Astronomy and Astrophysics

Activity & Lab Book

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ASTRONOMY AND ASTROPHYSICS: Activity & Lab Book
by Dr. Sarah Salviander

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Contents

The cover photo shows the spiral galaxy M74 taken by the Hubble Space Telescope. Credit: NASA, ESA, and the Hubble Heritage (STScI/AURA)-ESA/Hubble Collaboration.

1 Chapter 1: Astronomy as a Science and a Sense of Scale

1.1 The Universe According to You, Part I (Activity)

Date: ____

Just about every person has a concept of the universe—what he or she imagines it looks like, on small scales and large—even in the absence of any formal knowledge of the universe. In this first activity of the course, before you begin your formal study of the universe and its contents, you will draw your personal concept of the universe on the scale of the solar system and on the scale of the very large. You will also write a brief statement explaining your view of the origin of the universe. You will repeat this activity on the last day of the course, after you've learned a great deal about the universe, and compare your two concepts.

Equipment

- Two blank sheets of 8.5" x 11" paper
- Pencil and eraser
- Colored pencils (optional)

Your concept of the solar system

On the first sheet of paper, draw what you think the solar system looks like. You may construct the drawing any way you wish, as long as it conveys how you think the solar system is constructed. Include as much detail as possible. If you like to use color, by all means do so, but it is not required.

Your concept of the large-scale universe

On the second sheet of paper, draw what you think the universe looks like on a very large scale—as large as you can imagine. You may construct the drawing any way you wish, as long as it conveys how you think the large-scale universe is constructed. Again, make it as detailed as possible; and, if you like to use color, do so, but it is not required.

Origin of the universe

On the back of the large-scale drawing, write a short paragraph (2-3 sentences) explaining how you think the universe came into being.

Sign your name and the date to both of the concept drawings and save them for the end of the course.

1.2 A Sense of Scale, Part I (Activity)

Date: ______________________________

The following exercise will help you comprehend the size and makeup of our solar system and the distance to the nearest star. It will also give you practice using the metric system and scale models.

Recreate the Scaled Model of the Solar System table from the textbook using a marble to represent the Sun. In this activity you will only calculate the scale distances from the Sun, not the scale size of the objects.

Real diameter of the Sun (km) / Diameter of the marble (m)	=	Scale factor of the model (quantity all other numbers will be divided by)
1,392,000 / ____________	=	____________

A New Scaled Model of the Solar System

Object	**Real distance from the Sun (million km)**	**Scaled distance (m)**
Mercury	____________	____________
Venus	____________	____________
Earth	____________	____________
Mars	____________	____________
Jupiter	____________	____________
Saturn	____________	____________
Uranus	____________	____________
Neptune	____________	____________
Pluto	____________	____________
Oort Cloud	____________	____________
Proxima Centauri	____________	____________

Optional: If possible, take the marble and some other kinds of markers to a field and attempt to create a rough scale model of the solar system. Will you be able to include the Oort Cloud in this rough scale model? Why or why not? You won't be able to include Proxima Centauri in this model, so to get a sense of where it would be in the model, look on a map to find which city or town is approximately Proxima Centauri's scaled distance from your home.

1.3 A Sense of Scale, Part II (Activity)

Date: ______________________________

This exercise will help you comprehend the distances between galaxies and compare the makeup of galaxy groups to the structure of our solar system.

1. You will make a very simple scale drawing of the spatial relationship between our galaxy and its nearest neighbors. Draw a circle 1 cm in diameter in the corner of a normal sheet of paper. This will represent the Milky Way Galaxy. That means that the scale of this scale drawing will be:

   1 cm = 100,000 light-years

   Use this scale to position the nearest galaxy, Canis Major Dwarf (described in the textbook as the small irregularly-shaped one), the Large Magellanic Cloud, the Small Magellanic Cloud, and the Andromeda Galaxy on the sheet of paper. You will have to adjust the textbook's scale to the new scale indicated above. It isn't necessary to get the relative sizes of these galaxies, just their distances from the Milky Way Galaxy.

   A New Scaled Model of the Local Universe

Galaxy	Textbook scale distance from the Milky Way	New scale distance from the Milky Way
Canis Major Dwarf	13 cm	______________
Large Magellanic Cloud	30 cm	______________
Small Magellanic Cloud	35 cm	______________
Andromeda	4.8 m = 480 cm	______________

2. Compare this scale model with the scale model of the Solar System from Part I. What do you notice about the relative size of the space between objects in one model compared with the other?

1.4 Distance Formula (Activity)

Date: ____

Don't be afraid of algebra

A lot of people struggle with algebra and feel that they can never understand it. But, they can. The biggest problem with algebra and math in general is that it is one of the worst taught subjects, and this failure of the school system begins in elementary school and usually continues all the way through high school.

Students are usually shown what to do (do this step, then this step, and finally this step), but they are seldom helped to understand why things are done the way they are. Math as just a set of rules to be remembered is boring and confusing. Math should be taught as a problem-solving language. Let us show you how it works and then we'll apply it to your astronomy assignments.

Suppose that you want to solve an everyday problem such as how to replace the carpet in your bedroom or build a rectangular platform for a skateboard ramp. It would help to know how many square feet of material you need so you can estimate the cost. The problem will be written in English first, then in math, and then we'll compare the two different ways.

In English:

The area of a rectangle is equal to the length of the rectangle multiplied by the width of the rectangle.

Let's focus on the key words of the solution:

The area of a rectangle is equal to the length of the rectangle multiplied by the width of the rectangle.

The words we left in black are helpful to understand the problem, but they aren't really necessary. Let's take the necessary words that were underlined and make a simpler statement with them:

Area is equal to length multiplied by width.

Now let's make the statement even simpler by using initials for some of the words and basic math symbols for others:

Area	is equal to	length	multiplied by	width
A	=	L	×	W

$$\mathbf{A = L \times W}$$

This shows the real reason for algebra. When the solution to the area problem is written in English, it takes over 80 symbols (letters and punctuation). The same solution written in the language of math takes only 5 symbols. The math way takes far less work and makes the steps involved in the solution so much easier to understand.

$A = L \times W$ is an equation (it has an equal sign in it). But it isn't just an ordinary equation like the ones teachers often use to try to teach algebra skills and concepts (such as $X + Y = 2$) it is a special kind of equation that is actually used to solve real-life problems. We call these special equations formulas.

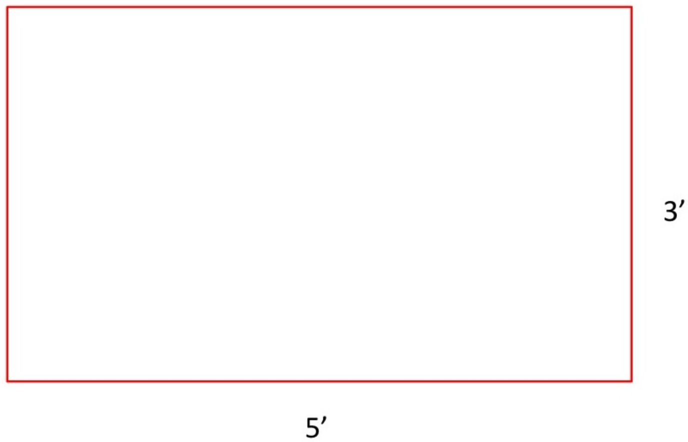
Think for a minute about what a formula does for you: $\mathbf{A = L \times W}$

First, the **A** to the left of the equal sign tells you what the formula is set up to do, ***find the area***. You just have to remember that this particular formula is designed to find the area of a rectangle. Other formulas start with **A** but they are set up to find the areas of other shapes. For example $\mathbf{A = \frac{1}{2}\, b \times h}$ is used to find the area of a triangle. The nice thing about the Internet age is that you really don't have to remember formulas anymore because you can find any formula in less than a minute by searching for it online. But, you do have to know how to use them once you find them.

Next, if you look to the right of the equal sign, the formula tells you exactly what quantities you need to know in order to find the desired answer. In this case you need to know **L** (the **length** of the rectangle) and **W** (the **width** of the rectangle). Sometimes someone will be able to tell you what they are, but most times in real life you will have to measure them yourself.

Finally, once you have numbers for **L** and **W**, the formula tells you exactly what to do with them. In this case the formula tells you to multiply them together (×).

Once a person gets over their fear of algebra and realizes how easy and useful it is, formulas become tremendously useful, even empowering. All the information you need to solve problems can be gained in a glance. Let's try an example. Find the area of the following rectangle:



The formula is: $\mathbf{A} = \mathbf{L} \times \mathbf{W}$ **so measure the rectangle to find the length and width**

Substitute them in $\mathbf{A} = (5') \times (3')$ **and then do the indicated math operation**

$\mathbf{A} = 15$ sq. ft.

Distance Problems

Now we're ready to take on some problems from Chapter 1. You were given the formula for doing distance problems:

$$\mathbf{D} = \mathbf{v} \times \mathbf{t}$$

The **D** indicates that the formula is set up to find a distance.

The **v** and **t** tell us what quantities we need to know in order to find the distance.

v stands for velocity (how fast something is going)

t stands for the amount of time an object goes that velocity

The × tells us exactly what to do with these two quantities once we know them.

Example: Find the distance a plane travels at 620 km/h for 3.3 hours.

$\mathbf{D} = \mathbf{v} \times \mathbf{t}$

$\mathbf{D} = \mathbf{(620\ km/h)} \times \mathbf{(3.3\ hours)}$

$\mathbf{D} = \mathbf{2046\ km}$

Trickier Example: Find the distance a rocket travels at 1620 km/hr for 20 minutes

Since the velocity of the rocket is given in km per hr, the time must be converted to hours as well: 20 minutes will be a part of an hour found by dividing 20 by the 60 minutes in an hour:

20/60 = 1/3 hour

Now you can use the distance formula as before:

$$\mathbf{D} = \mathbf{v} \times \mathbf{t}$$

$$\mathbf{D} = (\mathbf{1620\ km/hr}) \times (\mathbf{1/3\ hr})$$

$$\mathbf{D} = \mathbf{540\ km}$$

Solve the following problems:

1. How far does a person walk at 4.4 km/hr for 3 hours?
2. What distance does a space rocket cover at 12,250 km/hr for 60 days?
3. How far does a projectile go at 1200 meters per second for one minute?

Readjusting Formulas to Solve Other Problems

Formulas can be rearranged to solve other problems. For example:

How long would it take for a rocket to go 500,000,000 km at 2500 km/hr?

Here's how the formula can be rearranged to solve this problem. Our original formula is

$$D = v \times t$$

This formula can actually be written in an even simpler form:

$$D = v\ t$$

Mathematicians are somewhat lazy people in that if they can find a way to avoid writing something, they do. In this case, when two quantities are written next to each other in algebra with no operational sign between them, it is understood that the two quantities are to be multiplied times each other.

Now we can do some rearranging. A basic rule of algebra is that you can do whatever you want (whatever you find useful) to one side of an equation as long as you do the exact same thing to the other side. Watch what happens if we divide both sides of the formula by v :

$$D = v\ t$$

$$\frac{D}{v} = \frac{v\,t}{v}$$

Because any quantity divided by itself is 1, the v on the top on the right side and v on the bottom of the right side cancel each other out. All that remains on the right side is the t. So the formula now reads:

$$\frac{D}{v} = t$$

Better yet, we can turn the equation around:

$$t = \frac{D}{v}$$

Now the formula is set up to find the time (t) if you know the distance (D) and the velocity (v).

Solve the following problems:

4. How long would it take a car to travel 840 km at an average speed of 85 km/h?

5. How much time would it take an airplane to travel 3200 km at 500 miles per hour?
6. Rearrange the distance formula so it can be used to find velocity.
7. How fast would a person have to run (on average) to cover 500 meters in 40 seconds?
8. Express the answer for problem 4 in km/h.