Solve Your Building Maths. With a $10 Calculator

- Roof Angles
- Rafter Lengths
- Concrete Quantities
- Setting Out
- Checking For Square
- Chain Dimensions

By Bill Bradley

Using A Ten Dollar Calculator To Solve Construction Problems

Bill Bradley

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About The Author

Bill has been fully involved in the home building industry for over fifty years. He gained his qualifications as a Carpenter and Joiner from "The City & Guilds of London Institutes" in the UK before moving to Australia and forming his own construction company. Bill has taught many apprentices and young tradesmen over the years. While no longer actively building, in retirement he continues to share his wealth of practical knowledge by way of his popular website and these E-Books.

Other titles

- Asbestos, A Practical Guide.
- Stair Design Building comfortable and safe stairs

Contents

1 Introduction.

What this book is about.

It is an introduction to using one of the best value for money tools that anyone in the building industry can buy. A tool that will increase your speed and accuracy on the job. I will be showing how I have used it on site in many different applications.

I will try to simplify it's use and demystify the jargon that is associated with it.

What this book is not about.

Many of my examples use a touch of geometry, arithmetic and even algebra, but this is not any sort of instruction in those subjects. There are many books that explain these. However after reading this book you will be able to understand how those old text book examples can be used in real life, on site or in a workshop situation.

Why a $10 calculator?

I am fond of remarking that all the buildings that have ever been built in the whole of human history, prior to say 1950, have been built without the aid of computerized calculations.

Think about this for a moment, picture the medieval cathedrals of Europe. All this awe inspiring work done by simply drawing to scale and using longhand calculations.

- So, I believe that there is absolutely no substitute to learning the basics of maths, geometry, and drawing to scale.

- Once these basics have been learned, it is easy to move on to faster and more efficient ways of working.

- I am using a few building examples here, but the main reason for this booklet is to show you the possibilities and how easy it

is to use this wonderful yet inexpensive tool, **a modern pocket calculator**.

I do not advise anyone, whether an owner builder, apprentice carpenter, tradesman or whoever; to buy one of the dozens of specific purpose proprietary calculators that are available. They pander to the "easy quick fix" market. If you buy something like "The The Super Roofing Calculator" ("for the amazing low price of $..... "), this is what I happens.

1. First off you have to invest time in learning how to use it. Why not invest that same time in learning the basics?

2. You won't be able to cross check your results, you won't be able to work a problem out in any other way!

3. You are locked into the thing. If it gets broken or stolen too bad.

4. It may indeed be great for standard roof angles, but there are always odd complications that these things cannot cater for.

5. What about stairs? Or what about crown mould angles, raking mould, hoppers or the dozens of other problems that you may want to solve.

A basic ten dollar calculator will handle all this and more besides with ease.

What all of these proprietary products do, is to take away your ability to do it yourself. They take away your ability to even think for yourself.

So, get yourself a calculator, follow the steps I'll be laying out here; and learn how to use it.

Unless you use it often, (if you are anything like me :-), then you may forget it all fairly quickly. So at the end of this booklet I have drawn up a small "cheat sheet" that you can print out and keep with your calculator for future reference.

2 What sort of a calculator to choose?

There is no way that I can list all of the different controls on all the different makes and models of calculators available. What I will be doing instead is to tell you about the functions that I have used myself and that I consider are useful for us non technical, but practical guys.

I will point out a few of the mode type buttons that if they get pressed accidentally can cause confusion. So follow along here and identify the buttons on your machine that I am talking about. They may have slightly different names, but they will do the same things.

On the lowest rung of the calculator ladder is the desktop one that does arithmetic, addition and subtraction, multiplication and division, and quite possibly with a square root function. They are handy but not quite what what we want.
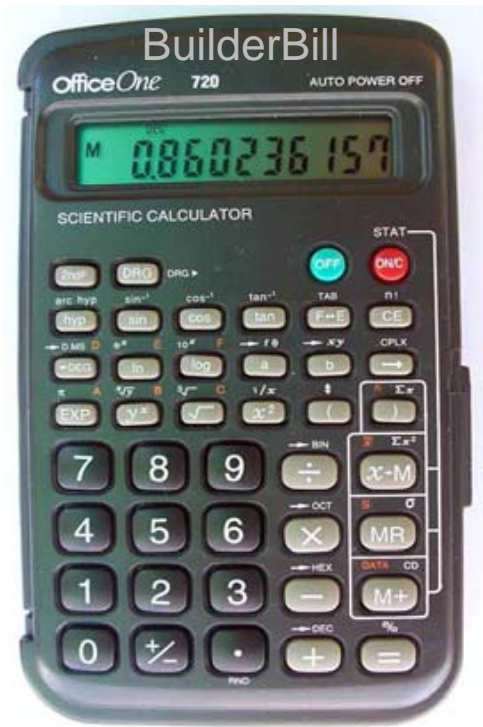
Img 2.0.1: A Ten Dollar Calculator

- You need to get what is known as a **scientific calculator**. or sometimes known as a **student's calculator**.

- What you are looking for is the extra section of keypad that shows a few scientific symbols on the buttons.

- The packaging may mention the various functions that it can perform, or how many there are.

- The one pictured here cost $10 and has 47 functions.

- They are sometimes known as a **student's calculator**. It's curious but the manufacturer's know what they are doing here. The huge market for these things is obviously high-school students, that use them for a short part part of their lives and then forget about them entirely.

- Who are we to complain. The economies of scale mean that these things are cheap as chips for us guys that sit on them, cover them with paint or otherwise destroy them in a working environment.
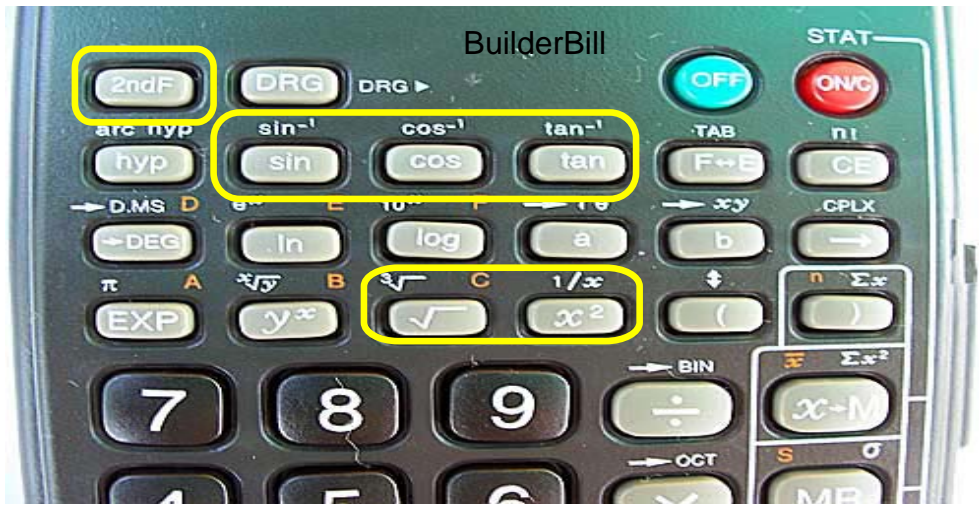
Img 2.0.2: Close-Up of Function Keys

Above is an enlargement showing the function buttons that we need. I have drawn around the ones that we use mostly in yellow.

- They are the trigonometry ratios, sine, cosine and tangent that are abbreviated to sin. cos. and tan. `sin` `cos` `tan`

- Below those is the square root function `√`

- The any number squared function `x²`

- The second function button `2ndF` (shift) Is on all calculators like this and when it is pressed a whole new range of functions become available, as indicated by the printed symbols above each button.

Unless you are a construction industry professional or studying to be one, I don't think that there is a lot of need to get anything more advanced than a basic calculator like the one above, with (as a minimum) the functions marked in yellow.

The cover photo shows a calculator that costs around $30 and has quite a few more features that I consider useful, but not necessary. I have to admit that it is the one I reach for first.

1. It is a Casio *fx-82AU* As it says on the body it has a natural display. In other words it uses the same notation as we would in algebra.

2. The display is significantly larger and easier to read.

3. The main buttons that I use on it that are not on the cheaper

calculator is a step back through the input and a delete button that allows editing of mistakes instead of typing the whole formula again.

4. Another useful feature is the ability to work with fractions.

Along with other features it is a more pleasant tool to use, but it is not better than the cheap one in the respect of accuracy or what we will be looking at here.

So to restate a couple of points from this chapter,

- More expensive does not mean better. For the average person that is. University students excepted.

- Buying an expensive, programmable calculator chock a block full of esoteric functions is definitely not needed to solve your average roofing problem.

- Keep it simple, sit on it when you are having your lunch, no big deal, a new one will probably cost you less than your next drink and burger.

- That being said, if you are a student and going to be using one for a lot of work, there are some nice ones out there, that make things a little clearer, have larger displays and have some nice features that the smaller ones don't have.

- For now I will use the $10 one that is entirely adequate for what we want to do.

- Definitely don't go wasting time looking for the exact same things that I show here. Any one with trig functions will do the job.

3 Looking at the Controls

When you get a calculator play about with it and get to know the controls. You need to find out how it handles simple input. There are differences from manufacturer to manufacturer. They sometimes use different notation. The two calculators here that I will use for these examples may work a little differently to your one, but don't panic the basics are the same. It goes without saying that you should have a look at the manual, and preferably keep it near when you are working through this book.

If you have not already got a calculator you can work through the examples here to a certain extent using the calculator that comes with your computer under the accessories menu. There are a few varieties of these, and nearly all of them have a view menu that allows you to shift from a basic view to another mode. Scientific is the one you should use.

On/C on/c	The on and clear all switch, switches on and if used while numbers are in the display it will clear them. Other calcs have another key for the clear all which simply empties the screen ready for a new calculation. (Don't ask me who picked the colours, green for off and red for on, one of life's little mysteries.)
Off off	This calculator is automatically switched off if it is idle for longer then 8 minutes..
+ − × ÷	The normal arithmetic keys.

= **=**	The equals key gives the answer. For example. 2.2 x 3.1 = 6.82 if you then continue on you can work with the answer or hit the ON/C to clear and start afresh.
2ndF **2ndF**	This one is used a lot, it is the second function key, sometimes called SHIFT so when it is pressed, then the second function of the next button pressed is ready to use. Typically the second function is printed onto the case just above the button that works it. On this calculator there is one exception and that is the RND (creates a random number) is located below the decimal point key.
DRG **DRG**	This is a mode button, when pressed, it cycles between DRG (degrees), RAD (radians) and Grad (grads). The mode currently selected is displayed in the top center of the screen. NOTE! Mode buttons in general. Get to know them and get to know what happens if you hit one by mistake. For the purpose of this book we will always be working with decimal degrees and as such we ALWAYS want to see DRG up there on the screen. So if you get what seems like nonsensical results when working with angles, check that DRG is set.
sin **sin** cos **cos** tan **tan**	The sine, cosine and tangent are the three trigonometrical functions. Use these buttons for working with and solving triangles. The main button inputs an entry in degrees into the relevant trig ratio. (Provided that you have DRG set,) Use the second function above them to change the ratio back into degrees.
x^2 **x²**	This button takes the number in the display (x) and multiplies it by itself. i.e. it squares it.
$\sqrt{}$ **√**	The square root button finds the square root of the number in the display.
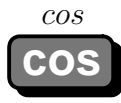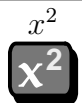
$x \to m$ **X►M**	Put the number in the display (x), into the calculators memory.
MR **MR**	Memory recall, the number stored in the memory is placed in the display.
$m+$ **M +**	Add the number in the display to the number that is already in the memory.
$+/-$ **+/-**	Change the value of the number in the display. It toggles between positive and +/- negative. Positive values are the default, and the plus sign is not shown, but if you change to a negative value, then the minus sign appears in the display, before the number NOTE! If you want to subtract a number from the memory, change the sign first.
F◄►E	This is the format exchange button. It toggles between **Floating Point Mode**. and **Scientific Notation Mode**. The default setting for this calculator is to have the numerical display set to Floating Point Mode. This means that an entry of say 2+4 = will return 6. An entry of 8.4 / 2 = will give the answer 2.4. If you do 10 / 3 = then the answer will be 3.333333333. that is, the decimal point will be positioned where it is needed to show non zero amounts. So when the answer is 6, that is all it will show. When the answer is 5.35 then it will show it. In the last case, 3.333333333 the calculator has gone to the limit of it's capability in this mode, showing nine decimal places.

If you do need more capacity, after you have reached the limit of 9 decimal places, hit this format exchange button and the answer will show up in Scientific Notation.

This notation system breaks down extremely large or very small numbers into a smaller base number, raised to a power of ten. You will see a number something like this 5.85296 08 That is 5.8 etc. then a gap of two spaces and 08, that denotes "times ten to the eighth power". Because this is also called **exponential notation**, some calculators would show an E where the two spaces are.

Again this is hardly relevant to what I am talking about here, except that if you happen to hit a wrong button at any time and see confusing numbers, this could be the one that did it.

The second function associated with the format exchange key is the TAB function.

Do This: 2ndF   F◄►E   2   =   0.00

TAB

This will set the display to show figures to only two decimal places. I usually like to set it zero, because I mostly work in millimetres, if you are working in inches, you may like to set it at two decimal places like here, if you are using metres then maybe 3 places.

Any other extra digits are just confusing and whatever unit you are using, it is pointless working with a greater accuracy than you can measure on the job.

There are quite a lot more functions available, and I will explain them when we get to them. So just to give you an idea of how I will be showing the keystrokes, here is a an example with an explanation under. To set the calculator to display only full numbers.

buttons that call up a function will be shown like this

standard key pad entries will be shown as plain numbers

answer in green and sometimes pointing to a part of a sketch (not necessarily after the equals key)

TAB

2ndF   **F↔E**   0   **=**   0

hit this key

then hit this key

because you hit the 2nd F key first, you are now invoking the second function of the next key that you hit. In this case it is the TAB function, not the F--E

hit the equals key

on the ordinary keypad hit 0, to show no decimal places

answer

Things to remember in this chapter before we go onto the details.

1. Don't forget: Find out what the mode buttons are, find out where they are and what the various modes look like on the screen.

2. Learn how to reset back to your standard view, if they get altered by mistake.

4 Learn how to do a very basic, self check.

Get an approximate answer before you open the calculator. If you only learn this one skill, you will be in front of the pack by miles.

The modern calculator (as indeed the computer in general) is a great tool if used correctly, but it is only that! A tool. You the user should be in charge, you should know the pitfalls as well as the benefits

In the previous chapter I stressed the point that if you press a wrong button and changed the mode then what appears to be at the least an unexpected answer may be seen in the display. I mentioned that you should learn to see these for what they are and to be able to do a quick reset when necessary.

Another very useful thing that you can teach yourself to do is to get an approximation of the answer before you even pick up a calculator.

- This is not so hard to do. We are only trying to get it close enough so that when we get a final answer come up on a screen, we can tell if we have the decimal point in the right place.

- At the same time we have to know that we have the right units as well as the right numerical answer. It is very easy to get mixed up with the units.
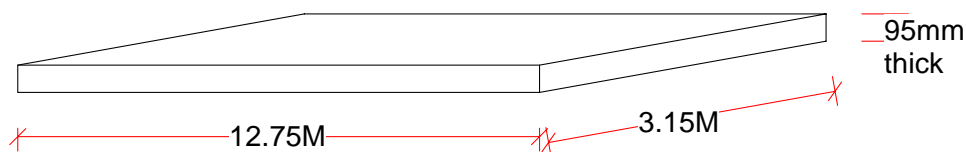
In the sketch above, lets say that we have a concrete slab to pour. We do a quick measure up and we punch in the figures

$$12.75 \text{ x } 3.15 \text{ x } 0.95 = 38.15$$

Which means... errrr 38 plus cubic metres. No way.

- That's more than six trucks of concrete.

- What we did was to confuse our units. We measured in the large dimensions in metres and then we measured the thickness in millimetres.

- We got the decimal point in the wrong place when we punched in .95. That is 950 millimetres.

- We should have punched in .095, to give us an answer of 3.815 cubic metres.

If I have something like this to calculate I round it off either mentally or on paper. I do :-

- 13 times 3 equals 39 divide by 10 equals 3.9 cubic M.

I rounded the numbers off so that I could get a ball park figure of what the calculator will later tell me accurately. This example is a bit simplistic, and It would be hard not to see this mistake, and yet many times mistakes like this get made.

Cultivating this habit of doing simple mental calculations can pay off many times over. In a concreting situation again, if we are doing a house slab pour we may order "36 cuM. plus". That means we get six, 6 cuM. full trucks and then we measure the bit that's left and the truckie radios it in. Most good concreters and builders can do a rough calc to measure the remaining concrete needed mentally.

A few years ago I was building a house, and we had about twenty 600 diameter foundation holes drilled, to varying depths for concrete footings for steel verandah posts.

The pest control guy comes out to spray the footings with insecticide for

termite prevention.

- He does the job, and then goes over to his vehicle to make out my certificate.

- I strolled over after about ten minutes to see what he was up to. He had to note onto his form how many square metres of ground that he had treated.

- He made his first mistake when he bought his calculator, it was a double sided one that unfolded like a book and would have had several hundred functions. Einstein himself would have had trouble with it.

- This poor guy probably hit a wrong mode button by mistake and couldn't correct his error.

- I also don't think that he had a grasp of the basics of what he was trying to do. (Which I think was to get the surface area of a cylinder less one end and then multiply it by the number of holes).

- He had never been taught to do a rough mental average of a calc. to check his calculator figures, because if he had, he could have done the whole thing in his head.

To even start the calc. he had to know some basic things about circle.
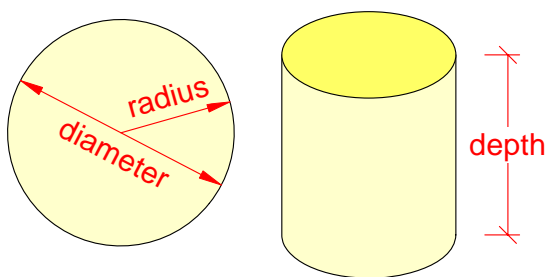
- Pi (Π) is a mathematical constant used to solve circles. On my small calculator at it's highest setting I get a value of 3.141592654. This is far too great an accuracy for non scientific work. 3.14 is adequate for anything like the problem we are talking about here. I can access Pi by using the second function of my EXP button but I rarely do. 3.14 is fine.

- Πr^2 Is the formula for finding the area of a circle where r is the radius.

- $\prod d$ Is the formula for finding the circumference of a circle where d is the diameter.

So while the guy was trying to come up with and answer I did a bit of rounding off and worked the following out with a pencil and paper.

I have the bottom of the holes 600 dia to get the area of.

3 times 3=9, times 3 and a bit....call it 30. = 0.3sqM

a 600 dia hole has a 300 radius, forget about the zeros radius squared, 3x3=9

This is pi at it's most basic, and most times it's enough.
3 and one seventh is closer and 3.14 better but harder to do mentally.

9 times 3 =27 plus the bit extra. This keeps the numbers easy.

so what does the 30 represent? I know that it is not 30 sqM and I also know that there has to be only a few 600 dia holes in 1sqM so the 30 represents 0.3sqM

Each hole bottom is 0.3 sqM and there are 20 of them.

3 times 2 = 6,   that's 6 sqM.......write down 6 sqM

Again there is no real need to worry about the decimals and the zeros in simple metal arithmetic.

You know it's neither be 60 sqM or 0.6 sqM They are the only other options

I need to get the circumference. In metres.

6 times 3 and a bit, call it 20. = 2 lineal M

circumference, 600 dia x Pi.

600 x 3 =1800mm so 2000 is OK

faced with the number 2, you know the answer is larger than 0.2, and it's less than 20 linM

The corners had holes 1200 deep and the intermediate columns were set in 900 deep holes, so I averaged them at 1M deep.

2 times 1 = 2 sqM, times 20 = 40 plus 6 = 46sqM

This is the circumference 2M times the depth 1M

The number of holes

The 6 sqM for the bottoms

So I said to the guy, write down 46 square metres. He said is that accurate ? I said It's as good as you need.

Now that exercise was as rough as guts, but it illustrates the main points here.

1. A lot of jobs just don't need much accuracy, so why go to the extreme?

2. Always try to get a ballpark answer. You may not think that you can do it so think about it this way.

3. It is a bit like totaling up your shopping trolley at a supermarket. Round off the amounts, rough enough is good enough, some up some down and you will always know, (more by a gut feeling) that the answer will be between $60 - $90 and not 60-90 cents or $600 - $900.

As a check up, of the last section I ran the figures through my calculator

1. Area of a 300 radius circle= .28 x 20 = 5.65 M^2

2. Circumference of a 600 diameter circle = 1.88M

3. 1.88 x 4 (holes) x 1200 (deep) = 9.05 M^2

4. 1.88 x 16 (holes) x 900 (deep) = 27.07 M^2

5. 5.65+9.05+27.07= 41.77sqM.

So, looking at my rounding off, It seems that I was 4M^2 out in almost 42M^2 . That's just about a 10% error. Not bad when we used a couple of figures for Pi as "3 and a bit".

The day before all this went on, I had to order my concrete. In theory I needed 5.38 cubic metres of concrete.

That's not what I ordered though, I looked around the site, considered that we were using wheelbarrows, (chance of spillage waste) my average depth might be a bit over and augered holes are always a bit wider than the drill.

I would have also taken into account that we order concrete in multiples of 0.2cuM and ordered at least 5.6cuM. It is hard to throw away excess concrete that you have paid for, but hey! you never want to have to get an extra truck sent out, with only 0.4cuM on board, That does hurt.

To drive the point home once again. Even though the calculator is capable of extreme accuracy, in actual use, many times the figures that we actually use are amended to allow for other factors such as waste.

Another example, timber suppliers may be selling the lengths of timber in increments of 0.3M (1 foot) 4.8, 5.1, 5.4 etc. so it is no good going to the timber yard with detailed precise figures. You use those later.

5 Chain dimensions.

My favourite trick, or why I always had a calculator with me on building sites

This is something that I learned years ago, quite by accident I think, and I have never seen it documented anywhere.

345   [=]   345
   [+] [=]   690
     [=]   1035
     [=]   1380
     [=]   1725
     [=]   2070
     [=]   2415
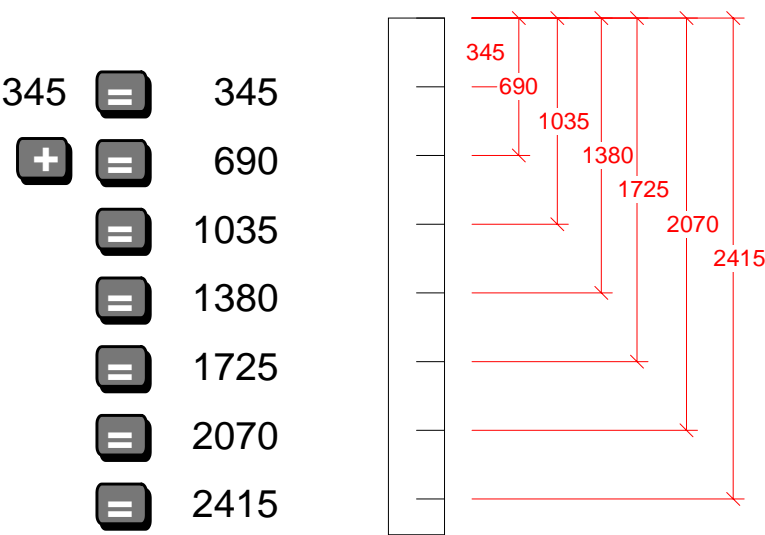
What I did was to establish a number and then add that same number to the previous answer with each stroke of the equal key.

On the right is say a representation of marking out a board from one end with a pencil mark every 345.

- "Why bother" you may ask, "why not just step out each distance from the end of the last one that you mark?"

- If you do this you are liable to creep. If you are a bit sloppy with your marking then you can get out by quite a bit.

- I have used this method for making a marking out rod for brickies, a brick plus joint being my increment, same thing with ceramic tiles, floor tile plus joint.

I ALWAYS do it with stairs. Once I have the Rise and Go worked out I get the angle distance or pitch by calculator and step it out on the stringer by this method. On a flight with say 17 steps it would be easy to get 10 to 15 mm out just adding each one to to the last when we are maybe talking about a pitch 345.8 . This is the same reason that I never step out distances with a steel square when roofing of on stair strings. There is always the tendency to creep.

> Many years ago I once did quite a large concrete slab, that used a grid of 12mm rebars at 125 centres.
>
> The supervisor came on the job one morning, looked around and without seeming to measure anything said "you're two bars short in this section Bill".
>
> "Bullshit, measure them" I said, handing him a tape measure.
>
> "Don't need that" he said, calculator in hand, "that distance divided by 125 should be this!". "You're two short".
>
> Marking say 80 bars out with a tape measure and chalk it is so easy to creep and yet not see any real mistake.
>
> I am not sure, I can't recall, but maybe after that I went out and bought a calculator :-)

Not every calculator will do this little trick, but most of them will with a little trial and error. For instance the Casio in Appendix A. has an ANS button, which you can hit to copy the answer in the display.

pressing the Ans key picks up the previous answer. Each hit of the = key adds 345 to the previous answer.
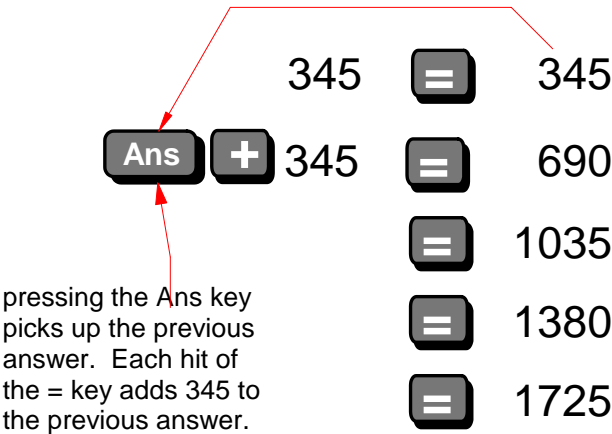
Even the humble Windows calculator in your accessories menu will do it.

345   **+** | enter | 690

| enter | 1035

| enter | 1380

| enter | 1725

6 Ratios, Proportions and Multiplier Factors

Because we use a calculator to do all the hard work for us, we can simplify many construction problems.

We get many instances of ratios and proportions in construction work.

1. Probably the most common one is in roofing, the North American guys use a ratio of span to rise. It is usually where 12 is the base usually meaning 12" and the other number as the rise in inches. So 6:12 would mean that you have 6" of rise for every 12" of span. So a carpenter might say he is building a six inch pitch roof.

2. Our plumbers might state that sewerage gradients should be between 1:40 and 1:110. with 1:80 being a good average. Maybe your plumber mate says to do it at $\frac{1}{8}$" and $\frac{1}{4}$" per foot. (These gradients are worked out so that the waste will flow at the correct speed that takes away all the solids).

3. We now have regs that say a ramp is steep at 1:8 and for wheelchair access it should be no more than 1:14. A driveway shouldn't be more than 1:6 .

4. You may want to mix concrete and a website says 2:5:7 may be a good ratio of cement to sand to aggregate.

5. You look at the information on a can of paint or at a manufacturer's data sheet and it says that the recommended coverage rate is between 12 M^2 per litre and 16 M^2 per litre, depending on the wall surface.

6. You may want to work out how many packs of shingles you are going to need if the manufacturer says that the coverage is 3 packs per square or your mate tells you that 1 bundle covers an 8' x 4' ply sheet.

7. You may be pricing a job and you want to add 12.5% extra for waste and then add 15% more for profit.

In all of these case there is a direct relationship between one value and another.

Now you can go on to the web and find heaps of information similar to the stuff in your old arithmetic text books at school about rations, proportion and percentages. It will be confusing to say the least.

One of the neatest applications of simplifying complicated ratios is the use of multipliers.

Nowhere have I seen the use of multipliers used for these sorts of problems, and yet it is so simple to do.

6.0.1 How to get the rise of a $7\frac{1}{2}$" pitch roof .
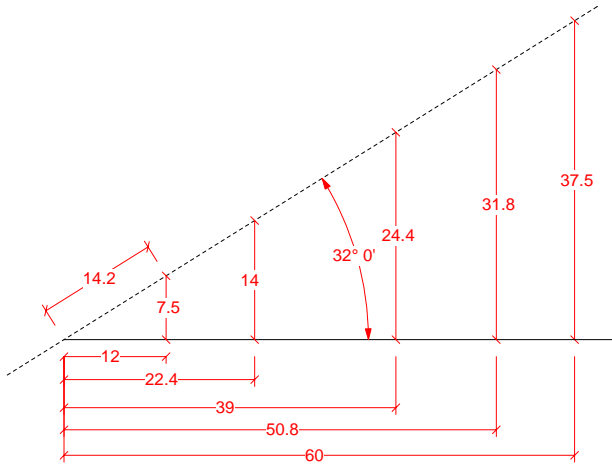
With ratios like this it does not matter if you are talking about inches, yards, metres or any other measurements. The rule is; if you are inputting inches then the answer is inches.

- The normal way to do this is to divide the span by 12 and then multiply by 7.5, that is two operations but easy to do and remember.

- Or alternatively you use a steel square which while simple to use, it takes time and is prone to error.

Another way is to find a multiplier that can be used to cut out one step if you have a lot of the same heights to work out.

1. To get the multiplier in this case divide 7.5 by 12.

2. $7.5/12 = 0.625$

3. **So to find the height of any $7\frac{1}{2}$" pitch roof just multiply the span or run by 0.625**

4. Try it with the figures shown. It always works. 22.4ft x 0.625=14ft rise, 39 yds x 0.625 gives a rise of 24.4yds. Etc.

There is not an awful lot of gain in using a multiplier like this but it explains the process.

6.0.2 How to get the rafter lengths of a $7\frac{1}{2}$" pitch roof .
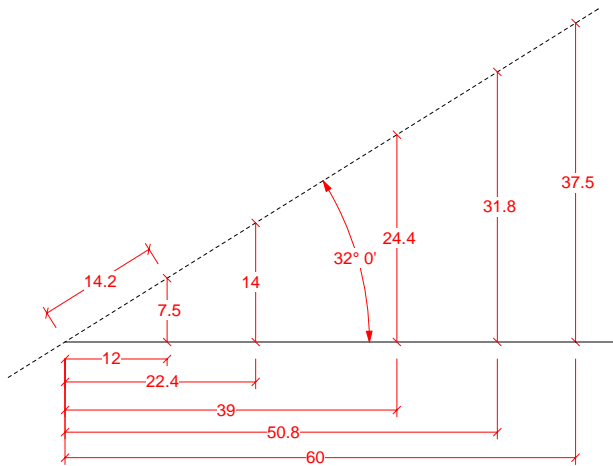
Look at this sketch again and you will see that I have given a dimension for the sloping part of the 12 : 7.5 section. In the next chapter you will see here 7.1.1 one of the ways we can calculate the length of a sloping side of a triangle.

- Now that takes a few more steps than the example above, so it is definitely worth our while to use a multiplier here.

- For all triangles that have this same 7.5" pitch roof then if we divide the sloping length of 14.2 by 12 we will get a multiplier value of 1.179

- Any distance on plan that represents a sloping surface, when multiplied by this amount will return the exact true length of the sloping surface.

- So a 22.4ft span x 1.179 = **26.4ft rafter length** .

- Now think how easy it will be to get eaves overhang lengths or jack rafters.

- Have a quick look here 8.4.2 and you will will see how easy it will be to use this roof slope multiplier to quickly estimate roofing quantities.

Now that is a lot quicker, and because it cuts out a few steps it is far less prone to errors.

6.0.3 How to get the amount of fall in a sewer pipe given the length of pipe run.

- Lets say that we want a 1:80 fall. That means that for every 80 units the fall is 1 unit.

- So for every unit of length the fall is $\frac{1}{80}$ so just divide your distance by 80;

- If the distance is 79.305 Metres then the fall required is 0.991, or 991mm.

- All of these straight out one to something else ratios are easy to do, you only have two choices to make, either multiply by the larger number or divide by it and if you pick the wrong one then there's little harm done as it is obvious from the answer that you have it wrong.

6.0.4 How to get the amount of fall for a wheelchair ramp given the rise.

- This is the same problem as above, just a different range of figures.

- So this time you have to set out a ramp for a wheelchair access that has a rise of 650mm. We want to use a slope of 1:18

- 0.650 x 18 = 11.7M.

6.0.5 How to get the amounts for home mixed concrete.

- The design of concrete batching is an art in itself so don't take what follows as anything but an exercise in using a pocket calculator.

- You mix in in the ratio of 2:5:7. That is 2 parts cement, 5 parts sand and 7 parts aggregate.

- You should get it in a ration of 1 to something so divide the number by 2

- That is the same a 1 : 2.5 : 3.5

- So I need to find the quantities for sand and aggregate that go with each unit of cement.

- We buy our bags of cement in 20kg bags so I could use a kilogram as my unit and work with weight.

- So let's say my mixer has the capacity to hold a half bag of cement 10 kilo plus the other materials.

	cement	sand	aggregate
This is the basic ratio	1	2.5	3.5
If we use 10 kg of cement then the others get multiplied by ten kg also	10kg	25kg	35kg
If we are using volume batching we may have 5.5 cuft. of cement per batch	5.5cuft	13.75cuft	19.25cuft

6.0.6 Percentages

I never use the percentage button on calculators, preferring to do the math myself so that it is clearer in my mind.

- If you multiply a figure by one then it stays the same.

- If you multiply a figure by 1.1 then you have multiplied it by $1\frac{1}{10}$ or in another way you have added 10% to the original sum.

  - From the introduction to this chapter I said that "You may be pricing a job and you want to add 12.5% extra for waste and then add 15% more for profit."
  - If the original amount is $17,562.00 the multiply by 1.125 = 19757.25.
  - Multiply that again by 1.15 and you get $22,720.84
  - Note You can add the 12.5% to the 15% to get 27.5%.
  - $17,562.00 x 1.275 = $22,391.55. By doing it this way you missed out on profit on the 12.5% wastage factor.

- If you multiply a figure by 0.9 then you have multiplied it by $\frac{9}{10}$ or in another way you have subtracted 10% to the original sum.

  - If you have a figure of $765.00 and you are eligible for a $6\frac{3}{4}$% discount, how much will you save. 765.00 * (1-.0675) = $713.36

- – If you just want to know the amount saved then 765.00 *
    0.0675 = $51.63

- With all these calculations watch where the decimal point is. Multiplying by 0.675 in the last example would give a result of $67\frac{1}{2}\%$. The differences are so large between a decimal point either way that they are easy to spot so don't let the risk of making an error stop you from trying any of these calculations on the job.
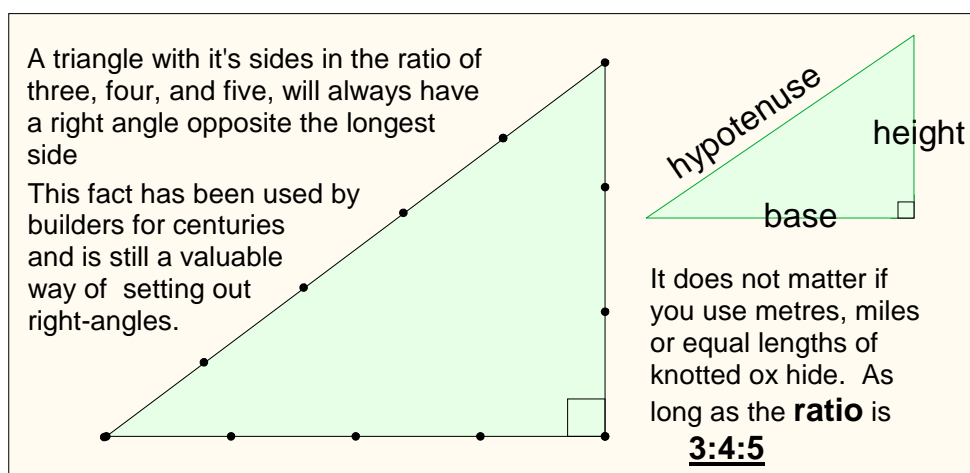
The examples here are fairly simple and it is just a matter of looking at the problem and then trying it out. Invariably the best way to do it is to start with a calculation that you know the approximate answer to and it is always easy to see if you have gone the wrong way round. Multiplied instead of divided.

7 Pythagoras and the 3:4:5 triangle

There are so many times in building work that we rely on triangles, from roofs to bracing walls. A lot of our trickier problems can be solved by finding out the missing properties of triangles. In particular the right-angle triangle.

A right-angle triangle consists of any triangle that has two of it's sides at 90° to each other.

We show that the angle is 90° by drawing the small rectangle at the join. This should be done all the time but this is not a book on geometry so in the rest of this book the right angles will be fairy obvious so I won't continue to do it. If it is not a right-angle I'll say.

A triangle with it's sides in the ratio of three, four, and five, will always have a right angle opposite the longest side

This fact has been used by builders for centuries and is still a valuable way of setting out right-angles.

hypotenuse

height

base

It does not matter if you use metres, miles or equal lengths of knotted ox hide. As long as the **ratio** is **3:4:5**

The people of ancient Babylon and of Egypt worked out methods of land measurement and setting out, using cords. Quite likely they were made out of leather and so obviously they had be knotted together and some unknown genius hit on the idea of standardising the lengths between the knots and so discovered the predecessors of our modern tape measures.

They then proceeded to lay down a large number of the universal rules of geometry that we still use today. It is known that they were familiar with the 3:4:5 triangle, but we had to wait a further two thousand years or so until a Greek scholar called Pythagoras turned his intellect onto the humble 3:4:5 triangle and discovered his proof or theorem regarding **all right-angled triangles**.

The Pythagoras theorem states:-

The square on the hypotenuse equals the sum of the squares on the other two sides.

Lets try it out with our old mate the 3:4:5 triangle:-

Some calculators require you to have the brackets around the terms and others don't. So first off, because the brackets are there on the keypad I wrap each section in brackets to be evaluated first as I would do in normal algebra if I was working it out longhand.

(3 × 3) + (4 × 4) = 25 √ 5

Nothing wrong with that so let's check it without the brackets to see how it handles the same phrase in a shorter form, less typing, eh!

3 × 3 + 4 × 4 = 25 √ 5

Yes, no sweat, the $10 beauty evaluates the multiplications first and then the additions, so I can safely work without the brackets from now on. What happens is that the calculator, like your computer when it sees an arithmetic expression like this evaluates the multiplication and the division expressions first and then it carries on and uses the results with the addition and subtraction parts of the formula.

This is known as precedence. The multiplication and the division aspects of the problem come before the addition and subtraction.
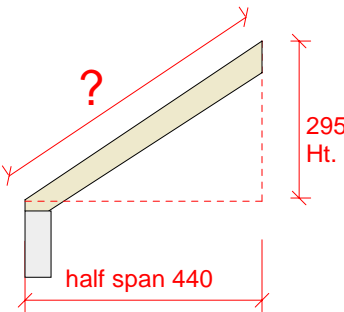
Some calculators require you to have the brackets around the terms and others don't.

We can of course cut the operation even a bit shorter by using two more of our buttons, the x^2 button then the $\sqrt{}$ button.

3 x^2 + 4 x^2 = 25 √ 5

7.1 Practical Examples of Using Pythagoras.

7.1.1 How to get the length of a rafter, given the half span and the height.

So we now know that when we have a right angle triangle, if we know the lengths of any two of the sides we can get the other side. In this case we need to find the hypotenuse, the long sloping side.

To get the longest side. We add the square of the short side to the square of the other short side, then get the square root of the result.

So the length of the rafter, that is the theoretical length is 530, in practice the physical piece of wood it is longer with the addition of the foot cuts, but that comes into roof construction. Here we are interested only in the calculations.

NOTE! The figures in blue are the intermediate results of the various keystrokes, that show up on the screen.

- As you can imagine they get to be quite large or small on occasions, and as it is not necessary to show them, I will not be showing them any more.

- Just be aware that these will be appearing on your calculator's display all the time.

- So from now on all I will show is your actual input, apart from the result at the end.

7.1.2 How to get the height, given the span and the rafter length.
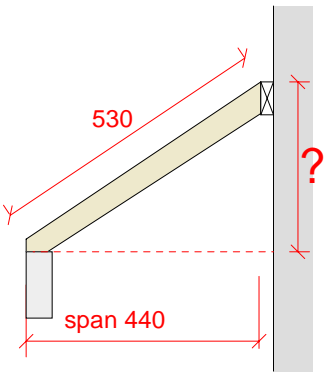
In this case we have the width at the bottom and we know the length of the rafters, but we need to know what height to fix the wall plate, that the tops of the rafters fix to.

the length of the
rafter or hypotenuse
squared

the length of the
span or other side
squared

To get an unknown shorter side. We take the square of the short side we know the length of, from the square of the long side, then get the square root of the result.

7.1.3 Setting Out A Building Foundation, Checking For Square
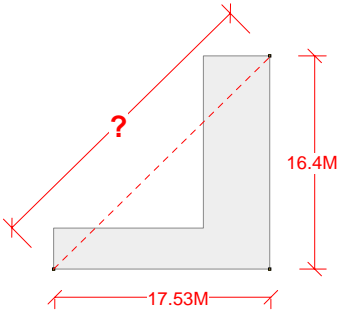
At the left we have a sketch of say an "L" shaped building.

- When we are setting it out, after putting a peg in the three main corners, we want to check for square before getting the rest of the profiles fixed.

- We could of course set it out as a rectangle and then measure the diagonals for being equal. Always the best and quickest way of squaring rectangles. Less chance of error.

- But let's say there is something in the way to stop us doing this. A tree or a building.

So we want to know the length of the red dotted line.

$$17.53 \boxed{x^2} \boxed{+} 16.4 \boxed{x^2} \boxed{=} \boxed{\sqrt{}} \quad 24.005$$

We now know that for there to be a true 90deg angle between the two sides, then the diagonal between them should be 24.005 Metres. (5mm longer than 24M).

- If it is not within say 50mm at the profile stage, before excavation then we have to adjust it. If we had already set the job out, and we were doing a check on say the formwork, then we would probably work to plus or minus 5mm. $\pm 5mm$.

Note that I have measured the longest of the possible diagonals. The longer and the closer to 45° the diagonal line is more accurate the squaring will be.

- It would have been quite prone to error to do the squaring in one of the long rectangles for instance.

7.1.4 Setting Out A Fence Line With An Angled Corner.
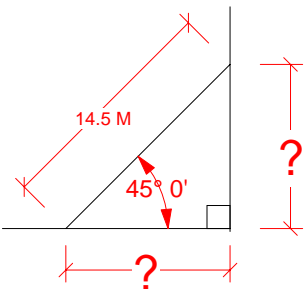
Here we have a sketch a corner of a fence line that has a 45° leg across a 14.5 M square corner ? On the drawings we are given the length of the angled section. How do we set it out, quickly and easily?

$$14.5 \boxed{x^2} \boxed{\div} 2 \boxed{=} \boxed{\sqrt{}} \quad 10.25$$

Measure in from the corner 10.25M each way and check the diagonal. It will be 14.5M

That's not a bad little trick at all. Solving a triangle set out and we only know one length and one angle. We were lucky of course, the angle being 45° made it possible.

With the aid of our calculator though, we can do the same with any angle. Read on and discover the magic of the Trig functions...!

8 The Trigonometry Ratios

The word trigonometry comes to us from the ancient Greeks, their words Tri (three) gonom (angle) and metron (measure) form our word for that part of maths involved with the measurement of three sided figures, or triangles.

It is a complicated subject that I hope to just give you an introduction to and to break the subject down to just enough to be able to use easily just for solving right-angled triangles that we come up against in the construction industry.

A quick touch of background first.

the longest side the hypotenuse is a radius of the circle.

30°

a right triangle with an angle of 30 is half of an equilateral triangle

as angle changes so does length of opposite side. This relationship is the sine ratio

a chord

half length of chord
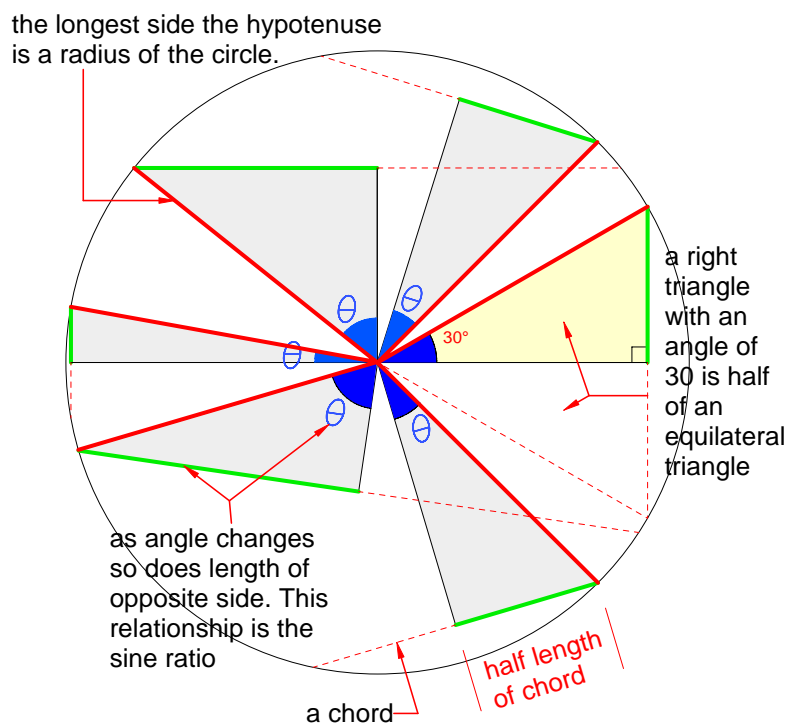
- Triangles, in particular the right triangle are vital in building construction and a knowledge of their working is a great advantage to all of us that have anything to do with construction.

- A **chord** is any line across a circle that does not go through the centre.

- The Greek and then later Hindu mathematicians discovered that when right triangles were drawn inside a circle, using the radius as the hypotenuse then the length of the opposite side, that is a half of a chord, had a relationship to the angle at the centre.

- By drawing painstakingly to scale many of the possible triangles that can be contained in a circle they produced sets of tables to aid mathematicians.

- These tables were themselves studied until a workable formula was discovered that worked for all those different triangles inside a circle**. This relationship or ratio became known as the sine ratio,** from the Hindu word for half a chord.

- That formula for the sine ratio is built into our calculators and it is called up when we press the `sin` key on our calculator. Sin is the accepted abbreviation of sine.

- Following on from being able to find the sine ratio two others were found.

- The cosine ratio (cos) that is accessed by our `cos` key.

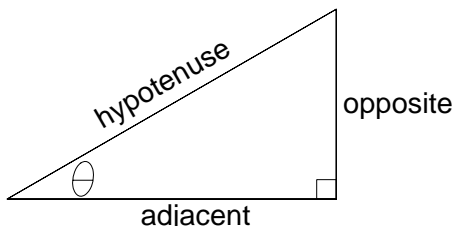- and the tangent ratio (tan) accessed by the `tan` key.

These three ratios when we are talking about right-angled triangles can be summarised like this. The Greek letter theta θ is commonly used to denote an unknown angle.

$$sin\theta = \frac{opposite}{hypotenuse}$$

$$cos\theta = \frac{adjacent}{hypotenuse}$$

$$tan\theta = \frac{opposite}{ajacent}$$

To remember these think of SOH - CAH - TOA.
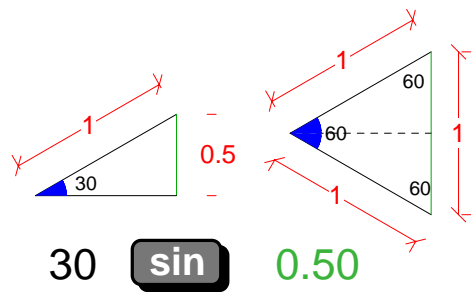
There is a special triangle which may have lead to the discovery of the sine ratio and it is the equilateral triangle shown above and I have included one in the previous sketch.

As you can see the two inputs of 30 and **sin** give an answer of 0.5 or half. This is an excellent way to find out if the calculator and all the settings are working OK.

Try a few hits with your calculator like the example below. Notice what happens to the results as the angle changes **Make sure that you are in the DEG mode!**

Try this out and if it doesn't work reverse the order to **sin** 30.

Below is an actual calculation.
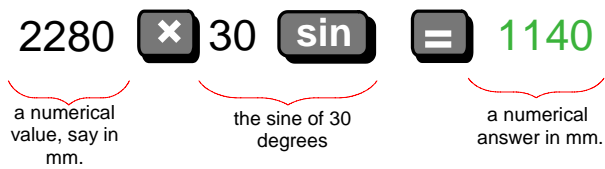
So using real figures this time, giving a value for the length of the hypotenuse we see that the answer remains half of the original value which it should be as we know that sin 30 has a value of 0.5.

8.1 Using The Sine Ratio

With these trig formulas for right-angled triangles we have two known quantities that help us find out the missing ones.

With the Sine ratio we work with an angle, the Opposite side and the Hypotenuse side. To remember this think of SOH

$sin\theta = \frac{opposite}{hypotenuse}$

Following the rules of algebra this basic formula can then be transposed to suit our needs and also we can put it into an order that is easy to input it into our calculator.
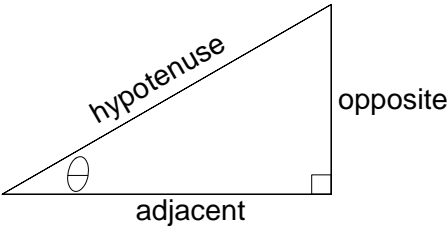
To find the angle.	opp/hyp=sinθ
To find the hypotenuse.	opp/sinθ=hyp
To find the opposite.	hyp x sinθ = opp

8.2 Worked Examples Using Sine Ratio

8.2.1 To find the angle given the opposite and the hypotenuse

To find the angle. | opp/hyp $= \sin\theta$

$$95 \div 687 = 0.14 \quad \boxed{2ndF} \quad \boxed{sin} \quad 7.95$$

sin^{-1}
using the second function of sin

Answer in decimal degrees
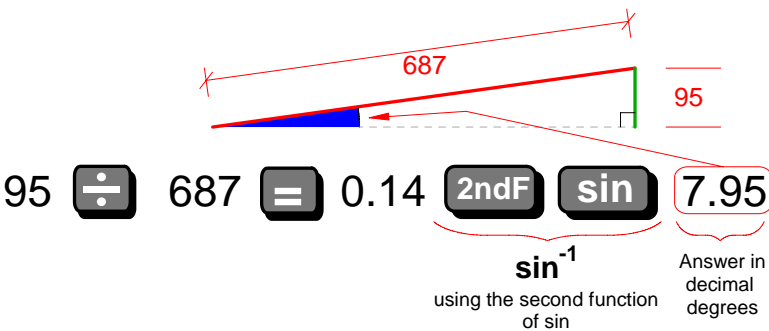
If you look above the sin button you will see $\sin^{-1}$ which is the inverse function of sin. Using sin you input the degree amount in numbers. To get a degree amount back out of the calculator we use the inverse $\sin^{-1}$ or the second function of sin.

8.2.2 To find the hypotenuse given the angle and the opposite

To find the hypotenuse. $\text{opp}/\sin\theta = \text{hyp}$

446 ÷ 62 sin = 505 /?

446

62 deg
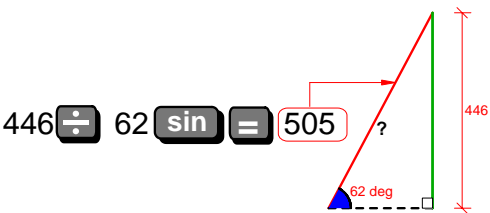
In the early section on Pythagoras we solved a few problems when we were given the lengths of 2 sides and we were able to find the length of the remaining side.

With the trig ratios we start using angles and finding them as well as getting missing side lengths like in the previous example.

8.2.3 To find the opposite given the angle and the hypotenuse

To find the opposite. | hyp x sinθ = opp

656

?

25deg

25 **sin**   ✖ 656 = 277

the sine of 25
degrees

a numerical
value, say in
mm.

a numerical
answer in mm.
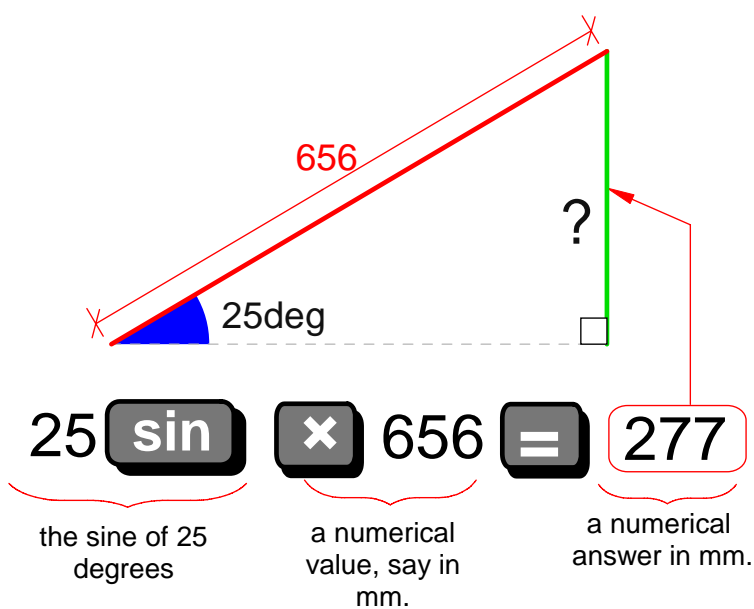
This is the third of the common uses of the sin ratio.

8.2.4 To find out the angle of an existing roof.

To find the angle. $\text{opp/hyp} = \sin\theta$

spirit level set level

pencil mark
on roof

216

766

Existing Roof
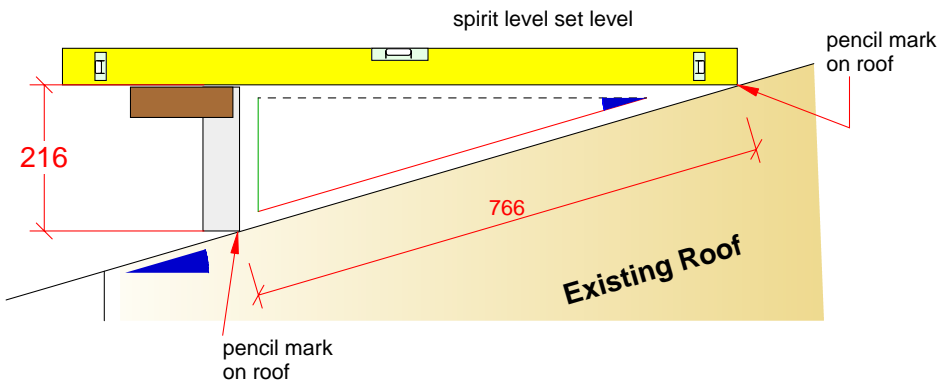
pencil mark
on roof

1. Put a pencil mark on the roof, place a try square to the mark and rest a spirit level on top of it.

2. Slide the level so that it is level and true to the square.

3. Put a mark on the roof where the level touches and measure the distance between the marks.

4. Measure the length of the square

5. Do the calculation below.

216 ÷ 766 = 0.28 **2ndF** **sin** 16.38

numerical values, in say mm.

$\sin^{-1}$
using the second function
of sin

Answer in
decimal
degrees

The practical example above is one that I have used often when designing and building an addition to an existing house.

The old drawings many times don't give an indication of the existing roof pitch, or if they do, I don't trust them, it is always better to check.

Quite often I just measure straight down from the end of my 1200 spirit level with a tape measure, and it is usually good enough for a flat pitch.

- A better way is to make sure in some way that your measurement is truly vertical, like using a square as shown.

- On steeper roof pitches you may have to use two spirit levels.

Other Options. The method above is accurate and quick, but like all things, there are alternative ways.

- You could for instance take an off cut of a wide board or piece of ply up there and rest it on the slope.

- Then you could use your level to mark a horizontal pencil line on the ply. Measuring the angle later with a protractor or using your calculator.

- There are a few small gizmos that give digital readings of angles, even spirit levels that give read outs, but to my knowledge, none of them are cheaper or more versatile than a standard pocket calculator.

8.3 The Cosine Ratio

$$cos\theta = \frac{adjacent}{hypotenuse}$$

With the Cosine ratio we work with an angle, the Adjacent side and the Hypotenuse. To remember this think of CAH .
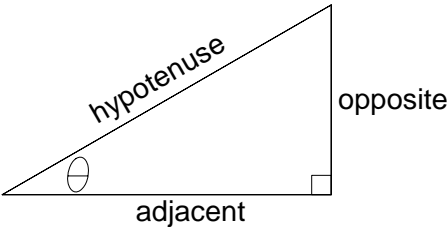
Once again, this basic formula can
be transposed to suit our needs putting it into an order that is easy to input it into our calculator.

To find the angle.	adj/hyp = cosθ
To find the hypotenuse.	adj/cosθ = hyp
To find the adjacent.	cosθ x hyp= adj

The cosine rule is useful for computing the third side of a triangle when two sides and their enclosed angle are known. Using right angle triangles it can work exactly as the examples given for the sine rule previously, except that the length of the unknown side is the opposite one.

8.4 Worked Examples Using Cosine Ratio

8.4.1 Finding a Rafter Length

To find the hypotenuse. $\boxed{\text{adj}/\cos\theta = \text{hyp}}$

Many many times we use this cosine rule to solve roofing questions. If you look at the triangle here, which shows that we know the angle and the base length, then with help of the memory jogger above it is fairly easy for us to find the length of the hypotenuse

- This could quite easily be a roofing layout. Say the half span of a pitched roof at 30 degrees.

- We could use these few brief keystrokes to get the length of rafters, roof sheeting etc.

For preparing estimates or quantities this is all we need. We don't need to know the height of the roof at this stage.

8.4.2 Measuring The Surface Area Of A Roof From The Plan

To find the hypotenuse. $\text{adj}/\cos\theta = \text{hyp}$

All the surfaces are an equal pitch of
let's's say 33 degrees.
The plan at the left includes the
overhangs
sizes in metres
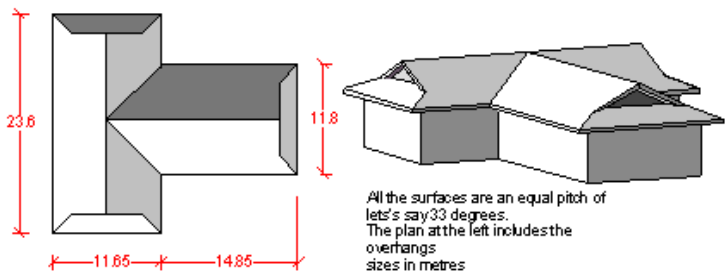
Here are a couple of sketches of a house roof. The 3D one shows it to be a "T" shape with what we call in Australia "Dutch Gables". Let's suppose that we have to work out a price for the roof . I am not talking about absolute accuracy, (even if there is such a thing) but the total square metres amount of roof surface, to enable us to price our main materials. Here's a quick way to do it.

$23.6 \times 11.65 + 14.85 \times 11.8 = \div 33 \; \cos \; 536.77$

The previous example just found the length of say a rafter, but that length multiplied by the width of the roof surface will give you the area of the roof surface.

- A rectangular plan with a roof on it, whether it is a single slope, gable or hip roof will have the same roof area, as long as the roof surfaces are all the same pitch.

- So you don't need to calculate each surface separately.

- In the example above I just added the two rectangular areas together and then applied cos 33 to the total.

So, these trig functions work just the same as any other ratios. They can be used with lines and lengths and also applied to surface areas. A very useful time saving technique.

8.5 Using The Tangent Ratio

With these trig formulas for right-angled triangles we have two known quantities that help us find out the missing ones.

With the Tangent ratio we work with an angle, the Opposite side and the Adjacent side. To remember this think of TOA.

$$tan\theta = \frac{opposite}{ajacent}$$

Following the rules of algebra this basic formula can then be transposed to suit our needs and also we can put it into an order that is easy to input it into our calculator.
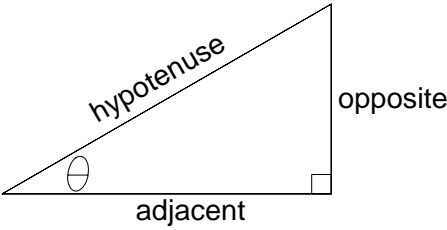
To find the angle.	opp/adj = tanθ
To find the adjacent.	opp/tanθ = adj
To find the opposite.	tanθ x adj = opp

8.6 Worked Examples Using The Tangent Ratio

8.6.1 To find out the angle of a roof in degrees, given the pitch ratio.

To find the angle. $\text{opp/adj} = \tan\theta$

- In North America it is common to refer to the pitch of a roof as a ratio of the amount of rise over the span, using a figure of 12 as the span.

- So the triangle above is depicting a roof pitch of 8:12

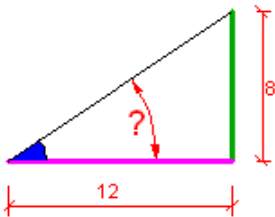Looking at the answer of 33°69' then a rough mental check tells me that it seems OK to me. Half of an equilateral triangle would have 12 : 6 ratio and I know that is 30° and a 45° angle would be a 12 : 12 ratio so it looks good.

- It is possible to build houses without ever needing to know the exact angle of the roof surface, the system works perfectly.

- Except that other people like solar panel suppliers and fixers work in degrees.

- Architects are now using sophisticated CAD programs that predict sunlight in windows, shade for awnings etc in degrees.

- So it is a case that many times the ratio has to be converted into something that the rest of the world understands. Fortunately it is easy with the memory jogger above an a $10 calculator.

8.6.2 To find the rise given the angle and the span

To find the opposite. | $\tan\theta$ x adj = opp
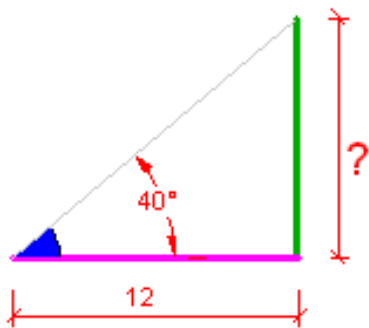
If you are a die hard "feet and inches" person and you have an angle only on the drawings then you can easily reverse the process.

9 Non Right Angle Triangles

9.1 The Law of Cosines

All our work with triangles so far has been with right angle triangles and it is fairly rare that we have to deal with a problem that we can't solve without them. I can think of a few times though, so we will look at a method of solving these odd triangles that don't make things easy for us.
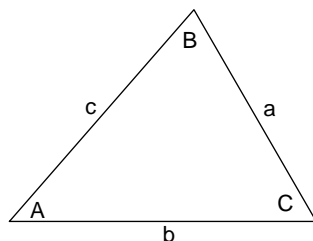
When looking at figures like this it is normal to name the sides a,b,and c in lowercase letters. When referring to the angles in the triangle the convention is to write them in uppercase or capitals. A,B, and C

$$a^2 = b^2 + c^2 - 2bc.cos(A)$$

$$b^2 = a^2 + c^2 - 2ac.cos(b)$$

$$c^2 = a^2 + b^2 - 2ab.cos(c)$$

The law of cosines is a formula that relates the three sides of a triangle to the cosine of a given angle. This formula allows you

1. to calculate the side length of non-right triangle as long as you know two sides and an angle.

2. to calculate any angle of a triangle if you know all three side lengths

Simplifying the formula to find a side given two sides and the angle between them

> To get the third side given two sides and one angle
> $$\sqrt{b^2 + c^2 - 2bc.cosA} = a$$
> ☑ b x² ➕ c x² ➖ 2 ✖ b ✖ c ✖ cos A 🟰 **ans**

The smaller calculator that I use does this calculation without any problems.

Simplifying the formula to find any angle if you know all of the sides

> To get the angle given three sides.
> $$\frac{a^2 + b^2 - c^2}{2ab} = cosC$$
> (a x² ➕ b x² ➖ c x²) ÷ (2 ✖ a ✖ b) 2ndF cos **ans**

Doing a calculation like this the use of brackets is needed. The small $10 calc. does this no problem but the brackets don't get shown on the screen and it is hard to follow what is going on here. There are 14 buttons to hit and 6 numeric inputs so it is quite possible to make a mistake and not know it.

My $30 calculator has a lot larger display area and it shows the brackets and more importantly it has a delete the last action button so it is possible to remove incorrect inputs.

9.2 Testing the cosine rule (1)

To get the third side given two sides and one angle

$$\sqrt{b^2 + c^2 - 2bc.cosA} = a$$

$\boxed{\checkmark}b\boxed{x^2}\boxed{+}c\boxed{x^2}\boxed{-}2\boxed{\times}b\boxed{\times}c\boxed{\times}\boxed{cos}A\boxed{=}\mathbf{ans}$

The calculation above is a bit daunting if you have never done any of this before. What I do with anything new like this is to test it out with something that I already know the answer to. Below is an equilateral triangle that is very simple to remember. We know the angles and we know the side lengths.
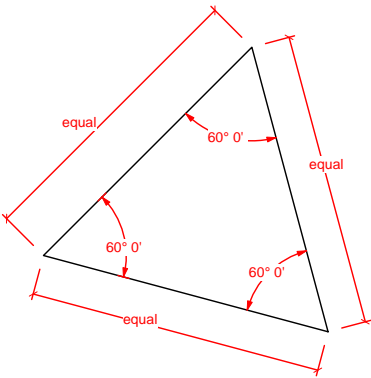
Try it out with a few different side lengths.

$\boxed{\checkmark}3.2\boxed{x^2}\boxed{+}3.2\boxed{x^2}\boxed{-}2\boxed{\times}3.2\boxed{\times}3.2\boxed{\times}\boxed{cos}60\boxed{=}3.2$

This is a great way to test anything new, to test the way that your particular calculator handles the inputs.

9.3 Testing the cosine rule (2)

To get the angle given three sides.
$$\frac{a^2+b^2-c^2}{2ab} = cosC$$

(a x^2 + b x^2 − c x^2) ÷ (2 × a × b) 2ndF COS **ans**

This time we have the sides, let's find the angle.
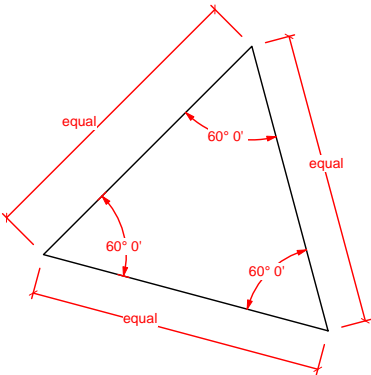
Say we use 7.7 for the side lengths.

(7.7 x^2 + 7.7 x^2 − 7.7 x^2) ÷ (2 × 7.7 × b7.7) 2ndF COS 60

If you don't get the expected answer then you made an input wrong or you may have to hit = after the last bracket to get the result of your input for this $\frac{a^2+b^2-c^2}{2ab}$ (which is 0.5) and then use 2ndF COS .5 and you will get the answer 60.

9.4 To get the third side given two sides and one angle

To get the third side given two sides and one angle

$$\sqrt{b^2 + c^2 - 2bc.cosA} = a$$

$\boxed{\sqrt{}}$ b $\boxed{x^2}$ $\boxed{+}$ c $\boxed{x^2}$ $\boxed{-}$ 2 $\boxed{\times}$ b $\boxed{\times}$ c $\boxed{\times}$ $\boxed{cos}$ A $\boxed{=}$ **ans**

When we build steel stairs we quite often use this calculation on site or in a workshop. We have a steel stringer that is welded to another section of steel that supports the landing. The angle at the joint between the two may be accurately cut but it is never just welded trusting a 200 long joint without getting some other longer dimension to check.
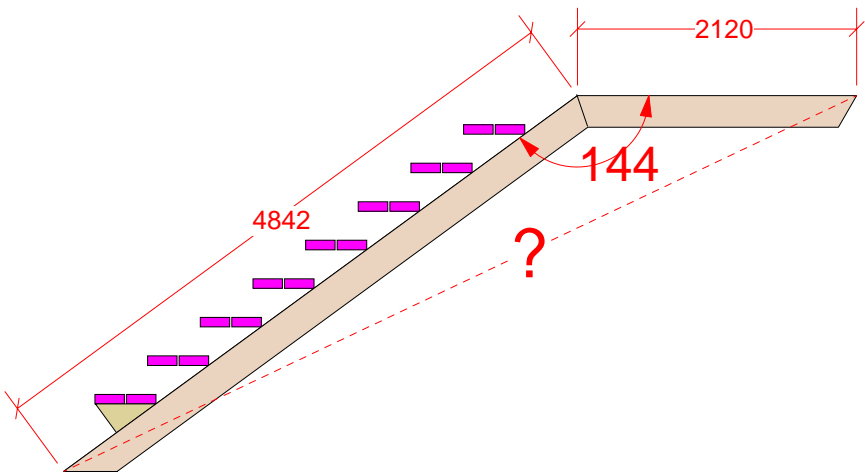
I like to know the length with the ? mark on it. When the pieces are laid out ready to weld I make sure that the long length is correct, even going to the extra trouble of clamping a brace across the members while doing the preliminary tack welds.

$\boxed{\sqrt{}}$ 4842 $\boxed{x^2}$ $\boxed{+}$ 2120 $\boxed{x^2}$ $\boxed{-}$ 2 $\boxed{\times}$ 4842 $\boxed{\times}$ 2120 $\boxed{\times}$ $\boxed{cos}$ 144 $\boxed{=}$ 6674

The sketch here represents half of a stair to a half turn landing, and another similar one will rise again to the top of the next floor.

- I have seen guys building stairs like this with the all sort of temporary props holding the members in place to make sure it is OK and then they weld it in position.

- It so so much easier to set up on a flat floor or a bench to make sure that there is no twist and do the bulk of the welding knowing that the frame, (whatever shape it is), is going to be accurate.

A steel stair

In case you think that the previous example was a bit of overkill or just not needed, here is a stair I built a few years ago that was the source of the previous sketch.

It is fairly easy to see from the layout of this stair that if those angles between the strings and the landings where not accurate, then a slight difference of say 1° could make enough difference to cause problems.

Running the previous calc again but using an angle of 145° the diagonal length would be 16mm longer. Do the same with the other one and there is a 32mm or $1\frac{1}{4}$" error in the stair.

Sure in this instance of an external stair it could be fudged and still turn out OK, but there is a heck of a lot of satisfaction gained by getting it right and seeing things work out perfectly.

Some things don't need accuracy but make sure that the ones that do need it, get it.

10 Appendix

Metric to Imperial Conversion Table

If you are working with imperial measurements quite a lot then the small calculator that I have been using for my examples will not work directly with fractions. You have to work in decimals. Change feet to inches and use this table to get the fractional amounts. I have also included the metric equivalents.

Inch-Fractions				decimal inches	mm	Inch-Fractions				decimal inches	mm
			1/64	0.02	0.4				33/64	0.52	13.1
		1/32		0.03	0.79			17/32		0.53	13.49
			3/64	0.05	1.19				35/64	0.55	13.89
	1/16			0.06	1.59		9/16			0.56	14.29
			5/64	0.08	1.98				37/64	0.58	14.68
		3/32		0.09	2.38			19/32		0.59	15.08
			7/64	0.11	2.78				39/64	0.61	15.48
1/8				**0.13**	**3.18**	**5/8**				**0.63**	**15.88**
			9/64	0.14	3.57				41/64	0.64	16.27
		5/32		0.16	3.97			21/32		0.66	16.67
			11/64	0.17	4.37		11/16		43/64	0.67	17.07
	3/16			0.19	4.76				45/64	0.69	17.46
			13/64	0.2	5.16				45/64	0.7	17.86
		7/32		0.22	5.56			23/32		0.72	18.26
			15/64	0.23	5.95				47/64	0.73	18.65
½				**0.25**	**6.35**	**¾**				**0.75**	**19.05**
			17/64	0.27	6.75				49/64	0.77	19.45
		9/32		0.28	7.14			25/32		0.78	19.84
			19/64	0.3	7.54				51/64	0.8	20.24
	5/16			0.31	7.94		13/16			0.81	20.64
			21/64	0.33	8.33				53/64	0.83	21.03
		11/32		0.34	8.73			27/32		0.84	21.43
			23/64	0.36	9.13				55/64	0.86	21.83
3/8				**0.38**	**9.53**	**7/8**				**0.88**	**22.23**
			25/64	0.39	9.92				57/64	0.89	22.62
		13/32		0.41	10.32			29/32		0.91	23.02
			27/64	0.42	10.72				59/64	0.92	23.42
	7/16			0.44	11.11		15/16			0.94	23.81
			29/64	0.45	11.51				61/64	0.95	24.21
		15/32		0.47	11.91			31/32		0.97	24.61
			31/64	0.48	12.3				63/64	0.98	25
½				**0.5**	**12.7**					**1**	**25.4**

Table 10.1: Fractional Inches to Millimetres

10.1 Cheat Sheets

Chain dimensions

345	=	345
+	=	690
	=	1035
	=	1380
	=	1725

		345	=	345
ans	+	345	=	690
			=	1035
			=	1380
			=	1725

345	+	enter	345
		enter	690
		enter	1035
		enter	1380
		enter	1725

Pythagoras 3,4, 5
To find the hyp.
$3^2 + 4^2 = 25 \;\sqrt{}\; 5$
To get shorter side
$5^2 - 4^2 = 9 \;\sqrt{}\; 3$

$sin\theta = \frac{opposite}{hypotenuse}$	
find angle.	opp/hyp=$\sin\theta$
find hypotenuse.	opp/$\sin\theta$=hyp
find opposite.	hyp x $\sin\theta$ = opp
$cos\theta = \frac{adjacent}{hypotenuse}$	
find angle.	adj/hyp = $\cos\theta$
find hypotenuse.	adj/$\cos\theta$ = hyp
find adjacent.	$\cos\theta$ x hyp= adj
$tan\theta = \frac{opposite}{ajacent}$	
find angle.	opp/adj = $\tan\theta$
find adjacent.	opp/$\tan\theta$ = adj
find opposite.	$\tan\theta$ x adj = opp

Cosine rule
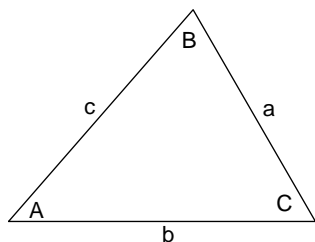
get third side from two sides, one angle
$$\sqrt{b^2 + c^2 - 2bc.cosA} = a$$

To get the angle given three sides.
$$\frac{a^2 + b^2 - c^2}{2ab} = cosC$$