# Unit 3
# Communication Electronics
# Lesson 3.1

**Prepared By** Jerry Hill, KH6HU
**Lesson Title** Basic Electronic Theory - The Metric System

**Curriculum Area(s)** Math

**Grade(s)** 6-8

**Duration** 2 class periods

**Content Standard** M-3

**Benchmarks** M-3.1

**Goals**
- Develop the students' operational understanding of the metric system.
- Develop the students' understanding of unit conversion within the metric system.

**Objectives**
- Students write the prefixes of the international system of metric units of measure.
- Students convert prefixes.

**Resource Materials**
*Now You're Talking, Chapter 5*
*Understanding Basic Electronics – Chapter 4*

**Instructional Content**
Metric Prefixes:
Tera, giga, mega, kilo, hecto, deca, unit, deci, centi, milli, micro, nano, pico.

**Suggested Activity**
Unit 3 – Activity Sheet #3.1
Metric System
Teacher's Guide
Student's Worksheet
Unit 3 – Activity Sheet #3.2
Unit Conversion

# Unit 3 Activity Sheet #3.1
# Student Worksheet
# Metric System

Robert Lah, KD5HAW

**Introduction:**

Scientists and engineers all around the world need to be able to speak to each other in a common "language." This "language" is called mathematics. Measurement is an important part of the scientific method. When we measure certain properties of the world around us we have to quantify those measurements, that is, make mathematical sense out of them. It would be very confusing if scientists in different countries used different measurement systems because then it would be impossible to "compare notes" without using complicated conversion formulas. For this reason, most scientists use the metric system of measurement. Most of the units of measurement (such as length, volume and mass) have some common factor that unifies them. Also, the units of measurement are organized in powers or multiples of 10 (10, 100, 1000, etc.) Electronic theory also uses the metric system and it is important for you to understand how the system works. It really is much easier to understand and work with the metric system than the so-called "English" system that most Americans grow up with! This lesson will introduce you to metric units and simple metric conversions. You will also do a simple experiment to show how the units are interrelated.

**Metric Units:**

Metric units can quantify or describe certain properties of space, matter and even energy. The basic unit of length is called a meter (m). It is a little longer than a "yardstick." It is divided up into smaller units: 10 decimeters or 100 centimeters or 1000 millimeters. If you took 1000 meter sticks and laid them end-to-end you would have a kilometer (a little more than half a mile.)

The basic unit of volume (three dimensional space) is the liter (l). It is a little bit bigger than a quart. It can be divided up into deciliters, centiliters and milliliters. A milliliter of water would fit in a medicine dropper.

Mass is measured in grams (g). A gram is not very massive; a small stump of chalk weighs about a gram. For this reason, the Standard International Unit of mass is the kilogram. A medium sized textbook may have a mass of approximately one kilogram.

You may have noticed that our units of measurement are either divided up or multiplied by powers of 10. This makes it easy to make conversions within the metric system. An easy way to learn how to make metric conversions is to use a metric conversion line. On a metric conversion line we can show all the divisions or multiples of any basic metric unit. Each division is labeled with a decimal number showing its "place" and a corresponding prefix that represents the decimal place in words. Study the metric conversion line show below and answer the questions.

| 1000 | 100 | 10 | 1 | .1 | .01 | .001 |
|---|---|---|---|---|---|---|
| kilo- | hecta- | deca- | unit | deci- | centi- | milli- |
| K- | H- | D- | | d- | c- | m- |

1) What prefix stands for 1/1000 (.001)? ________

2) How many units are in a kilo "unit" ?________

3) How many times smaller is a centimeter compared to a decimeter? _______

4) How many times smaller is a milliliter than a deciliter? __________

5) What letter is the abbreviation for kilo? ______

Some units are used more than others. You often hear about liters and milliliters but you don't hear much about deciliters. Kilometers, meters, centimeters and millimeters are common expressions but hectameter is not. Sometimes it is easier to speak in terms of the more common units and this requires us to make simple conversions.

Use the conversion line to make easy conversions. For example, how many millimeters are in 37.5 meters? To make the conversion, write 37.5 on your paper. Note that you need to go from meters to millimeters. Where on the line is the prefix "milli" ? It's on the right side of "unit" (meter). How many places to the right is it? It's three places to the right. With your pencil, draw three loops to the right of your starting decimal. Say the name of each prefix as you draw each loop: "deci-, centi-, milli." Stop when you get to "milli". Draw a dot where you stopped; that is where your decimal point is now located. Now write a 0 inside of each of the loops you made that is still empty. (The numeral 5 is inside the first loop.) Take your new number and rewrite it as 37,500. Add the label " mm" which stands for millimeters. 37.5 meters =37,500 mm.

Use this technique to make the following conversions.

6) 250 cl = ? l

7) 0.785 Kg = ? cg

8) 322,484 mm = ? Km

Sometimes we need to measure quantities smaller than "milli-" units or larger than "kilo-" units. A millionth of a unit (.000001) is called a "micro-" unit (*eg*. micrometer, microvolt.) Notice that a “micro-” is three more decimal places to the right of “milli-”. A billionth of a unit (.000000001) is called a “pico-” unit. Notice that it is three more decimal places to the right of “micro-”. Moving three decimal paces to the right is the same as dividing something up into a thousand smaller pieces. Thus, there are 1000 millivolts in 1 volt. There are 1000 microvolts in 1 millivolt. A Farad is a unit of electrical capacitance, or stored electricity. Electronic components called capacitors store electricity but in very tiny amounts called picoFarads. So, 1 Farad is equal to 1,000,000,000 picoFarads. A typical capacitor might store 470 picoFarads. This is usually written 470 pF.

A million of something is called “mega-” and is abbreviated “M”. In electrical theory, materials that oppose the flow of electricity (resistors) are said to have “resistance.” The unit of measurement is the ohm. Ohmic values can be quite high sometimes. A resistance of 6 megohms is equal to 6,000,000 ohms. It’s more convenient to write 6 megohms than 6,000,000 ohms.

Earlier we said that some units of measurement are interrelated. Below is an experiment that will help you understand this relationship.

**Problem:**
Is there a connection between the basic units of length, mass and volume?

**Materials:**
Scissors, 10 ml graduated cylinder, metric ruler, metric balance, clay, water.

**Procedure:**
Take a small lump of clay and form it into a perfect cube, one cm on each side. Use your metric ruler to measure the length of each of the sides. With the scissors, snip off bits of clay where you need to. Shape the clay by pressing it against the table-top or other flat surface. When you think you have a perfect cube, measure it again along each of the sides. When you are satisfied that you have a perfect cube then what you have now created is a cubic centimeter.

Fill the graduated cylinder up to the 5 ml mark. The water will creep up the sides of the container a bit forming a curved concave surface called a <u>miniscus</u>. Measure from the bottom of the miniscus; have your teacher help you. Carefully slide the clay cube down the inside of the tube into the water. Don’t splash any water out of the tube. Note how much the water level has risen since you put the cubic centimeter of clay inside. Write down the difference (<u>displacement</u>.)

1) Amount of water displaced (new value minus 5) = ____________

2) How much liquid volume (ml) is equal to one cubic centimeter? ______________

3) What is the relationship in the metric system between units of length and volume?

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Pour out the water into the sink and give the clay back to your teacher. Now shake excess drops of water out of the cylinder so that it is basically dry. Place the cylinder on a metric balance and record the mass of the empty graduated cylinder.

4) Empty mass = ?g __________

Now refill the cylinder with water exactly to the 10 ml mark. Carefully observe the position of the miniscus. Now, place the filled cylinder on the balance and weigh the cylinder.

5) Mass of cylinder plus 10 ml water = _________________

We want to determine the mass of the water alone so subtract the empty cylinder mass (question #4) from the water-filled cylinder mass (question #5.) Record the mass of 10 .

6) mass of 10 ml water = __________

Determine the mass of 1 ml water. (Hint: divide your answer to question #6 by 10.)

7) Mass of 1 ml water = _____________

By now you are probably beginning to see a connection between the various metric units. The mass of water is used as a standard because chemists use water to make many different kinds of chemical solutions. It is sometimes called a “universal solvent” although it can’t really dissolve everything! Chemists mix solvents and solutes in proportion to their relative masses. It’s easier to measure water in ml than in g. If you know that the units are proportional then you can mix water and other chemicals easily. Measure the liquids in ml and the solids in g. It’s really pretty simple!
Now answer the following questions.

8) After doing this experiment, do you see a connection between the different units of metric measurement? Is it logical? Do you think the metric system was designed this way or is it just a coincidence? Give evidence from the experiment to support your answers.

# Unit 3 – Activity Sheet #3.1
# Metric System: Teacher's Guide

Robert Lah, KD5HAW

**Introduction:**

Scientists and engineers all around the world need to be able to speak to each other in a common "language." This "language" is called mathematics. Measurement is an important part of the scientific method. When we measure certain properties of the world around us we have to quantify those measurements, that is, make mathematical sense out of them. It would be very confusing if scientists in different countries used different measurement systems because then it would be impossible to "compare notes" without using complicated conversion formulas. For this reason, most scientists use the metric system of measurement. Most of the units of measurement (such as length, volume and mass) have some common factor that unifies them. Also, the units of measurement are organized in powers or multiples of 10 (10, 100, 1000, etc.) Electronic theory also uses the metric system and it is important for you to understand how the system works. It really is much easier to understand and work with the metric system than the so-called "English" system that most Americans grow up with! This lesson will introduce you to metric units and simple metric conversions. You will also do a simple experiment to show how the units are interrelated.

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Mass is measured in grams (g). A gram is not very massive; a small stump of chalk weighs about a gram. For this reason, the Standard International Unit of mass is the kilogram. A medium sized textbook may have a mass of approximately one kilogram.

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| kilo- | hecta- | deca- | unit | deci- | centi- | milli- |
|---|---|---|---|---|---|---|
| K- | H- | D- | | d- | c- | m- |

1) What prefix stands for 1/1000 (.001)? *milli*

2) How many units are in a kilo "unit"? *1000*

3) How many times smaller is a centimeter compared to a decimeter? *10 times smaller*

4) How many times smaller is a milliliter than a deciliter? *100 times smaller*

5) What letter is the abbreviation for kilo? *K*

Some units are used more than others. You often hear about liters and milliliters but you don't hear much about deciliters. Kilometers, meters, centimeters and millimeters are common expressions but hectameter is not. Sometimes it is easier to speak in terms of the more common units and this requires us to make simple conversions.

Use the conversion line to make easy conversions. For example, how many millimeters are in 37.5 meters? To make the conversion, write 37.5 on your paper. Note that you need to go from meters to millimeters. Where on the line is the prefix "milli"? It's on the right side of "unit" (meter). How many places to the right is it? It's three places to the right. With your pencil, draw three loops to the right of your starting decimal. Say the name of each prefix as you draw each loop: "deci-, centi-, milli." Stop when you get to "milli". Draw a dot where you stopped; that is where your decimal point is now located. Now write a 0 inside of each of the loops you made that is still empty. (The numeral 5 is inside the first loop.) Take your new number and rewrite it as 37,500. Add the label " mm" which stands for millimeters. 37.5 meters =37,500 mm.

Use this technique to make the following conversions.

6) 250 cl = ? l    *2.5 l*

7) 0.785 Kg = ? cg   *78,500 cg*

8) 322,484 mm = ? Km    *.322484 Km*

Sometimes we need to measure quantities smaller than "milli-" units or larger than "kilo-" units. A millionth of a unit (.000001) is called a "micro-" unit (*eg*. micrometer, microvolt.) Notice that a "micro-" is three more decimal places to the right of "milli-".  A billionth of a unit (.000000001) is called a "pico-" unit. Notice that it is three more decimal places to the right of "micro-". Moving three decimal paces to the right is the same as dividing something up into a thousand smaller pieces. Thus, there are 1000 millivolts in 1 volt. There are 1000 microvolts in 1 millivolt. A Farad is a unit of electrical capacitance, or stored electricity. Electronic components called capacitors store electricity but in very tiny amounts called picoFarads. So, 1 Farad is equal to 1,000,000,000 picoFarads. A typical capacitor might store 470 picoFarads. This is usually written 470 pF.

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**Problem:**
Is there a connection between the basic units of length, mass and volume?

**Materials:**
Scissors, 10 ml graduated cylinder, metric ruler, metric balance, clay, water.
*(Teacher note: you may want to monitor the use of the clay to prevent it from ending up in unwanted places!)*

**Procedure:**
Take a small lump of clay and form it into a perfect cube, one cm on each side. Use your metric ruler to measure the length of each of the sides. With the scissors, snip off bits of clay where you need to. Shape the clay by pressing it against the table-top or other flat surface. When you think you have a perfect cube, measure it again along each of the sides. When you are satisfied that you have a perfect cube then what you have now created is a cubic centimeter.

Fill the graduated cylinder up to the 5 ml mark. The water will creep up the sides of the container a bit forming a curved concave surface called a miniscus. Measure from the bottom of the miniscus; have your teacher help you. Carefully slide the clay cube down the inside of the tube into the water. Don't splash any water out of the tube. Note how much the water level has risen since you put the cubic centimeter of clay inside. Write down the difference (displacement.)

1) Amount of water displaced (new value minus 5) = *1 ml (6 ml – 5 ml = 1 ml)*

2) How much liquid volume (ml) is equal to one cubic centimeter? *1 ml = 1 cubic cm*

3) What is the relationship in the metric system between units of length and volume?
*The cubic centimeter determines the unit of volume called the milliliter.*

Pour out the water into the sink and give the clay back to your teacher. Now shake excess drops of water out of the cylinder so that it is basically dry. Place the cylinder on a metric balance and record the mass of the empty graduated cylinder.

4) Empty mass = ?g *Answers will vary.*

Now refill the cylinder with water exactly to the 10 ml mark. Carefully observe the position of the miniscus. Now, place the filled cylinder on the balance and weigh the cylinder.

5) Mass of cylinder plus 10 ml water = *Answers will vary but the water will add 10 g to the mass.*

We want to determine the mass of the water alone so subtract the empty cylinder mass (question #4) from the water-filled cylinder mass (question #5.) Record the mass of 10 .

6) mass of 10 ml water = *10 ml water = 10 g.*

Determine the mass of 1 ml water. (Hint: divide your answer to question #6 by 10.)

7) Mass of 1 ml water = *1 ml water = 1 g.*

By now you are probably beginning to see a connection between the various metric units. The mass of water is used as a standard because chemists use water to make many different kinds of chemical solutions. It is sometimes called a "universal solvent" although it can't really dissolve everything! Chemists mix solvents and solutes in proportion to their relative masses. It's easier to measure water in ml than in g. If you know that the units are proportional then you can mix water and other chemicals easily. Measure the liquids in ml and the solids in g. It's really pretty simple!
Now answer the following questions.

8) After doing this experiment, do you see a connection between the different units of metric measurement? Is it logical? Do you think the metric system was designed this way or is it just a coincidence? Give evidence from the experiment to support your answers.

*If the students have measured carefully they should be able to see the relationship among the various metric units. It is logical and thus makes sense if it is to be used in the scientific method. Scientists specifically designed a universal system of measurements to facilitate ease of measurement and the exchange of ideas and discoveries. A one-to-one correspondence was seen between the units of length, cubic volume, liquid volume and the mass of water.*