Sononerds

in the classroom

ARDMS Topic:
n/a

Unit 1:
Formulas & Mathy Stuff

Sononerds Ultrasound Physics
Workbook & Lectures

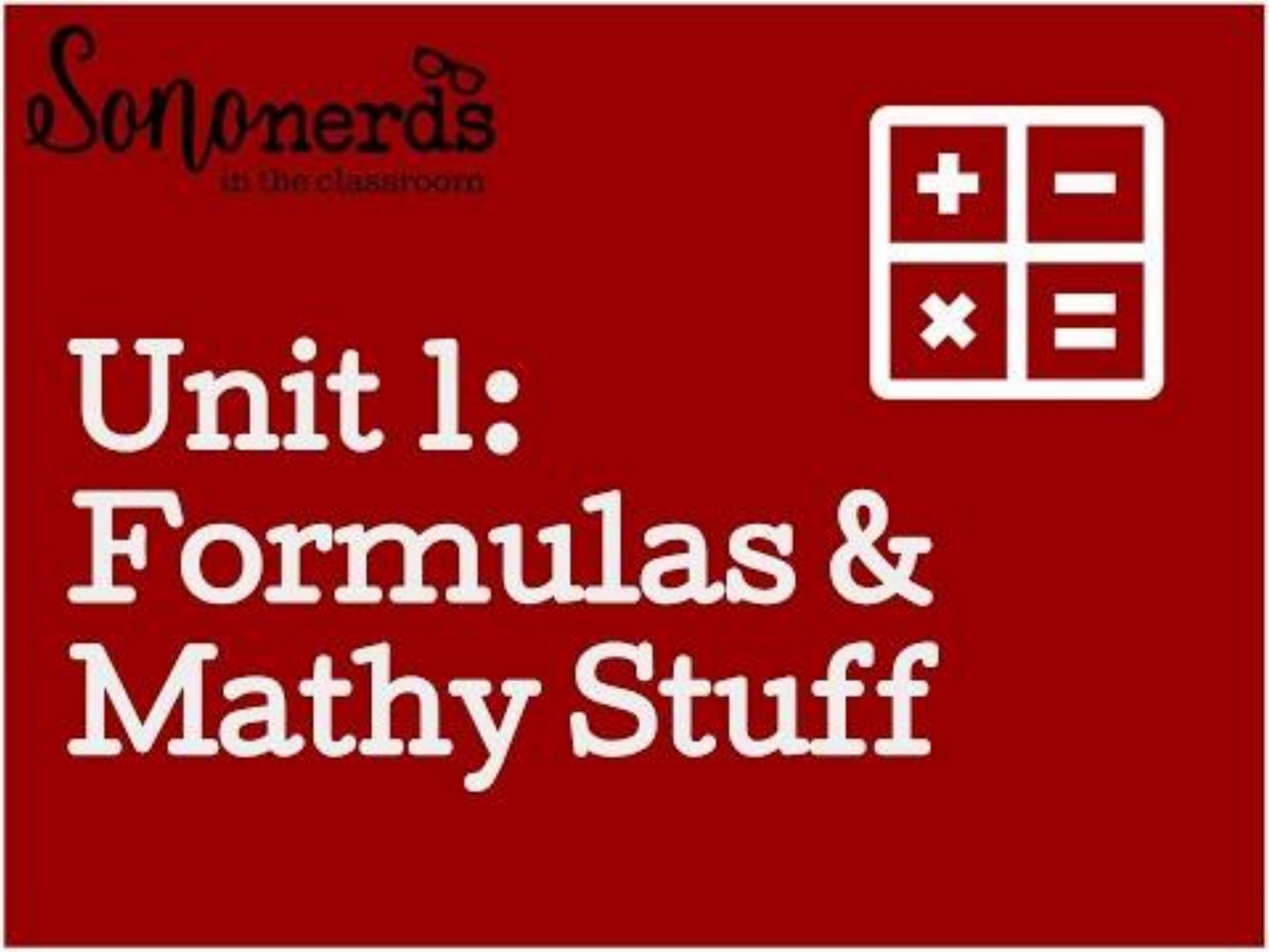
Unit 1: Formulas & Mathy Stuff

Table of Contents:

➔ These links will go the slide, the link on the slides will go to the video.

Unit 1: Formulas & Mathy Stuff

Entire Unit 1 Lecture



Section 1.1 - Formulas

There are several formulas that you will be shown throughout your studies of ultrasound physics. Understanding the formulas will be key to understanding the physical concepts of ultrasound, so we are going to work on manipulating formulas and how to break them down to better understand relationships.

1.1.1 Manipulating Formulas

The formulas that you will use have a variable that everything is equal to on one side of the equal sign and all the other variables will be on the other side. Here is a simple example:

$$a = \frac{b}{c}$$

You may need to transpose or rearrange the formula to solve for a different a variable. Using the example above, we can solve for **b** and for **c.** This is achieved by applying some basic algebraic principles.

$$a \times c = b \qquad \frac{b}{a} = c$$

All three of these equations show the variables in the same relationship to one another.

- ➔ When transposing formulas, you must always do the same mathematical operation to both side of the equation.

Let's solve for **b:** $a = \frac{b}{c}$

First, we can multiply both sides by **c:** $c \times a = \frac{b \times c}{c}$

When you have the same factors on either side of a division sign, they equal 1. So this equation is the same as:

$$c \times a = b \times 1$$

And anything multiplied by 1 equals itself, so in the end, we have transposed the equation to isolate **b** by itself on one side of the equation:

$$c \times a = b$$

If we wanted to solve for **c** now, we can divided both sides by **a**:

$$\frac{c \times a}{a} = \frac{b}{a}$$

Using the concepts above, we can now have isolated **c** on one side of the equation:

$$c = \frac{b}{a}$$

You can always check that you have rearranged a formula correctly by substituting some simple numbers.

$$a = \frac{b}{c} \qquad 10 = \frac{20}{2}$$

$$a \times c = b \qquad 10 \times 2 = 20$$

$$\frac{b}{a} = c \qquad \frac{20}{10} = 2$$

Manipulating Formulas - Practice

The formula for wavelength (λ) is: $\lambda = \frac{c}{f}$

Where **f** is frequency and **c** is speed of sound. . Can you rearrange the formula to solve for the other two variables?

$f =$	
$c =$	

1.1.2 Relationships in Formulas

The variables within a formula are all related to one another. This is a BIG theme in ultrasound physics: *What happens to X when Y changes?*

First let's talk about how things can be related and then we'll go over how to figure it out by looking at a formula.

There are 5 relationships statuses:

- ➔ **Unrelated:** Two items that have no association
- ➔ **Related:** Two items that are connected, but no specified relation
- ➔ **Directly Related/Directly Proportional:** Two items that are related so that when one increases, the other also increases
- ➔ **Inversely Related / Inversely Proportional:** Two items that are related so that when one increases the other decreases
- ➔ **Reciprocal:** Special inverse relationship when two factors are multiplied together, they equal one.

The two relationships that are especially important to ultrasound physics are the direct and inverse relationships. For example, you will learn that when frequency increases, the period decreases. This means that frequency and period are inversely related. Another example, when power increases, intensity increases. This means that power and intensity are directly related. Often times, we shorthand this information with arrows to indicate increasing and decreasing:

Frequency ↑, Period ↓

Power ↑, Intensity ↑

One thing that may be confusing about relationships is that when we say an item decreases or increases, we are referring to its numerical value.

What the variable is doing in physical space may use different terms. I encourage you to think of relationships in both aspects. Let's use the examples from before to show what I mean:

Frequency ↑, Period ↓

Really means when frequency gets higher, periods get shorter.

Power ↑, Intensity ↑

Really means when power gets stronger, intensity gets stronger.

Relationships in Formulas - Practice

Can you determine how these statements are related? (N)ot related, (D)irectly related, (I)nversely related.

	The amount I read my textbook & My physics grades.
	The number of trees in the forest & My house address.
	The time spent on the Instagram & My cell data usage
	The number of purchases made & the store's inventory.
	The number of days with cold temperature & the number of days I turn the furnace on.

So how do we find these relationships in formulas? It all has to do with how the formula is set up. Here are some terms that are going to help us explain the rules:

Factors = Variables in the formula

Product = answer when factors are multiplied

Quotient = answer when factors are divided

*When we are looking at relationships between variable and products/quotients, we are only changing **one variable** at a time.

<u>The rules:</u>

- Rule #1 - The factors are directly related to the product.

$$a \times b = c \qquad\qquad 10 \times 2 = 20$$

  - If **a** increases OR **b** increases, then **c** increases.

$$10 \times 2 = 20$$

$$20 \times 2 = 40$$

$$10 \times 6 = 60$$

  - If **a** decreases OR **b** decreases, then **c** decreases.

$$10 \times 2 = 20$$

$$5 \times 2 = 10$$

$$10 \times 1 = 10$$

➔ Rule #2 - The quotient is directly related to anything above the division bar (numerator) and inversely related to anything below the division bar (denominator).

$$a = \frac{b}{c} \qquad\qquad 10 = \frac{20}{2}$$

- If **b** increases & **c** remains the same, then **a** increases

$$10 = \frac{20}{2} \qquad\qquad 20 = \frac{40}{2}$$

- If **b** decreases & **c** remains the same, then **a** decreases

$$10 = \frac{20}{2} \qquad\qquad 5 = \frac{10}{2}$$

- If **c** increases, & **b** remains the same, then **a** decreases

$$10 = \frac{20}{2} \qquad\qquad 4 = \frac{20}{5}$$

- If **c** decreases & **b** remains the same, then **a** increases

$$10 = \frac{20}{2} \qquad\qquad 20 = \frac{20}{1}$$

- Note that the products and quotients are also proportional to changes.
  - If a variable doubles:
    - Directly related products/quotients will double
    - Inversely related products/quotients will be halved
  - This is the extent of a lof of the math that you will have to do on tests. You will practice more complex math with a calculator, but should be able to perform simple computations that include multiplying by factors or reducing by factors like doubling and halving.

Relationships in Formulas - Practice

The formula for the Nyquist Limit is:

$$NL = \frac{1}{2} \times PRF$$

What happens to the Nyquist Limit when the the PRF increases? And Decreases?

What happens to the PRF when the Nyquist Limit increases? And decreases?

The formula for the intensity is:

$$Intensity = \frac{Power}{Area^2}$$

What happens to intensity if the power increases? And decreases?

What happens to intensity if area increases? And decreases?

What happens to power and area if intensity increases? And Decreases?

Study Tip - Create a Formula Sheet

Create a document to record all the new formulas you come across while studying ultrasound physics. Make sure to include what each variable represents and units. Take it a step further by transposing the formulas to solve for each variable and writing out their relationships. This way, when you are presented with a problem, you can just plug your numbers in.

The more you work with the formulas, the more you will begin to understand them and the relationships between the variables.

Section 1.2 Mathy Things

"I'm not very good at math, is physics going to be hard?"

I see this question often and the answer is not always straightforward. You can't have physics without math, but this course covers ultrasound physics *and* instrumentation. The physics principles may be a little tricky, but we also have a lot of concepts and components to learn about in regards to the machine.

The last section showed you how to transpose formulas and the two rules when figuring our relationships based off of formulas. This section will cover some basic math topics that will help throughout your studies. Slightly complex math concepts will be introduced as they are needed for certain concepts in subsequent units.

- ➔ Math on your tests and national board exams is VERY minimal. You should know how to add, subtract, multiple and divide basic numbers. You also need know how to raise numbers to powers and convert units as well without a calculator.
- ➔ Focus on the relationships that are explained by math/formulas
- ➔ Because the math is minimal, quite often you are informed that a variable has increased by a factor of ____ or has decreased by a factor of ____.
  - ◆ Increasing by a factor means to multiply
  - ◆ Decreasing by a factor means to divide

Intensity increased by a factor of 2 means to take the intensity value and multiply it by 2. Any directly proportional variables will also increase by a factor of 2 (2x)

Intensity decreased by a factor of 4. Divided the intensity value by 4. Any directly proportional variables will also be divided by 4 (¼ x)

1.2.1 Units

I mentioned in the study tip that when you write formulas down, you should include the units. Units define numerical values.

The number 360 has no meaning, until it has a unit.

360 minutes, tells us time...

360 miles, tells us distance...

360 square yards, tells us area...

360 cubic centimeters, tells us volume.

- ➔ If your answer does not have unit or a percentage, it's wrong until you define it.

Common dimensional units you will use in ultrasound include:

- ➔ Length - any distance unit (cm, mm, feet, mile, meters). Length is used to measure anatomy/pathology in three planes (transverse, longitudinal and Anteroposterior) or the distance around a circle, known as a circumference.
- ➔ Area - any distance unit squared (cm^2, mm^2, $feet^2$, $mile^2$, $meters^2$) Using 2 measurements multiplied or the ellipse tool, the machine will calculate the cross sectional area.
- ➔ Volume - any distance unit cubed (cm^3, mm^3, $feet^3$, $mile^3$, $meters^3$) or a volume unit such as liters (which is actually dm^3), pints, gallons, etc.

Some other ultrasound parameters that have units include:

- Time - any unit of duration (seconds, minutes, hours, years). Used to evaluate how structures move in relation to time. Often used to quantify the motion of blood or heart anatomy.
- Velocity - any unit of length divided by any unit of time (cm/s, m/s) plus a direction. When the direction is missing, the parameter is speed, but when we record blood speeds, we are calculating blood velocity.
- Frequency - number of events per time. Most commonly we use hertz as a unit of frequency in the transducers, but other parameters use the hertz unit too. A special frequency we monitor is the heart rate often using “beats per minute.”
- Plus many more! This list is not exhaustive, but meant to show there are many units the sonographer will learn about and use in understanding the physics of ultrasound.

➔ Percentage is not technically a unit, but it is an acceptable numerical definition as it refers to parts of whole, the whole being 100%

➔ Most units used in ultrasound are based off the metric system or international system of units (SI).

➔ When using units in a formula, like units or complimentary units should be used.

1.2.2 Metric System

The metric system uses base units like:

Base unit		Describes
Meter	to describe	Distance
Liter		Volume
Gram		Mass
Second		Time
Hertz		Frequency

➔ This chart will help you to understand the relationship of the prefixes to the base, the symbols used and their exponential value.

Prefix	Value	Symbol	Exponent
Giga	Billion x base (1,000,000,000 x)	G	10^9
Mega	Million x base (1,000,000 x)	M	10^6
Kilo	Thousand x base (1,000 x)	k	10^3
Hecto	Hundred x base (100 x)	h	10^2
Deca	Ten x base (10 x)	da	10^1
Base (Meter = m, Second = s, Liter = L, Hertz = Hz)			10^0
Deci	One tenth of base (0.1 x)	d	10^{-1}
Centi	One hundredth of base (0.01 x)	c	10^{-2}
Milli	One thousandth of base (0.001 x)	m	10^{-3}
Micro	One millionth of base (0.000001 x)	μ	10^{-6}
Nano	One billionth of base (0.000000001 x)	n	10^{-9}

- The prefix column converts the base unit into new units.

- The value of the new unit it based on factors of 10, 100, 1000, etc.
    - A decaliter (daL) is 10 x bigger than a liter.
    - A megahertz (MHz) is 1,000,000 x higher than a hertz.
    - A centimeter (cm) is 100 x smaller than a meter or 1/100th of a meter.
    - A microsecond (μs) is 1,000,000 x shorter than a second or 1/1000000th of a second.

- The symbol used for each prefix is used when writing abbreviated units. The symbol for micro- is the μ, which is the lowercase Greek letter mu.

- The exponent column converts the factors into base 10 exponents (used in scientific notation)

- You should also be aware of the units the compliment one another as they are often used in formulas.

Giga	Mega	Kilo	Hecto	Deca
⬇	⬇	⬇	⬇	⬇
Nano	Micro	Milli	Centi	Deci

1.2.3 Unit Conversion

It might be easier to first think of unit conversion in smaller, tangible concepts. LIke 4 quarters = 1 dollar or 365 days = 1 year. These are taking one unit (quarters, days) and converting them to a different unit (dollar, year), but NOT changing the value..

When only the base unit is used, the numerical values of some measurements can get rather large or very tiny.

For example, ultrasound frequency, using the base unit Hertz, can be as big as 17,000,000 Hertz.

Where the flu virus' size is only 0.000010 meters.

To simplify the numbers, the metric system uses the prefixes in the chart like placeholders for the extra zeros.

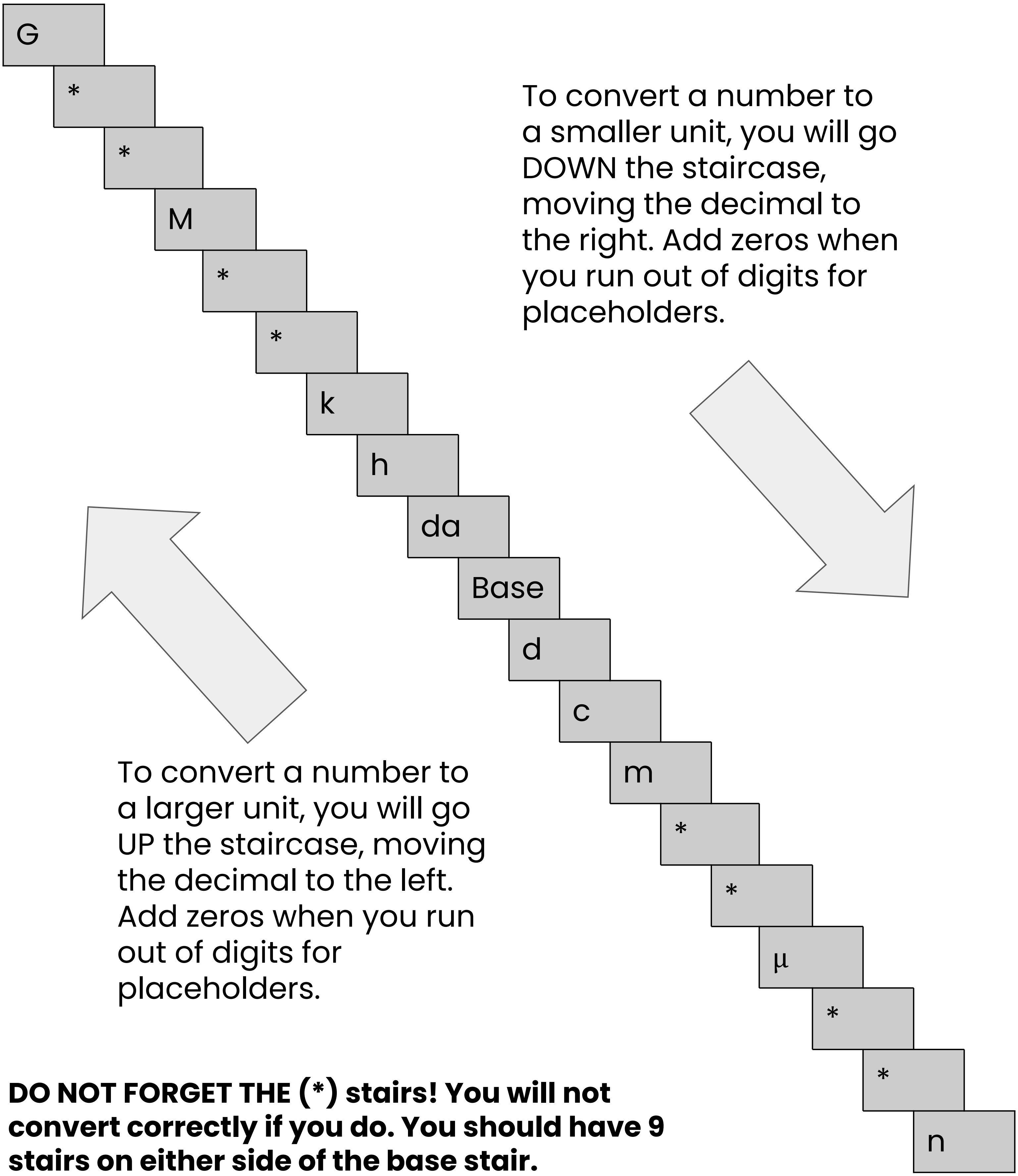
- 17,000,000 Hertz becomes 17 Megahertz
- 0.000010 meters becomes 10 micrometers.

These values are exactly the same, just using different units.

➔ When practicing unit conversions, you will want to understand how it works and be able to do it without a calculator. Some answers to questions will have different units and you will need to convert them all to the same unit to be able to answer the question.

The metric staircase is a helpful to for practicing conversions.

1.2.4 Metric Staircase

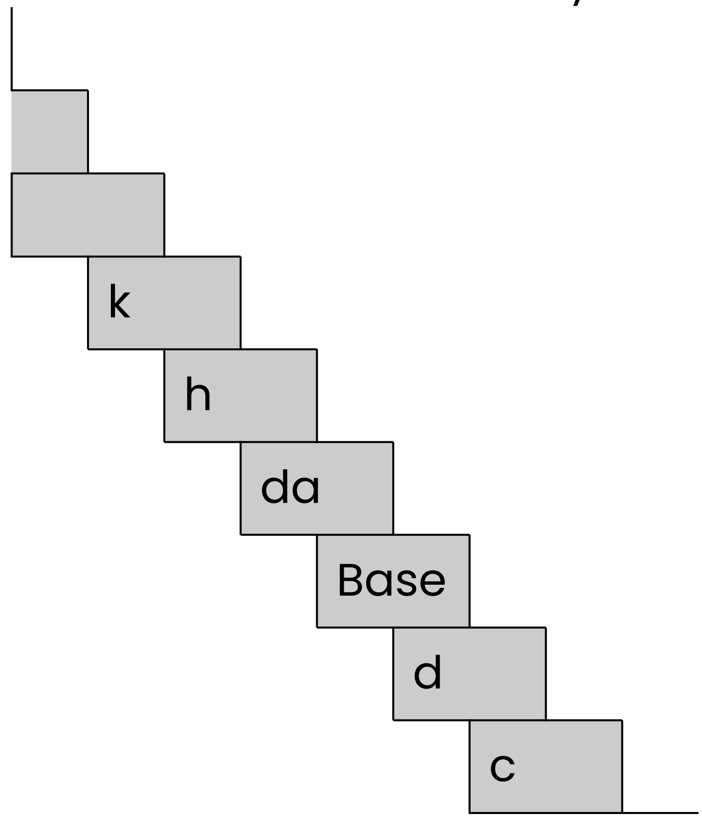


To convert a number to a smaller unit, you will go DOWN the staircase, moving the decimal to the right. Add zeros when you run out of digits for placeholders.

To convert a number to a larger unit, you will go UP the staircase, moving the decimal to the left. Add zeros when you run out of digits for placeholders.

DO NOT FORGET THE (*) stairs! You will not convert correctly if you do. You should have 9 stairs on either side of the base stair.

To convert into smaller units, count the number of stairs from the starting unit to the end unit. Then move the decimal that many places to the RIGHT.



300 kilometers = ??? centimeters

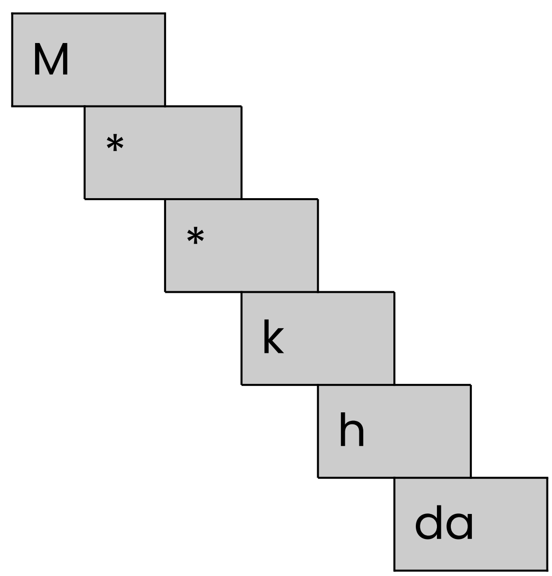
There are 5 stairs in between.

300 km = 30,000,000.0 cm

➔ You can think of the phrase

"I'll be RIGHT DOWN!"

To convert into bigger units, count the number of stairs from the starting unit to the end unit. Then move the decimal that many places to the LEFT.



75 decaliters = ??? Megaliters

There are 5 stairs in between.

75 daL = 0.00075 ML

➔ You can think of the phrase

"If it were LEFT UP to me"

[Horribly Catchy Song...you were warned.]

Metric Staircase - Practice

Let's do a couple practice examples using the the metric staircase to convert numbers. Then you can practice by filling in the rest of the chart.

0.1059	meters	→	105 900 000	nanometers
1.434	gigagrams	→		megagrams
15820000	nanohertz	→	0.01582	hertz
771.8	centigrams	→		milligrams
2172000	microliters	→		liters
87.31	hectometers	→		meters
2.767	megagrams	→		kilograms
0.8626	grams	→		nanograms
2143000	nanometers	→		meters
1244000	kilohertz	→		megahertz

If you would like more practice converting numbers, you can get 20 sample problems and the answers each time you refresh this link:

More conversion practice - click link and select download in top right corner

1.2.5 Powers of Ten

In the metric chart from section 1.2.3, you saw that there was a column labeled "exponent." That column converted the factors to a power of ten. 1 Billion (1,000,000,000) is the same as 10^9 (ten to the ninth power). Where 1 Billionth (0.000000001) is the same as 10^{-9} (ten to the negative ninth power).

To raise 10 to the ninth power means to multiple 1 by 10, 9 times.

1 x 10 = 10

X 10 = 100

x 10 = 1000

x 10 = 10,000

x 10 = 100,000

x 10 = 1,000,000

x 10 = 10,000,000

x 10 = 100,000,000

X 10 = 1,000,000,000

- ➔ When raising a number to positive powers, the number get very large.

Another way to write 1,000,000,000 is to say 1×10^9. This is called scientific notation. It basically means 1 x 1,000,000,000.

To expand scientific notation with a positive power, move the decimal to the **right** to make the number bigger, adding in zeros to mark the places.

2.5×10^3 = 2,500 ← the decimal was moved 3 places to the right.

OR 2.5 x 1000 = 2,500 ← this expands 10^3 as 1 x10x10x10 = 1000

To raise 10 to the negative ninth power means to divide 1 by 10, 9 times over. Another way to look at this is 1 / 10^9

1 ÷ 10 =0. 1

÷ 10 = 0.01

÷ 10 = 0.001

÷ 10 = 0.0001

÷ 10 = 0.00001

÷ 10 = 0.000001

÷ 10 = 0.0000001

÷ 10 = 0.00000001

÷ 10 = 0.000000001 → this is the same 1/1,000,000,000

- ➔ When raising number to negative powers, the number gets very small. (NOT NEGATIVE)

Scientific notation works for this as well. 1 billionth is the same as writing 1 x 10^{-9}. This is the same as saying 1 x 1/1,000,000,000.

To expand scientific notation with negative powers, you can move the decimal to the **left** to make the number small, adding in zeros for place holders.

2.5 x 10^{-3} = 0.0025 ← decimal moved 3 spots to the left

OR 2.5 x 0.001 = 0.0025 ← this expanded 10^{-3} to 1÷ 10÷ 10÷ 10 = 0.001

Last note on scientific notation and powers of 10:

- When <u>any number</u> is raised to the power of 0, it equals 1.

    - $2^0 = 1$, $6^0 = 1$, $10^0 = 1$

So if scientific notation uses 10^0, the number does not expand any more than it already is.

$2.5 \times 10^0 = 2.5$ ← the decimal moves zero places

OR $2.5 \times 1 = 2.5$ ← This expands 10^0 to equal 1

If the expanded number is greater than 10	The power of 10 is positive.
If the expanded number is between 1 and 10	The power of 10 is 0.
If the expanded number is less than 1, but more than 0	The power of 10 is negative.

To convert a large number to scientific notation, count the amount of spaces the decimal needs to move to the left to create a number that is between 1 & 10.

$2,240,000 = 2.24 \times 10^6$ ← decimal moved 6 places to create 2.24

To convert a small number scientific notation, count the amount of spaces the decimal needs to move to the right to create a number that is between 1 & 10.

$0.00000224 = 2.24 \times 10^{-6}$ ← decimal moved 6 places to create 2.24

Powers of Ten - Practice

Let's do a couple practice examples using the concepts of Power of 10 to convert numbers. Then you can practice by filling in the rest of the chart.

When you are typing powers, if you do not want to format them, a quick way to type it is using the ^ symbol above the #6.

10^2 is the same as 10^2

1,000,000,000,000 =	
7.8×10^{-5} =	
2,300 =	
3.3×10^{7} =	
0.0000034 =	
2.3 =	
8.6×10^{0} =	

1.2.6 Powers of Other Numbers

We know that raising 10 to a power means to multiply one x ten that many times over. The same concept is true for other numbers.

$10^2 = 1 \times 10 \times 10 = 100 \leftarrow$ 1 multiplied by 10 twice

$2^2 = 1 \times 2 \times 2 = 4 \leftarrow$ 1 multiplied by 2 twice.

$2^4 = 1 \times 2 \times 2 \times 2 \times 2 = 16 \leftarrow$ 1 multiplied by 2 four times.

$3^2 = 1 \times 3 \times 3 = 9 \leftarrow$ 1 multiplied by 3 twice.

So the generic way to think about this is :

$$X^n = 1 \times X \text{ (n amount of times).}$$

- ➔ Raising a number to a power of 2 is "squaring" it and raising a number to a power of 3 is "cubing" it.
- ➔ You should be able to do basic squares for all numbers and know how to do 2^0 through 2^8 for your tests without a calculator.

We know that raising 10 to a negative power means to divide 1 by 10 that many times over. The same concept is true for other numbers, but it might be easier to think of it in the generic format:

$$X^{-n} = 1/X^n$$

$10^{-2} = 1/100$

$2^{-2} = 1/4$

$2^{-4} = 1/16$

$3^{-2} = 1/9$

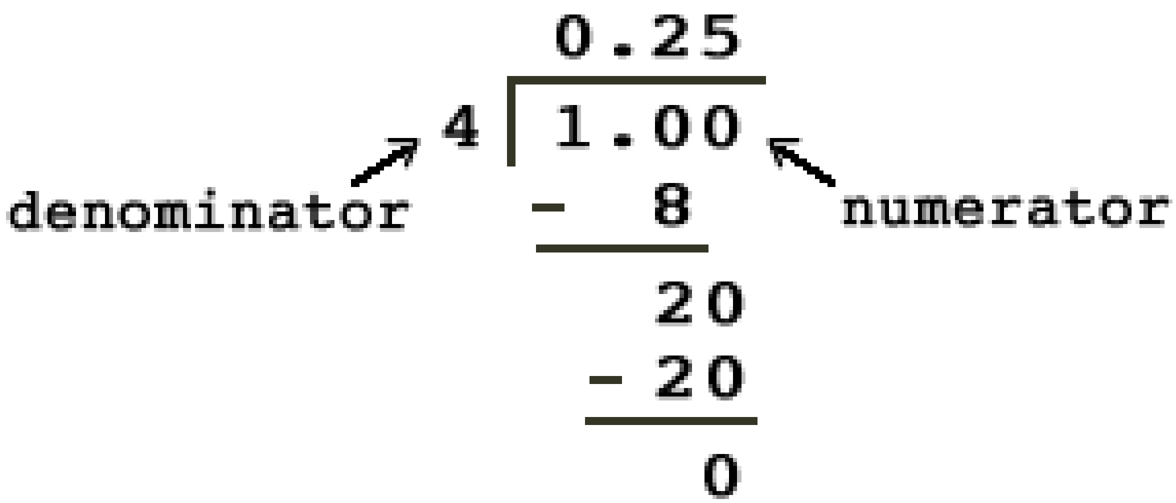
- ➔ This concept doesn't come up like it does for powers of ten, but it's still good knowledge to have.

1.2.7 Converting Fractions

As we saw in the last section that sometimes calculating fractions is easier on our brains.But what if our answers don't include fractions, but rather their decimal counter parts?

Let's take an easy example of 1/4 and convert it to decimal.

The 1 is the numerator because it is above the line, the 4 is denominator because it is below the line. You need to add zeros behind the one to achieve enough space to complete the division, but don't forget to carry your decimal point up too.



Converting Fractions - Practice

$\frac{3}{8} =$	
$\frac{5}{6} =$	
$\frac{1}{3} =$	
$\frac{4}{5} =$	

1.2.8 Reciprocals

A reciprocal was mentioned when we were discussing the relationship statuses found within formulas.

- ➔ A reciprocal is a special relationship that when two variables are multiplied, they equal 1.

There are two formulas you will see in your studies that are reciprocals: The formula relating frequency and period and the formula relating pulse repetition frequency and pulse repetition period.

$$f \times T = 1 \qquad PRF \times PRP = 1$$

Because the 1 is constant and won't change, the variables in the formulas are uniquely related. If one goes up, the other must go down, but they do so in a very particular way:

This is the only way that two numbers can be multiplied to equal one.

$$a \times \frac{1}{a} = 1$$

To find the reciprocal of a whole number, simply make the whole number the denominator of a fraction, where the numerator is 1.

20 x ?? = 1 → 20 x 1/20 = 1

The opposite is true, to find the whole number. Take the denominator and make it the variable missing.

?? x 1/25 = 1 → 25 x 1/25 = 1

Be aware though- your fraction portion can also be represented as a decimal! Which is why it is good to know how to convert fractions.

5 x ⅕ = 1 → 5 x 0.2 =1

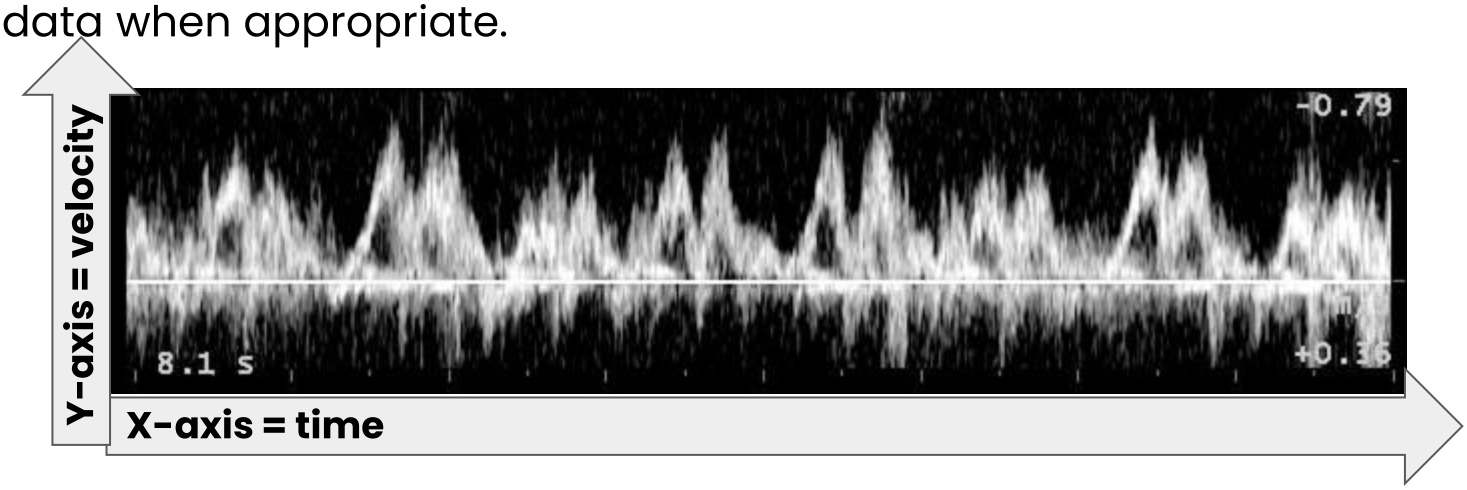
1.2.9 Graphs

The last basic math concept is graphs. When we look at 2 dimensional square, there is an X-axis, the horizontal edge and the Y-axis, the vertical edge.

➔ There is a 3rd axis known as the Z-axis. This axis gives us a look at the 3D world. So if we convert the square into a cube, the Z-axis is found along the 3rd edge, in a different plane than the X and Y-axis.

A lot of ultrasound images are based on mapping data on an axis. You will need to know how the axis is used and what can be plotted.

For example, Doppler Spectral tracings track time along the X-axis and Velocity along the Y-axis. You will learn more about displayed data when appropriate.



Section 1.4 Activities ← Link to Answers

1. Rearrange this formula to solve for Frequency (f) and Period (T)

$$f \times T = 1$$

f =	
T =	

1. (U)nrelated, (D)irectly Related, (I)nversely Related, (R)eciprocal

	When two factors are multiplied together, they equal one.
	How A & C are related in this equation: A x B = C
	How A & B are related in this equation: A x B = 1
	Two items that are related so that one increases, the other also increases.
	Two items that are related so that when one goes up, the other goes down.
	How A & C are related in this equation: C= A/B
	How B & C are related in this equation: C = A/B
	Two items that have no association with one another.

3.

A cm

B cm^2

C cm^3

D Liter

E Square yard

F Foot

	Units of Length
	Units of Area
	Units of Volume

4. Fill in the blanks from the chart.

Prefix	Value	Symbol	Exponent
	Billion x base (1,000,000,000 x)		10^9
	Million x base (1,000,000 x)		10^6
	Thousand x base (1,000 x)		10^3
	Hundred x base (100 x)		10^2
	Ten x base (10 x)		10^1
Base (Meter = m, Second = s, Liter = L, Hertz = Hz)			10^0
	One tenth of base (0.1 x)		10^{-1}
	One hundredth of base (0.01 x)		10^{-2}
	One thousandth of base (0.001 x)		10^{-3}
	One millionth of base (0.000001 x)		10^{-6}
	One billionth of base (0.000000001 x)		10^{-9}

11. What is reciprocal of 10?

As a fraction:

As a decimal:

12. What is the reciprocal of 0.25?

As a whole number:

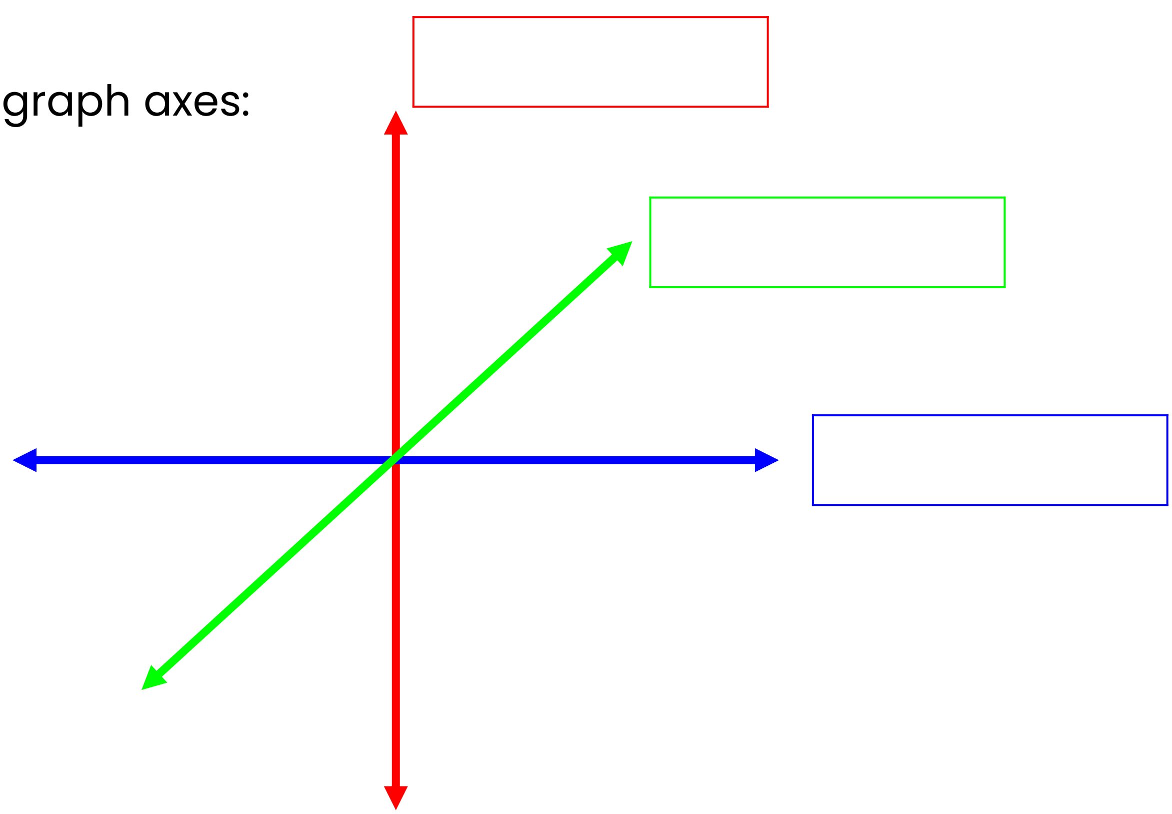
13. What is the reciprocal of 1/a?

As a whole number:

14. What is the reciprocal of a?

As a fraction:

15. Label the graph axes:



5. If megahertz is the unit used for frequency, then what unit would be appropriate for period? (hint: it is a number less than one)

6. Convert the units:

30	meters	→		kilometers
0.1	millisecond	→		seconds
20,000	hertz	→		megahertz
2,000	kilohertz	→		hertz
1540	m/s	→		km/s
5	MHz	→		Hz

7. Complete the chart:

10^0 =		10^5 =	
10^1=		10^6 =	
10^2 =		10^7 =	
10^3 =		10^8 =	
10^4 =		10^9 =	

8. Complete the chart:

10^0 =		10^{-5} =	
10^{-1}=		10^{-6} =	
10^{-2} =		10^{-7} =	
10^{-3} =		10^{-8} =	
10^{-4} =		10^{-9} =	

9. Complete the chart:

2^0 =		5^2 =	
3^1=		2^6 =	
4^2 =		2^{-2} =	
2^3 =		3^{-2} =	
3^2 =		4^{-4} =	

10. What are 2/5 , 1/5, and 7/16 as decimals ?

2/5 = ☐ 1/5 = ☐ 7/16= ☐

Section 1.4 Nerd Check!

1. How could you solve for B & C given this equation: A = B/C?
2. How could you solve for B & C given this equation: A = B x C
3. Given this equation: A = B/C, which letter is the numerator? Which letter is the denominator? Which letter is the quotient?
4. Define these 5 terms: unrelated, related, directly related, inversely related, reciprocal.
5. In this equation: A = B /C, how are B & A related? How are C & A related?
6. In this equation: A x B = C, how are A & C related? How are B & C related?
7. In this equation: A x B = 1, how are A & B related? What is another way you could write B?
8. When we say something increases or decreases, what is actually increasing or decreasing?
9. True or False, You will be able to use a calculator on your national tests (SPI, CCI, ARRT)?
10. What does it mean to increase by a factor of 5?
11. What does it mean to decrease by a factor of 5?
12. Which is the best way to answer the question how old are you? a. 20, b. 20 years, c. 7345 days - why?
13. What is length are what are some example of units?
14. What is area and what are some examples of units?
15. What is volume and what are some examples of units?
16. Is percentage a unit? Does a number need a unit if there is a percentage?
17. What are units in ultrasound based on?
18. Name the prefix, symbol and value for the 10 units discussed.
19. What unit prefixes match / compliment each other?
20. When converting to a bigger unit, which direction does the decimal move?

21. When converting to a smaller unit, which direction does the decimal move?
22. What does it mean when a number is raised to a POSITIVE power?
23. What does it mean when a number is raised to a NEGATIVE power?
24. What does it mean when a number is raised to the power of zero?
25. When writing scientific notation, the number multiplied by the power of 10 should be between the numbers of ___ & ___.
26. How would you explain to someone to calculate 2^4?
27. What does squared mean?
28. What does cubed mean?
29. Describe the steps to converting fractions.
30. Describe a reciprocal and how to find reciprocals.
31. What direction does the Y-axis run in? The x-axis?
32. What axis gives three-dimensions to a graph?