

Name: _____ Section: _____

Building an Understanding of Dimensional Analysis

Dimensional Analysis is a structured process for converting one set of units to another set of units. While this lesson is solely an introduction to this concept, developing an understanding of this process will provide you with a keen awareness of units and their importance. The purpose of this handout is to take you through a few activities that will help you build the appropriate skills to perform the process.

Part 1a - Using Your Current Knowledge and Skills

Directions: Working with a partner, try to solve the problems below. All efforts made to solve the problems should be written down in order to show your approach. In other words, you should not simply do all of your work on a calculator. Information you may find helpful has been provided.

Connections (Conversion Factors)	
2.54 centimeters = 1 inch 3 feet = 1 yard 4 quarts = 1 gallon 1 quart = 2 pints	1 day = 24 hours 1 hour = 60 minutes 1 minute = 60 seconds 2000 pounds = 1 ton

1. How many seconds are in six minutes?

2. How many centimeters are in 27 inches?

3. If a truck weighs 15,356 pounds, how many tons is it?

4. If you had 10.5 gallons of milk, how many pints would you have?

5. Students go to school for 180 days. How many minutes is this equal to?

Questions for Thought

1. In general, describe your approach for solving the previous five problems.
2. Did you find the information provided in the box helpful? Explain your reasoning.
3. Consider the math involved in solving the problems. What mathematical function(s) did you use to determine your answers?

Part 1b - Using Your Current Knowledge and Skills (with a Little Guidance)

Directions: Working with a partner, try to solve the following problems while using the US Conversion Steps (Dimensional Analysis) sheet for guidance. Similar to the Part 1a, all efforts made to solve the problems should be written down in order to show your approach.

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Part 2 - Identifying Necessary Information

All problems involving dimensional analysis provide you with important information that will help guide you through the process. Two important pieces of information are the starting point and the final destination. The starting point is simply the numerical information provided by the problem/question. This can be identified as a number followed by a unit and will provide you with necessary information for starting the process. The final destination is also provided by the problem/question, but it represents the unit you hope to have once you have successfully performed the conversion.

Consider taking a trip to an unfamiliar destination. If you want to arrive successfully it is probably necessary for you to use a map to provide you with direction. The map is only beneficial if you have a starting point and a final destination. Once you have these two pieces of information it is possible to determine the necessary steps. Below you will find two sample problems/questions where the starting point and final destination are identified for you.

How many feet are in: 50 yards?

- Since 50 yards is a number followed by a unit, it would be considered the starting point.
- Since feet is the unit of measure that is currently unknown, it would be considered the final destination - feet is the unit we would like to end up at.

One quart consists of 2 pints, how many gallons is this?

- Since 2 pints is a number followed by a unit, it would be considered the starting point.
- Since gallons is the unit of measure that is currently unknown, it would be considered the final destination - gallons is the unit we would like to end up at.

Directions: Identify the starting point and the final destination in each of the following problems/questions. You should circle the starting point and underline the final destination. Please provide a brief explanation that describes how you were able to identify these parts for each problem.

1. How many seconds are in six minutes?
2. How many centimeters are in 27 inches?
3. If a truck weighs 15,356 pounds, how many tons is it?
4. If you had 10.5 gallons of milk, how many pints would you have?
5. Students go to school for 180 days. How many minutes is this equal to?

Part 3 - Mapping Out Travel Plans

Now that you have identified your starting point and your final destination, it is necessary for you to determine how you will get from one to the other. If we use the map example again, imagine looking at your map after identifying your starting point and final destination. You would now try to determine the specific routes you would need to take to get from point A to point B. Sometimes you can navigate between these points directly and sometimes it is more complex. Either way, there are usually a variety of possibilities.

For example, if you would like to go to a friend's house down the street (starting point your house - final destination your friends house) the route to get there will be direct, just one road to travel. However, if you wanted to go to a friend's house in another town, your route would likely consist of multiple roads, without a direct way to get there. In dimensional analysis problems, the connections (conversion factors) represent the possible routes one can take to get from the start to the finish.

To get some practice with this idea of connecting a starting location to a final destination, try to map out the necessary route(s) to get from John's house to David's house.

Connected Roadways	
John's house to Park Street Harrison Avenue to Washington Place Sussex Boulevard to Court Street David's house to Washington Place Columbus Road to Sussex Boulevard	Park Street to Dead End Terrace Sussex Boulevard to South Street South Street to Washington Place Park Street to Columbus Road Court Street to Harrison Avenue

Below you will find two sample problems/questions that list the connections between the starting point and your final destination.

Connections (Conversion Factors)	
2.54 centimeters = 1 inch 3 feet = 1 yard 4 quarts = 1 gallon 1 quart = 2 pints	1 day = 24 hours 1 hour = 60 minutes 1 minute = 60 seconds 2000 pounds = 1 ton

How many feet are in: **50 yards?**

After looking in the connections (conversion factors) chart you will notice a direct relationship between feet and yards (3 feet = 1 yard). This direct connection is the only thing needed to get from the starting point to the final destination.

One quart consists of **2 pints**, how many gallons is this?

After looking in the connections (conversion factors) chart you will notice an indirect relationship between pints and gallons. This means you cannot get to gallons directly from pints, but you can get there if you go to quarts first. Therefore, you will use the connection between pints and quarts (2 pints = 1 quart) first and then you will use the connection between quarts and gallons (4 quarts = 1 gallon)

Directions: Use the chart below to identify the connections (conversion factors) needed, and the order in which you will use them to get from the starting point to the final destination for the problems. It will be beneficial to highlight the previously identified starting points and final destinations for each problem. **DO NOT ATTEMPT TO SOLVE THE PROBLEMS!**

Connections (Conversion Factors)	
2.54 centimeters = 1 inch 3 feet = 1 yard 4 quarts = 1 gallon 1 quart = 2 pints	1 day = 24 hours 1 hour = 60 minutes 1 minute = 60 seconds 2000 pounds = 1 ton

1. How many seconds are in six minutes?
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Part 4 - Starting Your Problem

Once you have identified the starting point, the final destination, and the necessary connections (conversion factors), it is time to begin the actual problem. When setting up your problem there are a few basic steps that should be done to ensure successful completion of the conversion. The setup of your problem should follow the bulleted steps below:

- Create a fraction by placing your starting point over one
- Multiply between fractions
- Write in the bottom unit of the new fraction. This should be the same as the top unit of the previous fraction.

When completing conversions using dimensional analysis, the above procedures represent the minimum amount of work that all individuals are capable of performing. Below you will find two sample problems/questions that highlight what the above procedures would look like.

How many feet are in: 50 yards?

(3 feet = 1 yard)

$$\left(\frac{50 \text{ yards}}{1} \right) \left(\frac{\quad}{\text{yards}} \right)$$

One quart consists of: 2 pints, how many gallons is this?

(1 quart = 2 pints)

(1 gallon = 4 quarts)

$$\left(\frac{2 \text{ pints}}{1} \right) \left(\frac{\quad}{\text{pints}} \right)$$

Directions: Set up the beginning part for each of the five problems below. It will be beneficial to highlight the previously identified starting points and final destinations for each problem. **DO NOT ATTEMPT TO SOLVE THE PROBLEMS!**

1. How many seconds are in six minutes?
2. How many centimeters are in 27 inches?
3. If a truck weighs 15,356 pounds, how many tons is it?
4. If you had 10.5 gallons of milk, how many pints would you have?
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Part 5 - Setting Up Your Connections (Conversion Factors)

Now that you have provided the starting components of your questions/problems you can begin your conversions. In **Part 3** you took some time to "map out travel plans." You will now take those previously identified connections (conversion factors) and use them in order to convert. Every time you use the connections (conversion factors) you simply create fractions out of them. For example, if 1 inch = 2.54 centimeters, then you can create a fraction of 1 inch over 2.54 centimeters or vice versa. Either way, the fractions you create are equal to one. The process of dimensional analysis is able to work because of this.

To set up the fractions for the conversion it is imperative that you allow the units from the starting point to guide you. It is for this reason that you write the unit from the starting point on the bottom of the new fraction. As you travel in a car from one destination to another, the signs along the roadways provide you with guidance - the units act as signs throughout the dimensional analysis process. To complete the first fraction after the starting point you need to find and insert the appropriate connection (conversion factor) that will help you get to the final destination. Sometimes it will only take one connection (conversion factor) to get to the final destination and other times it may take multiple connections (conversion factors). The more connections (conversion factors) needed, the more fractions you need to create. If your conversion requires more than one connection (conversion factor) you should use the top unit of the previous fraction to guide the arrangement of your next fraction. In the end, the unit at the top of your last fraction should be your final destination. Below you will find two sample problems that highlight the creation of fractions using the appropriate connections (conversion factors).

How many feet are in 50 yards?

(3 feet = 1 yard)

$$\left(\frac{50 \text{ yards}}{1} \right) \left(\frac{3 \text{ feet}}{1 \text{ yard}} \right) \xrightarrow{\text{final destination}}$$

One quart consists of 2 pints; how many gallons is this?

(1 quart = 2 pints)

(1 gallon = 4 quarts)

$$\left(\frac{2 \text{ pints}}{1} \right) \left(\frac{1 \text{ quart}}{2 \text{ pints}} \right) \left(\frac{1 \text{ gallon}}{4 \text{ quarts}} \right) \xrightarrow{\text{final destination}}$$

Directions: In addition to the starting point, use the connections to set up the remaining fractions for each of the five problems below. It will be beneficial to highlight the previously identified starting points and final destinations for each problem. **DO NOT ATTEMPT TO SOLVE THE PROBLEMS!**

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Part 6 - Finalizing Your Conversion

After organizing all fractions it is now necessary to determine the converted value. This is done by first canceling all diagonal units that are the same. This task is similar to simplifying fractions, but instead of simplifying numbers, the units are being simplified (or canceled out). This is an important part of the dimensional analysis process because it provides a check for determining if the fractions were set up correctly. If correctly organized, all units should cancel out with the exception of the unit to be found in the final destination.

Finally, all fractions should be multiplied across. After multiplying the fractions the product of the top should be divided by the product of the bottom. This will provide the converted value, but be sure that the value is appropriately labeled with the new unit. Below you will find two sample problems that highlight completed conversions.

How many feet are in: 50 yards?

(3 feet = 1 yard)

$$\left(\frac{50 \cancel{\text{yards}}}{1} \right) \left(\frac{3 \text{ feet}}{1 \cancel{\text{yard}}} \right) = \frac{(50)(3 \text{ feet})}{(1)(1)} = 150 \text{ feet}$$

One quart consists of: 2 pints; how many gallons is this?

(1 quart = 2 pints)

(1 gallon = 4 quarts)

$$\left(\frac{2 \cancel{\text{pints}}}{1} \right) \left(\frac{1 \cancel{\text{quart}}}{2 \cancel{\text{pints}}} \right) \left(\frac{1 \text{ gallon}}{4 \cancel{\text{quarts}}} \right) = \frac{(2)(1)(1 \text{ gallon})}{(1)(2)(4)} = 0.25 \text{ gallon}$$

Directions: Use all of the skills you have developed from **Part 2** through **Part 6** to solve the problems below.

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