

## Teacher Notes- “99.86%- Measuring Our Sun’s Mass”

Our sun, with a mass that consumes 99.86% of *everything* in our solar system, is beyond enormous. But how do you actually grasp that? Simple- you draw a box. But not just any box. One whose size represents .14% of the total area of a piece of paper.

It takes a 9-step mathematical journey to get to the end, but anyone can do the steps. The activity concludes with a tie-in to gravity.

1. Measure the length of your paper	__mm
2. Measure the width of your paper	__mm
3. Line 1 x line 2 = total area	__mm <sup>2</sup>
4. Measure the diameter of a hole	__mm
5. $\pi r^2$ to get area of circle	__mm <sup>2</sup>
6. $\times 3$ (3 holes)	__mm <sup>2</sup>
7. Line 3 - line 6	__mm <sup>2</sup>
8. Line 7 $\times .0014$	__mm <sup>2</sup>
9. $\sqrt{\text{of line 8}}$	* __mm
*draw a box with sides this long near the middle hole of your paper	

### Materials per student:

- 1-clean sheet of lined notebook paper
- 1-12-inch ruler
- 1-calculator

### And...

- 1 Marble
- PowerPoint-99.86%-Measuring Our Sun's Mass

### Beforehand:

1. Find a section in your textbook that deals with the sun. Anything will do, but if it mentions how massive it is then select that passage. Doing a short reading from your text sets a more academic tone to the lesson.
2. If you're using the PowerPoint, insert a picture from the internet<sup>\*1</sup> of the solar system on slide #1 (for copyright reasons, none were included). When you find one you like, right-click on it and “Copy”, come back to the PowerPoint and right-click then “Paste” it in. Drag a corner out to enlarge it. To put the words back over the front of the picture, right-click the picture → Order → Send to Back.
3. Go through the 9 steps yourself. That will give you a much better feel for what's going on, and will help you explain things better. You need confidence as you teach this lesson.
4. Print PowerPoint slide #5 notes for students who are slow writers or are absent.
5. Just before your first class comes in, remind yourself to keep things simple and focused. Don't stray too far- there's not much extra time, nor can students keep track of endless bits of excess information anyway.

**Procedure:**

1. As class starts, take care of some Preliminaries:
  - a.) Have students take out a clean sheet of lined notebook paper and to open their books to the page you'll be reading from.
  - b.) Begin the PowerPoint, showing the solar system picture on slide #1 that you inserted.

2. Give a general introduction:

*“True or false class- our sun is big (trick question – “big” is a relative term. It depends on what you’re comparing it to. Compared to us- earth- it’s big. But to other things, no.)<sup>\*2</sup>*

My goal is for everyone is to leave class today thinking, ‘My goodness, the sun is big!’. We’re going to use a 9-step mathematical process to calculate exactly how massive our sun is.

Don’t worry about the mathematics. Students of all mathematical abilities have done this. All you have to do is listen and do what each step says. All the hard work has already been done for you. You just plug in your numbers when you’re told to.”<sup>\*3</sup>

3. Read the section from the textbook about the sun aloud.

4. Clarify and focus the activity:

*“What we just read says that our sun is the most massive thing in our solar system. Did you catch how massive the sun is? (99.86% of the mass in our solar system alone belongs to the sun).*

*We’re not talking today about the size of our solar system.<sup>\*4</sup> The topic is mass. Mass is every thing...all the “stuff” that is in the solar system. Every proton, neutron, and electron everywhere.”*

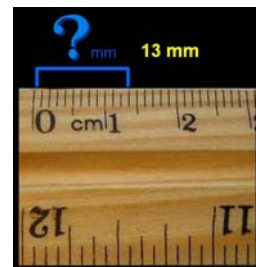
5. What is a solar system anyway? Surprisingly, many students don’t understand that we’re just talking about one star and all the objects that revolve around it:

*“Let’s make sure we all understand what a “solar system” is. Some of us know, but some of us aren’t sure. Who knows? (one host star and everything that revolves around it).*

*Which leads me to the picture you see on the screen behind me. When we talk about our solar system, or any solar system for that matter<sup>\*5</sup>, we’re referring to a host star and everything that revolves, or orbits, around it. I have a list of 7 main*

kinds of things that our solar system is made of. Let's see how many you can think of. (star/sun, planets, their moons, comets, asteroids, dwarf planets, dust)"

- Now go through the quick refresher slides on measuring with millimeters. We're using millimeters today because the little box we'll draw later is so small that its sides will be measured using that unit. Before leaving that slide, ask them how many mm 5 marks past 9 cm would equal (95 mm), and 8 marks past 23 cm (238mm). Now you're ready to move on.



- As directed by the PowerPoint, have students number from 1-9 on their papers, consecutively.
- Go through the 9 steps. Have students record their answers by each number:

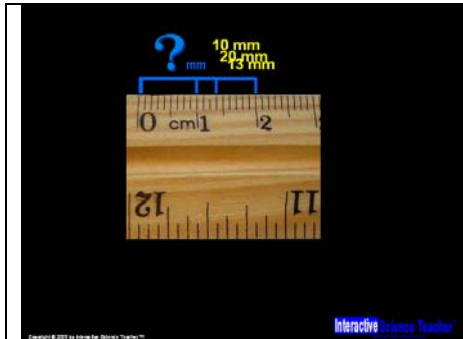
Step	Answer	Comment
1. Measure the length of your paper	Ave: 265 mm Range: ~250 – 280 mm, (depending on the brand/kind of paper)	<p>“Lay the ruler long-ways down your paper. Take the last centimeter number you see and multiply it by 10, then add to it the extra marks past the centimeter number.” (call on 2-3 students and talk through theirs as examples)</p> <p><i>(Do this along with your students- you'll describe what to do better and be able to show them what you mean.)</i></p> <p>“Each piece of paper is slightly different, so don't worry if your neighbor has a different number”</p>
2. Measure the width of your paper	Ave: 202 mm Range: ~190-220 mm	<p>Same method as in step 1, except now across the paper.</p> <p>Before proceeding to step 3, ask how many square feet a room that's 10 feet by 12 feet would be (120 feet<sup>2</sup>). Ask how they got that (by multiplying length x width). Bingo- let's do that for step 3.</p>
3. Step 1 x Step 2 = total area *6	Ave: 53,530 mm <sup>2</sup> Range: ~48,000- 60,000 mm <sup>2</sup>	<p>“Students, when you see the large number, don't panic. Since we're using a very small unit- millimeters- this number will be large. Just be mechanical and emotionless.”</p> <p>Leading up to step 4 ask (with a hint that you're up to something), “So...that's exactly how much <i>total</i> paper is in this space (referring to the area the paper takes up)? I don't know if I agree.” (You're about to break the news that they have to subtract out the space the holes take up.)</p>
4. Measure the diameter of a hole	Ave: 8 mm Range: 5-9 mm	<p>This step goes so fast that some students forget to write their diameter down, causing some to put answers on the wrong line.</p>

*(end of Teacher Notes preview)*

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- Sun
- 8 planets
- their 167 moons
- 3 dwarf planets
- Asteroids
- Comets
- Dust

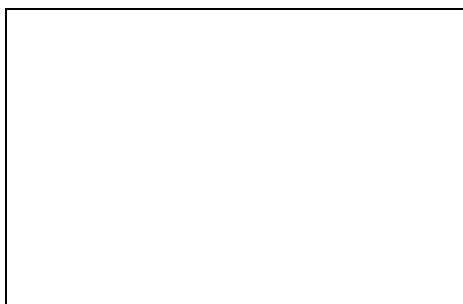
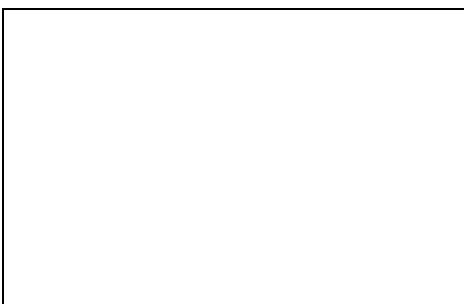


1. Measure the length of your paper \_\_\_mm
  2. Measure the width of your paper \_\_\_mm
  3. Line 1 x line 2 = total area \_\_\_mm<sup>2</sup>
  4. Measure the diameter of a hole \_\_\_mm
  5.  $\pi r^2$  to get area of circle \_\_\_mm<sup>2</sup>
  6.  $\times 3$  (3 holes) \_\_\_mm<sup>2</sup>
  7. Line 3 - line 6 \_\_\_mm<sup>2</sup>
  8. Line 7 X .0014 \_\_\_mm<sup>2</sup>
  9.  $\sqrt{\text{ of line 8}}$  \* \_\_\_mm
- \*draw a box with sides this long near the middle hole of your paper

- The area this sheet of paper takes up represents all the mass in our solar system
  - The sun's mass is all but this square
  - In this square is the combined mass of the planets, their moons, and everything else
  - Jupiter and Saturn take up 90% of this box!
- And so GRAVITY...
1. is the force of attraction BETWEEN 2 objects
  2. causes bodies to revolve around each other
  3. increases with mass and closeness
- Every object exerts a gravitational force on every other object!

- ### Common Examples
- If you throw a ball into the air, it comes back down
  - When you lose your balance on a ladder and fall
  - When you weigh yourself on a scale
  - Rain falling to earth...
  - Which turns into creeks, streams, then rivers, all flowing downhill
  - People on the other side of the earth are standing in the opposite direction that you are
  - The earth "holding onto" its atmosphere
  - The moon is tugging on you and me right now
  - Stars, though trillions of miles apart, stay together in clusters

This is a gravity switch. What would happen if gravity was switched "off"?



## ◆ Optional Student Handout

- 99.86% - Measuring Our Sun's Mass
1. Measure the length of your paper \_\_\_mm
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  3. Line 1 x line 2 = total area \_\_\_mm<sup>2</sup>
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  7. Line 3 - line 6 \_\_\_mm<sup>2</sup>
  8. Line 7 X .0014 \_\_\_mm<sup>2</sup>
  9.  $\sqrt{\text{ of line 8}}$  \* \_\_\_mm

## ◆ Quick Notes

Teacher Quick Notes- "99.86%"

**Materials:**

- 1-Clean sheet of lined notebook paper
- 1-12-inch ruler
- 1-compass
- Colored pencils (optional)
- 1 Marble
- PowerPoint-99.86%-Measuring Our Sun's Mass

**Procedure:**

1. Have students take out a sheet of paper and open their books to the reading page. Begin PowerPoint.
2. Read the section from the textbook about the sun.
3. Introduce the lesson, and make sure, before beginning, that everyone knows what we mean by "solar system". Ask what the 7 main parts of it are.
4. Practice using millimeters, as directed by the PowerPoint.
5. Have students number from 1-9 on their papers.
6. Go through the 9 step mathematical process. Have students record their answers by each number.
7. After step 9, draw a little box (about 8.5 mm X 8.5 mm), and color it.
8. Ask if anyone knows why we went through all the trouble of making it.
9. Have students copy the statements describing the box.
10. Cover the gravity section.
11. Assign homework-the gravity switch.

## ◆ Drawings & Pictures

Pic-9 Steps    Pic-Blank Sheet Of Paper    Pic-Homework    Pic-Numbered Sheet Of Paper

Pic-Reviewing Millimeters    Pic-Ruler    Pic-Statements About Box    Pic-Student Answers With Box Drawn

