**Measurment**

**Section 1**

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| 00:00:00 | TEACHER: Scientists use different methods of data collection based on what kind of data that they are collecting. However, all scientists use a similar system to communicate their findings with others. We'll talk about that system next. |

**Section 2**

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| 00:00:00 | TEACHER: Let's look at the metric system. The metric system originated in France in 1799. It uses the International System of Units, or SI, abbreviated from French-- pardon my French now-- Systeme International Unites. Nearly every country uses the metric system. However, the US does not use the metric system as its official system of measurements. |
| 00:00:28 | In the US, we use English System or customary system as system of measurements. Several things in the US are measured using the metric system. Others are measured using the English system. For example, the SI unit for length is the meters. Now, however, in the English units of yard or foot are often used to measure the length of things. |
| 00:00:57 | Science uses the metric system for measurements. Why? Since all areas of science involve mathematical calculations and or models, scientists everywhere can use the metric system to share their data or results. Now, there are two main advantages to using the metric system. |
| 00:01:17 | First, SI units are simple. Now, there is only one unit for each category of measurement. For example, the metric unit for mass is grams. Mass is grams. However, the English system has many units for weight, like pounds and ounces. The second advantage is that it is consistent. The English system has no consistency of units, |
| 00:01:48 | and uses fractions. But all metric units are in multiples of 10, or utilize decimal placement. We'll look at this in more detail later. SI units, because they're so simple, consistent, and universal, scientists use the metric system. Since the US continues to use the English system outside of science classes, you should |
| 00:02:15 | be able to recognize the common uses of the metric system. So comparison of units. Let's look at the definitions. Length is the distance from one point to another. Volume is the amount of space an object takes up. Mass is amount of matter in an object. And finally, temperature is a measure of average kinetic energy in the particles in a substance. |
| 00:02:46 | Now, note that for temperature, energy is simply how fast the atoms in a substance are moving about. The SI base unit for length, or distance, is the meter with the symbol m, as you can see in this table. Now, if you notice for English unit, what is it? It's in yard, or foot. Let's look at the rest. For volume, SI unit is liter, and it's |
| 00:03:14 | represented by symbol capital L. Now, for English unit, it's quart. For mass, it's represented in gram for SI unit, the symbol for lowercase g, and for the English unit, it is represented as pound. And finally, for temperature, you have degrees Celsius, or Kelvins, the symbol is degrees C, capital C, and capital K for the symbol. |
| 00:03:44 | English unit, it is in degrees Fahrenheit. |

**Section 4**

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| 00:00:00 | TEACHER: The metric system is based on multiples of 10. Note-- the base unit is shaded. Great. Only base units are written without a prefix. Base units might be meters, grams, seconds, and watts. As you move up the table, the numbers are getting larger. And as you move down the table, the numbers are getting smaller. |
| 00:00:25 | Let's look at the list of the prefixes together. You've got kilo, hecto, deca, base unit, deci, centi, and milli. If you have a hard time remembering them in order, what you can do is use what's called a mnemonic device or a memory device. You can use the one that's on the screen here or try having fun and come up with your own. |
| 00:00:49 | King Henry Died By Drinking Chocolate Milk. As you can see, the first letter of the word represents the prefix. Now, we'll start with the base unit and work our way up first. As we move from the base unit, we move up by multiples of 10. That's right. Let me erase this. Let's look at deca, represented by symbol |
| 00:01:16 | da and its multiples of 10. So from deca to hecto-- represented by lowercase h-- now it's 100. For kilo it's 1,000. Now we'll go back to the base unit and move downward. First we have deci, represented by a lowercase d. And in a decimal form, this is written as 0.1-- so equivalent of one tenth of the base unit. |
| 00:01:51 | Let's go downward. Centi is represented by a lowercase c. Now you have decimal point 0.01 or equivalent to 100th of a unit, which is equal to, again, 0.01. This is easy to remember if you know that $0.01 is 100th of $1 or there are 100 cents in $1. Finally, prefix milli is represented by lowercase m, and it's represented in decimal form as 0.001 or equivalent |
| 00:02:26 | to 1,000th of a unit. Next, let's see if you can remember the order of the prefixes. |

**Section 6**

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| 00:00:00 | TEACHER: Once again, our lesson question is, how are things measured using the metric system? There are six important prefixes you will encounter when using the metric system, as you can see on this table. The system was set up to make it easy to convert from one unit to another. For example, grams to kilograms or grams to milligrams. |
| 00:00:22 | Next, you will learn how to perform conversions between different units of the metric system. |

**Section 7**

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| 00:00:00 | TEACHER: As you already know, the metric system is based on multiples of 10. So you can change from one unit to another simply by multiplying or dividing by multiples of 10. Now to change to a smaller unit, you will multiply. So if you look at the arrow going from base unit to milli, it's getting smaller and we're going to multiply by 10. So base unit to deci, is times 10. |
| 00:00:29 | Base unit to centi is times 100. And base unit to milli is times 1,000. As you can see, the number is increasing by multiples of 10. Now to change to a larger unit, you will? If you say divide, you're correct. So the arrow now is going from right to left. And you're going to divide from base unit to deca, divide by 10. |
| 00:00:58 | And then from base unit to hecto, divide by 100. And base unit to kilo, divide by 1,000. Now it's a very good idea to copy this diagram down so you can use this as a reference to do the conversions later. Now if this information is way too much for you to handle right now, don't worry. We'll practice together and break it down |
| 00:01:23 | into simpler steps. So let's work through an example to get the hang of converting metric units. So let's read the problem together. It says to convert 5.64 centimeters to millimeters. Now, if you look at the problem, we're converting to millimeters. First thing you want to think about is millimeters. |
| 00:01:46 | Is that's smaller or larger unit than centimeters? It's smaller. So remember, we can convert to a smaller unit by? There you go. Multiply. Now what are we going to multiply by? What number? Times 10. |
| 00:02:06 | So let's go ahead and get this problem done together. So 5.64 centimeter equals-- now remember we are going to multiply by 10. 5.64 times 10, which equals 56.4-- and don't forget your units-- millimeters. Now you will see another trick here for converting metric units. We know that we should have more millimeters than centimeters |
| 00:02:39 | because the unit is small. Just like 100 pennies, which is a smaller unit, is equal to $1, which is a larger unit. Now you have more of the smaller unit. So we know we should have a greater number of millimeters than centimeters. Since we are multiplying by 10, we simply move the decimal place to the right one space, |
| 00:03:04 | making the number larger. So we move it one space because the number 10 contains one 0. So here, 5.64 centimeter equals-- if you move the decimal to the right one place, right here-- now it becomes 56.4 millimeters. Let's try a few more examples. |

**Section 9**

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| 00:00:00 | TEACHER: Now let's try converting 25.3 grams to kilograms. We're converting from a smaller unit to a larger one, so remember, we can convert to larger units by dividing. Now, what multiple of 10 are we going to divide by? Remember that grams is the base unit, so to get from grams to kilograms, we're going to divide by-- if you said 1,000, that's correct. |
| 00:00:29 | So let's write the problem. 25.3 divided by 1,000 equals 0.0253 kilograms. Now, there's actually a trick about moving decimal places to get the answer. We know that we're going to have a smaller number of kilograms than grams, so we're going to move the decimal to the left, making the number smaller. Now, since there are three zeros in 1,000, |
| 00:01:04 | we move the decimal to the left three places. So let me show you. So do it in different color. 25.3. Now we're going to move the decimal three places to the left. 1, 2, 3. And then here's the decimal. |
| 00:01:24 | So the answer comes out to, once again, 0.0253 kilograms. Let's see if you can try on your own. |

**Section 11**

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| 00:00:00 | TEACHER: In our last example, we're going to convert 91.7 kilowatts to milliwatts. We're converting from a larger unit to a smaller unit, so remember, we can convert to smaller units by multiplying. Now, to make it easier, let's break this into two steps. First, converting kilowatts into the base unit watts, and then converting watts to milliwatts. To get from kilowatts to watts, we need to multiply by 1,000. |
| 00:00:36 | Now, note that there are three 0s. Also, remember that we're converting to a smaller unit, so the decimal will move to the right three places. So let's go ahead and do this together. 91.7 kilowatts equals 91.7 times, remember by 1,000, so that will give us 91,700 watts. So we have completed the first step. Now, to get from watts to milliwatts, |
| 00:01:20 | we multiply again by 1,000. So let's go ahead and do this together. Let me try this in different color. 91,700 watts equals 91,700 times 1,000 again, which gives us 91,700,000-- I'm going to write the units on the bottom-- milliwatts. So we have completed the steps. |
| 00:02:03 | Now, if you can keep track of the 0s, it's OK to do these steps in one. You know that multiplying by 1,000 twice means that you will have six 0s total. So the decimal place will move six places to the right. So we're going to do the last step together where you're going to have six 0s total, multiplying by 91.7 kilowatts. |
| 00:02:31 | 91.7 kilowatts equals 91.7. Now we're going to multiply by 1,000 twice 1,000 times 1,000, which gives us, again, 91,700,000. I'm going to abbreviate it mw for milliwatts. Now, try converting units on your own. |

**Section 13**

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| 00:00:00 | TEACHER: In science, the metric system is used to record measurements of length, mass, volume, and temperature. These properties can be measured using a variety of tools you may be familiar with. As well as others you may not have seen before. Next, we will discuss how to measure these four properties with the appropriate tools. |

**Section 14**

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| 00:00:00 | TEACHER: Scientists typically measure length using a ruler. There are other tools that can be used measuring length. Smaller lengths may be measured with a caliper or micrometer. Longer distance may be measured with a meter stick or tape measurer. Now, you have probably used a ruler to make measurements before, but we will discuss how to properly use a ruler |
| 00:00:27 | to ensure that you know how to take accurate measurements. Remember, we went to use the metric system, so you'll be using a centimeter measurements instead of inches. To begin, be sure to align the edge of the object to the zero mark on the ruler. It's very important that the edge of the ruler might not be the zero mark, so the object should be aligned to the zero mark. |
| 00:00:53 | So as you can see in this image, the zero mark does not start here. Instead, it starts right there. Now, there are 10 tick marks between each whole number. So each of those marks represents 1/10 of a centimeter. You can see 5/10 or half is marked with the slightly longer marks to make it easier to read. |
| 00:01:20 | So if you look at this ruler, what would be the measurement of an object? Well, you can see it's at least 4.5 centimeters. However, it is just slightly past 4.5 by one small tick mark right here, so it comes to 4.6 centimeters. |

**Section 16**

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| 00:00:01 | TEACHER: Mass is also a quantity that is commonly measured in science. Triple-beam balances are commonly used to measure mass. Electronic balances are also common as you can see in this image. Two-pan balances may also be used, but they're less common. Now let's discuss how to use a triple-beam balance properly. With the pan empty, you're going to move the sliders to the far |
| 00:00:30 | left, so the balance reads 0 when the pan is empty. You're going to make sure that the pointer on the right side also points to the 0 marker. Then, you're going to place the object on the pan. Then, you're going to move the sliders separately until the pointer rests at the 0 mark. Always, always start with the 100 gram marker. Now, note that the slides each move separately, |
| 00:01:01 | starting with 100 gram marker right here, and then the 10 gram marker, and then fine tune with the 1 gram marker. Move it a little at a time until the pointer drops below the 0 indicator. Now if the 100 gram marker is too great, then you're going to reset it and move to the 10 gram marker. Repeat the process. |
| 00:01:31 | If the 10 gram is also too big, then you're going to move to the 1 gram. Once the pointer rest at the 0 mark, you have found the mass of the object. Now, this may be a combination of two markers or simply just one marker. So finally, add the numbers from the three sliders to find the mass of the object on the pan. |
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**Section 18**

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| 00:00:00 | TEACHER: Many experiments and calculations involve the measurement of volume. The volume of a regular solid, such as a cube, can be determined by measuring the solid's dimensions and using math to calculate volume. So you'd be able to use a ruler. Now for irregular shaped solids, such as a stone, however, the water displacement method is used to determine volume. |
| 00:00:23 | The irregularly shaped solid is placed into a known volume of water, so for example, in this beaker. And the volume change of the water is observed. The change in volume is equal to the volume of the solid. A wide variety of tools are used to measure the volume of a liquid. The graduated cylinder is probably the most common and is available in a range of sizes. |
| 00:00:48 | The pipette is also common, especially for measuring smaller volumes. Other tools used for measuring volume include the beaker, here, the volumetric flask, and the buret. Now notice the difference between the buret, here in this image, and the flask. A graduated cylinder is used to record |
| 00:01:15 | the volume of liquids and irregular solids. A meniscus forms in the liquid due to the forces between the liquid and the glass. Meniscus is the curved upper surface of the column of a liquid, as you can see in this image. Now, remember that meniscus is concave, or curves inward like a bowl shape. When recording liquid volume measurements, |
| 00:01:43 | the measurement must be taken at the bottom of the meniscus so that it obtains accurate measurement. So here, if you look at the image, the bottom of the meniscus lies right at about 20 milliliters. So there are 20 milliliters of the liquid in the graduated cylinder. You can also use a graduated cylinder to measure the volume of an irregular solid by measuring |
| 00:02:13 | the displacement of the liquid once the object is added to it. |

**Section 20**

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| 00:00:00 | TEACHER: Let's look at measurements of temperature. Temperature is another quantity that is commonly measured in science. Temperature is measured with a thermometer. You're probably familiar with liquid-based thermometers-- like this one. These are the kind you would use in a science classroom or in a lab. |
| 00:00:22 | These thermometers are inexpensive and easy to use. Some thermometers are digital-- like the one that you see in this picture. But these require calibration. The advantage of a digital thermometer is accuracy and the ability to combine with a computer software for data collection and processing. You may have used a digital thermometer |
| 00:00:46 | to take your temperature when you were sick or you have seen a digital reading from the thermometer in your car. There are several important things to remember when using a thermometer. First, handle the thermometer very carefully so it does not break. When measuring the temperature of a substance, |
| 00:01:06 | be sure the bulb-- the rounded tip here-- of the thermometer is completely submerged in the substance. Now make sure that you keep the thermometer bulb away from surfaces-- like the bottom and the sides of the container-- to avoid inaccurate measurement. You do not want to use thermometer for stirring. And, finally, use measurements in degrees Celsius. If you look at the picture here and you |
| 00:01:41 | have a thermometer submerged in this alcohol-- now let's look at the reading in degrees Celsius. Now on this side is Fahrenheit and then you have on this side-- it's in Celsius. It goes above 30, and it's right on this tick-mark right here. So that would be 37 degrees Celsius. |