way Atlas** configuration file to open Partiview. (Ideally, the computer is connected to an LCD projector.)

Explain: This is a computer model of the galaxy and right now we are looking at a view of the night sky as it looks from Earth. The connecting lines are there to make it easier to spot the constellations.

Ask: What do you know about constellations? Which ones do you recognize? Do you know any of the stories associated with the different constellations?

Discuss: Discuss the difference between the constellations as we see them from Earth and the actual stars in the galaxy that make up the constellations. While we see tiny points of light in the sky that are all about the same size and seem to be the same distance away, in reality these points are giant stars — some of them far larger than our own sun. What looks like a small flat picture is actually an arrangement of giant stars that may be hundreds or thousands of light years away from one other.

Part Two: Making Two-Dimensional Constellation Model

- 2] Introduce students to the activity of making three-dimensional models of constellations that represent the way constellations “really” look — the way you would see the stars if you could move around between them in outer space.
- 3] Divide the class into groups - with each group stationed at a computer - and have each group open the 3-D_Constellation_Modeling configuration file. If there are not sufficient classroom computers for each group to have its own terminal, then all groups can work from a single projected image. Students should view the file with the following data sets turned **on**: stars, Orion, OrionCluster, OpticalMilkyWay, and SunLabel.
- 4] Pass out a ruler, cardboard, scissors, spools of thread or string (students will likely need 6–8 feet), aluminum foil and paperclips to each group.

- 5] Working in groups, measure the distances between the stars in Orion in two dimensions (along x and y axes) and record the distances (cm. or in.) in height and width between the stars.

Explain: This will let you know how far apart to space the stars in your models. It is probably best to only work with the most important stars in the constellation. A model that tried to incorporate every star in the picture would be pretty crowded.

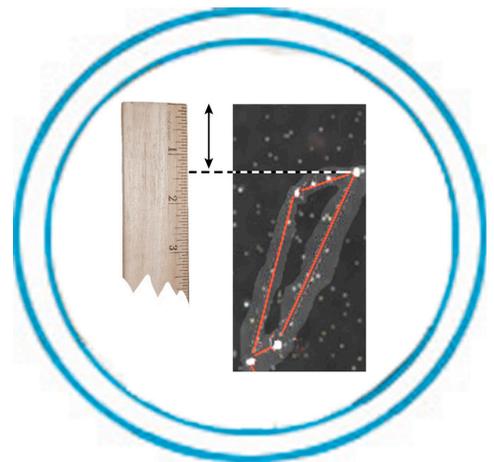
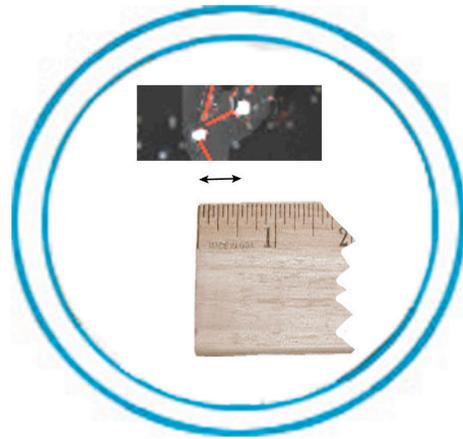
- 6] First, measure the distances between each star along the x (**horizontal**) axis.

Explain: There are a number of ways you can measure:

- a. Using the Digital Universe, you can use a ruler to measure the distances between stars right on the screen. You should move from left to right, measuring from the left-most star to the next star, from that to the next one, etc.
- b. You can make a printout of a screenshot of your constellation by first zooming in on the image and then hitting PrintScreen. Then you can measure the distances between the stars on paper. Teachers may also wish to make printouts of Orion in advance.

- 7] Next, measure the vertical (**y axis**) distance from the top of the screen or printout to each star. This will tell you how long to cut the strings from which you will hang each star.

- 8] Next, multiply each of your measurements by two or three and record the results for each distance. For example, if you measured and found that the first star in the constellation is 3/4 inches from the top of the screen,



multiply that by three and record the new distance as 2 and 1/4 inches.

Explain: By doubling or tripling our measurements we are changing the *scale* of the model. A model made on the same scale as the image on the computer screen would be too small to work with.

- 9] Now, make the cardboard frame from which the stars will hang. Cut long vertical slits in your cardboard — starting from one side and stopping an inch or two before you reach the other side. The slits should be the same distance apart as the stars in the constellation, so use the measurements you made (again, doubled or tripled) on the horizontal (x) axis to determine the distances between each slit.
- 10] Next, string your stars. First cut your thread into 2-foot strings — one string for each star in your model. So if you are including the fifteen most important stars in Orion, you will need fifteen two-foot threads.
- 11] Tape one end of each piece of thread to a six-inch square of foil.

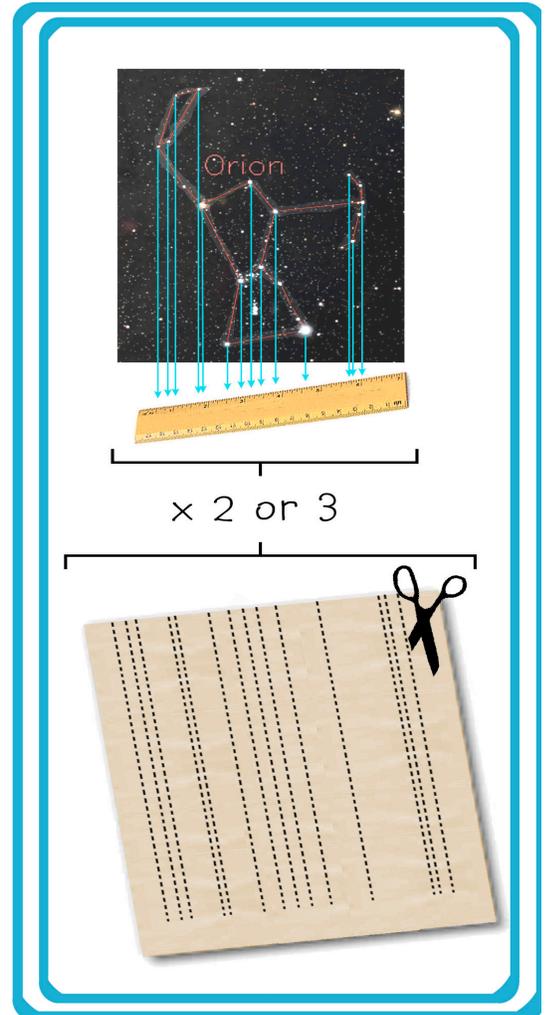


- 12] Crumple the foil into a ball around the end of the string to make a “star.” First wrap it into a loose ball around the end of the thread, then crumple it as tightly as possible to make a hard little ball. Repeat this process for each star.



- 13] Now, hang your stars. Slide the first thread into its appropriate slot in the cardboard frame, and pull the thread until the star is hanging at the proper length
Explain: This is where you should use the measurements you made along the vertical (y) axis. Pull the thread to match the length you recorded for the star (again, doubling or tripling the length to scale up the model, if necessary).

- 14] Once the star is hanging in place, tie a paperclip onto the thread at the point where it pokes through the cardboard. This will hold the star in place.

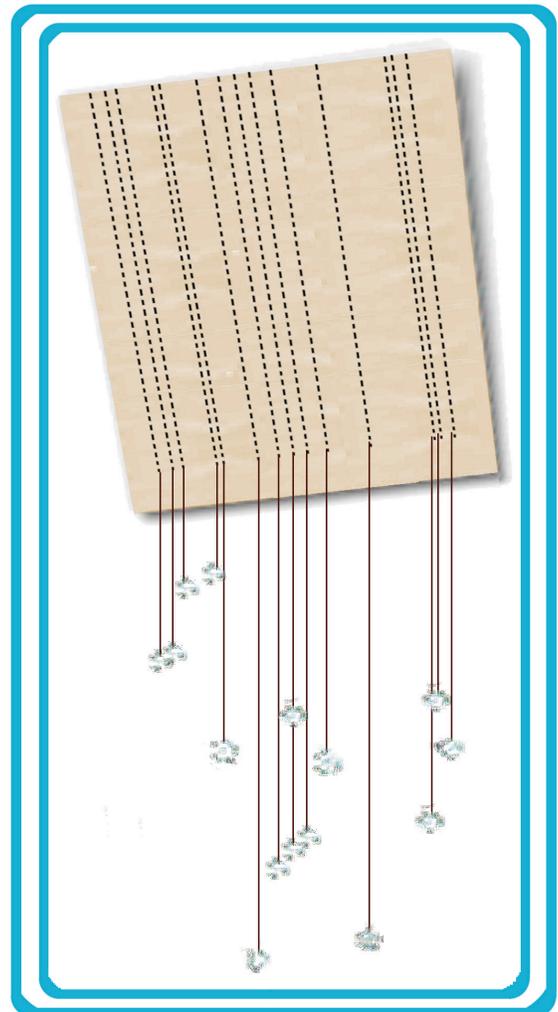


- 15] Repeat steps 11 and 12 for each star. When you have slid all the stars into place, you should have a two-dimensional model of Orion.

Explain: When students are ready to add the third dimension of depth, the slits in the cardboard will allow them to slide each star forward or backwards.

Part Three: Observing Constellation in Three Dimensions

- 16] Using the Digital Universe software, look again at Orion. Open the 3-D_Constellation_Modeling file. This will open Partview with the stars, constellation lines of Orion, and the visible Milky Way displayed.
- Explain:** Now we are going to fly out into space towards Orion. As we fly, you'll see that some of the stars in Orion are actually closer to Earth than others. Because they're so far away from us and form a pattern that we have recognized, we tend to think of these stars as a group. This may imply that they physically close together in space, when they are actually billions of miles apart. In order to make our models astronomically accurate, we need to know how far apart the stars are, which ones are in front and which ones are in back. So as we fly towards the constellation, write down which star we reach first, second, etc.



- 17] Run the Digital Universe animated flight path to Orion:

- Use the data group buttons to make sure all of the data sets are turned **on**
- Once you have introduced students to this view of the sky and pointed out Orion, you will want to turn the Constellations data set **off** so that only the lines connecting Orion are displayed.
- In the flight-path control bar (left), press **play**.



- 18] When you have shown the film once at regular speed, you will probably want to show it again more slowly, to give students a chance to note the order of stars and the distances between them:

- Return to the beginning of the film, either clicking and holding down the fast-reverse button, or dragging the slider all the way to the left.
- Now go through the flight path at a slow pace, stopping or moving backwards if students want to take a second look at something. You can control the flight in this way by (a) dragging the slider, which allows you to precisely control the progress of the flight, (b)



using the fast-forward and reverse buttons, which will move the flight forward or backward about one or two light years each time you touch the button, or (c) using the skip-forward or skip-reverse buttons, which will move the flight forward or backward approximately 22 light years each time you touch the buttons.



Explain: As we move through the film, write down the order in which we pass the stars, and pay attention to the signposts – those will give you an idea of how far away each star is from Earth, and how far the stars are from each other. That is how you will know how far apart to make the stars when you make your three-dimensional model. [If you are using the skip-forward button, you might add:] Every time we jump forward, we’re moving ahead about 22 light years, so if you count the number of jumps between each star, you can get a good idea of how far apart the stars are.

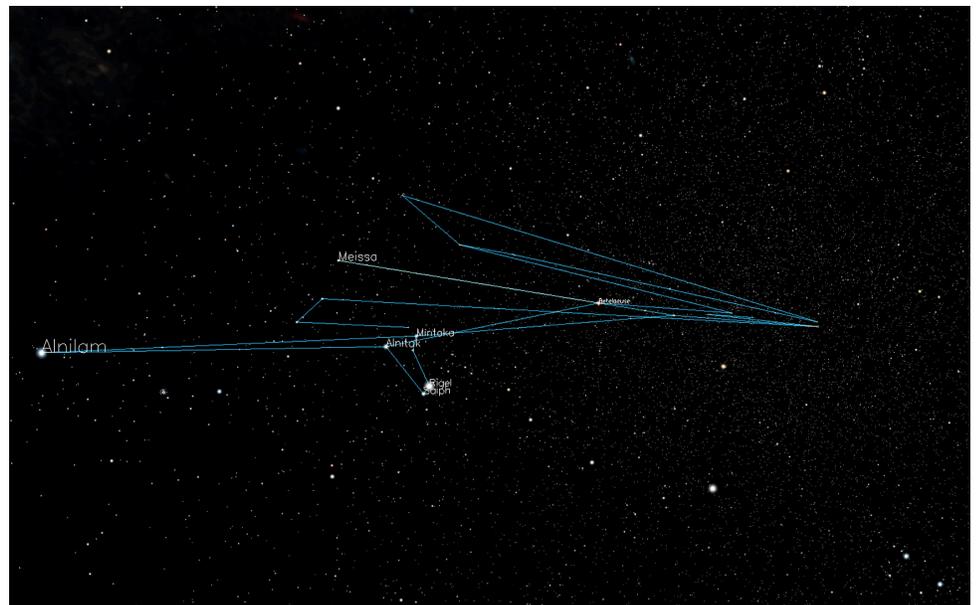
Part Four: Making Three-Dimensional Models

19] Have students make their models three-dimensional by sliding the stars forward or backwards along the slits in the cardboard.

Explain: Using the observations you made about depth in the Orion flight path, decide which star is in the front of the model, which comes next, which comes after that, etc. Try to make the relative distances between the stars in your model match up with the distances between stars along the flight path.

Part Five: Comparing Student Models to Scientists’ Model

20] Run the Digital Universe animated flight path that shows the *side* of Orion. This sequence will fly around to the side of Orion, so the class can compare the arrangement of stars in the constellation to their own models. Hit the ‘Path...’ button to load the flight path. A file explorer will open initially showing you the contents of the



folder that contains the Partiview program. Navigate to the ‘data’ folder, then to the ‘activities’ folder where you’ll see two flight path files. Select ‘orbit-orion.wf’ and the flight path will be loaded and ready to use. Now, you can control this flight path just as you did the first one.

Explain: This is what scientists think Orion really looks like from the side.

Ask: How does this compare to your models? How do you think scientists made their model?

Relevant Standards

From the National Science Education Standards: Science Content Standards: 5-8

Content Standard A: Science as inquiry.

As a result of activities in grades 5-8, all students should develop: abilities necessary to do scientific inquiry; understandings about scientific inquiry.... Fundamental abilities and concepts that underlie this standard include:

- [Ability to] develop descriptions, explanations, predictions and models using evidence.
- [Ability to] use mathematics in all aspects of scientific inquiry.

Content Standard G: History and nature of science.

As a result of activities in grades 5-8, all students should develop understanding of: science as a human endeavor; nature of science; history of science.... Fundamental abilities and concepts that underlie this standard include:

- Nature of science: Scientists formulate and test their explanations of nature using observation, experiments, and theoretical and mathematical models. Although all scientific ideas are tentative and subject to change and improvement in principle, for most major ideas in science there is much experimental and observational confirmation....
- ...[I]t is normal for scientists to differ with one another about the interpretation of...evidence....
- It is part of scientific inquiry to evaluate the results of scientific investigations, experiments, observations, theoretical models, and the explanations proposed by other scientists....

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