Math for Trades Volume 2

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Introduction

Introduction video

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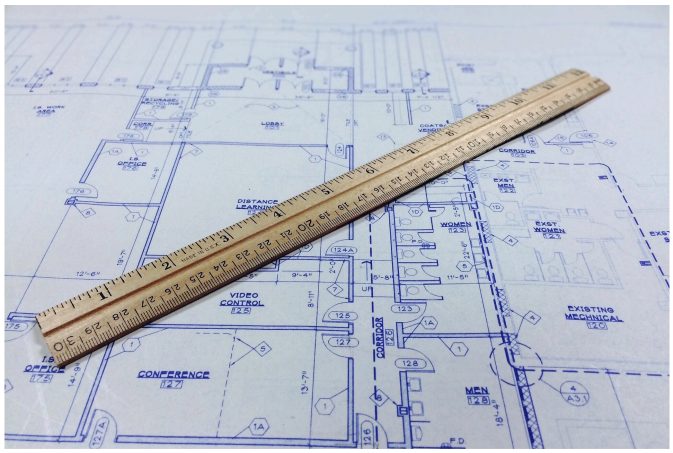
I

Understanding and Working with Units



Outcomes

- Introduction to the Metric and Imperial measuring systems
- Understand the work with linear measurements
- Understand and work with weight measurements
- Understand and work with heat energy measurements
- Understand and work with temperature measurements
- Understand and work with pressure measurements

1.

Introducing the Metric and Imperial Measuring Systems

If you watched the introduction video, you'll remember that Chad talked about the "SO WHAT" videos. Here is the first of those videos.

An interactive or media element has been excluded from this version of the text. You can view it online here: https://pressbooks.nscc.ca/mathfortradesv2/?p=29

Click play on the following audio player to listen along as you read this section.

An interactive or media element has been excluded from this version of the text. You can view it online here: https://pressbooks.nscc.ca/mathfortradesv2/?p=29

This chapter deals with working within units of measurement as well as converting units of measurement. For example we can work within units of measurement where…

$$1\text{ foot} = 12\,\text{inches}$$
$$\text{imperial} \rightarrow \text{imperial}$$

Or we can convert units of measurements such as the following…

$$1\text{ foot} = 0.304\,\text{metres}$$
$$\text{imperial} \rightarrow \text{metric}$$

In the trades we may get used to a certain way of doing things but understanding the terminology behind systems of measurement can help us when we work at jobs where the language is different. Once again, what we are doing is expanding our math vocabulary to help us understand the language of math.

I'll give you an example. When gas fitters learn about energy (or heat) calculations, they are given two numbers to work with. The imperial number is the British Thermal Units (BTU's) while the metric version is kilowatts (kW). Students often have a tough time in the beginning getting the relationship right between the two. Their frustration builds and eventually they begin to wonder why they have to learn two different ways to say the same thing in the first place.

The answer lies in the fact that in the gas fitting trades, students will run across appliances that are designated in both BTU's and kW's. If they are unable to work between the two, then there could be serious safety consequences if those appliances receive too little or, more importantly, too much gas.

For reasons such as the one mentioned above, it's important to know what the different units of measurement mean as well as how to work between them. I know from my experience as a trades instructor that once students begin to understand the language of measurement and are able to both visualize and apply this language, the concepts of math and measurement become a lot easier.

I think the first thing we should do at this point is go through the history of measurement and how the metric and imperial systems came to be.

A Brief History of Measurement: Metric and Imperial

The metric system

Have you ever heard of the guy on the right? Nope, me neither. His name is Nicolas de Condorcet, and he was a French mathematician, philosopher, and early political scientist. He lived way back in the 1700's.

What does he have to do with measurements, you might ask? Well, Condorcet stated that the metric system was to be "for all people all the time."

Back in those days there wasn't a standard measuring system being used in France (or probably anywhere in Europe for that matter), and they were bouncing ideas back and forth as to what measuring system they should use. The basic units being used for the metric system were taken from the natural world. A metre was a unit of length and was based on the dimensions of the earth while the unit of mass, the kilogram, was based on the mass of water which was contained in one liter.

The metric system was used, then not used, then used, then not used and then finally adopted in 1837 by France. During this time period, the metric system was also adopted by the scientific community. The metric system continued to be revised, updated, and adopted by different countries and agencies in the years that followed until it reached the model that is currently used today.

Canada is officially under the metric system, but in many circumstances, we also use the imperial system to measure stuff. This might be due to the fact that we are quite close to the United States, which uses the imperial system.

If you want to learn more about the history of the metric system, check out the following link: History of the Metric System (Wikipedia)

On another note, you may also run across the term "SI" units in your books. This stands for International System of units and is essentially the modern form of the metric system. It was first established in 1960 by the International Bureau of weights and measures and is recognized in most countries. It is the most widely used system of measurement in the world.

For our purposes, we'll just stick to the metric system and the units that fall within that. But if you were curious, you could once again check out the following link: International System of Units (Wikipedia)

The imperial system

The Imperial measurement system was first developed in Britain in the 1800's and replaced the Winchester standards which had been in place since the late 1500's. The Middle Ages provided the background for development of the British System. Thousands of Roman, Celtic, Anglo-Saxon, and other customary local units were used to derive the British system. The *Weights and Measures Act* was adopted in Britain in 1824, and the official British Imperial System began. This system lasted unit 1864 when the metric system was adopted in Britain.

The United States uses the Imperial System similar to the one developed by the British, but it's their own version.

If you want to know more about the history of the imperial system, check out the following link: Imperial Unit (Britannica)

2.

Linear Measurements

Click play on the following audio player to listen along as you read this section.

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Linear measurement can be defined as a measure of length. The length

of a table, the length of a piece of pipe and the length of a football field are all examples of linear measurement. We might also refer to it as distance.

Linear measurements represent a single dimension. This means there is only one line or one plane being measured. Basically it means that it's a line of some type, either straight, curved or wherever you want the line to go. It could be like a road in Saskatchewan which is long and straight or it could be a road in the interior of British Columbia which can be narrow and windy. It doesn't matter if the item or object you are measuring is straight on not. What you are measuring will only have a length.

Measuring length can be accomplished using many different types of units. You've heard of a mile, foot, yard and inch but have you ever heard of a furlong, link, pole or a league? Those are all examples of imperial linear measurement.

How about on the metric side. We have the metre, the centimetre and millimetre. Those would all be familiar to us. But how about micrometre, nanometre, pentametre, tetrametre and hexametre?

How we'll work this section is to first define metric lengths of measurement and work with them and then we'll move onto imperial lengths of measurement and work with them. After all that is done and settled we'll move on to working between metric and imperial.

The Metric System of Linear Measurement

If I were to ask you what is an example of a metric unit of measurement how would you respond? I think most of us might say a metre or a centimetre or even a kilometre.

One of the interesting things about the metric system of linear measurement is that it's all based on measurements of 10 and quite often it's referred to as a decimal based system.

For example, there are 10 millimetres in a centimetre, and there are 10 centimetres in a decimetres, and there are 10 decimetres in a metre. See the pattern. Once you get this pattern then working in metric actually becomes quite easy.

Another cool aspect to the metric system is that everything is derived from a base unit. All other units go from there using multiples of 10. Take a look at the table below to see how this works.

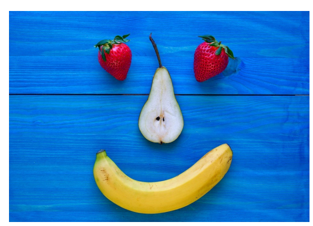
Unit	Multiplier
kilometre	1,000
hectometre	100
decametre	10
metre (base unit)	1
decimetre	0.1
centimetre	0.01
millimetre	0.001

The idea with the above table is that the metre is the place where all the other numbers work back to. So, for example, to go from kilometres back to metres we would multiply by 1000. If we had a length of one kilometre that means we would have a length of 1000 metres.

If we were to go from centimetres to metres the chart tells us that a centimetre is 1/100 of a metre. Therefore if we had one centimetre we would multiply that by 0.01 to get metres.

You might be wondering at this point whether that is all there is to the metric system of linear measurement. In fact there are a number of other measurements based on the metre. Take a look at the crazy table below to see how far the measurement spreads out from the metre.

Common metric prefix	Multiplier
yotta	1,000,000,000,000,000,000,000,000
zetta	1,000,000,000,000,000,000,000
exa	1,000,000,000,000,000,000
peta	1,000,000,000,000,000
tera	1,000,000,000,000
giga	1,000,000,000
mega	1,000,000
kilo	1,000
hecto	100
deca	10
metre (base unit)	1
deci	0.1
centi	0.01
milli	0.001
micro	0.000001
nano	0.000000001
pico	0.000000000001
femto	0.000000000000001
atto	0.000000000000000001
zepto	0.000000000000000000001
yocto	0.000000000000000000000001



Do you recognize any of these prefixes? You might see some of the larger ones such as mega, giga and terra used in computers when dealing with memory and speed.

Don’t worry though as we will generally never work with a lot of these in the trades and we will be sticking to the few that surround the metre.

What we want to do now is to work within the metric linear system. We want to be able to go from one unit of measurement to another and we will utilize the two tables up above for this.

Example

How many centimetres are there in 2.3 metres?

$$2.3\,\text{metres} = \text{X}\,\text{centimetres}$$

Similar to how we did things in the first four chapters we will go about this in steps.

Step 1: Find the multiplier

What we see is that going from centimetres to metres the multiplier is 0.01. What this is saying is a centimetre is 1/100th of a metre or that there are 100 centimetres in a metre.

It's important here to note that a centimetre is smaller than a metre and as this is the case then we would expect our answer to decrease.

Step 2: Build a ratio

$$\frac{1\,\text{m}}{2.3\,\text{m}} = \frac{100\,\text{cm}}{\text{X}\,\text{cm}}$$

What this ratio states is that if 1 metre is equal to 100 centimetres then 2.3 metres is equal to X centimetres.

Step 3: Cross multiply.

$$\frac{1\,\text{m}}{2.3\,\text{m}} = \frac{100\,\text{cm}}{\text{X}\,\text{cm}}$$
$$1 \times \text{X} = 2.3 \times 100$$
$$\text{X} = 230$$
$$\text{Answer} = 230\,\text{centimetres}$$

We'll try another example.

Example

How many kilometres are there in 1057 metres?

Step 1: Find the multiplier.

$$\text{multiplier} = 1000$$
$$1\,\text{kilometre} = 1000\,\text{metres}$$

Step 2: Build a ratio

$$\frac{1\,\text{km}}{\text{X}\,\text{km}} = \frac{1000\,\text{m}}{1057\,\text{m}}$$

Step 3: Cross multiply.

$$\frac{1\,\text{km}}{\text{X}\,\text{km}} = \frac{1000\,\text{m}}{1057\,\text{m}}$$
$$1 \times 1057 = \text{X} \times 1000$$
$$\text{X} = \frac{1057}{1000} = 1.057$$
$$\text{Answer} = 1.057\,\text{metres}$$

Practice Question

Try a couple practice questions yourself and check the video answers to see how you did. Make sure to follow the steps outlined above and think about whether your answer should be bigger or smaller.

Question 1

Barry owns a sheet metal company (Metal Sheet Incorporated) and he is making duct work for a heating system in a new video production studio under construction. The ducts are 0.79 metres wide by 0.45 metres deep. What is the depth of the ducts in centimetres?

https://video.bccampus.ca/id/0_ophwpsky?width=608&height=402&playerId=23448552

The Imperial System of Linear Measurement

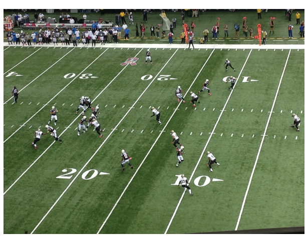
The imperial system isn't quite as straight forward as the metric system. If we were to try and follow the same principle as the metric system we would think that 1 foot would be equal to 10 inches but unfortunately it's not. One foot is equal to 12 inches and one mile is equal to 5280 feet.

Any guesses why there are 5280 feet in a mile? It turns out that it stems from an ancient linear measurement used by the Romans. Back then one mile was equal to 5000 Roman feet. Then the British started using it and decided to relate it to what worked for them which was agriculture. In agriculture they liked to use furlongs as their length of measurement. A furlong was 660 feet and one mile was decided to have 8 furlongs. Well 8 times 660 is equal to 5280 feet.

A foot also has a historical significance and if you guessed that it was based on an average human foot you would be right. There are some who believe that it is actually based on the average human shoe length. Either way naming it a foot makes sense.

Take a look at the table below to get an idea of how the imperial system of linear measurement works.

Unit Name	**Equivalent Values**
Inch	0.083 feet. 0.028 yards
foot	12 inches, 0.333 yards
yard	3 feet, 36 inches
fathom	6 feet, 72 inches
rod	5.50 yards, 16.5 feet
furlong	660 feet, 220 yards, 1/8 mile
mile	5280 feet, 1760 yards, 320 rods
Nautical mile	6,076 feet, 1.151 miles



At first glance this may seem a little more confusing than metric and realistically if we were dealing with all those different length measurements it just might be. Lucky for us we are only going to deal with 3 of the measurements for the most part. Those three include inches, feet and miles. Once in a while we might see yards come in to play. For instance an American football field is 100 yards long and 120 if you include the 2 end zones.

Once again our task it to work within the imperial system and be able to work between values. Before we start I want to remind you to think about the answer you are trying to find. What I want you to think about is whether or not the answer is going to be bigger or smaller.

An example would be feet to inches. If we were to cut a piece of pipe 2 feet long do you think it would this end up being more than 2 inches long or less than 2 inches long. I think we all agree that it would be more than 2 inches and in fact it is. It works out to be 24 inches. You might not be able to get 24 inches right away but you probably can figure out that 2 feet stated in inches should work out to be a greater number.

Let’s use that as our first example:

Example

How many inches are there in 2 feet?

Step 1: Find the number that states the relationship between inches and feet.

In this case:

$$1\text{ foot} = 12\text{ inches}$$

Step 2: Build a ratio

$$\frac{1\text{ foot}}{2\text{ feet}} = \frac{12\text{ inches}}{\text{X inches}}$$

Step 3: Cross multiply

$$\frac{1\text{ foot}}{2\text{ feet}} = \frac{12\text{ inches}}{\text{X inches}}$$
$$1 \times \text{X} = 2 \times 12$$
$$\text{X} = 24$$
$$\text{Answer} = 24\text{ inches}$$

Although you might have been able to do that in your head, it's important to follow the steps involved and think about the answer you expect to get. This will help when the numbers are more involved and not as easy to figure out.

Example

How many yards are there in 247 inches?

Step 1: Find the number that goes between yards and inches. Note that there are actually 2 numbers here to choose from. We could use:

$$1\text{ yard} = 36\text{ inches}$$
$$\text{OR}$$
$$1\text{ inch} = 0.028\text{ yards}$$

In this question we are going from inches to yards so working with the number 0.028 will be easier for us.

Step 2: Build a ratio

$$\frac{1\,\text{inch}}{247\,\text{inches}} = \frac{0.028\,\text{yards}}{\text{X yards}}$$

Step 3: Cross multiply

$$\frac{1\,\text{inch}}{247\,\text{inches}} = \frac{0.028\,\text{yards}}{\text{X yards}}$$

$$1 \times \text{X} = 247 \times 0.028$$

$$\text{X} = 6.916$$

$$\text{Answer} = 6.916\,\text{yards}$$

Practice Question

Try a practice question yourself and check the video answers to see how you did. Make sure to follow the steps outlined above and think about whether your answer should be bigger or smaller.

Question 1

The length of the duct work that Barry, our sheet metal tradesperson, has to create for the video production studio is 193 yards. How many feet of the duct does Barry have to order to complete the job?

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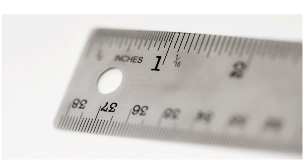
Working between the Metric and Imperial Linear Measurements Systems



What happens when we have to work between the metric and imperial systems? It really works just the same but we need to learn a few new numbers.

The table below is a list of numbers which can be used to help translate between metric and imperial linear measurements. What you'll note here is that the equivalent numbers represent units that are similar in length (or used similarly) in different situations.

An example would be kilometres and miles. Both are used to represent such things as distance travelled in a car, train, bus or airplane. We don't go and measure those long distances using centimetres or its imperial equivalent which is inches. That just wouldn't be convenient.

Likewise if we were to measure the length of a house we would most likely use the metres or its imperial equivalent which is feet.

Also note that we don't translate every metric and imperial number to their equivalents. As we won't be working with most of the units there is no real need to find all these numbers. Having said that, if you wanted to go through and find the numbers yourself on the internet or possibly even try and figure them out using the numbers in the tables above and below then it would most likely help with your understanding of how linear measurement units work with each other.

Metric	Imperial Equivalent
1 metre	3.28 feet
1 kilometre	0.62 miles
1 centimetre	0.393 inches
1 millimetre	0.0394 inches

It might also be helpful to look at those numbers in the reverse.

Imperial	Metric Equivalent
1 foot	0.305 metres
1 mile	1.61 kilometres
1 inch	2.54 centimetres
1 inch	25.4 millimetres

Even though we have a conversion number to go from miles to kilometres, and then a conversion number to go from kilometres to miles, we don't actually have to remember both.

Whichever of the two numbers is easiest for you to remember is all you need to memorize. Once you know one you can get the other.

Here's how it works.

We'll use miles and kilometres for this exercise. What we know is that 1 mile is equal to 1.61 kilometres.

$$1\,\text{mile} = 1.61\,\text{kilometres}$$

Now what we need to figure out is the reverse. In this case how many miles there are in one kilometre. Once again ask yourself whether you think the answer should be bigger or smaller than 1.

So to figure out our answer we need to do the following.

$$\#\,\text{kilometres} = \#\,\text{miles} \times 1.61$$
$$\downarrow$$
$$\#\,\text{miles} = \frac{\#\,\text{kilometres}}{1.61}$$
$$\downarrow$$
$$1\,\text{mile} = 0.62\,\text{kilometres}$$

So we end up with 1 kilometre equaling 0.62 miles.

We've just taken one constant to derive the other constant. You can do this with any of the numbers used to translate back and forth between metric and imperial.

Let's move on. Now what we will do is start to work between the imperial and metric systems and the easiest way to do this is by going through some example questions.

Example

How many metres are there in 42 feet?

Step 1: Find the number you can work with.

We know that:

$$1\,\text{metre} = 3.28\,\text{feet}$$
$$1\,\text{foot} = 0.305\,\text{metres}$$

As we are going from feet to metres we'll go with 1 foot = 0.305 metres.

Step 2: Build a ratio

$$\frac{1\,\text{foot}}{42\,\text{feet}} = \frac{0.305\,\text{metres}}{\text{X}\,\text{metres}}$$

Step 3: Cross multiply

$$\frac{1\,\text{foot}}{42\,\text{feet}} = \frac{0.305\,\text{metres}}{\text{X}\,\text{metres}}$$
$$1 \times \text{X} = 42 \times 0.305$$
$$\text{X} = 12.81$$
$$\text{Answer} = 12.81\text{metres}$$

Example

How many inches are there in 100 centimetres?

Step 1: Find the number you can work with.

We know that:

$$1\,\text{centimetre} = 0.393\,\text{inches}$$
$$1\,\text{inch} = 2.54\,\text{centimetres}$$

As we are going from centimetres to inches we'll go with 1 centimetre = 0.393 inches

Step 2: Build a ratio

$$\frac{1\,\text{cm}}{100\,\text{cm}} = \frac{0.393\,\text{in}}{\text{X}\,\text{in}}$$

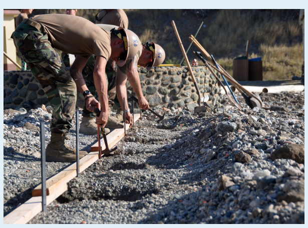
Step 3: Cross multiply

$$\frac{1\,\text{cm}}{100\,\text{cm}} = \frac{0.393\,\text{in}}{\text{X}\,\text{in}}$$
$$1 \times \text{X} = 100 \times 0.393$$
$$\text{X} = 39.3$$
$$\text{Answer} = 39.3\text{cm}$$

Practice Questions

Try a couple practice question for yourself. Make sure to go through the steps similar to the example questions above and also make sure to check the video answers to see if you are correct.

Question 1



Jakob is a carpenter who creates forms for concrete columns. The measurements for the column are in millimetres but Jakob would rather work in inches so he decides to translate the millimetres to inches. The columns are rectangular and are 400 mm by 250 mm. What are the measurements of the column in inches?

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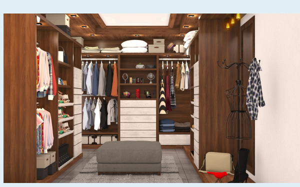
Question 2



Elias is a cabinetmaker from Sweden who is now an apprentice in Canada. He has been asked to order material for the job and it totals 427 feet of 1″ x 4″ wood. As he is used to working in metric he wants to change that to metres. How many metres of 1″ x 4″ is he going to need?

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3.

Weight Measurements

Click play on the following audio player to listen along as you read this section.

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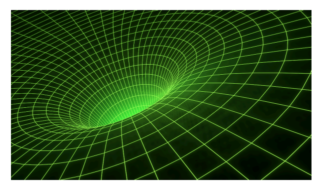
How much do you weigh?

According to the “always correct” internet, the average Canadian man weighs 182 pounds or 82.7 kilograms and the average Canadian woman weighs 153 pounds or 69.4 kilograms.

Pounds and kilograms are just two of the ways weight can be measured. Sometimes you might hear weight referred to as mass.



Weight and mass are actually two different things but for the most part we refer to them as the same thing. Weight is a reference to the amount of force an object experiences due to the effects of gravity. If the gravitational pull changes, like if you were on the moon, your weight would change. The mass of an object would stay the same regardless of the gravitational pull of an object. The mass of an object refers to how much matter it contains. This does not change.

Whatever the case we will refer to weight and mass as the same concept.

If you want to know more about the difference between weight and mass check out the following link: Mass versus weight (Wikipedia)

The Metric System of Weight

When dealing with weight measurements in metric we follow a pattern similar to the one used for metric linear measurements. We start with the base unit which is the gram and all other metric weights have a multiplier that relates back to the gram.

Now remember with metric linear measurements there were a lot of them on that table and most of them we really didn’t deal with. Its the same thing with metric weight measurements. We won’t deal with all of them but rather just the few that we deal with the majority of the time.

So using our gram as the base unit we have:

Unit	**Multiplier**
kilogram (kg)	1,000
gram (base unit) (g)	1
centigram (cg)	0.01
milligram (mg)	0.001

From this chart we can conclude that there are 1000 grams in a kilogram and that there are 1000 milligrams in a gram. Once again using the multiplier we can go from one unit to the other.

Let's throw in one other number here…the metric tonne.

$$1\ \text{metric tonne} = 1000\ \text{kilograms}$$

Just for fun we'll write down the metric weight of a few common (or maybe uncommon) items.

Example	**Weight**
Usain Bolt (sprinter from Jamaica)	94 kilograms
Hummingbird	4 grams (average)
Grizzly bear	300 kilograms (adult male average)
An electron	9.109×10−31 kilograms (very light)
The sun	1.989×10^{30} kilograms (very heavy)

The best way for us to go about working with metric weights is to go through a few examples to get used to it.

Example

A bag of potato chips weights 48 grams. How many milligrams is that?

Step 1: Find the multiplier

What we see is that going from milligrams to grams the multiplier is 0.001. What this is saying is that a milligram is 1/1000th of a of a gram or that there are 1000 milligrams in a gram.

Step 2: Build a ratio

$$\frac{1\,\text{gram}}{48\,\text{grams}} = \frac{1000\,\text{mg}}{\text{X}\,\text{mg}}$$

Step 3: Cross multiply.

$$\frac{1\,\text{gram}}{48\,\text{grams}} = \frac{1000\,\text{mg}}{\text{X}\,\text{mg}}$$
$$1 \times \text{X} = 48 \times 1000$$
$$\text{x} = 48,000$$
$$\text{Answer} = 48,000\,\text{grams}$$

Examples

1 cubic metre of concrete weighs 2.4 metric tonnes. How much is that in kilograms?

Step 1: Find the multiplier.

In this case if we go from a metric ton to kilograms the multiplier is 1000. What we are saying is that there are 1000 kilograms in one metric ton.

Step 2: Build a ratio

$$\frac{1\,\text{tonne}}{2.4\,\text{tonnes}} = \frac{1000\,\text{kg}}{\text{X}\,\text{kg}}$$

Step 3: Cross multiply

$$\frac{1\,\text{tonne}}{2.4\,\text{tonnes}} = \frac{1000\,\text{kg}}{\text{X}\,\text{kg}}$$
$$1 \times \text{X} = 2.4 \times 1000$$
$$\text{X} = 2,400$$
$$\text{Answer} = 2,400\,\text{kilograms}$$

Practice Question

Try a practice question yourself and check the video answer to see how you did. Make sure to follow the steps outlined above and think about whether the value you should get is greater or smaller than the original value.

Question 1

Istvan is a bricklayer originally from Hungary. His specialty is building red brick houses which tend to last longer than wood frame houses and are common back in Hungary. Each brick weights about 2.7 kilograms. How many centigrams is that?

As there is no direct multiplier from kilograms to centigrams your best bet might be to do this in 2 steps. You may want to go from kilograms to grams and then from grams to centigrams.

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The Imperial System of Weight

Although there is a lot of history behind the imperial system we are going to stick to the basics here.

If you would like to find out more information about the history of imperial weights check out the following link: Imperial Units (Britannica)

For our purposes we will only deal with 3 different measurements of weights in the imperial system. They are:

Unit Name	Equivalent Values
ounce (oz)	1/16 or 0.0625 pounds
pound (lb)	16 ounces
ton	2000 pounds

Okay, we'll throw one more in there and that is a "stone." It's a term you may hear once in a while and certainly much more common in Britain than in Canada. A stone is 14 pounds. The stone as a form of measurement developed many years ago and dealt with weight when people were trading goods. Originally a "stone" could have been anywhere from 5 to 40 pounds but now it's stabilized at 14 pounds.

And another thing……that ton that you see in this table is different than the metric equivalent. First the spelling is different. There is the metric "tonne" and the imperial "ton." Second there is the actual weight. A metric tonne weighs 1000 kilograms while an imperial ton weighs 2000 pounds. And that's not all! 2000 pounds is referred to as a "short" ton while a "long" ton is around 2400 pounds.

Once again here are those items from before just with weights that are now in imperial.

Example	Weight
Usain Bolt (sprinter from Jamaica)	206.8 pounds
Hummingbird	0.14 ounces (average)
Grizzly bear	660 pounds (adult male average)
An electron	2×10^{-30} pounds (still light)
The sun	4.385×10^{30} pounds (still heavy)

Now let's go through a few examples working between the imperial units for weight.

Example

A typical 4' × 8' sheet of plywood 3/4″ thick weighs approximately 61 pounds. How many ounces is that?

Step 1: Find the number that states the relationship between pounds and ounces. Remember that we are going from pounds to ounces.

In this case if we go from pounds to ounces the number we would use is 16. What we have is that one pound is equal to 16 ounces.

Step 2: Build a ratio.

$$\frac{1\,\text{pound}}{61\,\text{pounds}} = \frac{16\,\text{ounces}}{\text{X}\,\text{ounces}}$$

Step 3: Cross multiply

$$\frac{1\,\text{pound}}{61\,\text{pound}} = \frac{16\,\text{ounces}}{\text{X}\,\text{ounces}}$$

$$1 \times \text{X} = 61 \times 16$$

$$\text{X} = 976$$

$$\text{Answer} = 976\,\text{ounces}$$

We'll go through another example but in this case we'll add a little more to the question.

Examples

A piece of 2 × 4 wood weighs about 25.6 ounces per foot. A house is being framed and an order goes in for 103 eight foot lengths of 2 × 4. What will be the total weight of the wood in pounds?

Step 1: Find the total amount of wood required in the order in feet.

$$\text{Feet} = \text{pieces} \times 8\,\text{feet/piece}$$

$$\text{Feet} = 103 \times 8$$

$$\text{Feet} = 824$$

Step 2: Find the total weight of the wood in ounces.

$$\text{ounces} = \text{feet} \times 25.6\,\text{ounces/foot}$$

$$\text{ounces} = 824 \times 25.6$$

$$\text{ounces} = 21,094$$

Step 3: Find the number that works between ounces and pounds remembering that we are going from ounces to pounds.

In this case 1 ounce = 1/16 or 0.0625 pounds

Step 4: Build a ratio

$$\frac{1\,\text{oz}}{21,094\,\text{oz}} = \frac{0.0625\,\text{lbs}}{\text{X}\,\text{lbs}}$$

Step 5: Cross multiply

$$\frac{1\,\text{oz}}{21,094\,\text{oz}} = \frac{0.0625\,\text{lbs}}{\text{X}\,\text{lbs}}$$
$$1 \times \text{X} = 21,094 \times 0.0625$$
$$\text{X} = 1318.38$$
$$\text{Answer} = 1318.38\,\text{lbs}$$

Practice Question

Try a practice question yourself and check the video answer to see how you did. Make sure to follow the steps outlined above and think about whether the value you should get is greater or smaller than the original value.

Question 1

We're going to back to Istvan, our bricklayer. Istvan needs to buy some brick mortar when building the house. He buys 0.15 tons of mortar for the job. How much is this in pounds?

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Working between Metric and Imperial Weight Measurements

We're going to do the same thing in this part as we did in the linear measurement part and only deal with a few of the most common weight measurements in imperial and metric. Once again the units from metric that are translated into imperial and then back the other way are units that represent similar weight categories. For instance a metric tonne would be similar to an imperial ton.

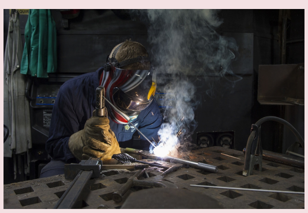
Below are the numbers to translate from metric to imperial and them from imperial back to metric.

Metric	**Imperial Equivalent**
kilogram (kg)	2.2 pounds
gram (g)	0.035 ounces
tonne	2200 pounds

Imperial	**Metric Equivalent**
pound (lb)	0.454 kilograms
ounce (oz)	28.35 grams
ton	909 kilograms

Let's just get right into the examples here.

Example



The Lincoln SA200 is a type of welding machine. In fact it's a pretty heavy welding machine that weighs about 410 pounds. How much would this be in kilograms?

Step 1: Find the number that translates between kilograms and pounds. Remember that we are going from pounds to kilograms. We know that 1 pound equals 0.454 kilograms.

Step 2: Build a ratio

$$\frac{1\,\mathrm{lb}}{410\,\mathrm{lbs}} = \frac{0.454\,\mathrm{kg}}{\mathrm{X\,kg}}$$

Step 3: Cross multiply

$$\frac{1\,\mathrm{lb}}{410\,\mathrm{lbs}} = \frac{0.454\,\mathrm{kg}}{\mathrm{X\,kg}}$$

$$1 \times \mathrm{X} = 410 \times 0.454$$

$$\mathrm{X} = 186.14$$

$$\mathrm{Answer} = 186.14\,\mathrm{kg}$$

Example

Slavka is a baker who works for a bakery located in a small town in the interior of British Columbia. One of the big sellers at this particular bakery is the fresh cooked European style crusty bread. Each loaf of bread requires about 10.6 ounces of flour. As Slavka has a Czech background she wants to translate that into grams. How many grams of flour does it take to bake one loaf of bread?

Step 1: Find the number that translates between ounces and grams. Keep in mind that we are going from ounces to grams in this case. We know that one ounce equals 28.35 grams

Step 2: Build a ratio

$$\frac{1\text{ oz}}{10.6\text{ oz}} = \frac{28.35\text{ g}}{\text{X g}}$$

Step 3: Cross multiply

$$\frac{1\text{ oz}}{10.6\text{ oz}} = \frac{28.35\text{ g}}{\text{X g}}$$

$$1 \times \text{X} = 10.6 \times 28.35$$

$$\text{X} = 300.51$$

$$\text{Answer} = 300.51\text{ g}$$

Example

Just for fun let's add another layer to this question. How many loaves of bread could Slavka make if she started with a 10 pound bag of flour?

Step 1: Change the 10 pounds into grams. Find a number that translates between the two.

Looking back at our table we find that we don't have a number that translates from pounds into grams. We do have a number that translates from pounds into kilograms though. We'll start with that.

We see that 1 pound = 0.454 kilograms.

We also see that 1 kilogram = 1000 grams.

We can use both these numbers to calculate the number of grams.

Step 2: Build a ratio from pounds into kilograms and cross multiply.

$$\frac{1\,\text{lb}}{10\,\text{lbs}} = \frac{0.454\,\text{kg}}{\text{X}\,\text{kg}}$$
$$1 \times \text{X} = 10 \times 0.454$$
$$\text{X} = 4.54$$
$$\text{Answer} = 4.54\,\text{kg}$$

Step 3: Translate kilograms into grams.

$$\frac{1\,\text{kg}}{4.54\,\text{kg}} = \frac{1000\,\text{g}}{\text{X}\,\text{g}}$$
$$1 \times \text{X} = 4.54 \times 1000$$
$$\text{X} = 4540$$
$$\text{Answer} = 4540\,\text{g}$$

Almost there!!!!

Step 4: Take the number of grams in a 10 pound bag of flour and divide it by the number of grams of flour it takes to make one loaf of European crusty bread.

$$\begin{aligned}\text{loaves of bread} &= \frac{\text{grams in a 10 pound bag of flour}}{\text{grams in loaf of bread}}\\ &= \frac{4540}{300.5}\\ &= 15.10\,\text{loaves of bread}\end{aligned}$$

Using our rounding skills developed in the earlier chapters we would round that down to 15 loaves. In fact, due to loss and waste during the bread making process we could assume that we would make even less loaves that that.

Practice Question

Try a practice question yourself and check the video answer to see how you did. Make sure to follow the steps outlined above and think about whether the answer you should get is greater or smaller than the original value.

Question 1

Keeping with food we'll move our attention over to cooking where Francois is cooking up a fish weighing 4 pounds 6 ounces. What is the weight of the fish in grams?

Once again you'll have to do this in two steps. Do it however you wish but think of the most efficient way to do it.

Hint: What is the imperial measurement of weight which corresponds to grams?

4.

Heat Energy Measurements

Click play on the following audio player to listen along as you read this section.

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Take a look at the picture of the fire to the left. If you were to describe that fire and you had the three words heat, temperature and energy to choose from, which would you say best describes the fire?

You might say that all three words could describe the fire and you would be right. As all three words can be used to describe a similar situation this could be confusing. As this chapter deals with heat energy you might have guessed that we are going look at this from the heat energy point of view. We'll get to temperature in the next section but for now know that temperature is a measure of the intensity of the heat. We could describe the fire as very hot which would indicate a high intensity of heat.

At this point we should get a definition of energy. I'm going to refer to WIKIPEDIA here for the definition:

Energy: In physics, energy is the quantitative property that must be transferred to an object in order to perform work on, or to heat, the object.

Thanks Wikipedia!

There are many forms of energy. We are just going to focus on heat energy in this section.

If you would like to know more about the different forms of energy check out the following link: Types of Energy (Solar Schools)

Measuring Heat Energy

In the last two sections we started off by going through the metric units and then the imperial units. Well there are only two units for each that we are going to deal with so we'll introduce them all at once and then work through examples within metric and within imperial and then work between them. The four units we are going to deal with are as follows:

Metric	Imperial
kilowatts (kW)	British thermal unit (btu)
calories (cal)	joules (J)

Let's take a look at the relationship between each of the units.

Unit	Equivalent
kilowatt	3412 btu's 860,421 cal
British thermal unit	0.293 kW 1055 J
calorie	4.186 J
joules	0.239 cal

Note that there are a couple of equivalent numbers missing such as the number of kilowatts in a joule. These are not included as they are either too small or way large to bother with. The numbers above are generally the ones we need to know.

Something else to note is that often instead of using calories and joules we use kilocalories and kilojoules. A kilocalorie (kcal) is 1000 calories and it takes 1 kilocalorie to raise the temperature of 1 kilogram of water 1°C. As we learned before there are 1000 grams in one kilogram. Following the logic it would then take 1 calorie to raise 1 gram of water 1°C.

$$\begin{aligned} \text{1 kilocalorie (1000 calories)} &\longrightarrow \text{raises 1 kilogram (1000 grams) of water } 1^\circ\text{C} \\ \text{1 calorie} &\longrightarrow \text{raises 1 gram of water } 1^\circ\text{C} \end{aligned}$$

This same logic follows for the joule. One kilojoule equals 1000 joules. If we relate it to increasing the temperature of water what we would see is that is takes 1 joule to raise 1 gram of water 0.24°C. Following the same logic as the calorie and kilocalorie it would take 1 kilojoule to raise 1 kilogram of water 0.24°C.

$$\begin{aligned} \text{1 kilojoule (1000 joules)} &\longrightarrow \text{raises 1 kilogram (1000 grams) of water } 0.24^\circ\text{C} \\ \text{1 joule} &\longrightarrow \text{raises 1 gram of water } 0.24^\circ\text{C} \end{aligned}$$

We can take this a bit further and talk about the heat energy in a British thermal unit. The heat energy in one BTU is enough to raise one pound of water 1 degree Fahrenheit. It's generally considered to be the amount of heat energy in a match.

Remember that you can derive any other number you need from the conversion numbers given. These are the only number that you have to memorize.

Let's go through a few example questions to see where we are at.

Example

How many joules (J) are there in 14 British thermal units (BTU)?

Step 1: Find the number that translates between joules and British thermal units. Keep in mind that we are going from BTU's to joules.

In this case we know that 1 BTU = 1055 joules

Step 2: As usual build a ratio.

$$\frac{1\,\mathrm{BTU}}{14\,\mathrm{BTU's}} = \frac{1055\,\mathrm{joules}}{\mathrm{X}\,\mathrm{joules}}$$

Step 3: Cross multiply.

$$\frac{1\,\mathrm{BTU}}{14\,\mathrm{BTU's}} = \frac{1055\,\mathrm{joules}}{\mathrm{X}\,\mathrm{joules}}$$

$$1 \times \mathrm{X} = 14 \times 1055$$

$$\mathrm{X} = 14,470$$

$$\mathrm{Answer} = 14,470\,\mathrm{joules}$$

Example

How many kilowatts (kW) are there in 1,495, 276 calories (cal)?

Step 1: Find the number that translates between kilowatts and calories.

In this case we know that 1 kilowatt is equal to 860,421 calories. Note that we are going from calories to kilowatts and we don't have the number of kW in one calorie. What we do have is the number to go from kilowatts to calories. We know that 1 kilowatt = 860,421 calories.

Step 2: Build a ratio using the number we do have.

$$\frac{1\,\text{kW}}{\text{X}\,\text{kW}} = \frac{860{,}421\,\text{cal}}{1{,}495{,}276\,\text{cal}}$$

What you'll note here is that when you get to the stage where you cross multiply the equation doesn't end up as nice and easy to work with as we've had so far. We don't end up with the "1 x X." What we have to do here is manipulate the equation to solve for X. This is a little out of the scope of what we have gone through so far but you'll find a full explanation in the next chapter. Having said all that let's go through the motions to solve the equation.

Step 3: Cross multiply

$$\frac{1\,\text{kW}}{\text{X}\,\text{kW}} = \frac{860{,}421\,\text{cal}}{1{,}495{,}276\,\text{cal}}$$

$$1 \times 1,495,276 = \text{X} \times 860,421$$

$$\text{X} = \frac{1,495,276}{860,421} = 1.738$$

$$\text{Answer} = 1.738\,\text{kW}$$

Now try a question for yourself

Practice Question

Try a practice question yourself and check the video answer to see how you did. Make sure to follow the steps outlined above and think about whether your answer should be bigger or smaller.

Question 1

Amir and Parviz are installing a boiler. The boiler is rated at 110 kW. Their gas fitting ticket allows them to install and fire appliances up to and including 400,000 BTU's per hour. Are they allowed to fire this appliance?

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5.

Temperature Measurements

Click play on the following audio player to listen along as you read this section.

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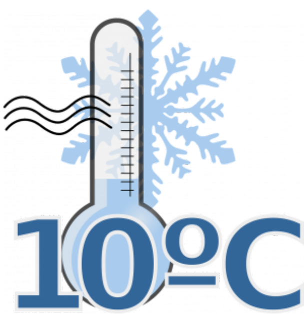
The units in the previous part of this section dealt with heat energy measurement. The answers we were calculating indicated an amount or quantity of heat. When measuring temperature we are not measuring quantity but instead we are gauging the intensity of the heat.



For example going outside on a day when it’s −10°C feels colder or much more intense that going outside on a day that is +20°C.

How much heat content would you think there is at −10°C? Honestly who cares? Just get inside and we can sort that out later.

If I were to ask you what units you generally associated with temperature what would you say?

I’m guessing most of you would respond with either Celsius or Fahrenheit. Those would be the two most common methods of describing the heat here in Canada and as Canada uses the metric system we would most likely be seeing the temperature in Celsius.

But have you ever heard of the Kelvin temperature scale or the Rankine temperature scale?

Well these temperature scales are based on what is known as “absolute temperature.”

If you go on the internet and look up absolute temperature you can get some pretty convincing definitions, some of which we might actually be able to comprehend. Basically, the absolute temperature scale starts at absolute zero and a simplified definition of absolution zero would be the following:

ABSOLUTE ZERO: The temperature at which all molecular movement ceases to exist.

As there is no molecular movement there is also no heat generated by the molecules.

If you want to know more about absolute zero check out the link: Absolute Zero (Wikipedia)

So what we start with are the Celsius scale which is the metric version of temperature and the Fahrenheit scale which is the imperial version. You might notice that when you are watching T.V. in Canada you will see much smaller temperature numbers than when you watch T.V. from a U.S. channel. This is due to the fact that if we took a temperature reading on the Fahrenheit scale and found a similar temperature on the Celsius scale the Celsius temperature reading would work out to be much smaller.

For example we could look at room temperature.

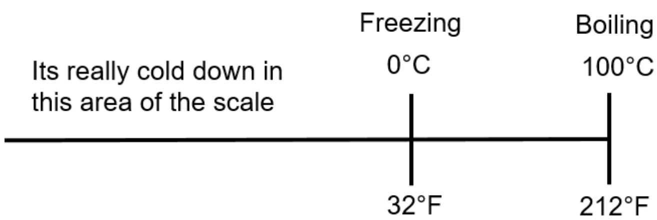
$$\text{Metric} = 20^\circ \text{ Celsius} \qquad \text{Imperial} = 68^\circ \text{ Fahrenheit}$$

On another note does anyone watch T.V. anymore or is it just the internet and Netflix? Anyway, back to Celsius and Fahrenheit.

What we want to do here is relate the metric and imperial scale with each other and then add the absolute scale equivalents. We'll start with the boiling point of water.

Water boils at 100°C and 212°F. Note the letter "C" represents Celsius while the letter F represent Fahrenheit.

Next we find the freezing point of water. Water freezes at 0°C and at 32°F. We can put all those together into a small drawing.



We'll go through how to go from Celsius to Fahrenheit and back in just a bit but before we get to that we should add the absolute temperature scales.

Absolute Temperature Scale

Metric	Kelvin
Imperial	Rankine

If we were to add them to our drawing it would look something like the following.

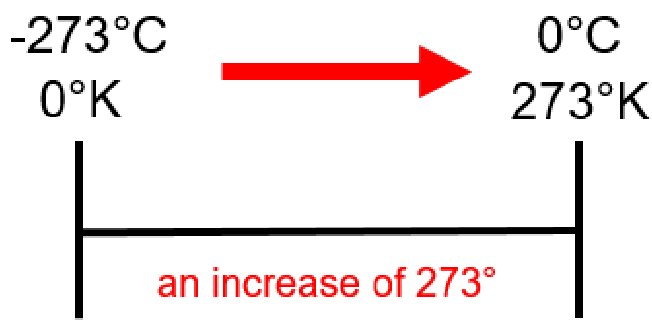
Note that it's not drawn exactly to scale. If it were then absolute zero would be a little farther to the left. Remember that absolute zero is where there is no molecular movement and therefore no heat generated.

We'll start with Celsius and Kelvin. What you'll note from the drawing above is that 0°K, also known as absolute zero, is −273°C.

What's also important to note is that 1°K is −272°C.

What that indicates is that a one degree change in Kelvin is equal to a one degree change in Celsius.

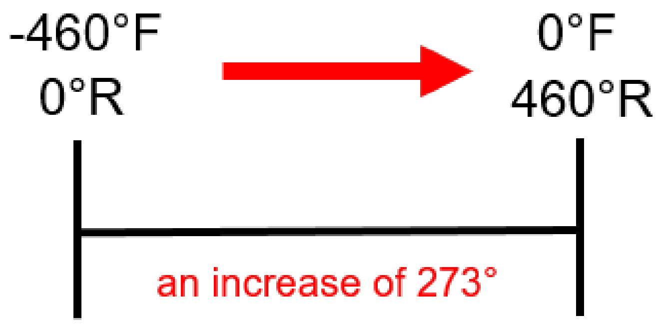
If I were to go from −273°C to 0°C this would be a change of 273 degrees. On the Kelvin scale it would have gone from 0°K to 273°K.



Fahrenheit and Rankine follow a similar pattern. Absolute zero on the Rankine scale is 0°R while on the Fahrenheit scale it's −460°F.

Once again we would find that 1°R is −459°F indicating that a one degree change in Rankine is equal to a one degree change in Fahrenheit.

If we would apply this idea to the imperial temperature scales we would get the following. To go from −460°F to 0°F would be a change of 460°. On the Rankine scale it would have gone from 0°R to 460°R.



How we deal with this mathematically is the following:

$$^\circ\text{Kelvin} = {}^\circ\text{Celsius} + 273$$
$$^\circ\text{Rankine} = {}^\circ\text{Fahrenheit} + 460$$

Let's go through a couple examples going from one to the other. These are going to be fairly straight forward so we won't go through all the steps like we usually do.

Example

The temperature outside is 10°C. What is the temperature in Kelvin?

$$^\circ\text{Kelvin} = {}^\circ\text{Celsius} + 273$$
$$^\circ\text{K} = 10^\circ\text{C} + 273$$
$$^\circ\text{K} = 283$$

Example

The temperature on the moon during the winter solstice has been measured at 25°Kelvin. What is this in Celsius? Note that we have to rearrange the formula to solve for Celsius.

$$
\begin{aligned}
{}^\circ\text{Kelvin} &= {}^\circ\text{Celsius} + 273 \\
{}^\circ\text{Celsius} &= {}^\circ\text{Kelvin} - 273 \\
{}^\circ\text{C} &= 25 - 273 \\
{}^\circ\text{C} &= -258
\end{aligned}
$$

Example

When baking a cake the oven should be preheated to a temperature of 350°F. What is this temperature in Rankine?

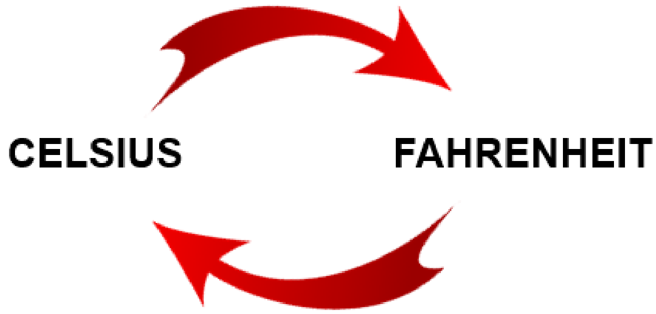
$$
\begin{aligned}
{}^\circ\text{Rankine} &= {}^\circ\text{Fahrenheit} + 460 \\
{}^\circ\text{R} &= 350{}^\circ\text{F} + 460 \\
{}^\circ\text{R} &= 810
\end{aligned}
$$

Example

The average daily high temperature in Jerusalem in July is 544°Rankine. How much is that in Fahrenheit? Note that we have to rearrange the formula to solve for Fahrenheit.

$$
\begin{aligned}
{}^\circ\text{Rankine} &= {}^\circ\text{Fahrenheit} + 460 \\
{}^\circ\text{Fahrenheit} &= {}^\circ\text{Rankine} - 460 \\
{}^\circ\text{F} &= 544 - 460 \\
{}^\circ\text{F} &= 84
\end{aligned}
$$

Celsius to Fahrenheit and Fahrenheit to Celsius



This is probably what we've all been waiting for here in this part of the chapter. Going back and forth between Celsius and Fahrenheit is probably the most common temperature calculation tradespeople are required to make.

We could be dealing with gas fitting appliances and have to calculate temperature rise through the appliance in either Celsius or Fahrenheit. We may have to change numbers in code books from one designation to the other. If you are a cook or a baker you might be dealing with a recipe that states the oven temperature in Celsius but your oven only has Fahrenheit on it. In all cases being able to translate between the two temperature scales in important.

If we are going to change Celsius to Fahrenheit the formula is as follows:

$$^{\circ}\text{Fahrenheit} = {^{\circ}\text{Celsius}} \times \frac{9}{5} + 32$$

There are a couple of things to note here. One is the order the calculation needs to be done. The first thing to be done here is to multiply the degree Celsius by 9/5. After that add the 32.

Doing it this way follows the rules of math and in the next chapter we go through a thorough explanation of those rules. For now just follow the path laid out.

The second thing to note is that the fraction can also be stated as a number. Writing out the formula using a number instead of a fraction would look like this:

$$\text{First:} \quad \frac{9}{5} = 1.8$$

$$\text{Then:} \quad {^{\circ}\text{Fahrenheit}} = {^{\circ}\text{Celsius}} \times 1.8 + 32$$

You can use either of the two formulas as they both end up with the same answer. It just depends on which one you are more comfortable using.

Now let's go through a couple examples.

Example

The temperature of the water in a hot water heater is required to be set at 55°Celsius. Convert this temperature to Fahrenheit.

Step 1: Find the formula to work with.

$$^{\circ}\text{Fahrenheit} = {}^{\circ}\text{Celsius} \times \frac{9}{5} + 32$$

Step 2: Plug the numbers into the formula.

$$^{\circ}\text{Fahrenheit} = {}^{\circ}\text{Celsius} \times \frac{9}{5} + 32$$

$$^{\circ}\text{Fahrenheit} = 55 \times \frac{9}{5} + 32$$

$$^{\circ}\text{F} = 131$$

Example

The approximate flame temperature for natural gas is 1980°Celsius. What is this in Fahrenheit?

Step 1: Find the formula to work with.

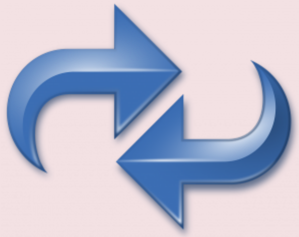
$$^{\circ}\text{Fahrenheit} = {}^{\circ}\text{Celsius} \times 1.8 + 32$$

Step 2: Plug the numbers into the formula.

$$^{\circ}\text{Fahrenheit} = {}^{\circ}\text{Celsius} \times 1.8 + 32$$

$$^{\circ}\text{F} = 1980 \times 1.8 + 32$$

$$^{\circ}\text{F} = 3596$$



Now we have to do the reverse. We have to turn Fahrenheit into Celsius and for that we once again need a formula.

$$^{\circ}\text{Celsius} = (^{\circ}\text{Fahrenheit} - 32) \times \frac{5}{9}$$

Example

An oven is required to be preheated to a temperature of 425°Fahrenheit. What is the corresponding temperature in Celsius?

Step 1: Find the correct formula to work with.

$$^{\circ}\text{Celsius} = (^{\circ}\text{Fahrenheit} - 32) \times \frac{5}{9}$$

Step 2: Plug the numbers into the formula

$$^{\circ}\text{Celsius} = (^{\circ}\text{Fahrenheit} - 32) \times \frac{5}{9}$$

$$^{\circ}\text{C} = (425 - 32) \times \frac{5}{9}$$

$$^{\circ}\text{C} = 218.3$$

Take a close look at the formula for changing Celsius into Fahrenheit:

$$^{\circ}\text{F} = {^{\circ}\text{C}} \times \frac{9}{5} + 32$$

Quite often we are required to remember formulas. But if we are able to relate the numbers to a reason why they are in the formula then remembering the formula can become a lot easier. Going from Celsius to Fahrenheit is a great example.

Take the number 32. Where would you guess that number comes from?

It comes from the difference between Celsius and Fahrenheit when dealing with the freezing point of water. The freezing point in Celsius is 0 and the freezing point in Fahrenheit is 32. Therefore a difference of 32.

How about 9/5? Where might that come from?

Well 9 ÷ 5 = 1.8

The number of degrees in Fahrenheit from freezing to boiling is 180 (212 – 32). In Celsius it's 100. (100 – 0). If you were to take 180 divided by 100 you would get 1.8. 1.8 is simply a ratio between the two. For every 1° Celsius you increase or decrease, you would increase or decrease 1.8° on the Fahrenheit scale.

Practice Questions

Try a couple of practice questions yourself and check the video answers to see how you did.

Question 1

Bonnie is an apprentice chef studying to get her papers. She's been asked to work at a restaurant in Montreal as part of her apprenticeship. A particular recipe she is working on requires the oven to be preheated to 200°Celsius. What is this in Fahrenheit?

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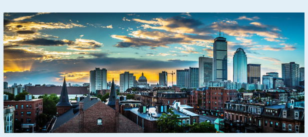
Question 2



Bonnie decides to take a trip to Boston for the weekend which is a 5 hour drive if traffic is good. She checks the weather forecast and it's going to be sunny and about 40° Fahrenheit. What is this in Celsius?

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6.

Pressure Measurements

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Click play on the following audio player to listen along as you read this section.

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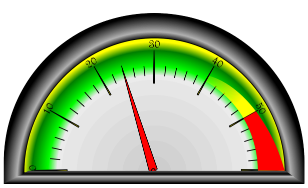
Dealing with the pressures of life can certainly be a balancing act. There is family, work, money and all the other fun stuff that makes up life. How would you describe that pressure?

The pressure we're going to talk about in this section differs from the pressures of everyday life.

The word pressure actually has a few different definitions. The version we are going to work with goes something like this:

Pressure: The force exerted by an object on another object or the force exerted by an object per unit area. That area could be any area you could come up with but for the most part we use a square inch or a square metre.

When dealing with pressure our starting point is going to be pounds per square inch (psi). Pounds per square inch is the imperial version of pressure and the one most of us are most likely familiar with. We use this measurement when dealing with things like pumping up car or bike tires or when dealing with water pressure.



The most common metric version of pressure is known as the Pascal (Pa) and quite often we put Pascals into groups of 1000 and just like the metric system likes to do it's called a kilopascal (kPa). Now as pressure is defined as force per unit area we should define what a Pascal actually is. One Pascal is equal to a pressure of one Newton per metre square (n/m2) where a Newton is a measure of force.

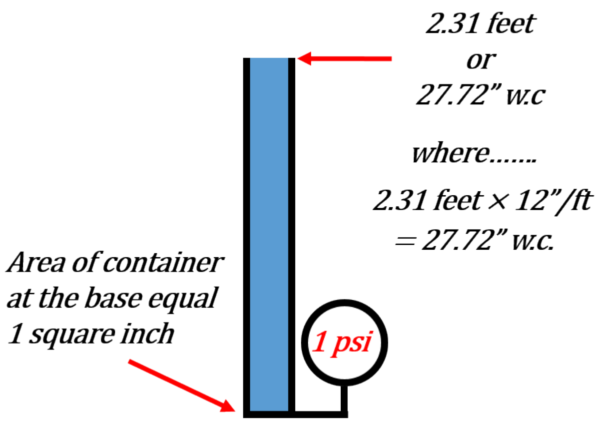
If we want to get technical here is the definition of what a newton is.

Newton: is the force needed to move (or accelerate) an object weighing one kilogram at one metre per second squared.

We can also include pounds in the idea of force where pounds can be defined as a unit of force as well. It is sometimes referred to as pounds-force or lbf.

Whatever the case we basically have our two measurements of force to work with. One being the Pascal (Pa) (or kilopascal(kPa)) and the other being pounds per square inch (psi).

Those are not the only pressure measurements that we'll deal with. Another couple of pressure measurements that are common in the world of trades are inches of water column and feet of head.



Both are in reference to a column of water. The idea is that having a column of water creates a pressure at the base of the column. The higher the column of water the greater the pressure. One pound per square inch is equivalent to having a column of water 2.31 feet in height. The pressure at the base of that column of water would be 1 psi. As it turns out 27.72 inches is equal to 2.31 feet so if we had a column of water 27.72 inches (2.31 feet) we would have a pressure of one pound per square inch at the base of that column of water.

If you are wondering if this will work for other liquids the answer is yes. Inches of mercury (Hg) is another common way to measure pressure.

Inch of mercury (Hg): This one we might actually use as its common when measuring a vacuum. We would be required to measure vacuum for such things as vacuum pumps in medical facilities or to measure vacuum in refrigeration systems. 2.04 inches of mercury is equal to 1 pound per square inch.

Let's throw in another few examples of ways pressure can be expressed.

Bar: Approximately the average pressure at sea level. (It's actually 1.013 Bar). It's also equivalent to 100,000 Pascals.

Torr: Was originally meant to be equal to 1 mmHg but it's not quite that anymore. It is now defined as 1/760 of an atmosphere where one atmosphere is defined as 101.325 kPa. One atmosphere is essentially the pressure at sea level exerted on all objects. You might sometimes also hear it referred to as standard atmospheric pressure. Standard atmospheric pressure is also known to be 14.7 psi.

In any event a Torr is roughly equal to 133.32 Pascals.

Let's put all the main players when dealing with pressure into a table with the starting point being one pound per square inch.

One pound per square inch equals:

- 6.895 kilopascals (kPa)
- 2.04 inches of mercury (Hg)
- 2.31 feet of head (ft/hd) (water)
- 27.72 inches of water column (″ w.c.)

As we have done in the previous parts of the chapter it's time to go through some examples working between these numbers.

Example

How many kilopascals are there in 10 psi?

Step 1: Find the number that works for kilopascals and psi. In this case:

$$1\,\text{psi} = 6.895\,\text{kilopascals}$$

Step 2: As usual build a ratio

$$\frac{1\,\text{psi}}{10\,\text{psi}} = \frac{6.895\,\text{kPa}}{\text{X}\,\text{kPa}}$$

Step 3: Cross multiply

$$\frac{1\,\text{psi}}{10\,\text{psi}} = \frac{6.895\,\text{kPa}}{\text{X}\,\text{kPa}}$$

$$1 \times \text{X} = 10 \times 6.895$$

$$\text{X} = 68.95$$

$$\text{Answer} = 68.95\,\text{kPa}$$

Example

How many pounds per square inch are there in 150 kilopascals?

Step 1: Find a number that works for kilopascals and psi.

$$1\,\text{psi} = 6.895\,\text{kilopascals}$$

Step 2: Build a ratio.

$$\frac{1\,\text{psi}}{\text{X}\,\text{psi}} = \frac{6.895\,\text{kPa}}{150\,\text{kPa}}$$

Step 3: Cross multiply.

$$\frac{1\,\text{psi}}{\text{X}\,\text{psi}} = \frac{6.895\,\text{kPa}}{150\,\text{kPa}}$$
$$1 \times 150 = \text{X} \times 6.895$$
$$\text{X} = \frac{150}{6.895} = 21.75$$
$$\text{Answer} = 21.75\,\text{psi}$$

Example

A column of water has a pressure at the base of 14 pounds per square inch. What is that pressure in feet of head (ft/hd)?

Step 1: Find a number that works for psi and feet of head.

$$1\,\text{psi} = 2.31\,\text{feet of head}$$

Step 2: Build a ratio.

$$\frac{1\,\text{psi}}{14\,\text{psi}} = \frac{2.31\,\text{ft/hd}}{\text{X}\,\text{ft/hd}}$$

Step 3: Cross multiply.

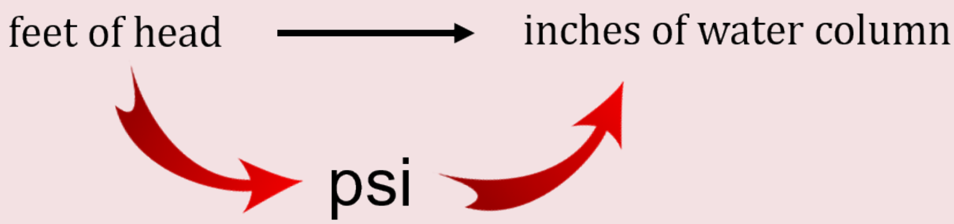
$$\frac{1\,\text{psi}}{14\,\text{psi}} = \frac{2.31\,\text{ft/hd}}{\text{X}\,\text{ft/hd}}$$
$$1 \times \text{X} = 14 \times 2.31$$
$$\text{X} = 32.34$$
$$\text{Answer} = 32.34\,\text{ft/hd}$$

Now change that feet of head into inches of water column.

Step 1: Find a number that works between feet of head and inches of water column.

Do you see a problem? The issue here is that we don't have a number than translates between the two of them. Although we could figure this number out mathematically it would mean that in the end we would have a lot more numbers to remember.

The solution here is to find a number that they both relate to and that number is pounds per square inch. What we can then do is go from feet of head to pounds per square inch and then from pounds per square inch to inches of water column.



Step 2 (really step 1): We first need to change the feet of head to psi.

$$1\,\text{psi} = 2.31\,\text{feet of head}$$

Step 3: Build a ratio.

$$\frac{1\,\text{psi}}{\text{X}\,\text{psi}} = \frac{2.31\,\text{ft}/\text{hd}}{32.34\,\text{ft}/\text{hd}}$$

Step 4: Cross Multiply.

$$\frac{1\,\text{psi}}{\text{X}\,\text{psi}} = \frac{2.31\,\text{ft}/\text{hd}}{32.34\,\text{ft}/\text{hd}}$$

$$1 \times 32.34 = \text{X} \times 2.31$$

$$\text{X} = \frac{32.34}{2.31} = 14$$

$$\text{Answer} = 14\,\text{psi}$$

What you'll notice here is that we are back to where we started from. We actually just proved that our first calculation was correct.

Step 5: Change the pounds per square inch into inches of water column. Find the number that translates between those two.

$$1\,\text{psi} = 27.72\ ''\text{w.c.}$$

Step 6: Build a ratio.

$$\frac{1\text{ psi}}{14\text{ psi}} = \frac{27.72\text{ ''w.c.}}{\text{X ''w.c.}}$$

Step 7: Cross multiply.

$$\frac{1\text{ psi}}{14\text{ psi}} = \frac{27.72\text{ ''w.c.}}{\text{X ''w.c.}}$$

$$1 \times \text{X} = 14 \times 27.72$$

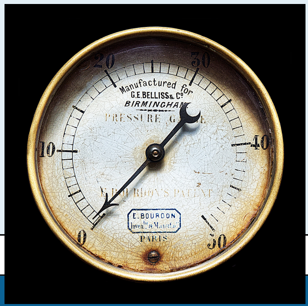
$$\text{X} = 388.08$$

$$\text{Answer} = 388.08\text{ ''w.c.}$$

Practice Questions

Try a couple of practice questions yourself and check the video answers to see how you did.

Question 1



Adam and Riley are both gas fitters and today they are installing a new boiler in a warehouse. They checked the gas pressure gauge leading into the warehouse and it reads 34.5 kilopascals. What is that in pounds per square inch?

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Question 2

Zhang Wei is a plumber originally from China. He is now a plumber in Canada and has decided to specialize in hydronic heating. He is required to buy a circulating pump that puts out 32 feet of head. As he is used to working in pounds per square inch he wants to translate 32 feet of head into psi. How many psi is going to be required from the pump?

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7.

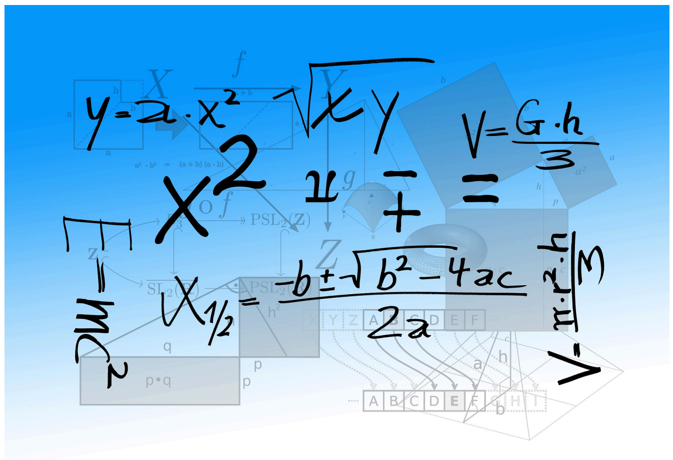
Practice Quiz

An interactive H5P element has been excluded from this version of the text. You can view it online here: https://pressbooks.nscc.ca/mathfortradesv2/?p=93#h5p-1

If using the print, PDF, or eBook copy of this book, navigate to the above link to complete the quiz. However, the quiz questions are also provided in Appendix A at the end of the book for offline use.

II

Working with Equations



Outcomes

- Understand key terms when it comes to equations
- Order of Operation
- Transposing Equations

8.

The Basics of Equations and Formulas

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9.

Order of Operations

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What does it mean when we talk about “order of operations” in math? Well the order of operations are a set of rules that need to be followed when dealing with math equations. Why do we need rules you ask? If there were no rules then you might end up with two different answers to the same math question.

Take a look at the following equation and calculate what you think the answer would be.

$$5+4\times 3=?$$

$$\begin{aligned}\text{Option A}\quad \text{Start with:}\quad & 5+4=9\\ \text{Then:}\quad & 9\times 3=27\end{aligned}$$

$$\begin{aligned}\text{Option B}\quad \text{Start with:}\quad & 4\times 3=12\\ \text{Then:}\quad & 12+5=17\end{aligned}$$

The idea here is that you can’t have two answers for the same question. That just won’t work in math. One of the two answers must be correct and in both options the actual math (by that I mean if you plugged the numbers into a calculator) is correct. No mistakes were made. The issue is that the order of operations in one of the options is wrong.

And the correct answer is… Option B.

The next question then becomes “what are the rules to follow when dealing with equations?”

This is where the term “BEDMAS” comes into play.

Bedmas

Bedmas is an acronym used to identify the order of operations when dealing with math. When you have equations that use different operations such as addition, subtraction, multiplication, and division, BEDMAS sets out the order to do those calculations.

The example above shows us that having these guidelines will make sure that we don't get the wrong answer when working through math problems.

BEDMAS

- Brackets
- Exponents
- Division
- Multiplication
- Addition
- Subtraction

Bedmas tells us the order of operations when performing calculations within an equation. For example we multiply before we add which in turn is done before we subtract.

We should all be familiar with division, multiplication, addition and subtraction at this point but what about dealing with brackets and exponents? What are they and how do they work?

Brackets are the first order of business in Bedmas and look like the following:

$$[\quad\quad]$$

Sometimes brackets can also be referred to as "parenthesis" and you may see the acronym PEDMAS used instead of BEDMAS. It means the same thing, and the symbol for parenthesis looks like the following:

$$(\quad\quad)$$

You can look at brackets as a mechanism that is used to group numbers or symbols together. The calculations within the brackets (or parenthesis) are then the first to be done.

For example:

$$\mathrm{Z} = 4 \times 2 \times (5 \times 9)$$

This situation would indicate the first calculation we perform is 5×9. Then we would work through the rest of the equation.

Exponents are the second order of operation in Bedmas. Have you ever looked at a math problem and seen the following?

$$\mathrm{D} = 4 + 8 \times 5 - 3 + 9^3$$

Well the 9^3 is what we are talking about when dealing with exponents. Specifically we are dealing with the 3 portion.

Exponents tell you how many times you multiply a number by itself within an equation. In this case the 3 indicates that we multiply the 9 three times.

$$9^3 = 9 \times 9 \times 9$$

We can look at another example to see how exponents work.

$$5^6 = 5 \times 5 \times 5 \times 5 \times 5 \times 5$$

After brackets and exponents we move onto dividing, multiplying, adding and subtracting.

Let’s we go through a couple of examples to see if you get the idea.

Example

$$\mathrm{A} = 1 + 2 \times 6 \div 3$$

Although we won’t include this in the steps to answer the question, the first thing you might want to do is write down Bedmas so you can refer to it visually.

- **B**rackets
- **E**xponents
- **D**ivision
- **M**ultiplication
- **A**ddition
- **S**ubtraction

Step 1: There are no brackets in this equation and no exponents either. The first calculation we come to is division.

$$A = 1 + 2 \times \mathbf{6} \div \mathbf{3}$$

$$6 \div 3 = 2$$

$$\text{So now we have:}$$

$$A = 1 + 2 \times 2$$

Step 2: Move on to the next step in Bedmas which is multiplication.

$$A = 1 + \mathbf{2} \times \mathbf{2}$$

$$2 \times 2 = 4$$

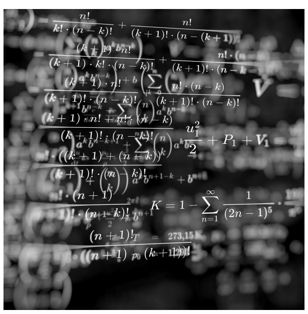
$$\text{So now we have:}$$

$$A = 1 + 4$$

Step 3: We only have one more operation to go so we are nearing the end. Just add the one and four and we have our answer.

$$A = 1 + 4$$

$$A = 5$$



You can now see that if you didn't follow the rules for order of operations, things could get a little fuzzy. There might be a few different answers you could come up with. Could you imagine writing a multiple-choice math exam where every answer seems to be right depending on how you did the math?

This is the importance of BEDMAS!

We're probably at the point now where a few more examples are in order.

Example

Solve for Y.

$$Y = (24 + 36) \times 2 + 4^2$$

Step 1: Refer to BEDMAS. Work through the brackets first.

$$\mathrm{Y} = \mathbf{(24 + 36)} \times 2 + 4^2$$

$$24 + 36 = 60$$

$$\mathrm{Y} = 60 \times 2 + 4^2$$

Step 2: Deal with the exponents next.

$$\mathrm{Y} = 60 \times 2 + \mathbf{4^2}$$

$$4^2 = 4 \times 4 = 16$$

$$\mathrm{Y} = 60 \times 2 + 16$$

Step 3: Work through the multiplying.

$$\mathrm{Y} = \mathbf{60} \times \mathbf{2} + 16$$

$$60 \times 2 = 120$$

$$\mathrm{Y} = 120 + 16$$

Step 4: The last step in this question is to do the addition.

$$\mathrm{Y} = 120 + 16$$

$$\mathrm{Y} = 136$$

$$\text{Final Answer: } \mathrm{Y} = 36$$

Once you go through a few questions and learn to work things out using Bedmas, working through any math equation or formula becomes routine. After a while, you will just naturally know the steps to take.

Example

Solve for M.

$$\mathrm{M} = 17^2 \times 24 + 13 + 7 \times (45 \div 5)$$

Step 1: Work through the brackets first.

$$\mathrm{M} = 17^2 \times 24 + 13 + 7 \times \mathbf{(45 \div 5)}$$
$$45 \div 5 = 9$$
$$\mathrm{M} = 17^2 \times 24 + 13 + 7 \times 9$$

Step 2: Deal with the exponents next.

$$\mathrm{M} = \mathbf{17^2} \times 24 + 13 + 7 \times (45 \div 5)$$
$$17^2 = 17 \times 17 = 289$$
$$\mathrm{M} = 289 \times 24 + 13 + 7 \times 9$$

Step 3: Work through the multiplying.

$$\mathrm{M} = \mathbf{289} \times \mathbf{24} + 13 + \mathbf{7} \times \mathbf{9}$$
$$289 \times 24 = 6936$$
$$7 \times 9 = 63$$
$$\mathrm{M} = 6939 + 13 + 63$$

Step 4: Complete the addition.

$$\mathrm{M} = 6939 + 13 + 63$$
$$\mathrm{M} = 7012$$
$$\text{Final Answer: } \mathrm{M} = 7012$$

Practice Questions

Try a couple practice questions for yourself and check the video answers to see how you did.

Question 1

Solve for D.

$$\mathrm{D} = 5 + 6 \div 2 \times 7 + 4^3 \times (5 + 7)$$

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Question 2

Solve for R.

$$\mathrm{M} = 17 + (6 \times 3) + 5^2 \div 5 - 22$$

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10.

Transposing Equations

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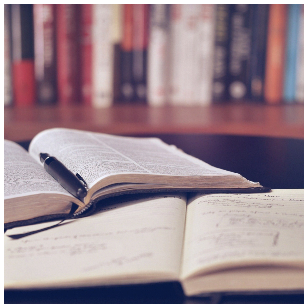


Have you ever come across a situation during your math studies where you're required to solve for a variable which doesn't seem to be in the right place? Take a look at the following example to see what I mean.

$$A = B^2 \times 0.7854 \times H$$

In a perfect world, you would like to solve for "A" and at the same time be given the values of both "B" and "H."

But what if you were given "A" and you had to solve for "B"? How would you go about doing this?

The idea here would be to move the variables around and isolate "B." What this means is that "B" is on one side of the equation by itself, and everything else is on the other side. Take a look at the equation again when this has been done.

$$B = \sqrt{\frac{A}{.7854 \times H}}$$

Changing the formula around is referred to as "transposing" an equation.

It's not as simple as just moving stuff around though. There are rules to get to this point, and those rules and their application are what we are going to deal with in this part of the chapter.

Rule #1! El Rule Grande! La ruele!

The most important thing to remember when transposing equations is that whatever is done to one side of the equation must also be done to the other side of the equation.

If you look at it mathematically, this makes sense. We already determined that an equation is two mathematical expressions that are separated by an equal sign.

What this means is the addition, subtraction, division, and multiplication variables and constants on one side of the equation are equal to all the addition, subtraction, division, and multiplication variables on the other side of the equation.

So if you decide to add 5 to one side, you must add 5 to the other side. What this does is keep the equation equal.

Take a look at the following example.

$$10 + 7 = 9 + 8$$

This works out to be:

$$17 = 17$$

Here we have an equation that is true. Now add 5 to the left hand side of the equation, and you'll see that, in order to keep the equation true, you'll have to add 5 to the right hand side of the equation.

$$10 + 7 + \mathbf{5} = 9 + 8 + \mathbf{?}$$

$$22 = 9 + 8 + ?$$

$$22 = 9 + 8 + \mathbf{5}$$

$$22 = 22$$

Keep in mind that this is an example where we **added** to one side. If we had **subtracted**, **divided**, or **multiplied,** things would be different. We would have to do the same thing to the other side.

Transposing Equations Using Addition and Subtraction

Start with a simple equation.

$$7+2=8+1$$
$$\text{This works out to be:}$$
$$9=9$$

Then add 4 to one side of the equation and solve.

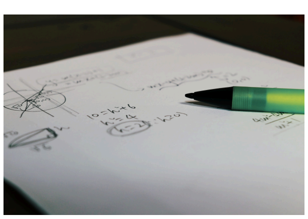
$$7+2+4=8+1+\ ?$$

As the left hand side of the equation has had 4 added to it, the right hand side of the equation also has to have 4 added to it. We get:

$$7+2+\mathbf{4}=8+1+\mathbf{?}$$
$$13=9+\ ?$$
$$13=9+\mathbf{4}$$
$$13=13$$

As stated before, the rule is that whatever you do to one side you must do to the other. In this case, if we add 4 to one side then we have to add 4 to the other side to keep it equal.

Subtraction would work the same way. If we were to subtract 4 from one side we would have had to subtract 4 from the other side in order to keep it equal.



Let's try out this concept with an equation that has an unknown variable in it. Take a look at the following equation and solve for "J."

$$7+\mathrm{J}=5+8$$

In order to solve for "J" we must isolate "J" on one side of the equation, and it actually doesn't matter which side we isolate "J" on. If we follow our rule, in order to isolate "J" we would have to get rid of the 7 on the left side. The question becomes, how is that done? What we essentially have to do is move the 7 from the left side to the right side.

$$7 + \mathrm{J} = 5 + 8$$

Once again, we always have to keep in mind that whatever we do to one side, we must do to the other.

Start with this. Would you agree that **7 − 7 = 0?**

What if we subtracted 7 from the left hand side of the equation? What we would be left with is just “J” on the left side, which solves the problem of isolating “J.”

$$\mathbf{(7 - 7)} + \mathrm{J} = 5 + 8$$
$$0 + \mathrm{J} = 5 + 8$$
$$\mathrm{J} = 5 + 8$$

Mathematically this is not correct yet as we only dealt with the left side of the equation. What we need to do now is to do the same thing to the right side and then solve the equation. So we end up subtracting 7 from the right side of the equation to make everything equal once again.

$$(7 - 7) + \mathrm{J} = 5 + 8 - 7$$
$$0 + \mathrm{J} = 13 - 7$$
$$\mathrm{J} = 13 - 7$$
$$\mathrm{J} = 6$$

You can always check that your answer is correct by taking the answer and putting it back in the equation to replace the variable.

$$\begin{aligned} &\text{Replace J with 6} \\ &\qquad\qquad\quad\downarrow \\ 7+\mathrm{J} &= 5+8 \\ 7+6 &= 5+8 \\ 13 &= 13 \end{aligned}$$

Example

Solve for G.

$$27+\mathrm{G}=43+49$$

Step 1: Isolate the variable you are trying to find. In this case "G." In order to do this, we must remove the 27 from the left side of the equation. This is done by subtracting 27 from the left side and then also from the right side.

$$27+\mathrm{G}=43+49$$
$$\mathbf{(27-27)}+\mathrm{G}=43+49-\mathbf{27}$$

Step 2: Work through the equation.

$$(27-27)+\mathrm{G}=43+49-27$$
$$0+\mathrm{G}=92-27$$
$$\mathrm{G}=65$$

Step 3: Check your answer.

$$\begin{aligned} &\text{Replace G with 65} \\ &\qquad\qquad\qquad\quad\downarrow \\ 27 + \mathrm{G} &= 43 + 49 \\ 27 + 65 &= 43 + 49 \\ 92 &= 92 \end{aligned}$$

Example

Solve for H.

$$\mathrm{H} - 16 = 13 + 19$$

Step 1: Isolate the variable you are trying to find. In this case "H." In order to do this we must remove the 16 from the left side of the equation. This is done by adding 16 to the left hand side of the equation and then also adding 16 to the right hand side of the equation.

$$\mathrm{H} - 16 = 13 + 19$$
$$\mathrm{H} + \mathbf{(-16 + 16)} = 13 + 19\mathbf{+16}$$

Step 2: Work through the equation.

$$\mathrm{H} + (-16 + 16) = 13 + 19 + 16$$
$$\mathrm{H} + 0 = 32 + 16$$
$$\mathrm{H} = 48$$

Step 3: Check your answer.

$$\text{Replace H with 48}$$
$$\downarrow$$
$$H - 16 = 13 + 19$$
$$48 - 16 = 13 + 19$$
$$32 = 32$$

Practice Questions

Now it's time to do a couple of practice questions for yourself. Make sure to check the video answers to see how you did.

Question 1

Solve for S.

$$142 + S = 198 + 257$$

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Question 2

Solve for Y.

$$Y - 22 = 51 + 53$$

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Transposing Equations Using Multiplication and Division

Transposing equations using multiplication and division uses the same basic principle as addition and subtraction in that whatever you do to one side you must do to the other.

Before we dive into this part of the chapter, we should refresh our memories a little and talk about reciprocals as it relates to math. Take a look at the following two numbers with one being a whole number and the other a fraction.

$$4 \text{ and } \frac{1}{4}$$

Don’t forget that when we write the number 4, we could also write it as:

$$\frac{4}{1}$$

Do you remember what will happen if we multiplied those two together?

$$4 \times \frac{1}{4} = \frac{4}{4} = 1$$

Reciprocals are numbers that when multiplied together equal 1. This is an important concept when transposing using multiplication and division. If we divide a number by its reciprocal and end up with one, we have essentially removed that number from the equation.

Here is an example. Solve for K.

$$8 \times \mathrm{K} = 14 \times 17$$

Similar to transposing equations with addition and subtraction, the first thing to do is to isolate the variable we are trying to find. In this case, “K.” This means that the 8 needs to be removed from the left hand side of the equation. Multiplying 8 by its reciprocal will give us a value of 1. Perfect!

$$8 \times \frac{1}{8} = \frac{8}{8} = 1$$

Now adding this information to the equation, we would end up with this:

$$8 \times \frac{1}{8} = \frac{8}{8} = 1$$

$$\frac{\mathbf{1}}{\mathbf{8}} \times 8 \times \mathrm{K} = 14 \times 17$$

$$\frac{8}{8} \times \mathrm{K} = 14 \times 17$$

$$1 \times \mathrm{K} = 14 \times 17$$

$$\mathrm{K} = 14 \times 17$$

This would leave us with 1 × K on the left hand side of the equation which would end up being just "K" when multiplied together. This is exactly what we are looking for. We are not quite finished yet though. Now back to the golden rule.

Whatever you do to one side of the equation you must do to the other. Therefore, as we multiplied the left hand side of the equation by ⅛ we need to multiply the right hand side of the equation by ⅛.

$$\frac{1}{8} \times 8 \times \mathrm{K} = 14 \times 17 \times \frac{1}{8}$$

So now if we followed this through we would end up with:

$$\frac{\mathbf{1}}{\mathbf{8}} \times 8 \times \mathrm{K} = 14 \times 17 \times \frac{\mathbf{1}}{\mathbf{8}}$$

$$\frac{8}{8} \times \mathrm{K} = \frac{238}{8}$$

$$\mathrm{K} = 29.75$$

We should do a check of the answer like we did previously to see if we are correct.

$$\begin{aligned} &\text{Replace K with 29.75} \\ &\qquad\qquad\qquad\qquad\downarrow \\ 8 \times \mathrm{K} \; &= 14 \times 17 \\ 8 \times 29.75 \; &= 14 \times 17 \\ 238 \; &= 238 \end{aligned}$$

Example

We'll try another example, but this time we'll deal with fractions that will have to be moved around. We'll also start to do this in steps as we have done with previous questions.

Solve for L.

$$\frac{4}{9} \times \mathrm{L} = 12 \times 12$$

Step 1: Isolate L. In this case, we have to move the 4/9 from one side to the other. In order to do this we have to multiply both sides by the reciprocal of 4/9. This will essentially remove 4/9 from the left hand side of the equation. The reciprocal is of 4/9 is 9/4.

$$\frac{4}{9} \times \frac{9}{4} = \frac{36}{36} = 1$$

Therefore we get:

$$\frac{4}{9} \times \frac{9}{4} \times \mathrm{L} = 12 \times 12 \times \frac{9}{4}$$

Step 2: Solve the equation

$$\frac{4}{9} \times \frac{9}{4} \times \mathrm{L} = 12 \times 12 \times \frac{9}{4}$$

$$1 \times \mathrm{L} = 144 \times \frac{9}{4}$$

$$\mathrm{L} = \frac{1296}{4}$$

$$\mathrm{L} = 324$$

Step 3: Confirm your answer

$$\text{Replace L with 324}$$
$$\downarrow$$
$$\begin{aligned}\frac{4}{9}\times \mathrm{L} &= 12\times 12\\ \frac{4}{9}\times 324 &= 12\times 12\\ \frac{1296}{9} &= 144\\ 144 &= 144\end{aligned}$$

Example

This one is a bit more challenging. You'll note in the question that there are no numbers, only letters. Take a look at the question, and see if you can come up with any ideas on how you would solve this equation.

Solve for "D" in the following equation.

$$\frac{\mathrm{A}}{\mathrm{B}}=\frac{\mathrm{C}}{\mathrm{D}}$$

Step 1: Determine which variable you must isolate. In this case it's given for us and it's "D."

$$\frac{\mathrm{A}}{\mathrm{B}}=\frac{\mathrm{C}}{\mathbf{D}}$$

The challenge here is that "D" is in the denominator (bottom) of the fraction. If we were to isolate it but it was still in the denominator of a fraction we would not have something that we could work with.

When "D" is isolated it must not only be by itself on one side of the equation but also appear as a whole number and not as the denominator of a fraction.

Step 2: To make this process easier break the equation down to look like the following.

$$\frac{A}{1} \times \frac{1}{B} = \frac{C}{1} \times \frac{1}{D}$$

Remember that:

$$\frac{A}{1} \times \frac{1}{B} = \frac{A}{B}$$

We haven't really changed anything mathematically we have just made the equation into something that is easier to work with.

Step 3: Isolate "D." In order to do this we must remove "C" from the right hand side of the equation. Do this by multiplying both the right and left hand side by 1/C.

$$\mathbf{\frac{1}{C}} \times \frac{A}{1} \times \frac{1}{B} = \frac{C}{1} \times \frac{1}{D} \times \mathbf{\frac{1}{C}}$$

Now this might start looking a little bit complicated but if you follow it through you'll start to see the answer form. Look at the right hand side of the equation. It now has both and C/1 and a 1/C. Multiplying those reciprocals together you get 1 and effectively take out the "C" on the right hand side.

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

So we end up with:

$$\frac{1}{C} \times \frac{A}{1} \times \frac{1}{B} = 1 \times \frac{1}{D}$$

If we wanted to simplify this we could just do the following:

$$\frac{A}{C \times B} = \frac{1}{D}$$

Step 4: Get D into the numerator of the equation. What we need to do will take a little bit of math and some patience. We need to follow the same rules that we have been following.

The idea here is to multiply each side by D/1. This will make the right hand side of the equation equal to 1 but now the left hand side of the equation will have D in the numerator.

$$\frac{D}{1} \times \frac{A}{C \times B} = \frac{1}{D} \times \frac{D}{1}$$

$$\frac{D}{1} \times \frac{A}{C \times B} = 1$$

What you'll notice is that it actually creates more work but we have managed to get "D" into the numerator of the equation. The only problem is that we also have a bunch of other stuff on the same side as "D" and now our job becomes getting rid of all that stuff.

Now all we have to do is follow the rules and get the A, B and C over to the right hand side and isolate D. I'll do this simply and in one quick calculation.

$$\frac{D}{1} \times \frac{A}{C \times B} \times \frac{C \times B}{A} = \frac{C \times B}{A}$$

What we end up with is:

$$D = \frac{C \times B}{A}$$

There is a lot of math involved there but if you follow the rules and go one step at a time you'll eventually get there. My suggestion here is that you go over what we just went through a couple times before moving on. Understanding the math involved here is quite important when it comes to transposing formulas and equations.

At this point you might be wondering if there was a shortcut and as luck would have it there is for this procedure which I'll go through now.. We'll start with an example.

Take the following equation:

$$\frac{3}{4} = \frac{3}{4}$$

This equation is true. Now take each of the fractions and flip them around.

$$\frac{4}{3} = \frac{4}{3}$$

It seems that if you flip both fractions around then the equation is still true. Mathematically you are doing the same thing to one side as you are doing to the other. There is a lot of math involved here but the main point is that if you were to do all the math you would end up with the same answer.

How we can use this to help us simplify our question is to just do the following. Remember we started with:

$$\frac{A}{B} = \frac{C}{D}$$

We needed to isolate D but the main problem (and the thing that causes us to do a lot of work) was that D was in the denominator and we needed it in the numerator.

Through our math wizardry we can get D into the numerator by just flipping around the left hand fraction. Whatever we do to that side we then must do to the right side. What we end up with is:

$$\frac{B}{A} = \frac{D}{C}$$

All we need to do now is get C out of the left hand side by multiplying it by C/1 and then doing the same thing to the left hand side.

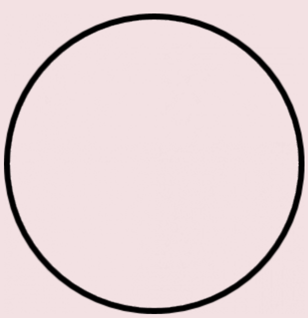
$$\frac{C}{1} \times \frac{B}{A} = \frac{D}{C} \times \frac{D}{1}$$

We end up with…

$$\frac{C \times B}{A} = D$$

Now to take all that in in one shot might be a little much so you may want to go back and reread that whole explanation. But always keep in mind the math that goes along with that.

Example



In this example, we are going to use the formula for the area of a circle. Calculating the area of a circle is actually something we are going to do further into this volume, but for now we are just going to deal with the formula itself.

$$\text{Area of a circle}$$
$$A = D^2 \times 0.7854$$
$$\begin{aligned} \text{Where:} \quad & A = \text{area of the circle} \\ & D = \text{diameter of the circle} \end{aligned}$$

Solving for the area of the circle would be pretty straight forward but as we are dealing with transposing equations in this section what we'll do is solve for the diameter (D).

Step 1: Identify the variable you are trying to solve for.

$$A = \mathbf{D^2} \times 0.7854$$

From this you can see we have a couple problems we have to deal with. The first one is that we have to isolate D. The second one is that D has the exponent 2 attached to it so we have to somehow eliminate that.

Step 2: Isolate D.

For this we have to move the 0.7854 from the right hand side of the equation to the left hand side. We simply follow the rules we have used up to this point.

$$\frac{\mathbf{1}}{\mathbf{0.7854}} \times \mathrm{A} = \mathrm{D}^2 \times 0.7854 \times \frac{\mathbf{1}}{\mathbf{0.7854}}$$

$$\frac{\mathrm{A}}{0.7854} = \mathrm{D}^2 \times \frac{0.7854}{0.7854}$$

$$\frac{\mathrm{A}}{0.7854} = \mathrm{D}^2 \times 1$$

$$\frac{\mathrm{A}}{0.7854} = \mathrm{D}^2$$

That takes care of the first problem. Now we have to tackle the D^2 issue.

Step 3: Remove the exponent from D.

Once again we go back to our original rule. Whatever you do to one side you must to the same thing to the other side.

We have to refer to the video that you watched earlier in this section regarding exponents and square roots. We'll do a quick refresher before we solve for D.

Remember that:

$$\mathrm{D}^2 = \mathrm{D} \times \mathrm{D}$$

$$\text{and...}$$

$$\sqrt{\mathrm{D} \times \mathrm{D}} = \mathrm{D}$$

So what we see is that if you square root a number that is squared (has an exponent of 2) you end up with the number itself. I'll quickly show you with numbers.

$$4^2 = 4 \times 4$$

$$4^2 = 16$$

$$\sqrt{16} = \sqrt{4 \times 4}$$

$$\sqrt{16} = 4$$

Having gone through all that we can now solve the problem.

$$\sqrt{\frac{A}{0.7854}} = \sqrt{D^2}$$

$$\sqrt{\frac{A}{0.7854}} = D$$

Practice Questions

Now it's time to do a couple of practice questions for yourself. Make sure to check the videos answer to see how you did.

Question 1

Solve for B.

$$\frac{A \times B}{C} = \frac{D \times E}{F}$$

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Question 2

Solve for C.

$$\frac{A \times B}{C} = \frac{D \times E}{F}$$

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11.

Practice Quiz

An interactive H5P element has been excluded from this version of the text. You can view it online here: https://pressbooks.nscc.ca/mathfortradesv2/?p=122#h5p-2

If using the print, PDF, or eBook copy of this book, navigate to the above link to complete the quiz. However, the quiz questions are also provided in Appendix A at the end of the book for offline use.

III

Perimeter and Area

Outcomes

- Calculate the perimeter of a square, rectangle, and polygon
- Calculate the perimeter of a circle
- Calculate the area of a square, rectangle, and triangle
- Calculate the area of a circle and cylinder

12.

Perimeter

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Click play on the following audio player to listen along as you read this section.

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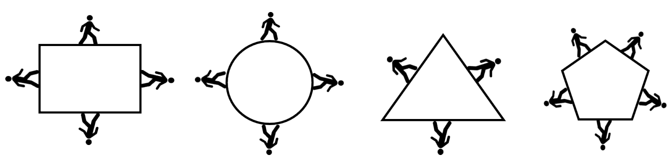
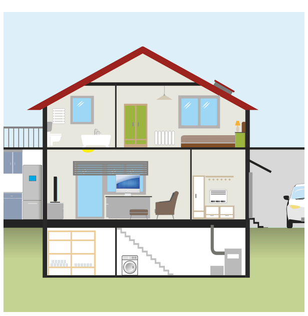
What does the word perimeter refer to? What if someone asked you to walk the perimeter of a baseball field? What does that mean?

Perimeter: A perimeter is a path that surrounds a two-dimensional object. The word comes from the Greek peri (around) and metre (measure). The term may be used either for the path or its length – it can be thought of as the length of an outline of a shape. The perimeter of a circle is called its circumference.

If you were to walk the perimeter of a baseball field you would walk around the outer edges of the field and calculate the length. If you wanted to find the perimeter of anything it would basically be like walking around the outer edge of it. Obviously we can't do that for smaller shapes or objects but you get the idea.



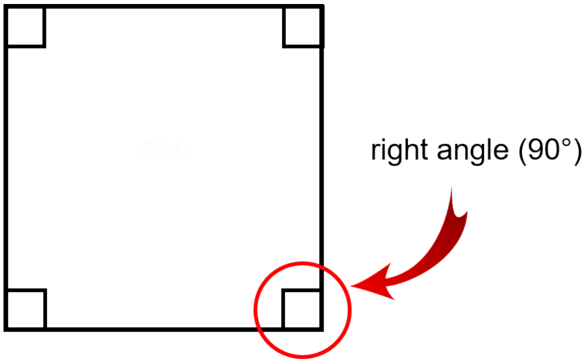
When calculating perimeter the answer will always be a linear (or one dimensional) measurement such as feet, inches, metres or centimetres.



Why would perimeter be important to us in the construction world?

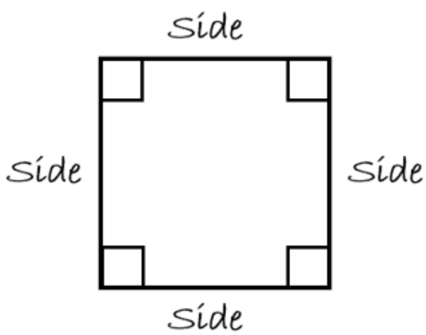
Let's say you are a carpenter and you want to put baseboard in a room. Calculating how much baseboard you need around the walls involves calculating the perimeter of the room. This would also be true for plumbers if they are putting perimeter drain around a house. Perimeter can be used in many different areas of the construction world.

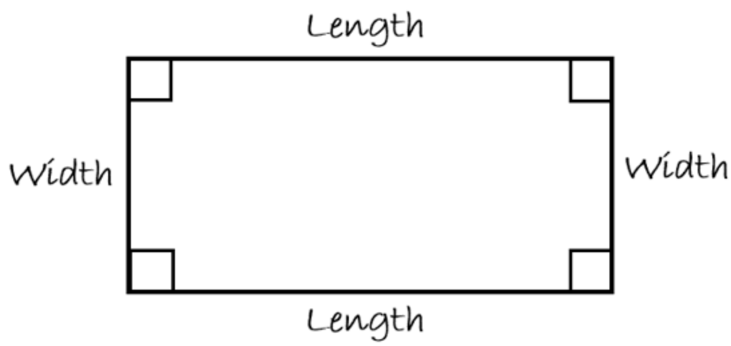
The Perimeter of a Square and a Rectangle



A square and a rectangle are both similar in that they have four sides. Another characteristic that is common to both is each has four right angles. A right angle is an angle of 90 degrees.

In a square, all four sides are equal while in a rectangle the opposite sides are equal but not the adjacent sides. Calculating the perimeter of a square and a rectangle is very similar. First we'll define what each side is called.





The square is straight forward as the length of each of the sides is the same, and the name of each side is simply "SIDE." In a rectangle, the long side of the rectangle is referred to as the "LENGTH" while the shorter side is referred to as the "WIDTH."

Before I go through calculating perimeter of a square and rectangle, take a guess at what the formula might be.

Square	**Rectangle**
Perimeter = ________________	Perimeter = _____________________

CONTINUE BELOW

If we go back to our definition and say that the perimeter is the length that surrounds a two dimensional object, then the perimeter of both would be the length of the four sides combined.

$$\begin{array}{ll}\textbf{Square:} & \text{Perimeter} = \text{side} + \text{side} + \text{side} + \text{side} \\ \textbf{Rectangle:} & \text{Perimeter} = \text{length} + \text{width} + \text{width} + \text{length}\end{array}$$

Would there be any other way to express the two formulas?

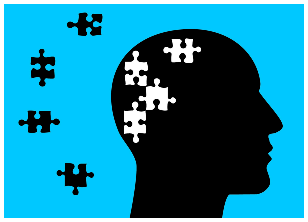
Take a guess.

Square	Rectangle
Perimeter = ________________	Perimeter = _____________________

CONTINUE BELOW

$$\begin{array}{ll}\textbf{Square:} & \text{Perimeter} = \text{side} \times 4 \\ \textbf{Rectangle:} & \text{Perimeter} = (\text{length} \times 2) + (\text{width} \times 2)\end{array}$$

Both versions of each formula are correct and you can use whichever you choose to answer questions.



This might be a good time to stop and discuss memorization.

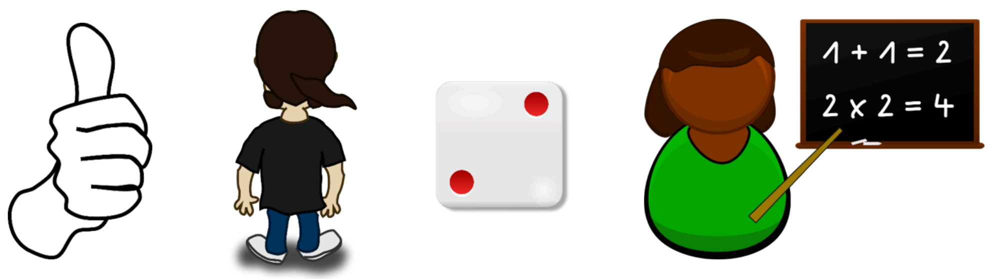
Memorization is a topic that comes up quite frequently in math. Students often ask if they have to memorize formulas and for the most part the answer is yes.

Memorizing formulas can become time consuming and can also take up a lot of your brain power.

The problem that occurs when students memorize formulas is they often forget what the formula represents. Students get really good at plugging numbers into formulas but they don't really understand what the formula does.

If the numbers were to change or the question was asked in a different manner than normal the student might become lost.

You might want to think about the following. Every time you get a formula, instead of memorizing that formula try to VISUALIZE that formula. What I mean by that is visualize what the formula represents. Hopefully it will become easier for you to work with the formula and easier for your brain to recall the formula when needed.



OKAY BACK TO MATH

Example

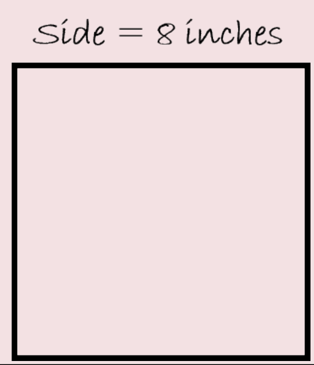
Find the perimeter of a square which has a side measuring 8 inches.

Step 1: Write down the formula.

$$\text{Perimeter} = \text{side} + \text{side} + \text{side} + \text{side}$$

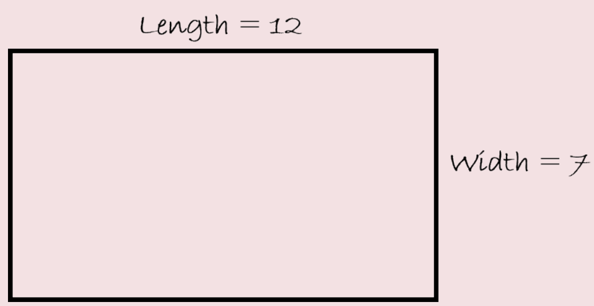
Step 2: Solve for perimeter.

$$\text{Perimeter} = 8 + 8 + 8 + 8$$
$$\text{Perimeter} = 32\,\text{inches}$$



Example

Find the perimeter of a rectangle if the length is 12 and the width is 7.



Step 1: Write down the formula

$$\text{Perimeter} = (\text{length} \times 2) + (\text{width} \times 2)$$

Step 2: Solve for perimeter

$$\text{Perimeter} = (7 \times 2) + (12 \times 2)$$
$$\text{Perimeter} = 14 + 24$$
$$\text{Perimeter} = 38$$

The Perimeter of a Polygon

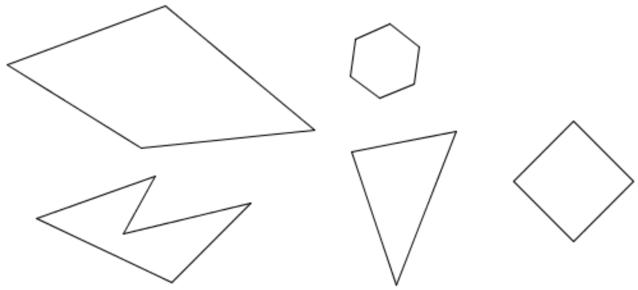
First of all, what is a polygon? Ever heard of one?

Definition:

A polygon is a plane figure (plane refers to it being two dimensional) with at least 3 sides and those sides must be straight.

We've actually already worked with polygons in this chapter. By the definition both a square and a rectangle are polygons. By definition a circle is not a polygon due to the fact that it doesn't have straight lines.

The following are some examples of polygons…



Each of the shapes is different but all have straight lines.

The question becomes: Are we going to need a different formula to calculate the perimeter of each of the shapes?

The answer: **NO**

So if a polygon is made up of sides, all of which are straight lines, how do you think we would calculate the perimeter?

Finding the perimeter of a polygon can be done by adding up all the sides of that polygon. And if fact we could make a generic formula for this.

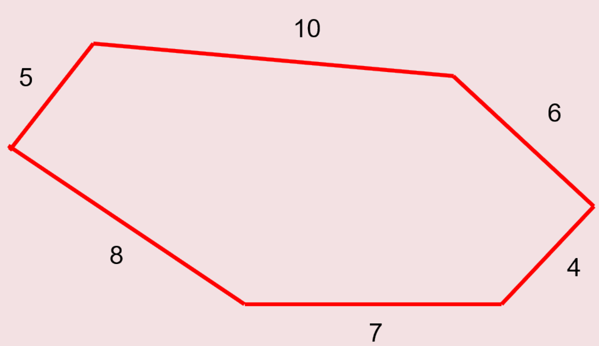
Formula:

$$\text{Perimeter of a polygon} = \text{side} + \text{ side} + \text{side and so on...}$$

What the formula is saying is just add up all the sides to get the perimeter.

Example

Calculate the perimeter of the following polygon.



Click on the image to see it full size.

Step 1: Write down the formula

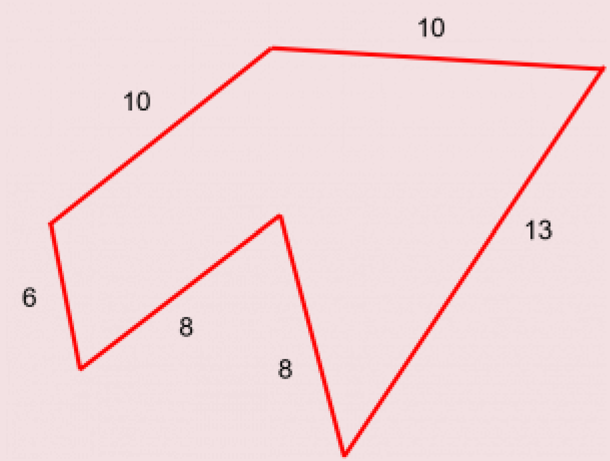
$$\text{Perimeter of a polygon} = \text{side} + \text{ side} + \text{side and so on...}$$

Step 2: Solve for perimeter

$$\text{Perimeter of a polygon} = 5 + 10 + 6 + 4 + 7 + 8$$
$$\text{Perimeter} = 40$$

Example

Find the perimeter of the following polygon.



Click on the image to see it full size.

Step 1: Make sure to use the correct formula.

$$\text{Perimeter of a polygon} = \text{side} + \text{ side} + \text{ side} + \text{side} + \text{ side} + \text{ side}$$

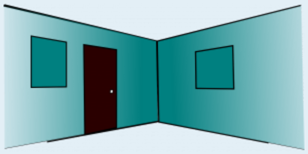
Step 2: Solve for perimeter

$$\text{Perimeter} = 10 + 10 + 13 + 8 + 8 + 6$$
$$\text{Perimeter} = 55$$

Practice Questions

Try a couple practice questions for yourself. Make sure to check the video answers to see how you did.

Question 1



Jacques is a carpet layer who is going to re – carpet a room. In order to do this he has to nail a small piece of wood to the ground which runs the entire perimeter of the room. This wood is there to attach the carpet at the edges of the room.

The room itself is in the shape of a rectangle with the length being 12 feet 2 inches and the width being 10 feet 1 inch.

How much wood does Jacques need?

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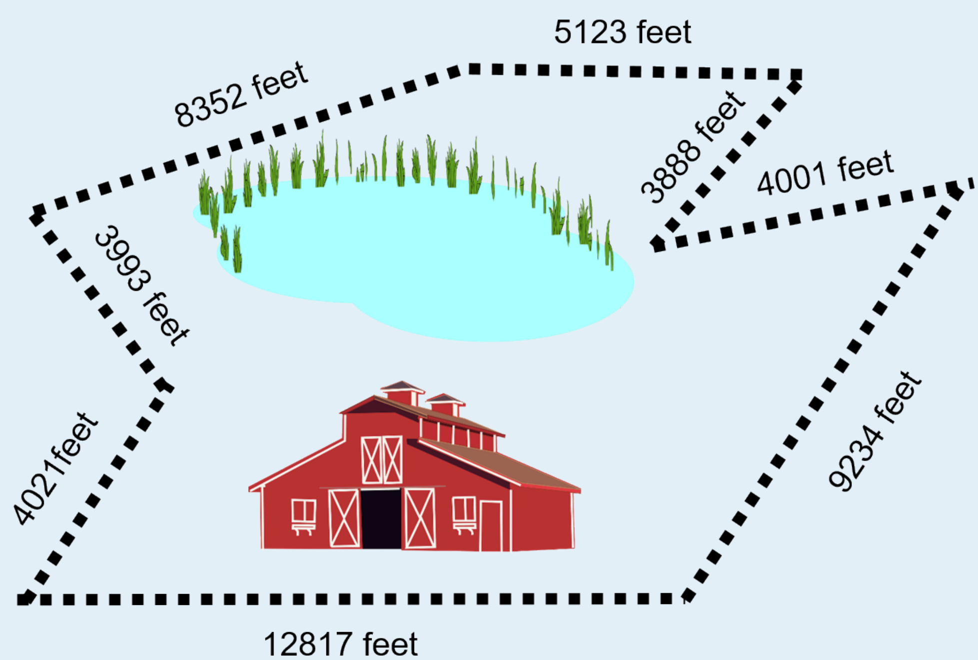
Question 2

Fred is a farmer who is a "jack of all trades." Fred has to build a new fence around the farm that he owns. The area that he has to build the fence is neither a square or rectangle but has many straight sides and contains a large pond in it. Take a look at the picture below and calculate the total perimeter of the farm and pond where Fred had to construct the fence.



Click on the image to see it full size.

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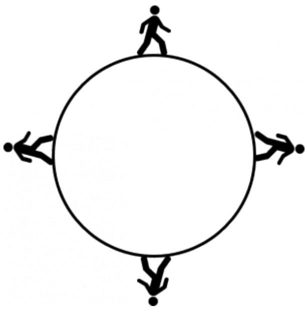
Perimeter of a Circle

Take a look at the circle below.

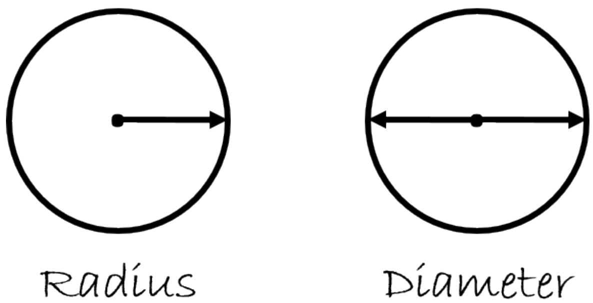


Notice anything different between the circle and the square or rectangle?

Answer: The circle doesn't have any straight lines. It's just one continuous line.

What we are calculating when dealing with a circle is not referred to as the perimeter but as the circumference. Essentially the circumference is the perimeter of a circle.

In order to find the circumference we need to know a thing or two about the circle. We need to know either the diameter or the radius. Take a look at the next picture to see what the diameter and radius are.



If you go to the exact center of a circle and then draw a straight line to the edge of the circle the distance measured is referred to as the radius.

If you start at any point on the edge of the circle and draw a straight line through the circle ending up on the other side, you have the diameter. Note that this straight line must go through the exact center of the circle.

As it turns out, the radius of a circle is exactly half the diameter or…

$$\text{radius} = \frac{\text{diameter}}{2}$$

Working with the equation we could also state that…

$$\text{diameter} = \text{radius} \times 2$$

No matter which way you work it both equations represent the relationship between the radius and diameter.

Having gotten that out of the way we can look at the formula for finding the circumference of a circle.

Before I go through the formula try and take a guess at what the formula is. Once again think about the relationship between the variables and how they might work together in the formula.

Circle

Circumference = ______________

Formula:

$$\textbf{Circle}$$
$$\text{Circumference} = \pi \times \text{diameter}$$

We could also write it as…

$$\mathrm{C} = \pi \times \mathrm{D}$$

Hang on a minute!

What is that symbol?

$$\pi$$

Have you ever seen or heard of this symbol before?

Well it’s a constant. It’s referred to as “pi,” and if you were to sound it out, it would sound like “pie.”

What “pi” represents is the relationship between the circumference of a circle and the diameter of that same circle. “Pi” is a constant and never changes.

Having said that, the number “pi” is a bit of an anomaly. You would think that a constant would be something like 7 or maybe 12.64 or maybe even 0.00004.

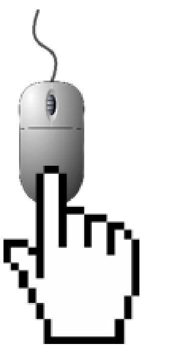
“Pi” is a bit trickier than that. The following is the value of “pi.”

$$\pi = 3.141592653589793238462643383279$$

And that’s just the first few digits. The constant “pi” goes on forever. It doesn’t actually stop. People have figured out “pi” to thousands of digits.

The good news for us is that we don’t have to worry about all those digits that come after the decimal point. For our purpose we’ll use just the following…

$$\pi = 3.14$$



If you want to find out more about the number “pi” and how far people have calculated it, check out the following websites: Pi (Wikipedia) and 1 Million Digits of Pi (piday).

Example

Find the circumference of a circle given that its diameter is 24.

Step 1: Write down the formula.

$$\text{circumference} = \pi \times \text{diameter}$$
$$\text{OR}$$
$$\text{C} = \pi \times \text{D}$$

Step 2: Solve for circumference.

$$C = \pi \times D$$
$$C = 3.14 \times 24$$
$$C = 75.36$$

Example

Find the circumference of a circle given that its radius is 8.

Step 1: Write down the formula.

$$C = \pi \times D$$

The formula calls for the diameter but we are given the radius. We have to use the relationship between radius and diameter to find the diameter.

$$\text{diameter} = \text{radius} \times 2$$
$$\text{diameter} = 8 \times 2$$
$$\text{diameter} = 16$$

Step 2: Solve for circumference.

$$C = \pi \times D$$
$$C = 3.14 \times 16$$
$$C = 50.24$$

We're going to take the difficulty up a step here, and we'll need to use the rules of transposing in the last section to help us out.

Example

Find the diameter of a circle given that the circumference is exactly 153.

Step 1: Write down the formula.

$$\text{circumference} = \pi \times \text{diameter}$$

Step 2: Rework the formula to solve for diameter.

$$\text{diameter} = \frac{\text{circumference}}{\pi}$$

Step 3: Solve for diameter.

$$\text{diameter} = \frac{\text{circumference}}{\pi}$$

$$\text{diameter} = \frac{153}{3.14}$$

$$\text{diameter} = 48.73$$

Practice Questions

Try a couple practice questions for yourself. Make sure to check the video answers to see how you did. Note: Check out the “SO WHAT” video at the end of the practice questions before you head over to the next section.

Question 1

Haley is a Red Seal welder and is fabricating stainless steel tanks for a food storage facility. The radius of the tanks is 24 inches. What is the circumference of the tanks going to be?

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Question 2

Floyd is a concrete worker who is building a foundation for a cabin. The cabin and wraparound deck are supported by round concrete footings. The radius of each footing has been engineered to be 4 inches. What is the circumference of the footings?

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13.

Area

https://video.bccampus.ca/id/0_unmtgsvp?width=608&height=402&playerId=23448552

Click play on the following audio player to listen along as you read this section.

https://video.bccampus.ca/id/0_6gsilpeh?width=608&height=50&playerId=23448552

John is a painter who is going to paint a wall in a house. What he needs to know is how much paint he needs to buy for this one particular wall. He knows that the wall is in the shape of a rectangle and that the dimensions are 10 feet high by 27 feet wide.

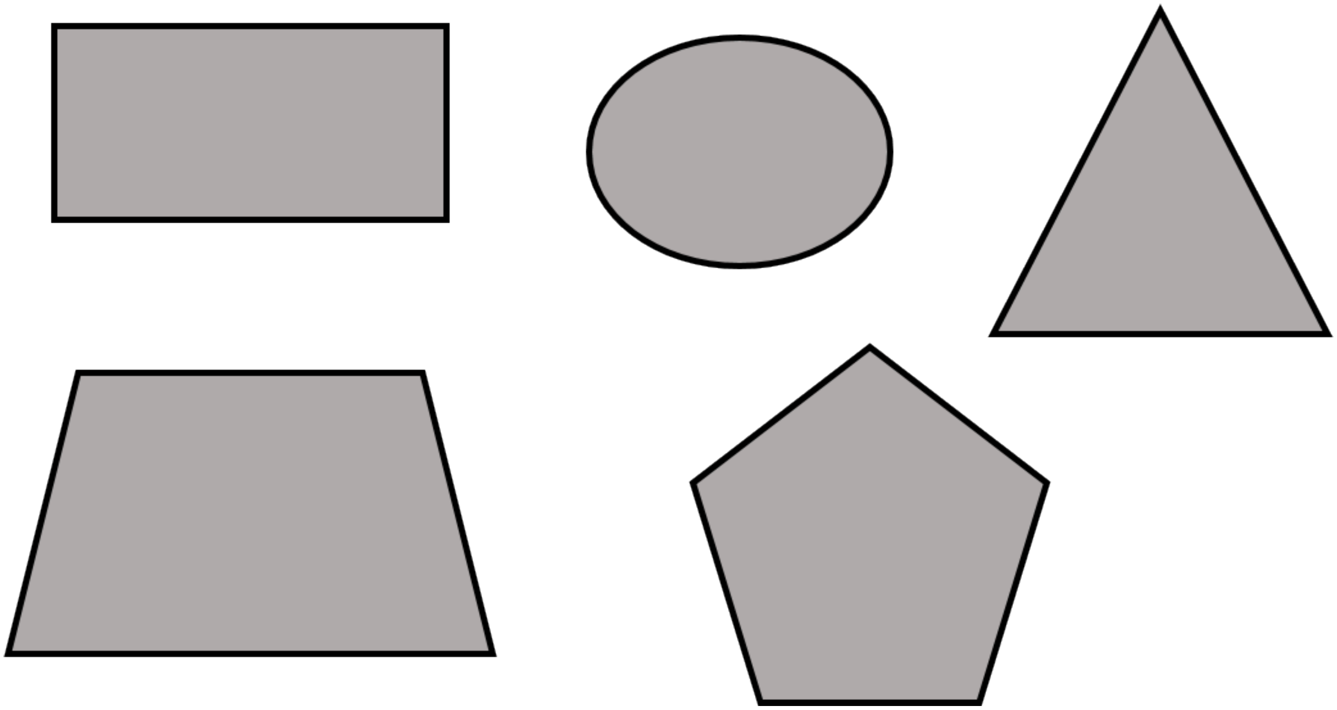
How do you think he would go about solving this problem?

The answer lies in finding the area of the wall. A can of paint will be able to cover a certain area and if John can find out the area of the wall then he can figure out how many cans of paint he will need.

The first thing we should do here is write down the definition of area.

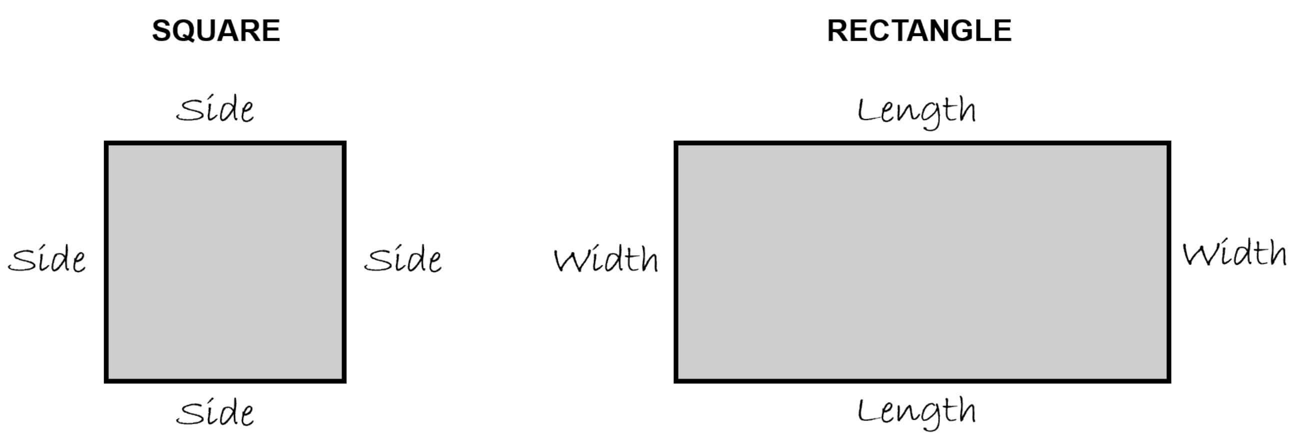
Area: The amount of space inside the boundary of a flat (2-dimensional) object such as a triangle, square, or circle.

The following are some two dimensional shapes shaded in grey. The grey portion represents the area of the object while the black lines surrounding the object represent the perimeter.



Area of a Square or Rectangle

Before we begin going through the motions to calculate the area of a square or rectangle lets take a quick visit back to perimeter and more specifically how we defined the dimensions of both a square and a rectangle.



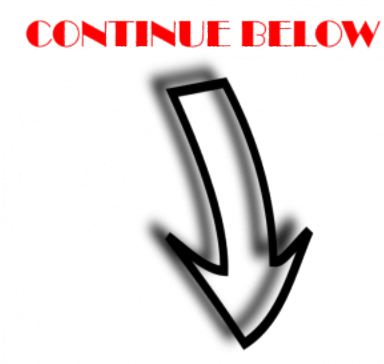
Once again the portion shaded grey is the area of each of the object. The question becomes this…

Can we use those dimensions when calculating the area? Or do we need to somehow come up with other dimensions in order to get to our answer?

Well as it turns out, those dimensions will work for us. Not only do they come in handy when we are calculating perimeter, but they also work really well when calculating area.

The next question then becomes HOW do we use these dimensions?

Before you move on to see how it's done, take a minute to think about it. Maybe even write down some of your thoughts. Once again, this goes back to something we talked about before. If you are able to understand the concept then the process involves less memorization.



Here are the formulas for calculating the area of both a square and a rectangle.

$$\begin{aligned} &\textbf{Square:} && \text{Area} = \text{side} \times \text{side} \\ &\textbf{Rectangle:} && \text{Area} = \text{length} \times \text{width} \end{aligned}$$

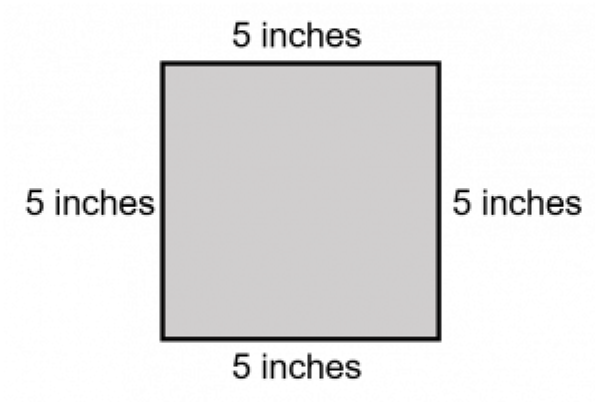
Take note here as there are a couple things different than dealing with perimeter. The first is that we are now multiplying rather than adding. This ends up leading to our second point.

If we take a look at the formula for the square we see that we multiply a side by a side. As all the sides are the same it doesn't really matter which two sides we multiply together.

The issue becomes the units that we end up with. Remember that when dealing with perimeter we are only dealing with a one dimensional line. Our units end up being linear or essentially one dimensional.

With area we end up with units that give us an answer using two dimensional units. The best way to understand this is to go through an example.

Let's say we have a square where each side is 5 inches long.



Using the formula for area of a square we would get…

$$\text{Area} = \text{side} \times \text{side}$$
$$\text{Area} = 5\,\text{inches} \times 5\,\text{inches}$$

We can conclude that 5 times 5 is equal to 25 but what happens when we multiply inches times inches.

$$\text{inches} \times \text{inches} = ?$$

Well inches times inches ends up being inches squared or if you were to write it down it would look like this:

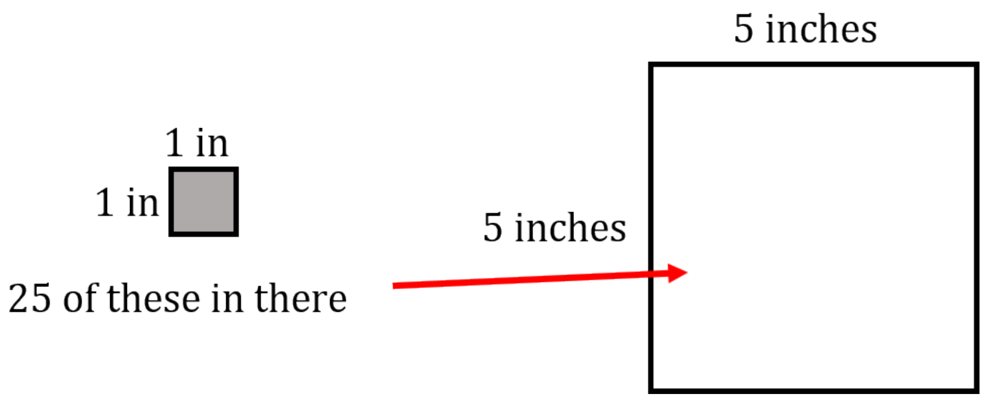
$$\text{inches}^2 \quad \text{OR} \quad \text{in}^2$$

So when you see measurements, such as feet, inches, miles, kilometres and so on with the square symbol after them what you are dealing with is a measurement of area. Put another way it is a measurement stated in two dimensions.

If we go back to our example we would end up with this:

$$\text{Area} = \text{side} \times \text{side}$$
$$\text{Area} = 5\,\text{inches} \times 5\,\text{inches}$$
$$\text{Area} = 25\,\text{in}^2$$

If we were to look at it visually here is what we would have:



Example

Calculate the area of a square where a side is 14 cm..

Step 1: Write down the formula.

$$\text{Area} = \text{side} \times \text{side}$$

Step 2: Solve for area.

$$\text{Area} = \text{side} \times \text{side}$$
$$\text{Area} = 14\,\text{cm} \times 14\,\text{cm}$$
$$\text{Area} = 196\,\text{cm}^2$$

Example

A rectangle has a length of 22 inches and a width of 15 inches. Calculate the area of the rectangle.

Step 1: Write down the formula.

$$\text{Area} = \text{length} \times \text{width}$$

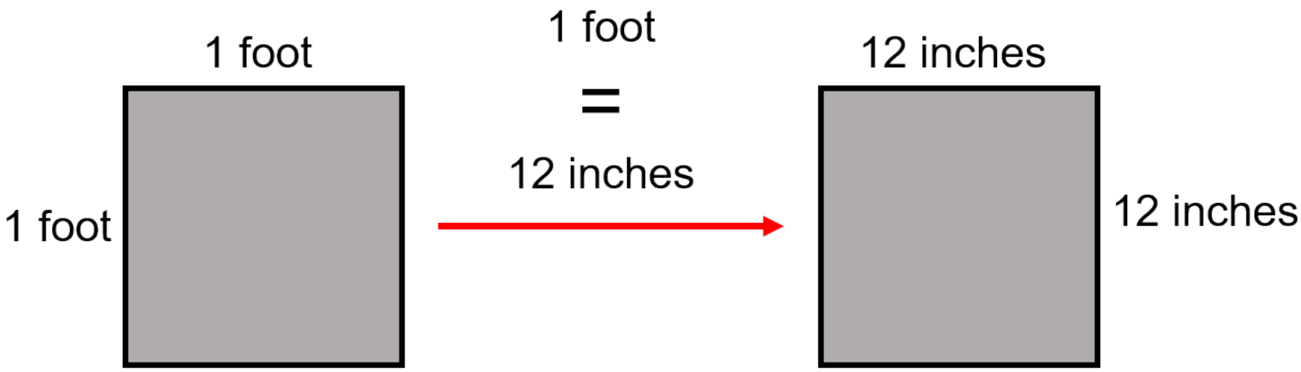
Step 2: Solve for area.

$$\text{Area} = \text{length} \times \text{width}$$
$$\text{Area} = 22\,\text{in} \times 15\,\text{in}$$
$$\text{Area} = 330\,\text{in}^2$$

Let's say that we wanted to get the answer into feet squared (ft^2). How do you think you would go about that? The best way to look at that is visually. The first thing that we have to remember is that:

$$\text{foot} = 12\,\text{inches}$$

Remember that's a linear or one dimensional measurement. What we are looking to end up with is a two dimensional measurement.



$$\begin{array}{cc} \text{Area} = \text{side} \times \text{side} & \text{Area} = \text{side} \times \text{side} \\ \text{Area} = 1\,\text{ft} \times 1\,\text{ft} & \text{Area} = 12\,\text{in} \times 12\,\text{in} \\ \text{Area} = 1\,\text{ft}^2 & \text{Area} = 144\,\text{in}^2 \end{array}$$

$$\text{therefore} \longrightarrow 1\,\text{ft}^2 = 144\,\text{in}^2$$

Basically it takes 144 square inches to make one square foot.

Example

A square has a side of 15 inches. What is the area of the square in square feet?

Step 1: Write down the formula.

$$\text{Area} = \text{side} \times \text{side}$$

Step 2: Solve for area.

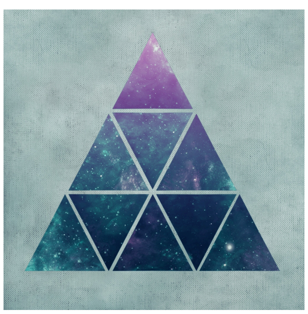
$$\text{Area} = \text{side} \times \text{side}$$
$$\text{Area} = 15\,\text{in} \times 15\,\text{in}$$
$$\text{Area} = 225\,\text{in}^2$$

Step 3: Convert inches squared to feet squared.

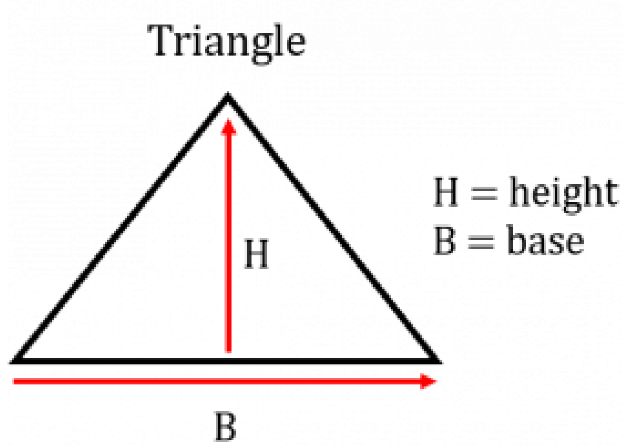
$$1\,\text{ft}^2 = 144\,\text{in}^2$$

$$\text{therefore} \qquad \longrightarrow \quad \text{ft}^2 = \frac{\text{in}^2}{144/\text{ft}^2}$$
$$\text{ft}^2 = \frac{225\,\text{in}^2}{144\,\text{in}/\text{ft}^2}$$
$$\text{ft}^2 = 1.56\,\text{ft}^2$$

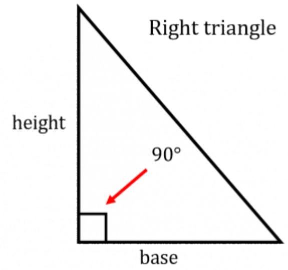
Area of a Triangle



Although a triangle has straight lines similar to a square or a rectangle it differs in the fact that it has three sides and not four. This means that the previous equations using side, length or width will not work in this example. Consider the following picture of a triangle. What we have to work with in our equation is known as the “base” and the “height.”

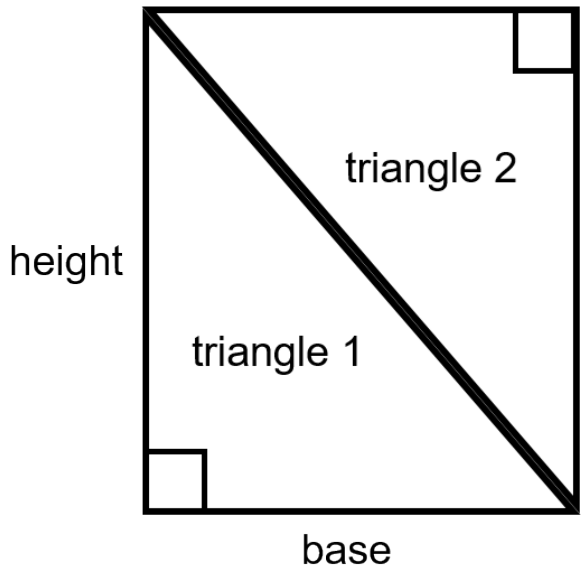


As it turns out triangles are not always in the configuration shown above. It doesn’t matter though as you could turn the triangle any which way and eventually get to a point where there is a "base" and a "height."



Click on the image to see it full size.

Another version of a triangle is the one pictured to the left. This version is the one that helps us derive our formula for area of a triangle. What we have to the left is what is known as a "right" triangle. A right triangle is defined as any triangle that has one angle of 90°. It also has the characteristics of a triangle in that it has a base and a height along with three sides. Now take that triangle and make another one exactly like it but reverse its position like the picture below.



What'll you note from the above drawing is that when you put the two triangles together they make a rectangle. They could also make a square if the base and the height were the same.

In any case when we look back at the formula for a rectangle is was length multiplied by width. In this case if we multiplied the base time the height we would end up with the area of both triangles.

So it make sense then that the area of one of the triangle would be the area of the base multiplied by the height and then take that answer and divide it into two equal parts.

And in the end that's exactly what the formula for a triangle is. Note that this works for any triangle even if it's not a right triangle. The main goal is to get the correct base measurement and the correct height measurement.

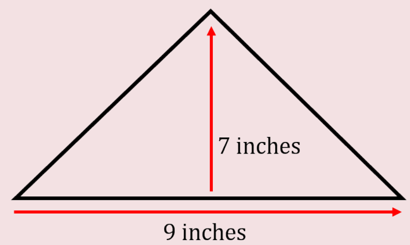
Formula:

$$\text{Area} = \frac{\text{base} \times \text{height}}{2}$$

Let's go through as example.

Example

Find the area of a triangle given that it's base is 9 inches and it's height is 7 inches?



Click on the image to see it full size.

Step 1: Write down the formula.

$$\text{Area} = \frac{\text{base} \times \text{height}}{2}$$

Step 2: Solve for area.

$$\text{Area} = \frac{9\,\text{inches} \times 7\,\text{inches}}{2}$$
$$\text{Area} = \frac{63\,\text{in}^2}{2}$$
$$\text{Area} = 31.5\,\text{in}^2$$

Examples

Find the area of a triangle given that it's base is 12 inches and it's height is 10 inches?

Step 1: Write down the formula.

$$\text{Area} = \frac{\text{base} \times \text{height}}{2}$$

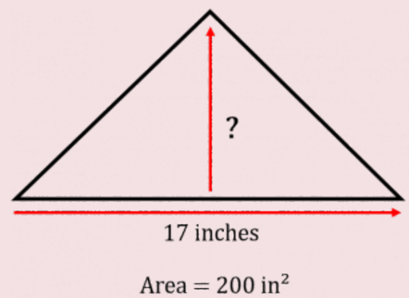
Step 2: Solve for area.

$$\text{Area} = \frac{12\,\text{inches} \times 10\,\text{inches}}{2}$$
$$\text{Area} = \frac{120\,\text{in}^2}{2}$$
$$\text{Area} = 60\,\text{in}^2$$

We'll try one more example but this time we'll switch it up a bit and the area and base will be given and we'll have to solve for height.

Example

Find the height of a triangle whose base is 17 inches and whose area is 200 in².



Click on the image to see it full size.

Step 1: Write down the formula.

$$\text{Area} = \frac{\text{base} \times \text{height}}{2}$$

Step 2: Rearrange the formula so solve for height.

$$\text{Height} = \frac{\text{Area} \times 2}{\text{base}}$$

Step 3: Solve for height.

$$\text{Height} = \frac{\text{Area} \times 2}{\text{base}}$$
$$\text{Height} = \frac{200\,\text{in}^2 \times 2}{17\,\text{in}}$$
$$\text{Height} = 23.53\,\text{in}$$

Take a look at the units the final answer is in. Note that they are in inches but in the question the area is in inches squared.

It does make sense that the height is in inches as it's a linear measurement and one dimensional but how do we arrive at that answer? Is there a mathematical explanation for it?

The answer is yes. Here is how it works.

What we need to start with is the units in the equation we are working with. We don't worry about the actual values just the units.

$$\text{Height} = \frac{\text{area in inches}^2}{\text{base in inches}}$$

$$\downarrow$$

$$\text{Height} = \frac{\text{in}^2}{\text{in}} \longrightarrow \text{Height} = \frac{\text{in} \times \text{in}}{\text{in}}$$

$$\downarrow$$

$$\text{Now what we do is cancel out}$$
$$\text{any units that are the same}$$

$$\downarrow$$

$$\text{Height} = \frac{\text{in} \times \cancel{\text{in}}}{\cancel{\text{in}}}$$

$$\downarrow$$

$$\text{Height} = \text{ inches}$$
$$\text{And we are left with inches}$$

Practice Questions

Try a couple practice questions for yourself. Make sure to check the video answers to see how you did.

Question 1

We'll go back to John the painter for this one. John has to paint a wall with dimensions of 22 feet in length by 9 feet in width. The width is really the height of the wall in this case. Calculate the area in both square feet and square inches.

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Question 2

We’ll stick with John the painter for the second question. He has been asked to put a new coat of paint on a barn. He has calculated the area of most of the barn using the formula for a rectangle but the upper portion of the barn forms a triangle shape. Calculate the area to be painted in the triangle portion of the barn keeping in mind that there is one triangle on one end of the barn and another triangle on the other end of the barn.. The triangle portion has a base of 37 feet and a height of 9 feet.

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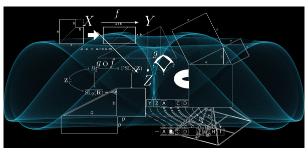
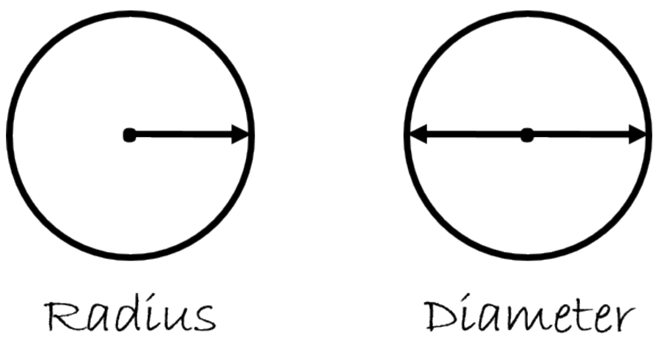
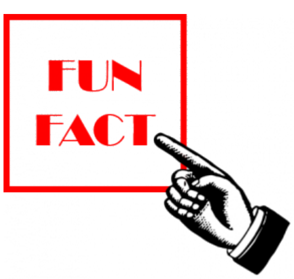
Area of a Circle



If you remember back in the perimeter portion of this chapter we looked at the perimeter (circumference) of a circle. To get that calculation we had to know one of two characteristics of the circle. Finding the area of a circle follows a similar path. Once again height, width or length will not work for us as there are no straight lines on a circle. What we need to work with is either the radius or the diameter.

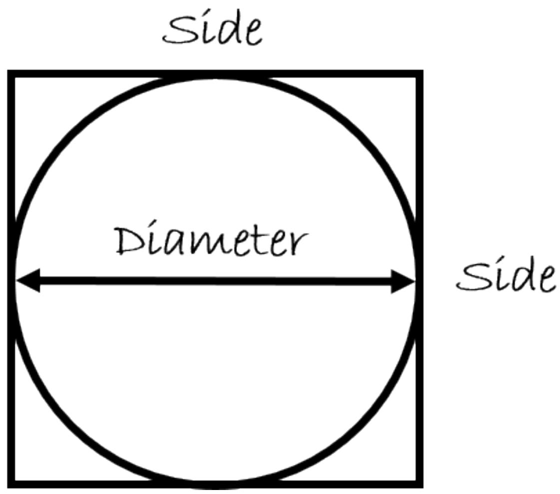


Interestingly there are two different ways to find the area of a circle. One includes using the radius and one includes using the diameter. Both equations work equally well but generally when dealing with the trades we use the formula which uses diameter.



Remember at some point back in another chapter I talked about the idea that learning to understand concepts can help to eliminate the need to memorize formulas. Well this fun fact can help your conceptual understanding of the area for a circle.

The first step in the process is to take a circle and fit it perfectly into a square.



What you will notice is that the side of the square is the same length as the diameter of the circle.

$$\text{DIAMETRE} = \text{SIDE}$$

Here’s the fun fact!

As it turns out the area of a circle that is put perfectly inside a square takes up exactly 78.54 percent of the area of the square.

This information is how we can derive the formula for area of a circle.

If the formula for area of a square is side × side then if we took 78.54 percent of that answer we would get the area of the circle.

Now as we can see that the diameter is the same length as the side then we can say going diameter × diameter would get us the area of the square and then taking 78.54 percent of this would also get us the area of the circle.

Lucky for us the diameter is one of the characteristics of a circle that we would use.

So after that long winded explanation what we end up with is this:

$$\textbf{Area of a circle}$$

$$\text{Area} = \text{diameter} \times \text{diameter} \times 0.7854$$

$$\text{OR}$$

$$\text{Area} = \text{d}^2 \times 0.7854$$

In this formula the 0.7854 represents the 78.54 percent that we were talking about earlier.

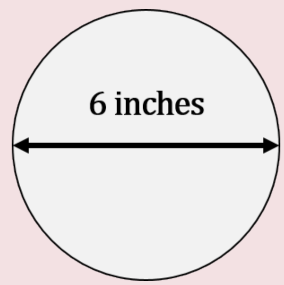
You may be looking at this equation thinking you remember another equation for the area of a circle and in this case your memory would be correct. The formula above is the one we use for trades but if you were to use the formula below you would also be correct.

$$\text{Area} = \pi \times \text{radius}^2$$
$$\text{OR}$$
$$\text{Area} = \pi \text{r}^2$$

In this case π is a constant.. As stated before this formula is also correct but generally when doing trades math we'll stick to the formula using diameter.

Example

What is the area of a circle if the diameter is 6 inches?



Step 1: Write down the formula.

$$\text{Area} = \text{d}^2 \times 0.7854$$
$$\text{where: diameter} = 6\,\text{inches}$$
$$\text{constant} = 0.7854$$

Step 2: Input variables and solve for area.

$$\text{Area} = \text{d}^2 \times 0.7854$$
$$\text{Area} = 6^2 \times 0.7854$$
$$\text{Area} = 6\,\text{in} \times 6\,\text{in} \times 0.7854$$
$$\text{Area} = 28.27\,\text{in}^2$$

Remember that as we are finding the area of a two dimensional object our answer ends up being squared. Once again inches squared represents two dimensions. Before we go on to another example let's try the same question but this time we'll use the other formula for area.

Step 1: Write down the formula.

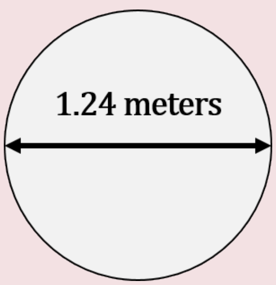
$$\text{Area} = \pi \text{r}^2$$
$$\text{where: diameter} = 6\,\text{inches}$$
$$\text{radius} = 3\,\text{inches}$$
$$\text{constant} = 3.14$$

Step 2: Input variables and solve for area.

$$\text{Area} = \pi r^2$$
$$\text{Area} = \pi \times 3^2$$
$$\text{Area} = 3.14 \times 3\,\text{in} \times 3\,\text{in}$$
$$\text{Area} = 28.26\,\text{in}^2$$

As you can see either formula generates the same answer. Although any questions we go through will use the formula with diameter feel free to use the formula with radius. In the end all that matters is the you understand the process and you get the correct answer

Example



What is the area of a circle given that the diameter of the circle is 1.24 metres?

Step 1: Write down the formula.

$$\text{Area} = \text{d}^2 \times 0.7854$$
$$\text{where: diameter} = 1.24\,\text{metres}$$
$$\text{constant} = 0.7854$$

Step 2: Input variables and solve for area.

$$\text{Area} = \text{d}^2 \times 0.7854$$
$$\text{Area} = 1.24^2 \times 0.7854$$
$$\text{Area} = 1.24\,\text{m} \times 1.24\,\text{m} \times 0.7854$$
$$\text{Area} = 1.208\text{m}^2$$

Practice Question

Try a practice question for yourself. Make sure to check the video answer to see how you did.

Exercises

Jascarn is installing 6 inch pot lights in the ceiling of a friend’s house. What is the area of the hole that Jascarn will have to cut out in order to fit in a 6 inch diameter pot light?

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14.

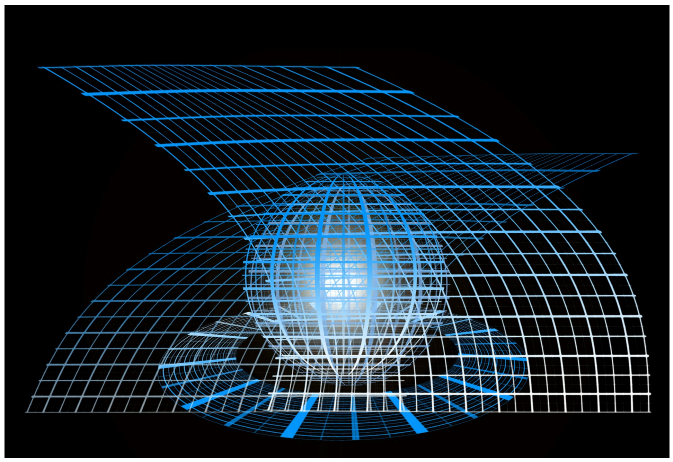
Practice Quiz

An interactive H5P element has been excluded from this version of the text. You can view it online here: https://pressbooks.nscc.ca/mathfortradesv2/?p=181#h5p-3

If using the print, PDF, or eBook copy of this book, navigate to the above link to complete the quiz. However, the quiz questions are also provided in Appendix A at the end of the book for offline use.

IV

Volume



Outcomes

- Calculate the volume of a cube or rectangular tank
- Calculate the volume of a cylinder
- Convert between different units of volume

15.

Volume of a Cube or Rectangular Tank

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Click play on the following audio player to listen along as you read this section

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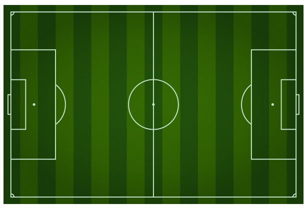
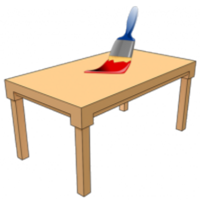
If you were asked to describe the volume of an object, what would that look like? How would you describe the units your calculation would be in?

This chapter deals with the calculation of volume and the units used when calculating volume.

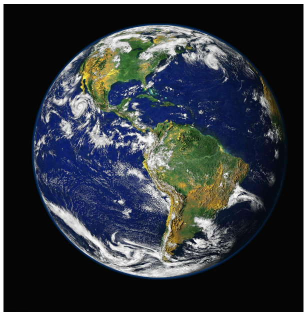
In the last chapter we dealt with perimeter, which is a linear measurement. As we found out, perimeter is one dimensional and essentially takes on the characteristics of a line. A good example of perimeter would be if you walked around the outside of a soccer field. You would have walked the perimeter of the field.



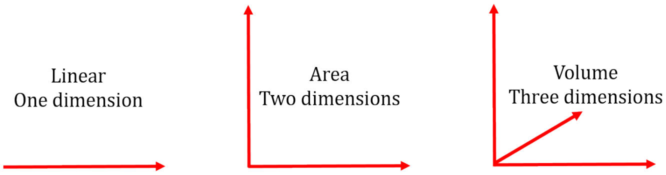
Then we took a look at area, which is a two-dimensional measurement. A good example of that is a table top. If you were to take a paint brush and repaint the top of the table, you would be painting the area of the table top.



When dealing with volume, we are adding one more dimension, and this ends up making volume a three-dimensional measurement. A good example of a three dimensional object would be the planet Earth.



Here is another visual representation of each of the three. Each line represents a plane.



Now let's revisit units. When we deal with a linear measurements, we deal with units as they are. By that I mean we would get the answer in metres, feet, inches, centimetres and so on.

When we deal with area, we keep dealing with units such as metres, but they are squared to indicate that they have two dimensions. For instance, an apartment might have an area of 1200 feet squared or 1200 ft^2. The squaring of the feet indicates two dimensions, such as a width AND length.

But now we add one more dimension into the mix. Not only might we have a length and a width, but we might also have a depth. This leads us to ask, "What would the units be in this situation?"

Well if we had metres as our unit then the answer would be metres cubed. If we were to write it similar to how we wrote down area, it would look like this:

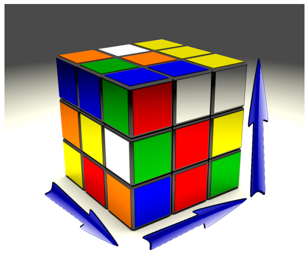
$$\text{metre}^3 \quad \text{or} \quad \text{m}^3$$

The "3" in this case represents three dimensions and is responsible for the term "cubed" when we sound it out. Now we are ready to go on and find out the formula for the volume of specific objects.

Volume of a Cube

When the word "cube" is stated, we can think of a square but just with another dimension added. Each dimension on a square is identical and a cube follows that same logic.

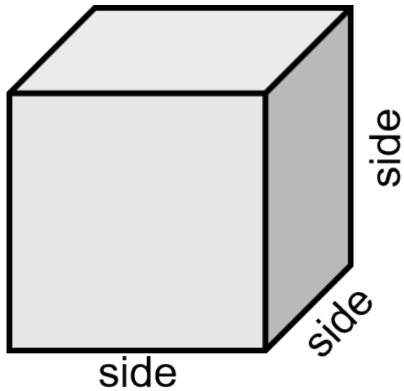
If you add a third dimension, you get all possible dimensions being the same. Take a look at one of the most famous cubes in the world:



In order to find the volume of the cube, we need to multiply three sides together. More specifically, we would look at multiplying the length, the width, and the height. Because all three sides are the same, the formula ends up looking like the following:

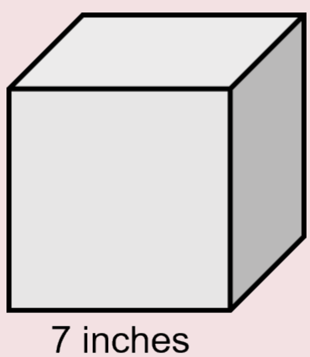
$$\text{volume of a cube} = \text{side} \times \text{side} \times \text{side}$$

To find the area of a cube is pretty straight forward. All you have to know is the length of one side, and you have all the information you need.



Example

Find the volume of a cube where one side is 7 inches.

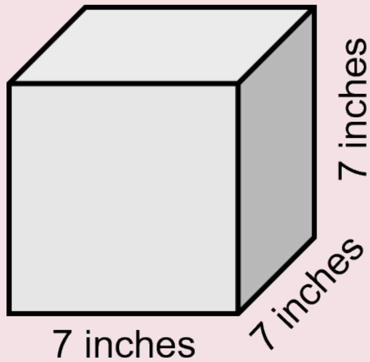


Step 1: Write down the formula.

$$\text{volume of a cube} = \text{side} \times \text{side} \times \text{side}$$

Step 2: Solve for volume.

As all the sides of a cube are the same, it means that each side is 7 inches.



So when putting the variables into the equation they are all equal.

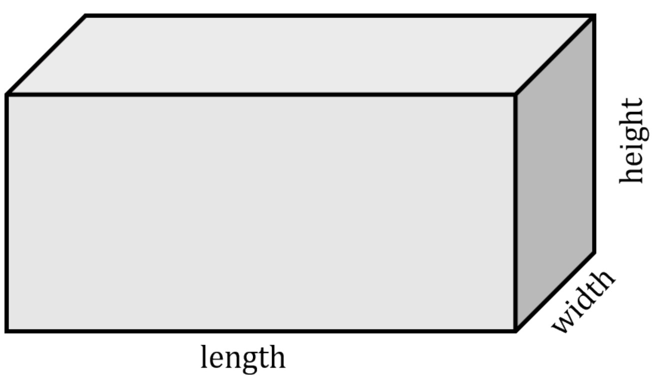
$$\text{volume of a cube} = \text{side} \times \text{side} \times \text{side}$$
$$\text{volume} = 7\,\text{in} \times 7\,\text{in} \times 7\,\text{in}$$
$$\text{volume} = 343\,\text{in}^3$$

Volume of a Rectangular Tank

How to calculate the volume of a rectangular tank is very similar to how to calculate the volume of a cube except for the fact that the dimensions of a rectangular tank will all be different. From this point on, we'll just refer to it as a tank.

What we also get is that the names of the variables in the tank are different. When we dealt with a rectangle, we referred to the variables as length and width.

Now we are just adding another variable that we will call "height."



Once again, we are working with three dimensions, and the formula is going to be similar to that of a cube just with the variable "side" replaced by the three different variables of a tank.

Formula:

$$\text{volume of a tank} = \text{length} \times \text{width} \times \text{height}$$

Example

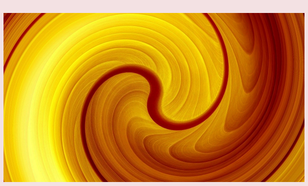
Calculate the volume of a tank that has a length of 17 inches, a width of 12 inches, and a height of 13 inches.

Step 1: Write down the formula.

$$\text{volume of a tank} = \text{length} \times \text{width} \times \text{height}$$

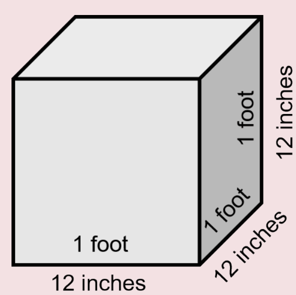
Step 2: Solve for volume.

$$\text{volume of a tank} = \text{length} \times \text{width} \times \text{height}$$
$$\text{volume} = 17\,\text{in} \times 13\,\text{in} \times 12\,\text{in}$$
$$\text{volume} = 2652\,\text{in}^3$$



Let's put a twist on this now and put the answer into cubic feet.

The first thing we have to do is calculate how many cubic inches there are in a cubic foot and the best way to do that is visually.



We would all agree that 1 foot equals 12 inches. Therefore using the formula for a cube we would get the following:

$$\begin{aligned}
\text{In feet:} \qquad \text{volume} &= \text{ side} \times \text{side} \times \text{side} \\
\text{volume} &= 1\,\text{ft} \times 1\,\text{ft} \times 1\,\text{ft} \\
\text{volume} &= 1\,\text{ft}^3 \\
\text{In inches:} \qquad \text{volume} &= \text{ side} \times \text{side} \times \text{side} \\
\text{volume} &= 12\,\text{in} \times 12\,\text{in} \times 12\,\text{in} \\
\text{volume} &= 1728\,\text{in}^3
\end{aligned}$$

So what we end with is:

$$1\,\text{ft}^3 = 1728\,\text{in}^3$$

Now we can answer the question.

How many cubic feet are there in a tank which contains 2652 cubic inches?

What you do here is take the number of cubic inches you have and divide it by the number of cubic inches there are in one cubic foot.

$$\text{ft}^3 = \frac{\text{in}^3}{\text{in}^3/\text{ft}^3}$$

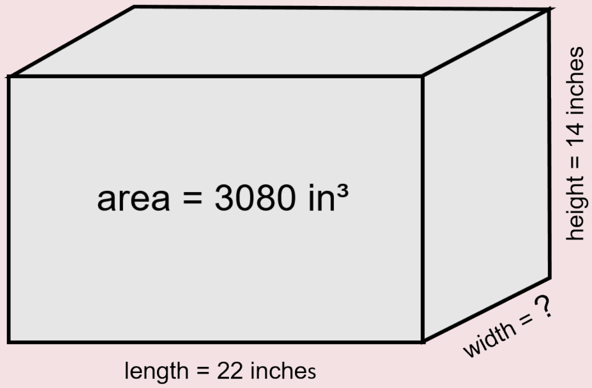
$$\text{ft}^3 = \frac{2652\,\text{in}^3}{1728\,\text{in}/\text{ft}^3}$$

$$\text{ft}^3 = 1.53$$

Let's go through another example and once again we'll put a spin the the question.

Example

Find the width of a tank that has a length of 22 inches, a height of 14 inches and a total volume of 3080 cubic inches.



Step 1: Write down the formula.

$$\text{volume} = \text{length} \times \text{width} \times \text{height}$$

Step 2: Rearrange the formula to solve for width.

$$\text{volume} = \text{length} \times \text{width} \times \text{height}$$

$$\text{width} = \frac{\text{volume}}{\text{length} \times \text{height}}$$

Step 3: Calculate width.

$$\text{width} = \frac{\text{volume}}{\text{length} \times \text{height}}$$

$$\text{width} = \frac{3080\,\text{in}^3}{22\,\text{in} \times 14\,\text{in}}$$

$$\text{width} = 10\,\text{inches}$$

Practice Questions

Try a couple practice questions for yourself. Make sure to check the video answers to see how you did.

Question 1

Lyle works for a gas fitting company called “Night and Day Heating.” He’s designing a heating system for a building designed by an eccentric architect. The building is in the shape of a cube with one of the sides being 30 feet.

Lyle has to take into consideration the volume of the building before designing the system. What is the volume of the cubed building?

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Question 2

Kate owns a septic tank installation company in rural British Columbia, and she has just hired Rachael who is originally from East Africa and has never installed a septic system before.

The tank is for a four-bedroom home and needs to have a total volume of at least 170 cubic feet according to the engineer who designed the system. The dimensions of the tank they are planning to install are down below. Given those dimensions, is the septic tank going to be large enough to meet the engineer’s demands.

Length = 7.5 feet

Width = 5.25 feet

Height = 4.5 feet

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16.

Volume of a Cylinder

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What do you think is in the tank in the picture to the left?

Maybe water? Maybe grain? Maybe old math textbooks for the construction trades?

math textbooks for the construction trades

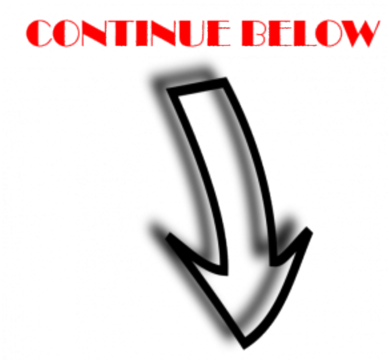
For us right now, it's less important to know what is in the tank and more important to know how to figure out how much stuff can fit into the tank.

This type of tank in known as a cylinder and is comprised of three basic parts. It has a top, a bottom, and a middle section. We will assume that the top and the bottom are both perfect circles with equal diameter and equal area.

A good example of a cylinder would be a hot water tank. Take a look at the hot water tank to the right and ask yourself what you might need to know if you were required to calculate the volume of the tank.

What did you come up with? How about trying your hand at coming up with a formula. I'll give you one hint before you give it a shot.

Hint: Volume is in cubic form. For example: cubic feet, cubic metres, cubic inches, etc.

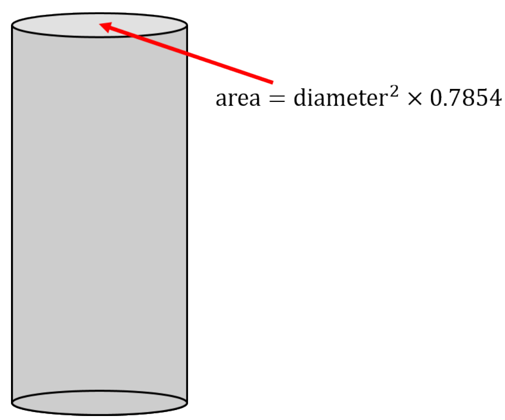


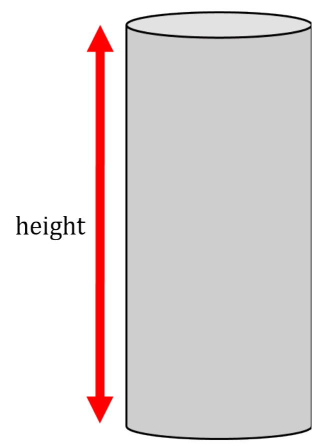
Formula for Volume of a Cylinder

Here's the formula.

$$\text{volume of cylinder} = \text{diameter}^2 \times 0.7854 \times \text{height}$$

Remember that the top of a cylinder is simply a circle. It has a diameter, a radius, and a circumference. The bottom of the tank has the same dimensions as the top of the tank.





So we need this calculation (the area of the top or bottom) to use as a starting point.

The next question that would come about is, "How high or how long is the tank?"

This would also play a big part in calculating the volume.

Put this all together and you get your formula:

$$\text{volume of cylinder} = \text{diameter}^2 \times 0.7854 \times \text{height}$$

One last question:

What kind and type of units will we be dealing with in our answer?

Units for Volume of a Cylinder

There are actually two parts to this answer.

Part 1

The answer remains in whatever units the variables are that we are dealing with. So for instance, if we are dealing with feet then our answer would end up being some version of feet. If we are dealing with inches then our answer would end up being some version of inches.

Note that you have two different variables here, diameter and height. Make sure that when working out your answer that both variables are in the same units. If diameter is in inches and height is in feet, you would have to convert one or the other so that they would both be the same unit.

Part 2

As stated earlier, our answer would be in cubic units. Although we have only two variables (diameter and height), the diameter is squared therefore we could write the formula like the following:

$$\text{volume} = \text{diameter} \times \text{diameter} \times 0.7854 \times \text{height}$$

In the end, we would actually have three variables with two of them being the same. This is how we get our answer in cubic (3) units.

Examples

A cylindrical tank has a diameter of 7 inches and a height of 51 inches. What is the volume of the tank?

Step 1: write down the formula and identify the variables.

$$\text{volume of a cylinder} = \text{diameter}^2 \times 0.7854 \times \text{height}$$

$$\textbf{Variables}$$

$$\text{height (h)} = 51\,\text{inches}$$

$$\text{diameter (d)} = 7\,\text{inches}$$

Now before we move on, check and make sure the variables are in similar units. If they are different, we'll have to change them so they are both the same.

Lucky for us, in this question they are both in inches so we are good to go.

Step 2: Plug the variables into the formula, and work through the question.

$$\text{volume} = \text{d}^2 \times 0.7854 \times \text{h}$$
$$\text{volume} = 7\,\text{in} \times 7\,\text{in} \times 0.7854 \times 51\,\text{in}$$
$$\text{volume} = 1962.7\,\text{in}^3$$

Example

Calculate the volume of a cylindrical tank that has a diameter of 555 millimetres and a height of 7.9 metres.

Step 1: Write down the formula and identify the variables.

$$\text{volume of a cylinder} = \text{diameter}^2 \times 0.7854 \times \text{height}$$
$$\textbf{Variables}$$
$$\text{height (h)} = 555\,\text{millimetres}$$
$$\text{diameter (d)} = 7.9\,\text{metres}$$

The two variables are in different units. We have to change one or the other to put both in the same units. In this case, we will work with metres and our answer will then end up in metres cubed.

The height being 7.9 metres works for us but the diameter being 555 millimetres does not. We will have to change that to metres in order for everything to be consistent.

We will have to go back a few chapters and into our memory bank for this one.

Remember that 1 metre = 1000 millimetres.

To get the number of metres in 555 millimetres we do the following:

$$1\,\text{metre} = 1000\,\text{millimetres}$$

$$\text{metres} = \frac{\text{number of millimetres}}{1000\,\text{millimetres/metre}}$$

$$\text{metres} = 0.555\,\text{metres}$$

Now that both of the variables are in similar units we can go ahead and solve for volume.

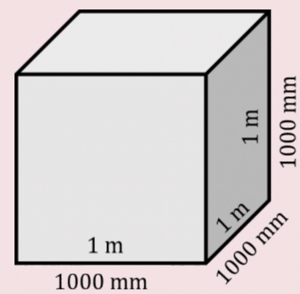
Step 2: Plug the variables into the formula and work through the question.

$$\text{volume} = \text{d}^2 \times 0.7854 \times \text{h}$$

$$\text{volume} = 0.555\,\text{m} \times 0.555\,\text{m} \times 0.7854 \times 7.9\,\text{m}$$

$$\text{volume} = 1.91\,\text{m}^3$$

So we have our answer in cubic metres but what if wanted to change that answer to cubic millimetres? We'll go back to our drawing of a cube to find out the relationship between cubic metres and cubic millimetres.



In metres:

$$\text{volume} = \text{side} \times \text{side} \times \text{side}$$

$$\text{volume} = 1\,\text{m} \times 1\,\text{m} \times 1\,\text{m}$$

$$\text{volume} = 1\,\text{m}^3$$

In millimetres:

$$\text{volume} = \text{side} \times \text{side} \times \text{side}$$

$$\text{volume} = 10\,\text{mm} \times 10\,\text{mm} \times 10\,\text{mm}$$

$$\text{volume} = 1,000,000,000\,\text{mm}^3$$

So in the end one cubic metre equals a lot of cubic millimetres More precisely one cubic metre equals one billion cubic millimetres.

So how many cubic millimetres are there in our cylindrical tank in the example above.

$$\text{mm}^3 = \text{mm}^3 \times 1,000,000,000\,\text{mm}^3/\text{m}^3$$

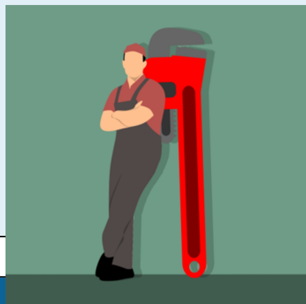
$$\text{mm}^3 = 1.91^3 \times 1,000,000,000\,\text{mm}^3/\text{m}^3$$

$$\text{mm}^3 = 1,910,000,000$$

Practice Questions

Try a couple practice questions for yourself. Make sure to check the video answers to see how you did.

Question 1



Gerrard is going to be installing a new hot water tank. The tank is 1 foot three inches in diameter and 5 feet 2 inches in height. What is the volume of the tank in cubic feet?

https://video.bccampus.ca/id/0_lfjq3890?width=608&height=402&playerId=23448552

Question 2

A one gallon paint can is approximately 6 ½ inches in diameter and 7 ½ inches in height. One gallon is enough to paint up to 400 square feet which works out to be about the area of a small bathroom.

Calculate the volume of the paint can in both cubic inches and cubic feet.

https://video.bccampus.ca/id/0_qwbbcu9v?width=608&height=402&playerId=23448552

17.

Volume of a Sphere

Click play on the following audio player to listen along as you read this section.

https://video.bccampus.ca/id/0_04mym8gr?width=608&height=50&playerId=23448552

To the left we have a picture of our beautiful planet, Earth. Although the picture itself is two dimensional, we know that Earth is three dimensional. This implies that Earth has a volume. What is also true is that Earth is an example of a sphere.

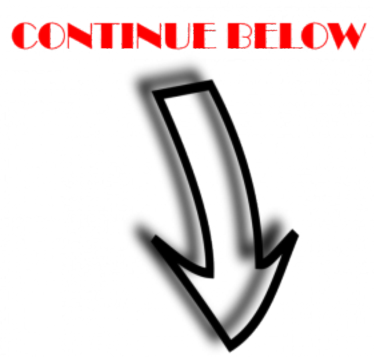
So far we've calculated the volume of cubes, rectangular tanks, and cylinders. Using that information, how do you think we would calculate the volume of a sphere? What variables do you think you would use? Take a few moments to think about it before we go through the explanation below.

Just in case you were wondering, Earth has a volume of…

$$1,083,206,916,846 \text{ cubic kilometres}$$

There are two things to note here:

1. The answer is once again in cubic units.
2. That's a lot of volume.



We should start this explanation off by revisiting the formula for a circle.

Remember that a circle had a radius, diameter, and circumference. Also remember that to find the formula for a circle, we could have used one of two formulas.

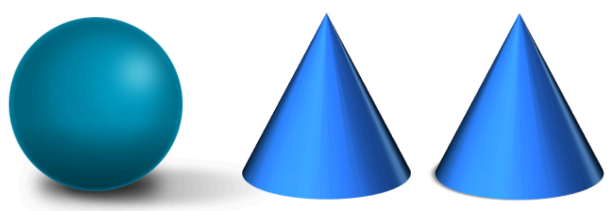
$$\begin{aligned} &\text{Formula one:} \quad \text{area} = \mathrm{d}^2 \times 0.7854 \times \mathrm{h} \\ &\text{Formula two:} \quad \text{area} = \pi \mathrm{r}^2 \end{aligned}$$

When dealing with the formula for a sphere, we can use formula two as a starting point. The formula for a sphere has a similar feel to it but with a little twist. The similarities include having both pi and radius in the formula, but that is where the similarities end.

Here is the formula:

$$\text{volume} = \frac{4}{3}\pi \mathrm{r}^3$$

The question becomes, "Where does the 4/3 come from?" Well the explanation for that is actually quite a long one, and I'll leave that for another day. Quickly stated, it comes from the fact that if you took two cones with similar measurements to the sphere, it would end up that the volume of those two cones would equal the volume of the sphere. Using a bit of mathematical wizardry the 4/3 ends up being derived from this fact.

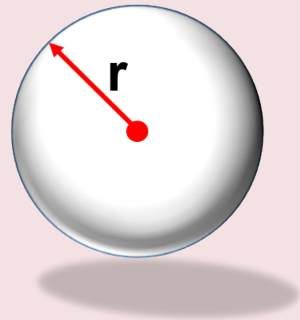


The pi in the formula is the constant that we use when finding the circumference of a circle, and the radius, as you might remember, is half the length of the diameter. The last thing is that the radius is cubed. This relates to the fact that in the end we are solving for volume, which has three dimensions.

Now I didn't expect you to get the formula as it's quite a bizarre one, but understanding where it comes from helps to conceptualize the formula. As we talked about previously, the purpose of this exercise is to rely less on memorization and more on an understanding of how stuff is derived.

Example

Find the volume of a sphere with a radius of 7 inches.



Step 1: As usual write down the formula.

$$\text{volume} = \frac{4}{3}\pi r^3$$

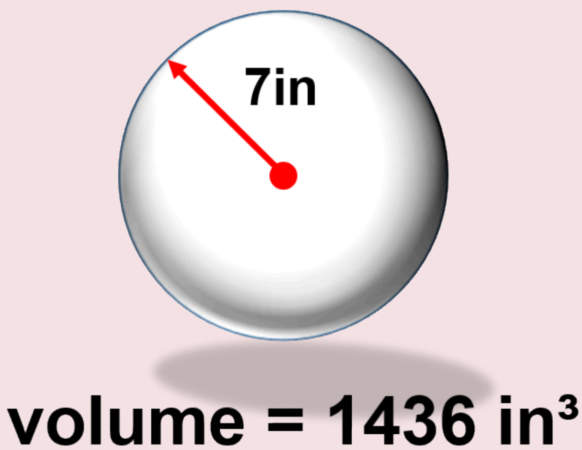
Step 2: Plug in the variables and solve for volume

$$\text{volume} = \frac{4}{3}\pi r^3$$

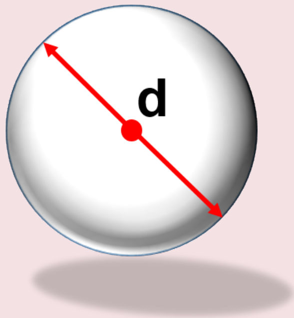
$$\text{volume} = \frac{4}{3}\pi 7^3$$

$$\text{volume} = \frac{4}{3} \times \pi \times 7 \times 7 \times 7$$

$$\text{volume} = 1436\,\text{in}^3$$



Examples



Let's take a step up here and add a little twist. Find the volume of a sphere with a diameter of 24. Note that the diameter will go through the exact center of the sphere. Think of where you are standing right now, and drill a hole straight down through the Earth to the exact other side making sure to go through the dead centre of the Earth. (Disclaimer: I think there is an Arnold Schwarzenegger movie plot somewhere inside this question.) Anyway, back to the question.

Step 1: As usual, write down the formula.

$$\text{volume} = \frac{4}{3}\pi r^3$$

I'm going to guess that by this time in the book, you've started to see some patterns and have picked out the fact that we need to use the radius in the formula but we only have diameter. We'll have to work a little math magic, and pull the radius out of the diameter before we start.

$$\text{diameter} = \text{radius} \times 2$$

$$\text{radius} = \frac{\text{diameter}}{2}$$

$$\text{radius} = \frac{24}{2}$$

$$\text{radius} = 12$$

Now we have what we need to work with.

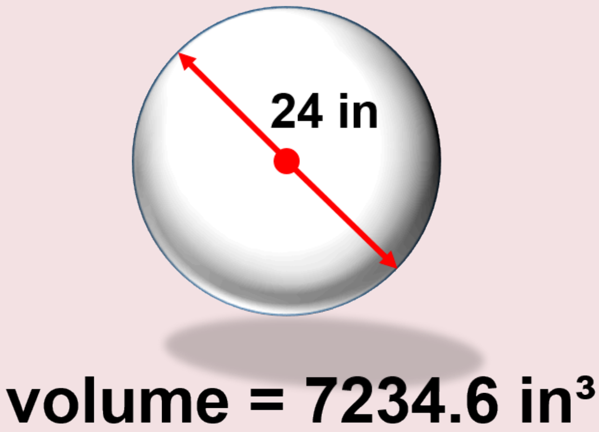
Step 2: Plug in the variables and solve for volume.

$$\text{volume} = \frac{4}{3}\pi r^3$$

$$\text{volume} = \frac{4}{3}\pi 12^3$$

$$\text{volume} = \frac{4}{3} \times \pi \times 12 \times 12 \times 12$$

$$\text{volume} = 7234.6\,\text{in}^3$$



Hey! Should we throw in a bonus question here? Okay, let's do it. Change the volume from cubic inches into cubic feet.

Step 1: Write down the formula.

$$1\,\text{cubic foot} = 1728\,\text{cubic inches}$$

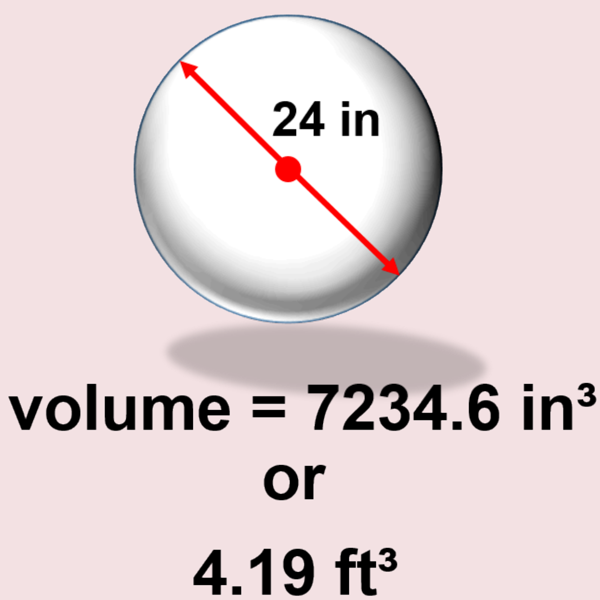
Step 2: Cross multiply

$$\frac{1\ \text{ft}^3}{\text{X ft}^3} = \frac{1728\,\text{in}^3}{7234.6\,\text{in}^3}$$

$$1 \times 7234.6 = \text{X} \times 1728$$

$$\text{X} = \frac{7234.6}{1728}$$

$$\text{X} = 4.19\,\text{ft}^3$$



Practice Question

Try a practice question yourself and check the video answer to see how you did.

Question 1

Josh and Jatinder are both fans of the NBA and in class they are discussing what the volume of a basketball might be. They've figured out that the diameter of a basketball is 9.5 inches. Calculate the volume of the basketball.

https://video.bccampus.ca/id/0_jr1r3ugq?width=608&height=402&playerId=23448552

18.

Practice Quiz

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://pressbooks.nscc.ca/mathfortradesv2/?p=227#h5p-4

If using the print, PDF, or eBook copy of this book, navigate to the above link to complete the quiz. However, the quiz questions are also provided in Appendix A at the end of the book for offline use.

V

Practice Test

An interactive H5P element has been excluded from this version of the text. You can view it online here: https://pressbooks.nscc.ca/mathfortradesv2/?p=229#h5p-5

If using the print, PDF, or eBook copy of this book, navigate to the above link to complete the quiz. However, the quiz questions are also provided in Appendix A at the end of the book for offline use.

Appendix A: Offline Copies of Chapter Quizzes

Unit 1 Practice Quiz

1. Convert 3.2 kilometres to metres.
2. Convert 640 milliliters to litres.
3. 6 feet 5 inches is what in metres? (Round to the nearest hundredth)
4. 50 degrees Fahrenheit is equal to [blank] degrees Celsius.
5. If Harjinder buys 2.3 tonnes of cement for a job, he has bought [blank] pounds. (Round to the nearest hundredth)
6. Water boils at 100 degrees Celsius or degrees [blank] Fahrenheit (At sea level).
7. 165 Kwh is the equivalent of [blank] thousand BTU's.
8. 256 psi is the equivalent of [blank] kilopascals. (Round to the nearest tenth)
9. How many feet is Denver (the mile-high city) above sea level?
    A. 5280 ft
    B. 5820 ft
    C. No one really knows for sure.
    D. 450 ft
10. Water freezes at what temperature in Fahrenheit?
    A. 0
    B. 32
    C. 23
    D. −40

Answers

1. 3200 metres
2. 0.64 litres
3. 1.96 metres
4. 10
5. 5070.63
6. 212

7. 563
8. 1765
9. A
10. B

Unit 2 Practice Quiz

1. $11 = x - 3$
   A. $x = 7$
   B. $x = 14$
   C. $x = 21$
   D. $x = 10$
2. $3Y = 123$
   A. 14
   B. 41
   C. 36
   D. 63
3. Using the formula P = EI, calculate the power in watts for a range that has 24 A and 220 V.
   A. 5280 Watts
   B. 1200 Watts
   C. 2600 Watts
   D. 5820 Watts
4. Use the formula F= 9/5(C + 32). Convert 175 degrees Celsius to Fahrenheit.
   A. 337 degrees
   B. 372.6 degrees
   C. 378.8 degrees
   D. 388.8 degrees
5. Use the formula A = (pi)r^2. Determine the radius in centimetres of a circle with an area of 255 cm^2.
   A. 71.6 cm
   B. 81.16 cm
   C. 9 cm
   D. 18.17 cm
6. $15 = 29 - (2x)$

A. x = 7
B. x = 5
C. x = 14
D. x = −7

7. C = π42. What is C?
    A. 133.648
    B. 131.946
    C. 131.947
    D. 131.946
8. 2[13 + (8 – 5)] = x. What is x?
    A. 52
    B. 32
    C. 23
    D. 43
9. N + 2(3 – 1) = 8. What is N?
    A. 2
    B. 0
    C. 4
    D. 6
10. 27 = 8(n + 3). What is n?
    A. 2
    B. 3/4
    C. 3/8
    D. 3/16

Answers

1. B
2. B
3. A
4. B
5. C
6. A
7. C

8. B
9. C
10. D

Unit 3 Practice Quiz

1. A construction site 27 m by 76 m must be fenced in before excavation starts. How many metres of fencing are required to enclose it?
    A. 2052 m
    B. 103 m
    C. 206 m
    D. 309 m
2. A contractor is deciding which floor covering to use in the room shown below. Cork floor tiles 0.25 m by 0.25 m cost $1.10 each, and carpeting costs $16.95 a square metre. Floor tiles would be cheaper than carpet. True or false?
3. A rectangular panel measuring 36 inches × 18 inches has two holes 6 inches in diameter to receive stereo speakers and a rectangular opening 8 inches × 10 inches for a rear window defroster. What is the surface area of the panel after the holes have been cut to the nearest square inch?
    A. 511 square inch
    B. 540 square inch
    C. 560 square inch
    D. 584 square inch
4. The cylindrical water tank servicing a construction site must be erected on a wooden cradle and fastened by three metal straps around the outside. If the tank is 44 inches in diameter, what is the total length of metal required for the straps, to the nearest 1/16 inch?
    A. 138.25 inches
    B. 276.5 inches
    C. 453.56 inches
    D. 414.67 inches
5. A circle and a triangle with a base of 9 in. both have an area of 28.2744 in^2. The diameter of the circle is greater than the altitude of the triangle. True or false?
6. What is the area of a triangle with base of 21.5 inches and an altitude (or height) of 8 inches?
    A. 44 in^2
    B. 172 in^2
    C. 104 in^2

D. 86 in^2

7. How much ceiling trim is required for the perimeter of the room shown in Figure 1?

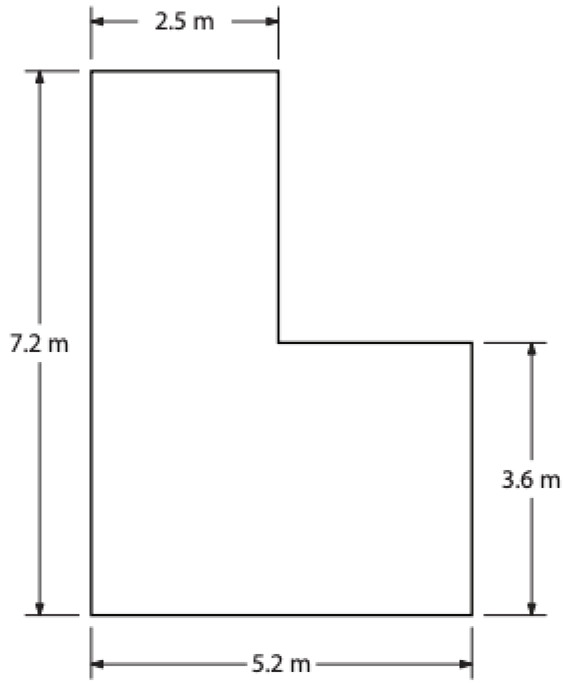


Figure 1. [Image Description]

A. 12.4 m

B. 18.5 m

C. 24.8 m

D. 32.5 m

8. A DC generator contains four brush assemblies, with each assembly containing six brushes. The surface of each brush is 0.065 m by 0.025 m. Calculate in square metres the total surface area of all the brushes.

A. 0.028 m^2

B. 0.039 m^2

C. 0.0016 m^2

D. 0.0098 m^2

9. Calculate the cost of all moulding needed to go around the window in the figure, if the cost per metre is $6.50. Round your answer to the nearest cent.

A. $12.70

B. $25.40

C. $15.55

D. $10.85

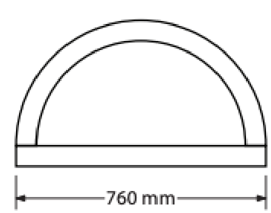


Figure 2.

10. A rectangular steel bar has a cross sectional area of 468 mm2 . The bar is to be reformed into a triangular-shaped bar with the same cross-sectional area. If the height of the triangle is 36 mm, what is the length of the base?
    A. 22 mm
    B. 26 mm
    C. 28 mm
    D. 32 mm

Answers

1. C
2. False
3. A
4. D
5. True
6. D
7. C
8. B
9. A
10. A

Unit 4 Practice Quiz

1. A solvent tank measures 135 cm × 50 cm × 45 cm. To the nearest litre, how many litres of solvent will it take to fill it three-quarters full? (1 cm^3 equals 1 mL)
    A. 228 L
    B. 304 L
    C. 508 L
    D. 104 L
2. A truck has a cylindrical air pressure reservoir for its air brake system with an outside diameter of 39 cm and an outside length of 84 cm. What is the internal volume of the reservoir in cubic centimetres if the cylinder walls are 0.5 cm thick?
    A. 95,266 cm^3
    B. 88,463 cm^3
    C. 100,346 cm^3
    D. 122,863 cm^3

3. A cleaning tank for small parts measures 15 cm by 35 cm by 12 cm deep. The tank has a fill line 4 cm from the top. How many litres of cleaning fluid will the tank hold if filled to the fill line? (1 cm^3 = 1 mL)
   A. 6.3 L
   B. 4.2 L
   C. 3.8 L
   D. 5.8 L
4. The diameter of an underground tank is 2.6 metres and is 7 metres in length. How many gallons will the tank hold? (Round to the nearest gallon.)
5. A room 10 ft wide, 8 ft high, and 14 ft long will hold [blank] cubic metres of air.
6. A solvent tank measures 140 cm × 50 cm × 30 cm. To the nearest litre, how many litres of solvent will it take to fill it to three quarters full? (1 cm^3 equals 1 mL)
7. A pipe has an inside diameter of 2 inches and is 10 feet in length. If one end was plugged, the pipe would hold [blank] gallons. (Round to the nearest tenth.)
8. 50 ounces is equal to [blank] litres. (Round to the nearest tenth.)
9. 5 gallons is [blank] litres. (Round to the nearest tenth.)
10. 8 cubic feet is the same as [blank] cubic metres. (Round to the nearest hundredth.)

Answers

1. A
2. A
3. B
4. 9818
5. 31.7
6. 157.5 L
7. 1.6
8. 1.5
9. 18.9
10. 0.23

Practice Test

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18. $2[13 + (8 – 5)] = x$. What is x?

A. 52

B. 32

C. 23

D. 43

19. $N + 2(3 - 1) = 8$. What is N?

A. 2

B. 0

C. 4

D. 6

20. $27 = 8(n + 3)$. What is n?

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B. 3/4

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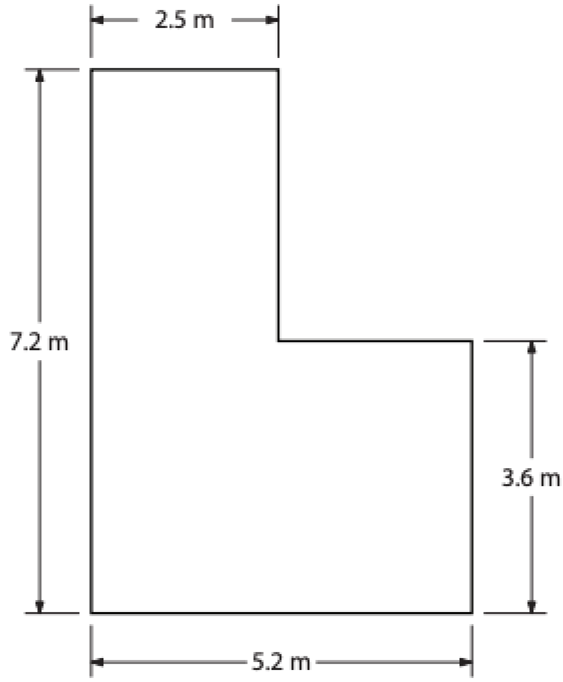

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    C. $15.55

    D. $10.85

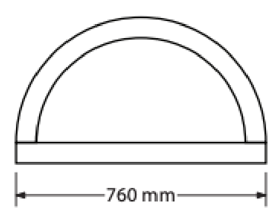

Figure 2. Click on the image to see it full size.

30. A rectangular steel bar has a cross sectional area of 468 mm2 . The bar is to be reformed into a triangular-shaped bar with the same cross-sectional area. If the height of the triangle is 36

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38. 50 ounce is equal to [blank] litre. (Round to the nearest tenth)
39. 5 gallons is [blank] litres, (Round to the nearest tenth)
40. 8 cubic feet is the same as [blank] cubic metres. (Round to the nearest hundredth)

Answers

1. 3200 m
2. 0.64 litres
3. 1.96 metres
4. 10
5. 5070.63
6. 212
7. 563
8. 1765
9. A
10. B
11. B
12. B
13. A
14. B
15. C
16. A
17. C
18. B
19. C
20. C
21. C
22. False
23. A
24. D
25. True
26. D
27. C
28. B
29. A
30. A
31. A
32. A

33. B
34. 9818
35. 31.7
36. 157.5 L
37. 1.6
38. 1.5
39. 18.9
40. 0.23

Image Descriptions

Figure 1 image description: the shape of the ceiling looks like a rectangle that was cut into a L-shaped polygon. The length of the rectangle is 7.2 metres, and its width is 5.2 metres. After the top right corner was cut off from the rectangle, the top width of the L shape is 2.5 metres, and its right length is 3.6 metres. [Return to Figure 1]

Figure 2 image description: the shape of the ceiling looks like a rectangle that was cut into a L-shaped polygon. The length of the rectangle is 7.2 metres, and its width is 5.2 metres. After the top right corner was cut off from the rectangle, the top width of the L shape is 2.5 metres, and its right length is 3.6 metres. [Return to Figure 2]

Versioning History

This page provides a record of edits and changes made to this book since its initial publication in the B.C. Open Textbook Collection. Whenever edits or updates are made in the text, we provide a record and description of those changes here. If the change is minor, the version number increases by 0.01. If the edits involve substantial updates, the version number increases to the next full number.

The files posted by this book always reflect the most recent version. If you find an error in this book, please fill out the Report an Open Textbook Error form.

Version	Date	Change	Details
1.00	June 21, 2021	Book published.	