How To Measure and Mark

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Introduction Thanks for volunteering to help at a construction site. Your efforts will make a difference not only to one particular family in need of decent, affordable housing but also the whole neighborhood.

In this Construction Volunteer How-To article we discuss measuring and marking. Almost all of the steps in building a house literally from the ground up are merely adding pieces to it. You add concrete to form a foundation, you add wood on top of the foundation, you add wood on top of that wood to make a floor, you add wood to that floor to make walls, you add wood and shingles to the tops of those walls to make a roof, you add siding to the exterior walls, you add drywall to the insides of the walls, and so on. Those pieces must, of course, be the right size and shape, and they must be installed in particular places in particular orientations.

Measure, Mark and Cut And many of those pieces that are added to the house go through the same three-step process, which is **MEASURE, MARK and CUT.** You need to cut a piece of lumber to a certain length so you MEASURE out to there, you make a MARK there, then you CUT it on that mark.

Information about how to *cut* wood and drywall, which make up the bulk of the house, can be found in How To Use a Circular Saw and How To Drywall. Some of the detailed information you'll find in those articles on how to measure and mark is not repeated here.

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Typical example of measuring and marking TOP

You need to cut a piece of 2 by 6 lumber to make a *cripple stud,* so it will just fit between the bottom of a window and the top of the floor.

You grab your tape measure and measure the distance, which turns out to be, say, 12-1/8 inches.

On the board you've chosen to cut, you hook your tape measure over one end and pull it out past the mark at 12-1/8 inches. You grab your carpenter's pencil and make a crow's-foot mark at exactly 12-1/8 inches. You stow your tape and grab your Speed Square. You place your pencil point on the crow's foot and slide the Speed Square up to it. You slide your pencil along the fence created by the Speed Square to create a cut line, i.e., where to make the cut.

The two main parts of this article are a description of the various tools used to measure, grouped by what it is they measure, and then a description of the various tools used to mark. Following that are more glossary terms you should learn first if you want to.

But first, some general advice about measuring and marking.

The Carpenter's Rule There is a rule about measuring and marking that's so important it's called The Carpenter's Rule, and it's pretty simple: **MEASURE TWICE, CUT ONCE.** It's rare that measuring a second time is as costly in time and materials as cutting wrong.

The corollary to The Carpenter's Rule is IF YOU'RE GONNA CUT WRONG, CUT LONG. Once you've removed too much of whatever it is you're cutting, you can't turn around and cram any of it back on.

How close is close enough?

A reasonable question many novice volunteers often face throughout the day is just how accurate – how careful -- they need to be. The short answer is it depends.

Sometimes unnecessary accuracy is a waste of time. For example, if you're trying to cut a board to 92-5/8 and it ends up being 92-7/8, it would be almost certainly be a waste of time to bother trying to trim off that last quarter of an inch with your circular saw, which is a particularly difficult cut anyway. (That's not to say you shouldn't try to figure out what went wrong so it doesn't happen again.)

In other cases a quarter of an inch is way too far off, as in setting the height of certain cabinets above certain refrigerators.

Generally, you should be as accurate as you can be, especially because of the possibility of **cumulative error.** There are many chances for error from the beginning to the end of the processes of measuring, marking and cutting. Here's one example.

1. You measure a distance that needs to be filled in with a 2 by 6 cripple stud. Because your tape's hook is bent out and because it isn't pushed up against the wood and because it has some crud on it, you're short by 1/8 inch. No big deal so far.

2. Because you forget to press the curved tape flat against the wood, parallax error causes you to mis-see the correct spot on the tape by 1/8 inch. Now you're a total of 1/4 inch short, which is barely OK for a cripple stud. But an error of 1/4 inch will make for an ugly baseboard corner and a decidedly non-square window buck.

3. At the board to be cut, for the crow's foot you place your pencil carelessly and miss the spot you intended by 1/16 inch. This brings you to an error of 5/16 inch total, which is over tolerances even for most rough framing. And this assumes you get everything else just right, which, as you'll see, you don't.

4. You mark your crow's foot with the pencil turned the wrong way, so it makes two too-thick lines at the vertex. When you apply your Speed Square to mark the cut line, you choose a spot in that blob that's 1/8 inch short.

5. You make the mistake of placing the Speed Square on the crow's foot and then placing the pencil instead of the other way around, and again you turn the pencil sideways – will you never learn? -- which combine to make you 1/8 inch short when you draw the cut line.

6. When you apply the saw, you mistakenly take all of that wide, misplaced line, which subtracts 1/16 inch more than it should.

1/8 + 1/8 + 1/16 + 1/8 + 1/8 + 1/16 = a whopping 5/8 inch short. Each error by itself is acceptable, but when they tend to accumulate in the same direction, the result becomes less and less tolerable. The lesson is to take the time to get each step right to begin with, at least to try to nullify the errors others might make, to try to tend back towards perfection.

Why measuring and marking matter

It might seem that a little bit off is OK but, as you know from the box above, those little bits can add up. What else can add up is the number of problems that arise from any one error. One problem with using volunteer labor to build houses is that a volunteer who makes a mistake one day is unlikely to be around to see all the results of that error the next day or month or decade.

For example if, because of errors in measuring and marking, a wall is erected incorrectly, here's what can happen.

(1) Measurements made from that wrong wall can also be in error (which themselves could spawn whole new serieses of problems).

(2) The piece of exterior sheathing in that area has to be specially cut so it will fit the non-square corner, which process is error-prone to measure and mark for and often wasteful of wood and always wasteful of time.

(3) The piece of siding in that area has to be specially cut so it will fit, which costs time.

(4) The drywall in that area has to be specially cut, which means lots more chances for error and a waste of time for sure.

(5) The nearby window opening is not square, which takes time and materials to rehabilitate.

(6) The baseboard doesn't fit, so it has to be specially cut, which is time-consuming, which is bad.

(7) The cabinets that rest on the floor of the kitchen are awry, and the same with the wall cabinets. Fixing this problem can involve lots of extra time even when done by experts.

(8) The floor tile in that corner has to be specially cut, which is – you guessed it – time-consuming.

So, again, do try to measure and mark accurately. Your time is valuable to us, and so is the time of everyone downstream from you.

Tools used to *measure* TOP

A number of tools are used to measure for distance, square, straight and angles. We'll discuss each of these criteria in turn and the tools used for them. After all that we'll discuss the various tools used to *mark*.

Distance TOP

If a particular distance is supposed to be, say, 92-5/8 inches, then it should be 92-5/8 inches, and it all starts with measuring accurately.

The most common tool for measuring lengths on a job site is a tape measure, but several others are used, including a 200-foot tape measure and a 4-foot T-square. Keep reading to learn all about all of them.

● **Tape measure** A tape measure, sometimes called a *steel tape* or just a *tape,* is probably the most frequently used tool in measuring on a job site. There's more to know about it than you think.

30-foot steel tape measure

A tape measure is a long strip of steel (sometimes called the *blade*), typically an inch wide by 8 to 30 feet long, that's marked in inches and parts of an inch that's coiled onto a spring-loaded reel, and that reel is in a case. In the photo at right the tape is extended a few inches and the *hook* is at the far right. The black rectangle in the yellow background is a slider you can push down to lock the tape. If you pull out the tape and then shake the hook end loose from whatever you attached it to, the spring reels it back in, which is handy. When you want to prevent the tape from doing that, just press up on the bottom of the tape with your forefinger.

Tip: Do not allow the tape to slam back into the case, which can damage the hook or the tape where the hook attaches. Instead, just as the hook is about to enter the case, remember to slow it down and ease it in.

Tip: Please don't let sand or mud or wet concrete or anything like that get on the tape. If the tape gets mud or paint or caulk or any similar substance on it and then gets reeled in, especially if it then sits unused for a while, the foreign substance can permanently immobilize the reel. Take the time to wipe off any tape that's gotten icky (or even wet with water, which can cause rust).

Tip: No one is born knowing how to read a tape measure; you have to learn it. If you are not sure how to read halves and fourths and eighths and so on, take the time to get a quick lesson from someone before you start making mistakes.

Tip: For almost all measurements it's best to use inches only, not feet. For example, if you're asked to measure a certain distance, you could report it as 7 feet, 8-5/8 inches, but that's much easier to confuse than simply 92-5/8 inches.

Pretty much useless information: What are those diamonds? On many tapes you'll find small, black diamonds at certain rule marks. The first one is at 19.2 inches, and the rest are spaced evenly at that same distance. For some walls that is the distance between studs, as opposed to the more common 16 inches. Unless you know different, you may assume that 2 by 4 studs should be 16 inches apart from center to center (often referred to as "16 inches on center," where "on center" itself is often abbreviated to "O.C."). Studs made of 2 by 6 wood, typically for exterior walls, are sometimes set at 24 inches O.C.

Stand-off The curve along the length of that skinny coil of steel is a vital feature of a tape measure. If the tape were flat instead of curved, when you pulled it out of the case it would flop down according to gravity, which means you couldn't attach the hook end to anything more than your arm's-length away. But because of that curve, the tape measure allows you to extend the hook several feet before it finally does give way under its own weight. Narrower tapes will have a *stand-off* of maybe three feet, whereas tapes that are 1-1/2 inches wide can stand off more than 10 feet.

However, because of that very curve, the potential exists for parallax error, discussed in detail below. The solution is to take the time to roll either the top or the bottom edge of that curved tape flush against the material before you take your measurement or make your mark.

When the distance you're measuring requires a partner, one of you will take the hook end and the other the reel end. The hook end is sometimes called the *dumb end* because whoever's holding the reel end, the *smart end,* has to do the reading and maybe some math.

The corner problem And sometimes that can be more of a problem than you might think. Imagine you want to measure the distance of a wall with an adjacent wall on each side of it. You can easily place the hook end against one of the side walls, of course, but then how do you place the smart end? You can't run it past the point to be measured in the usual way because there's a wall in the way. Here are some options.

● Just push the bend of the tape as deep into the corner as you can before you take your reading, remembering that this situation is also likely to result in parallax error unless you make sure your eyes are lined up correctly. Even then, you have to mentally add a bit because the tape simply won't go *completely* into the corner. If you aren't sure you've got this measurement right and a carpenter is nearby, ask her.

● Another method is to use the depth of the tape's case. If you examine the case you'll probably find a dimension printed on or molded into it, typically 2-1/2 to 4 inches, that tells you the distance from the back of the case to the line where the tape comes out. If there is no such marking then bend the tape back on itself and measure that distance and memorize it, or write it on the case if you want. Then simply push the back of the case into the uncooperative corner and add that distance. For example, if the case is 3-1/2 inches wide and the reading at the tape end of the case is 120 inches, the total distance is 123-1/2.

● Sometimes you can avoid the corner problem by merely swapping the dumb end for the smart end.

● Sometimes you can avoid the corner problem by measuring to a different surface that's the same distance as the point you want to measure to. For example, if a corner stud at the reel end is nailed to a second stud, you can measure to that second stud and subtract a teeny amount for the change in angle.

For a distance that really is 10 feet long, if your tape measures to a spot 3-1/2 inches off-angle, the measurement that should be 120 inches will be too high by only .051 inches, which is well under 1/16th inch.

● Sometimes you can avoid the corner problem by measuring from a different location. For example, you might be able to make the same measurement from the other side of a wall.

Measuring above your head You can use the stiffness of the tape to measure certain distances you couldn't otherwise reach. For example, you want to measure the distance between two boards above your head, and no ladder is handy. By bending the tape into a triangle, where you're holding the bottoms of two legs and it's bent twice at the top, you can move that stiff middle part of the tape back and forth till it's pressed up against the surface you want to measure. Then, of course, you have to do the subtraction. As handy as this method is, keep in mind that it is doubly vulnerable to parallax error, plus it's easy to let the tape move, so take your time.

Measuring a long distance along a floor or deck Sometimes you need to pull out a tape a long distance over a floor and there's no place to hook the hook end over because there's a wall there, and you don't have a helper. An example would be measuring for a piece of baseboard. Here's the method, which is easilier demonstrated than described. Let's say you're measuring from left to right.

While standing a few feet from the wall at your left, feed the hook end into the corner and then force the tape to bend down to the floor. Feed out more tape while keeping the hook firmly pressed against the left wall. Start walking right and keep feeding out tape so that it lies against the wall whose distance you're measuring, still keeping pressure on the hook, till you get to the end of the wall. Run your tape a few inches past it, look down, and there's your measurement. Easy, eh?

Tip: Here's a tip even some real carpenters don't know. If you check out the end of a tape measure you'll see that the hook slides back and forth a little bit. This is not a defect, it's a necessary part of the design. If it didn't slide back and forth a bit then the tape would measure accurately only about half the time. If you think about it, you'll realize there's a difference here between an inside and an outside measurement. If you're taking an inside measurement, you (should) push the hook up against a surface, whereas if you're measuring to the outside you clip the hook over an edge and pull the rest of the tape away from it.

For the inside measurement you want the distance to the outside of the hook, but for the outside measurement you want the distance to the inside of the hook. It's no coincidence that the distance the hook slips is the same as the thickness of that hook. The point is that if you're making an inside measurement, with a helper holding the dumb end, make sure the hook is pushed towards the rest of the tape, not pulled away from it. Get it wrong and your measurement will be short by only about 1/32", but at least now you know why the hook slides back and forth on purpose.

Also, now you understand why to make sure that hook isn't bent. If you drop or step on your tape, check it against a known-good ruler to make sure it still measures accurately both inside and outside, because if your tape's got a built-in broken part, you should want to know it. For example, if the bottom of your hook is bent in an eighth of an inch, every outside measurement and mark you make will be long by that amount.

Another way a steel tape's hook can get off is if it's clogged with any of various adhesives found on job sites. If there's a build-up of cement or drywall compound or tile mastic or any kind of caulk or other stuff that sticks, even mud, on either face of the hook, your marks and measurements will be inaccurate to that extent.

Why measuring is bad

Despite how often a tape measure or other measuring device must be used on construction sites, it is rarely desirable to use one if you don't have to. Every time you pull out your tape to measure for a cut line you introduce at least two chances for error, and often many more.

Scenario 1 Imagine this common scenario: You measure a distance with your tape measure for the length of the next piece of siding to be installed, you call out that distance to your runner, who relays it to the sawyer who measures out that distance with her tape measure, following which she saws the piece to length.

Scenario 2 Here's a different scenario: You hold the next piece of siding in place up against where it belongs and mark a crow's foot where it's supposed to be cut. The runner takes it to the sawyer, who cuts it on your mark.

Which scenario is more likely to produce a costly error?

In the first scenario there are seven chances for error: (1) You might mis-read your tape measure, (2) you might call out the wrong distance, (3) the runner might mis-hear it, (4) the runner might mis-remember it, (5) the sawyer might mis-hear it, (6) the sawyer might mis-remember it, or (7) the sawyer might mis-measure it.

In the scenario that doesn't involve measuring at all, none of these seven chances for error exists, which is why we say measuring is bad.

Here's another example. You are assigned to cut out the sheathing over a window. OSB-type plywood is covering the window opening, and now it needs to be cut out, from the outside with a circular or reciprocating saw, and you want to mark the four straight cut lines that define that presumed rectangle.

Scenario 1 One way is to measure. To do this, from the inside you need to pick a spot left or right from which to measure that lines up with a spot that's also accessible from the outside so you can transfer that measurement. Then you have to measure the width of the window. Those steps will locate the sides of the window opening. And you also have to perform the same steps for the top and bottom of the window opening. And you have to hope all the elements – not just the house but all your lines and marks and measurements – are pretty darned square and plumb and level and flush and straight and otherwise precise, which, even for experienced professional carpenters, is unlikely.

Scenario 2 Keeping in mind that the goal is to mark four straight cut lines on the outside of the OSB that show where to saw, can you think of a better way, one that doesn't involve measuring at all? One option is simply to **drive a nail** from the inside at each corner of the opening. Where they poke through on the outside will show you the four corners for your cut lines, presumably then to be connected with a chalk box or a long level. Because this method does not involve measuring, it is virtually foolproof.

The lesson is that measuring is bad whenever a simpler, quicker, more direct, and less error-prone alternative is available. Don't be ruled by a ruler.

● **200-foot tape measure** Used during early phases for measuring long distances, a 100- or 200-foot tape measure is similar to a regular tape measure, described immediately above. Here are some differences.

200-foot fabric tape

- The 200-footer's tape is made of steel or unstretchable fabric, and it does not stand off at all.
- The 200-footer's hook is more complicated, including two moving parts and a hole to hook over a carefully placed nail.
- Unlike a regular steel tape, these really long tapes do not reel themselves in with a spring. Instead you'll find a fold-out stem or crank that you turn to reel it in.

Here are some tips for using a long tape measure.

- Be sure the hook is where it should be.
- Be sure the tape isn't twisted. Each twist makes the tape show a longer measurement than it should.
- Be sure the tape is taut. If it isn't taut it will show a longer measurement than it should.
- Unlike with a regular tape measure, it's easy to mis-read a 100-foot tape; be sure you're always using feet and inches consistently. Generally, it's better to stick with all inches rather than feet and inches.
- These long tapes need special care. Don't let them scrape excessively against a rough surface, and, with a steel tape especially, don't let it bend too far. When you reel in a long


100-foot steel tape

tape, make sure every inch of it is clean of any debris or crud or even moisture; sometimes these tapes go for months without being used. They are expensive and practically impossible to repair, and they are not designed to withstand careless use.

● **Four-foot T-square** A four-foot T-square is often used for measuring distances in the process of drywalling. See below for more information.

● **Other tools** Some levels also include rulers on the edges, so those can also be used to measure distance, but not for fine work or over great lengths. Similarly, Speed Squares and combination squares and try-squares and framing squares sport rulers you can use to measure short distances to various degrees of precision.

See below for more information on these tools.

Square TOP

Square means at a 90-degree angle, also called a *right angle.* Hundreds of times throughout the process of building a house it is necessary to check for square. For example, the corners in openings for doors and windows must be square, the angle between a wall and the floor must be square, and the angle between two walls that form a corner must be square.

Tools used to check for square include a Speed Square, a framing square, a combination square, a try-square, a four-foot T-square, and the Pythagorean Theorem.

● **Speed Square** One of the mostly commonly used tools for measuring or marking for square is what's called a Speed Square. Depending on what you're doing, during the framing phases of construction a Speed Square can be an indispensable tool that performs a number of functions.

6-inch Speed Square

A Speed Square is nothing more than an isosceles right triangle of rigid material with a flange on both sides of one of the two legs. In the illustration the flange is flush against the top edge of the board. The other leg is marked in eighths of an inch. (All the other markings have to do with calculating such things as roof angles, and you will not be responsible for understanding any of that.)

In addition to giving you a portable right-angle fence for marking cut lines pretty much anywhere, a Speed Square can be used to test for square, such as between a cabinet and a wall. A less obvious example is checking whether the blade of a circular saw or a table saw is truly perpendicular to its base.

Speed Squares can also be used to check or mark for a 45-degree angle, such as for the corners of the interior trim pieces around doors and windows.

Speed Squares are made of plastic or aluminum. The aluminum ones, which cost more, are virtually indestructible, but they are heavier, and they get hot when laid out in the sun, and they get cold in the winter. Please be careful not to overstress the plastic ones, which can fracture.

Speed Squares come in two sizes, a 6-incher and a 12-incher. The more common 6-incher is easily carried in a nail apron or tool belt or hung on the pencil in your back pocket; but the 12-incher will reach across wood or siding that's wider than 6 inches.


framing square

● **Framing square** For reaching across even greater distances to mark or check for square, a framing square, also called a *carpenter's square*, is nothing more than an L-shaped piece of metal with a square corner. Its main uses on a job site are to test for square, to measure, and to mark a line. Two sizes are usually available; of the larger, more common size, one leg is 24 inches long by 2 inches wide and the other leg is 16 inches long by 1-1/2 inches wide.

Both sides of both edges of both legs are ruled in inches, so you can use a carpenter's square to measure and mark a line up to 24 inches. Unlike a Speed Square there is no built-in 45-degree angle, but one can easily be determined using matching numbers on the ruled edges. And unlike a Speed Square there is no flange, which sometimes makes it fiddlier to use for measuring and marking.

Tip: Unlike an aluminum Speed Square, a framing square can get out of whack, so be careful not to drop or step on one, which also means you should feel free to check any framing square you're unfamiliar with to make sure it really is square and that both legs are straight. If you find one that's questionable, please let your site supervisor know.

One of the tasks a framing square is particularly suited for on a construction site is the marking of *stringers,* which are the long, saw-toothed, diagonally oriented boards, usually 2 by 12s, that support the treads and risers of a staircase.

A carpenter's square can also be used to measure a particular staircase or roof pitch.

● **Combination square** A combination square is a tool of many uses. As you can barely see from the illustration, it consists of a simple steel ruler and a base piece that is attached to it at a right angle. By loosening a nut the base piece can be slid to anywhere along the ruler, which allows you to test not only for square but also for any particular length, typically up to 12 inches. There is also a set 45-degree angle. The model shown, a pretty typical version, also sports a small spirit level and a small, removable scribe.

combination square

Unlike all the other squares we're discussing, a combination square has moving parts. It is typically used for finer work such as door and window trim, as opposed to rough framing, which deals in thicker wood and allows greater tolerances for inaccuracy. It is more fragile and has sharper corners than, say, a Speed Square, so if you find yourself using one, do treat it with care.

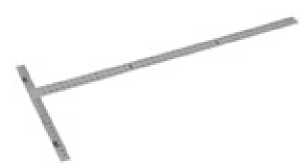
● **Try-square** A try-square, which sometimes substitutes for a Speed Square, is designed to measure and mark for a right angle. It consists of a steel blade attached at a right angle to a wooden or plastic handle. The handle is thicker than the blade, so you can slide it up to a certain spot, press the handle against the material, and mark a perpendicular cut line along the blade, just as with a Speed Square.

try-square

Because the blade is ruled it can be used to measure short distances, typically up to 6 inches, with higher precision than a Speed Square. And because the blade is dead straight it can be used to test for planarity.

A try-square is generally used for finer work than rough framing, however, the fact its blade is 1-1/2 wide means it is well-suited for marking both stud-width placement lines on wall plate at the same time.

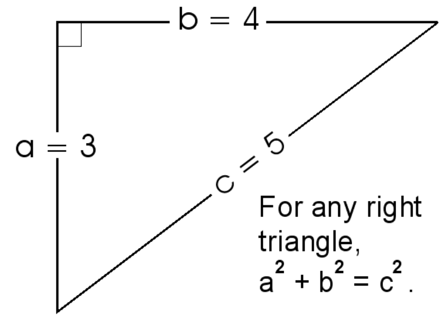
● **Four-foot T-square** A four-foot T-square is usually used in drywalling to mark for square (and also to make the cut). Such a square can also be used for marking square, cross-cut cut lines on sheet goods such as OSB and floor decking.



four-foot T-square

Be careful to not to stress the joint that keeps it at 90 degrees. A T-square that's not truly square is worse than no T-square at all, so be sure when you set one down that you take a moment to make sure it won't get knocked over or stepped on or otherwise damaged.

● **Pythagorean Theorem** As any fan of Pythagoras (Greek mathematician, circa 500 B.C.) knows, the Pythagorean Theorem, one of the fundamental axioms of trigonometry, states as follows:



> **The square of the hypotenuse (c) of a right triangle is equal to the sum of the squares of the other two sides (a and b).**

This is useful in checking a corner for square on construction sites. For example, you're building a deck and you want to establish a line that's square to the house for a rim joist. You can apply the Pythagorean Theorem using the *Three-Four-Five method.* Here's how.

(1) Measure out **3** feet on the joist (leg a in the example above) and make a crow's foot. (2) Measure **4** feet along the *ledger board* attached to the house (leg b) and make another crow's foot. (3) Now measure the distance between your two marks (leg c), which will be the hypotenuse of a presumably right triangle. If it isn't **5** feet you've done something wrong, because 3 squared, which is 9, plus 4 squared, which is 16, add up to 25, which is 5 squared. If you've measured and marked the two legs accurately, then just swivel the free end of the board till the hypotenuse does equal 5 feet.

You must measure and mark carefully. Choose the *vertex,* that exact spot where the two legs meet, carefully and use the same spot for both leg measurements. Avoid parallax error when making the two marks, and place the marker carefully just where it should be.

For even greater accuracy, mark the legs at 6 feet (square root of 36) and 8 feet (square root of 64) and see whether that hypotenuse is 10 feet (square root of 36+64). For long, narrow rectangles you can also use the three following Pythagorean Triplets: leg=5 leg=12 hypotenuse=13 or leg=8 leg=15 hyp=17 or leg=7 leg=24 hyp=25.

If you want to calculate your own triplets and any angle, open the spreadsheet referred to here.

● **Rectangularity** The Pythagorean Theorem referred to above lets you test a single corner for square, but you can use a simpler method – one that requires only two measurements and no marking at all – to check an entire rectangle for true rectangularity.

Here's a common example where you *must* use this method.

The skeleton of a wall is made of 2 by 4 sticks of lumber (often 2 by 6 for exterior walls), and those boards are nailed together lying down flat to form a supposed rectangle that's typically 97-1/8 inches tall by anywhere from one to 50 feet long. Sometimes you will nail together these boards on the floor in our warehouse for later transportation to the job site. And sometimes you will also nail on the sheathing, which is 4-foot by 8-foot sheets of OSB plywood.

Nailing on that sheathing will permanently set the skeleton in place, which means that if it isn't square many significant problems will arise later (see here above for more information), problems that we have learned are much more time-consuming than taking the time to make sure everything that's supposed to be a rectangle really is.

To test whether a wall or other structure as built is rectangular, simply measure the two diagonals. If they are not equal, it is not square. Walls rarely are till you adjust them.

Let's say you measure one diagonal at 336 inches and the other diagonal at 337 inches. Your next step is to kick or otherwise nudge one corner of the 337-inch diagonal toward the other by a distance of 1/2 inch. Re-measure the diagonals and keep adjusting till they're equal. Once they are, make sure nothing moves till you can set the skeleton in place.

Straight TOP

Straight just means without any change in angle. For example, when two 20-foot wall sections are connected to make a 40-foot wall, they must be straight from one end to the other, and you might be called upon to help "check for straight."

Tools used to check for straight include a string line, a straight board, and your practiced eye. Other tools are a level and, for shorter distances, a Speed Square.

● **String line** A string line is simply a really long length of barely elastic string or cord on a reel, and its only purpose is to be a straight line over a long distance. For example, to make sure the wall you're building out of landscape stones is straight, you might first drive stakes at the correct places at both ends and then pull a string line taut between them. That line, of course, has no choice but to be straight, so you can use it as a guide for the placement of each stone. A chalk line can also be used as a string line.

By adjusting the heights of the two ends of the string you can establish not only a straight line but also one of any given height from any given line. By incorporating a line level, described below, you can establish a straight line that's also level. And by doing some math (see the spreadsheet referred to here below for more information) you can establish a straight line of any given angle or calculate the angle of a line you've already established.

Tips for using a string line. A string line doesn't make sense unless the string is pulled taut. By definition, if you pull too hard the line will be damaged in some way, but if you don't pull hard enough it will be overly affected by gravity or even wind and therefore sag, which means it isn't straight, which is the whole idea behind using a string line. Ideally you will pull right up to the point where you're about to damage the line. The tip here is that most novices don't pull quite hard enough.

● If you do part a string line and you know your knots, go ahead and bend them together with a Fisherman's knot. If you don't know that one, use a Surgeon's knot. If you don't know that one, use a Reef knot, also called a Square knot, which is tied using this simple ditty: Right over left and down under, then left over right and down under. Once you're sure your knot is secure, cut off the two little tails. If you have no idea how to tie a knot that is both tidy (small) and fast (unslippable), ask around.

● Sometimes while you're setting up a string line it will have to pass over various surfaces, sometime under tension. These *scrape points* will fray away at the string line, which will make it more susceptible to failure when it's pulled on later. Try to avoid stressing a string line against any scrape point.

● When it comes time to reel in a string line, take the time to get it right. If there's mud or concrete or other crud on the string, take the time to wipe it away. Take the time to reel in the line so it's spaced more or less evenly across the length of the spindle. Remember that you won't be the last person to use this string line.

Using stand-off blocks. One good use of a string line is to check whether a long stud wall really is straight from end to end, and that might be a distance of 50 feet. You might think to attach one end of the string line to one end of the wall and the other end 50 feet away at the other corner. The idea is to move the wall till it's parallel everywhere to the known-straight string line.

But once you get the wall pretty close, the string line will be lightly touching the wall, sometimes at just one point and sometimes more. When that happens, which it always will, you'll realize that the wall might still not be straight and that your string line is no longer of any use.

The solution is to use two stand-off blocks. The idea is to move the string line a little bit away from the two corners *but by exactly the same amount.* You do that by adding a stand-off block at each corner so that the string line is held away from the wall. Instead of pulling the string taut between the ends of the wall itself, you pull them taut between two blocks that are the same small distance from that wall.

A typical stand-off block is simply a piece of 2 by 4 lumber maybe a couple feet long. Nail or screw or merely have someone hold one of these vertically at the top of one corner of the wall, do the same at the other end 50 feet away, and run the string line taut between them. This way the string line stands off 1-1/2 inches from the wall, which means it will never bump lightly into it and become useless.

To straighten the wall, measure at various locations to make sure the distance between the wall and the string line is 1-1/2 inches. If it's more, move the wall toward the string line; if it's less, move the wall away. This procedure often involves a sledge hammer, and it's satisfying when you get it right.

● **Known-straight board** Another way to check for straight over long distances is with a known-straight board. If you have a long enough board that you've already checked for straight using some other method, you can use that board's good edge to check two or more contiguous surfaces for straight by holding it up against them. The rafter tails along the eave of a roof, for example, must all line up aligned in a straight line

● **A practiced eye** Under certain circumstances, merely looking by eye is good enough to check for straight, assuming your eye really is good enough. It is difficult for most novices to know whether to trust their own eyes, so consult a site supervisor or any other expert if you're uncertain.

Checking for crown. An example is checking floor joists for crown. *Floor joists* are boards of lumber that lie horizontally on edge and on top of which the plywood floor decking will be fastened. (*Ceiling joists* are merely the floor joists of the story above.) Certain floor joists we use on job sites are pieces of stick lumber, usually 2 by 10s. But those really long boards often have a *crown,* which means the edges form a slight arc rather than a straight line. If you have a crowned board, and if your eye is good enough, you can tell which edge is which. If you're asked to crown floor joists, that means to ascertain which side is bowed up in the middle and mark it as such, with an up-pointing arrow on one or both faces.

A crowned joist must be placed crown *up* so that the weight of the house on top of it will tend to straighten it out; if it is placed crown down then only the ends will ever be supporting weight.

● **Other tools** A long-enough level, which presumably always has at least one dead-straight edge, can be used to check for straight. A framing square or other square can be used to check shorter distances. Press the straightedge against the surface to be checked. If you can rock it, the surface is bowed towards the straightedge; if you can see light between the straightedge and the surface, it's bowed the other way.

Angles TOP

Typical angles that need to be marked or checked on a job site are level, plumb and 45s, but other angles, such as for roofs and siding, can also be measured and marked and checked.

(You might be on a site when a laser level is being used. Because of the great variety among such devices, which can range in price from 20 dollars to several thousand, we offer no instruction here on how to use them. In short, though, a *laser level* is positioned so it's level and it projects a laser beam on any surfaces within its reach, typically framing members or walls. This can be useful, for example, for setting kitchen cabinets.)

● **Level** Level means horizontal, i.e., parallel to the horizon. Level is perpendicular to plumb. For example, the tops and bottoms of walls, windows and doors must be level to work and look right. Tools used to check for level are the various types of spirit level and a special kind called a line level.

Spirit level This measuring tool, typically just called a *level* but sometimes a *bubble level,* is used to test whether the surface you place it on is level (horizontal) or plumb (vertical). Some levels also allow you to test for whether an angle is at 45 degrees.

A level consists of a bar, ranging in length from just a few inches up to 6 feet and, rarely, even longer, with at least one dead-straight edge. Set into that bar are small, transparent glass or plastic tubes filled with a clear, freeze-proof liquid that doesn't expand or contract in the heat or cold. A precisely sized bubble of gas is permanently captured in that tube. The tube is marked with lines that show when the bubble is centered, i.e., whether the device, as it is currently oriented, is truly level.

The liquid in the tube always obeys gravity by moving down, which forces the less massive bubble *directly* up. If you're checking for level and the bubble is to the right of center, then the right side of the level is high, or, said the other way, the piece you're testing for level slopes down to the left. The simple rule for achieving level is to **lower the bubble side.**

A level is only as good as the surface it's on. If the surface is bowed in or out or it's bumpy in places where the level touches, your reading might be inaccurate. Check the surface for these problems and either avoid them or rehab them. Also, use the longest level you have for long distances; a 6-foot level is more likely to be useful than a 1-foot torpedo level when testing, say, an entire stud in a stud wall, because it's easier to see whether the stud is bowed. **Tip:** If you need to span an even longer distance, find a known-straight board and attach or simply hold the level to it.

It's especially important to pay attention the problem of parallax error when reading any type of bubble level.

Tip: Here's how to check whether your level really is level. If you suspect your level is defective, it's worth it to do this, because a level that is out of whack is worse than no level at all. First, find a flat vertical surface where you can make a couple of marks, like a top plate or a piece of Sheetrock, and grab a sharp pencil. Second, place the level on that surface horizontally and carefully center the bubble, then make a mark such as a crow's foot or a line or a dot near each end of the level. Third, simply rotate the level 180 degrees end for end and line it up with your two marks. If the bubble isn't centered, your level must be repaired or discarded. To check the plumb bubble, make the two marks with the level vertical, then rotate it on its long axis to test.

Line level A line level is used to check whether the string line it's attached to is level. It's a really short (maybe three inches), really lightweight spirit level that's designed to hang from a presumably level string line that can span many dozens of feet. Being able to test a string line for level is useful when you're determining, for example, how long the corner posts for exterior siding should be.

line level

You run your string line and pull it tight, then you hang the line level at the center of that line and check it for level. Adjust one or both ends of the string line till the bubble is centered. Make sure the line level is free of mud or crud where it hangs from the line, and make sure the line itself is free of frays or knots or any foreign substance where you hang it.

● **Plumb** Plumb means vertical, i.e., oriented in a straight line from a particular point to the center of the Earth. Plumb means straight up and down, or perpendicular to level. Walls, columns, posts, and the sides of windows, doors and cabinets, for example, must be plumb or they won't work or look right.

Tools used to check for plumb include a spirit level, a plumb bob, a chalk box, and a post level.

Spirit level In the same way a spirit level can be used to check for level, it can also used to be checked for plumb. There will be a bubble located at one or both ends of the level that, when the level is truly plumb, will be centered in its tube. If the bubble is to the right of center, you need to move the top right (or the bottom left) to get closer to plumb, and, of course, vice versa. The simple rule when testing for plumb is **move the top towards the bubble.**

Plumb bob A plumb bob is one of the oldest and most foolproof measuring devices ever thought of. It consists of a string and a weight. You hang the string from wherever you want to check for plumb, and you let the weight at the bottom obey gravity, which means it will always point to the center of the Earth, which means the string is dead plumb, which means the top of the string is exactly above the pointy part


plumb bob

of the weight at the bottom. It's because they work on gravity that you almost never see plumb bobs being used a lot by astronauts.

You can use a plumb bob, if one is available, to test for plumb from above or below. To find the spot that is precisely below a given spot above, attach the top of the string to the spot you want to measure down from, then let out (or take in) just enough string so the bottom of the bob is really close to the surface you're measuring down to. Make sure the bob is stationary, of course. Once you're satisfied that you know where the bob is pointing you can reach in carefully with a pencil or a Sharpie and mark the spot with a cross.

For greater accuracy, take the time to follow this procedure: Pull the bob *straight down* the last few millimeters and push the point into the surface. If it's wood, push just hard enough to leave a visible depression, then remove the bob and mark a cross through that point with a pencil or a Sharpie or a keel.

However, if you're marking points on concrete, which can happen when we set stringers, press the point into the concrete and then swipe a mark right into it, then go back immediately and carefully mark a cross at the origin of that mark.

To measure up from below, move the top of the string in various directions till the bob is exactly above the spot below which you're measuring up from, then mark the location of the string with a cross.

Makeshift plumb bob. Many chalk boxes are designed with a pointy part at the bottom just so you can use them as a makeshift plumb bob, but they aren't as good as a true plumb bob, for three reasons:

(1) Because they're typically smaller in weight and larger in surface area, chalk boxes are more subject to moving in the wind; (2) the pointy part of many chalk boxes is not *as* pointy as that of a plumb bob, so it's inherently less accurate; and (3) the pointy part of many chalk boxes cannot scratch or indent a mark into a surface as well the pointy part of a plumb bob.

Post level *Posts* and *columns* are vertical members that are typically beefy, weight-bearing, and square or round in cross-section such as those supporting a deck and Lally columns supporting the big I-beam. Posts must be set plumb in order to look right and, more importantly, to work right.


post level

To check a post with a normal level, test it on one face, then check the face 90 degrees in either direction. Only when it passes both tests at the same time is it truly plumb.

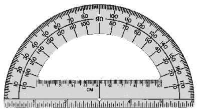
If one is available you can also use a special level called a *post level* (an example is shown at right) which contains two bubbles on hinged panels that wrap around the post or the column so you can take both readings at once.

● **45-degree angles** Sometimes you need to measure for or mark a 45-degree angle. Tools you can use for this include a Speed Square, certain levels, a combination square, and a framing square.

You might use a Speed Square to check a table saw's tilt for 45 degrees, and you might use a combination square to test a 45-degree miter cut you think you just made.

● **Other angles** There are a few tools you can use to check or measure for angles other than level, plumb and 45 degrees. They include a protractor, a bevel gauge, and a framing square.

Protractor You can use a protractor to measure or transfer any angle. Just like the ones you remember from geometry class, protractors are flat circles or semi-circles with degree marks painted or etched onto them. You position the center of the diameter at the vertex of the angle and read or mark the degrees on the perimeter.


protractor

bevel gauge

Bevel gauge You can use a bevel gauge, also called a *sliding bevel,* to transfer any angle from one location to another. The device consists of a straight metal blade housed in an equally straight case, like a pen knife, with a hinge at one end.

You loosen the hinge with a nut or lever, then position the two legs so they match the angle you want to duplicate. Then you tighten the hinge to lock in that angle and you transfer it to wherever else you want.

Just as with a spirit level and a plumb bob, the bevel gauge is foolproof in the sense that it does not involve any math or even any numbers.

Framing square In the hands of an expert a framing square, described in more detail above, can be used to measure and mark for certain pitches and common angles, and if you want to do some trigonometry you can use one to calculate or mark for *any* angle. We will not essay here to describe how to use a framing square to its fullest extent, but the table below lists the results of 20 such calculations.

Table of Angles and Pitches (and some math) TOP

You can calculate the angle of, say, a roof pitch if you know the rise and the run figures, and vice versa. The *rise* is the total purely vertical distance of the slope in question, and the *run* is the purely horizontal distance. For most roofs (and staircases) the run figure is almost always given as 12 inches, so a roof whose pitch is such that for every 12 inches of horizontal change there is vertical change of 5 inches, that would be called a “five/twelve roof.” A 12/12 pitch is exactly 45 degrees, which is pretty steep for any roof and especially steep for a typical house built by volunteers.

Use the table at right, which always assumes a Run figure of 12, to solve 20 selected right triangles. To *solve a triangle* is to determine all three angles and all three leg-lengths. For these examples, we already know one angle is square (90 degrees) and one leg, the horizontal Run, is 12 inches.

If you know either of the non-square angles, look it up in the “Second angle” or “Third angle” column. They range from 4.76 degrees to 85.24 degrees. For example, if you have measured one of the two non-square angles at just over 67 degrees, you might guess you’re dealing with a 5/12 pitch, i.e., the hypotenuse rises exactly 5 units vertically for every 12 units it goes horizontally.

On the other hand, if you know the pitch is a 6/12, you can be sure one of the angles should be 26.57 degrees and the other 63.43 degrees. For a Run of the standard 12 inches, that hypotenuse will be 13.42 inches. (**Tip:** 7/11 = 7.6363/12 = 32.47 degrees.)

And on the final hand, if you know the hypotenuse of a triangle with a Run of 12 is 15, you can be sure that’s a 9/12 pitch.

If this table doesn’t satisfy your needs – for example, you want to enter your own angle or a different Run value – or if you want to see the formulas behind the table, go to the handy-dandy **Excel spreadsheet** here. It’s more useful than you might think.

Second angle	Third angle	Hypot-enuse	Slope	Rise **over 12**
45	45	16.97	1.0000	12
42.51	47.49	16.28	0.9167	11
40	50	15.66	0.8391	10.07
39.81	50.19	15.62	0.8333	10
36.87	53.13	15	0.7500	9
35	55	14.65	0.7002	8.40
33.69	56.31	14.42	0.6667	8
30.26	59.74	13.89	0.5833	7
30	60	13.86	0.5774	6.93
26.57	63.43	13.42	0.5000	6
25	65	13.24	0.4663	5.60
22.62	67.38	13	0.4167	5
20	70	12.77	0.3640	4.37
18.43	71.57	12.65	0.3333	4
15	75	12.42	0.2679	3.22
14.04	75.96	12.37	0.2500	3
10	80	12.19	0.1763	2.12
9.46	80.54	12.17	0.1667	2
5	85	12.05	0.0875	1.05
4.76	85.24	12.04	0.0833	1

20 selected right triangles with a Run of 12

This spreadsheet will solve any right triangle, and it provides a lot of other information, but one particularly handy formula can help if you know the Rise over the Run, which you usually do or can measure. That formula gives you one of the two angles, and from there you can solve the triangle completely.

The formula is **Angle = ARCTANGENT (Rise / Run) X (180 / Pi)**. For example, if you know the Rise is 5 feet and the Run is 12 feet, then

2nd Angle	=	ARCTANGENT (Rise / Run) X (180 / Pi)
	=	ARCTANGENT (5 / 12) X 57.3
	=	ARCTANGENT (0.4167) X 57.3
	=	0.3948 X 57.3
	=	**22.62 degrees**
3rd Angle	=	90 minus 2nd angle
	=	90 minus 22.62
	=	**67.38 degrees**
Hypotenuse	=	SQUARE ROOT ((Rise ^ 2) + (Run ^ 2))
	=	SQUARE ROOT ((5 ^ 2) + (12 ^ 2))
	=	SQUARE ROOT (25 + 144)
	=	SQUARE ROOT (169)
	=	**13**

As you can see, these are the answers shown in the 5/12 pitch row in the table above.

If you have a calculator with trigonometric functions you can use that. If you have access to printed tables of arctangents and square roots, use that. If you can get online you should go to the spreadsheet referred to above, of course, but you can also simply enter **arctangent .41666*(180/pi)** into Google's search box, which will give the answer 22.6195395. For the square root function enter **sqrt (5 ^ 2 + 12 ^ 2)** and get the answer 13.

Mistaken tape angles

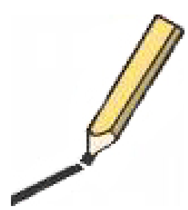
You can also use trigonometry to calculate just how far off your tape or other ruler can be from parallel before you get into trouble. For example, imagine you're looking to make a crow's foot mark at 92-5/8ths inches on a 4-foot by 8-foot sheet of plywood. You hook your tape over the left end of the sheet right at the top and you pull it out to the right and you make your mark at that spot on the tape. Only then do you realize that the smart end of the tape has dropped down 1 inch. Should you re-mark?

Logic tells us your measurement will be short by some distance or other. Trigonometry tells us that your measurement will be short by only 1/200th of an inch, so don't sweat it. At this distance your tape would have to be a full 6-13/16 inches low before your mark would be short by 1/4 inch. In fact, your tape can be 1 inch low *over a distance of only 2 inches, a full 30 degrees of error,* and the distance short will still be just a smidgen over 1/4 inch. Who knew?

Tools used to *mark* TOP

In the big section above we discussed tools used to measure. In this next big section we discuss how to make marks. You can use several tools to make marks on surfaces, among them a carpenter's pencil, a regular pencil, a utility knife or other scribe, a chalk line, a plumb bob, a keel, a felt-tip marker, and a compass.

Carpenter's pencil The most common marker on a job site is a carpenter's pencil. During certain phases of a house build you'll probably want to get in the habit of keeping one in your nail apron or in a pocket or behind your ear or under your ball cap or, well, you get the idea.


carpenter's pencil

Unlike a round or hexagonal regular pencil, a carpenter's pencil is flat, so when you set it down it can't roll away. The lead in the pencil is also flat, which means it has a fine edge and a blunt edge. Mark with your pencil turned so you're using the fine edge, not only because that makes a narrower line but also because the lead is less likely to snap in that direction. Notice that the pencil in the illustration above is turned the *wrong* way.

New carpenter's pencils are unsharpened, so you'll need to sharpen yours using a utility knife or one of those fancy-schmancy, newfangled sharpeners designed for non-round carpenter's pencils. And thereafter it is desirable to keep the point sharp. The blunter it gets, the wider your lines or marks will become, which leads to inaccuracy.

Also, real carpenters often hold the pencil differently from the usual way. They press it between the thumb and the forefinger with the shaft *inside* the hand, because it's easier to make a sturdy crow's foot or a straight line that way.

Novices tend to make several light, overlying marks, which can turn into multiple lines; carpenters use just one confident, continuous mark of the correct pressure and at the same angle from the beginning to the end.

But sometimes you can't make one continuous line because you can't reach that far, and when that happens do make sure that the angle of the pencil does not change relative to the straightedge when you mark any subsequent lines. Which should remind you that the correct way to make such a line is to place the point of the marker on the first line, then slide the straightedge up to it rather than the other way around.

Regular pencil The lead of your standard, regular Number 2 Ticonderoga pencil is too small and delicate for many marking purposes on a construction job site, especially during framing. Not only does the lead break more easily, it needs to be sharpened more often. A properly sharpened carpenter's pencil can make a clearly visible line that's maybe a hundred feet long before it needs re-sharpening. A regular pencil will go maybe five or ten.

A carpenter's pencil can draw a nice, fat line quickly over the rough surface of a sheet of OSB, where the lead of a regular pencil would snap almost instantly.

Unlike a carpenter's pencil, a regular pencil can cause a puncture wound as you reach for it, say, in a pocket. And, as noted, unlike a carpenter's pencil, a regular pencil will roll away from you the first time gravity or a stiff wind gives it a chance.

Regular pencils do have their uses, though, on a job site. They are better at detailed work than carpenter's pencils because they make a finer mark for preciser cutting, such as for baseboards and window trim and bending aluminum fascia.

Utility knife Another way to make a very precise mark is with a utility knife, which in this application is a tool that marks not by leaving behind a substance such as pencil lead or colored chalk but rather by cutting a shallow and very narrow slit, called *scribing,* into the material.

utility knife

(A utility knife, which goes by many other names, is one of the most useful tools you can carry during many phases of construction. Along with a tape measure and a pencil and a Speed Square and a hammer, a utility knife is a device you'll find in every carpenter's tool belt.)

You can also scribe a line with any loose nail or screw or even a plain old pocketknife, but the point (get it?) is to scratch a very narrow line into the material.

Chalk line A chalk line, also called a *chalk box,* is used primarily to mark long straight lines on material such as a 4 by 8 sheet of plywood. A chalk box is a metal or plastic case that houses a reel with string wound on it, and that case is filled with colored, powdered chalk. To use it, you stretch out the dust-impregnated string taut between two points you've already identified. Then you lift the string a few inches and let go,

chalk box

which will cause the string to snap back forcefully onto the surface, leaving behind a trail of chalk dust in the form of a straight line.

Here are some tips on using a chalk line.

● If the last line you snapped is suddenly too light to see, before you pay out the string the next time, take a moment to turn the box upside down and shake it a few times or whap it on the heel of your hand to reload it with chalk. Especially for long runs, angle the box so it points down, which feeds chalk onto the line as it leaves the hole. On the other hand, don't overdo it, because a string with too much chalk will not only make a mess, it will leave a blobby mark on the material.

● If you're doing the snapping, make sure to lift the string directly away from the surface and release it from exactly there. If you pull it from any other angle, it can mark the line with a swerve instead of the straight line you always expect from using a chalk line.

● After the snap, emulate experienced carpenters and take the time to reel in the string correctly. First, if you're holding the hook end, lift it straight away from the line you just snapped, so the string won't make a second mark. Second, keep it well away from any objects till it's reeled in so it doesn't pick up sawdust or mud or crud. Third, if you're doing the reeling-in, you too have to make sure the line is lifted straight up and gets reeled in free of crud.

● As with a string line, make sure to pull taut enough, but also make sure not to overstress the string. If you do sever it, you can easily repair it as long as you don't reel the line all the way or, worse, lose the hook.

● A chalk box can be used as a makeshift plumb bob. See here above for more information.

● Do not use a chalk line with red or black powder on the good side of a sheet of drywall unless it will be covered by drywall tape, because those dark colors can telegraph through primer and multiple coats of paint. Red and black chalks are notoriously difficult to erase under any circumstances.

● If you find yourself helping with the layout of the walls on the floor, you might be using a different sort of chalk line. It's maybe a hundred feet long, and it uses much thicker line, closer to cord than string. It is especially important not to sever this cord, because tying it back together makes a knot that won't pass though the hole.

Plumb bob As you know from here, if you've got your plumb bob set just right, and if it's the kind with a sharp point at the bottom, you can carefully pull it down just a bit and make a slight mark, whether a puncture wound or a laceration, with that point. Another option, useful if you're working by yourself, is to let the bob drop fast enough and from high enough up so that the sharp point makes an indentation in the surface to be marked; this is why purpose-built plumb bobs are often very dense with a very sharp, very hard point.

Keel A keel, sometimes called a *lumber crayon,* is a big, sturdy wax crayon that is better for making certain marks than the trusty carpenter's pencil.

yellow and red keels

A keel is well-suited for making big marks that would otherwise be difficult to see, such as for a crow's foot on a surface that's far away. A lumber crayon is also better for marking rough-cut timber, whose uneven surfaces might snap the point of even a carpenter's pencil.

A lumber crayon is also the preferred marker for concrete and stone, because a lead pencil will wear out right away and need to be sharpened, whereas keels are never sharpened. Finally, because it's wax, the mark of a keel is not only waterproof but more scuff-proof than a pencil line.

Felt-tip marker In some circumstances a Magic Marker or a Sharpie or similar felt-tip marker is useful because the line is so distinct or because it marks certain surfaces well that a pencil marks poorly. Examples are marking a line on a copper pipe or a cross on smooth concrete such as you find in a basement. But the mark made by such a marker is permanent, so make sure whatever you're marking will not show in the finished product. For example, you wouldn't use a permanent marker on siding, would you? Also, note that a felt-tip marker can show through multiple layers of paint.

Compass You can use a compass to draw a circle of a known diameter. Compasses are typically used to mark for circular cut-outs in drywall and siding such as for a light fixture.

compass

Many such fixture boxes are 4 inches across, so to mark a 4-inch-diameter on the material, set the distance between the pointy part and the pencil part to a radius of 2 inches, then place the pointy part into the center of the circle you want to mark and swivel the pencilly part around in a circle.

It's easy to make mistakes in this process, so double-check everything to make sure you've got it right. Once you've gotten started sawing or cutting, you can't take it back.

More glossary terms TOP

Above we introduced a lot of terms in italics. Below are some more glossary terms.

Board stretcher A mythical device that makes a board you cut too short longer.

Cut line A mark, usually a straight line, on a piece of material that shows where it should be cut, usually with some sort of saw or other blade. Tools used to mark a cut line include a carpenter's pencil and a chalk line.

Parallax error Under certain circumstances, you must recognize and correct for parallax error. For a foolproof demonstration of the problem, do this.

1. Close your left eye.
2. Choose any single point in your field of view. An ideal choice is the corner where two walls and the ceiling meet.
3. Hold your fingertip so it's lined up between your right eye and that point.
4. Now, without moving your finger or your head, switch eyes and you'll see that your fingertip is well right of that spot. This problem is called parallax error.

Obviously neither your finger nor the corner of the room moved. What moved is the direction from which you were viewing your fingertip relative to the corner of the room. The same problem can arise in measuring and marking on construction sites, no matter which eyes you keep open.

The problem of parallax error does not arise when the distance between the two points is practically zero. For example, when you press one edge of a steel tape (the equivalent of your fingertip) flush against a piece of lumber (the equivalent of the corner of the room) to make a mark at a certain distance, the tape is so thin that there's little room for parallax error, even if you view the two points from several *feet* to the right or left.

Said another way, if you were to actually touch that corner of the room with your fingertip, either eye would show the same alignment.

But as you move your fingertip away from that corner, the parallax error increases. Try it now by holding your fingertip as far away as you can and testing both eyes, then move your fingertip just a few inches away from your eyes to see how much greater the parallax error is.

What this tells us is that as the distance from the measuring point to the piece to be marked increases, the potential for parallax error increases. Few measuring tools frequently used during any phase of construction offer a thickness as thin as a steel tape measure's. A Speed Square, a carpenters's square, a four-foot T-square, a try-square, and even a combination square have a blade thickness that can lead to parallax error. The solution when using such a tool to measure or mark a ruled distance is to make sure your eye is directly in front of the ruler mark. If you're off to one side and you mark what you see, you *will* mark wrong.

Occasionally you can't get your eyes directly on-axis with the two points, so you must make the appropriate correction. If you're forced to view the points from right of where you'd like your eye to be, make the mark to the right of where it looks like it should be. Another solution is to move farther away, because that has the effect of reducing the angle of error, although presumably you can't move so far away that your arm won't reach to make the mark unless you have a helper.

Flush The condition of two objects' surfaces being parallel and adjacent and ending at the same place. For example, if you have cut one board to length and you want to cut another to that same length, you'd lay the short one on top of the long one to make the mark, but before you do that you need to make sure the other end and both edges are flush.

Crow's foot A crow's foot is a mark made with a pencil or similar marker that designates a single point on a surface. It is V-shaped, and it is actually two marks, each of which emanates from the vertex. The *vertex* of the V is at the point to be marked, and the two lines that emanate therefrom are the two legs. See photo at right.

crow's foot

In many circumstances a crow's foot is better than a single line, because it's so easy to make the single line at an angle other than parallel to the cut line. If the single line is made at such an angle, the two ends will, by definition, mark different spots. Especially if the line is long (which it sometimes must be) or the piece will be passed on to someone else for cutting, there's a risk the wrong end of the line will be used.

That risk drops to zero if you use a crow's foot.

Also, if you're making a mark to show where to align a surface with, if you use a straight line, even if it's straight and accurately placed, about half the time as you're adjusting the surface to your line you'll cover it up completely, which means you can't see how far away you are from it, which means you have to adjust the other way just to bring your line back into sight.

These problems don't arise if you use a crow's foot.

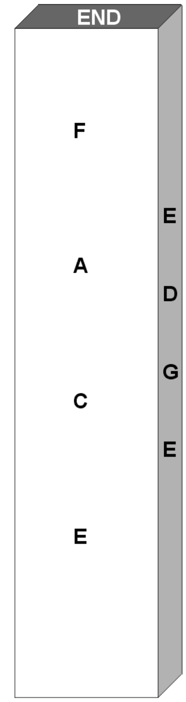
Novices sometimes tend to make small marks that can end up being hard to see from eight feet away, so get in the habit of making marks that are long and dark and thick enough to be visible.

Scrap side, keeper side Often enough it's obvious when you make a cut which side you want to keep. If you're cutting one inch off a 96-inch board, you know which piece to keep. But if that board needs to be cut down to 47-1/2 inches, it's all too easy to lose track of which is the keeper side and which is the scrap side, especially when you're cutting to someone else's mark or making a mark someone else will cut.

Consequently, another habit you should instantly adopt if you're marking for cut lines is to make a quick X on the scrap side. On the other hand, if you're a sawyer looking at someone else's cut line with an X on one side of it, that tells you the X side is the scrap side. On the third hand, you might want to scratch out any X left over from a previous marking if it's now on the keeper side.

Names of surfaces It is useful not only to understanding these How-To articles from the construction department but also to understanding what people say on job sites if you know the terms used to describe certain surfaces of certain materials. Let's look at a plain old piece of stick lumber, let's say a 2 by 4, shown in the illustration below. All such pieces have three parallel pairs of surfaces for six in total.

End The ends are the two surfaces that define the length of the board; if a board is 6 feet long then the ends are six feet apart. On a 2 by 4 the two ends measure 1-1/2 inches by 3-1/2 inches.



stick lumber

Face The faces are the two broad surfaces that run the length of the board. On a 2 by 4 the faces are 3-1/2 inches across.

Edge The edges are the two narrow surfaces that run the length of the board. On a 2 by 4 or any other 2-inch wood, the edge measures 1-1/2 inches from face to face.

If you want to shorten a piece you'd hook your tape measure over one of the two *ends* to measure and mark, then you'd cut across the two opposing *faces* from one *edge* to the other.

Sheet goods In addition to stick lumber, on job sites we work with sheet goods. Sheet goods such as plywood and drywall and siding use the same terminology, with the short sides being the ends and the long sides being the edges.

> **Safety notice** One type of wooden sheet product we use a lot on job sites is called *OSB* (oriented strand board), and the two opposing faces are not identical. While they are both 4 feet wide by 8 feet long, their textures are different. The face labeled THIS SIDE UP has a rougher texture than the other side, and the rough-texture side should always be – you guessed it – UP when you're sheathing a roof, because the smoother, shinier side is too slick for anyone to walk on safely. If you mistakenly install a piece smooth-side up, ask for your site supervisor's advice and make sure no one walks on it till you get it.

Posts For various posts (which are, by definition, vertical) such as you might use to build outdoor decks, the horizontal cross-section is square, which means there are still two ends but now four equal-size faces and no edges. For information on measuring, marking for and cutting big posts to length, which requires more than one pass of a circular saw, see How To Use a Circular Saw.

Lengths, widths and heights

You noticed above that what's called a "2 by 4" is actually 1-1/2 inches by 3-1/2 inches. Improvements in lumber production over the years combined with tradition are why we still call it a 2 by 4. Also, it would take too long to say, "Go grab me a 1-1/2 by 3-1/2."

Table of Stick Lumber For measuring and marking you'll want to understand what the various terms mean. At right is a table that correlates the nominal ("in name only") sizes to their actual sizes.

Dimensional "Stick" Lumber and Posts

Nominal	Actual Width	Actual Thickness	Typical Lengths
2 by 4 stud	3-1/2 "	1-1/2 "	92-5/8, 104-5/8 "
2 by 4 plate	3-1/2 "	1-1/2 "	12 - 16 '
2 by 6 stud	5-1/2 "	1-1/2 "	92-5/8, 104-5/8 "
2 by 6 plate	5-1/2 "	1-1/2 "	12 - 16 '
2 by 8	7-1/4 "	1-1/2 "	8 - 16 '
2 by 10	9-1/4 "	1-1/2 "	8 - 16 '
2 by 12	11-1/4 "	1-1/2 "	8 - 16 '
1 by	as above	3/4 "	8 - 16 '
5/4 by	as above	1 "	8 - 16 '
2 by 2 spindle	1-1/2 "	1-1/2 "	36 - 42 "
4 by 4 post	3-1/2 "	3-1/2 "	8 - 16 '
6 by 6 post	5-1/2 "	5-1/2 "	8 - 16 '

2 by 4 *studs* are the vertical pieces of interior and sometimes exterior walls, and what's called *plate* is used horizontally – twice at the tops and once at the bottoms of those series of studs to hold them together. Exterior walls are usually 2 by 6 wood.

Because the 2-by wood that's over 6 inches can vary slightly in width, it's prudent to go ahead and measure to make sure you know exactly what you've got. 2 by 8s can be used for headers above doors and windows. 2 by 10s can be used as floor joists and ledger boards. 2 by 12s are usually used for the stringers that support staircases.

What is called “one-by wood” or “1-inch wood” is sometimes used for certain trim pieces, and it’s useful to remember that it’s actually 3/4 inch thick. What is called “five-quarters wood” might be used for the floor of an outdoor deck or for the treads or risers of a staircase, and it is actually 1 inch thick. Sometimes the four corners that run the length of a 5/4s board are rounded over.

The last three in the table above, which are square in cross-section, are used outdoors and are water-resistant. *Spindles,* also called *balusters, pickets, posts,* and *pales,* are the vertical pieces of a fence or railing, similar to studs, except that they will be visible. 4 by 4 posts serve as good newel posts for outdoor staircases. 6 by 6 posts can be used as pillars to support the roof of a front porch. Confusingly, some posts called “6 by 6 posts” really are 6 inches by 6 inches instead of 5-1/2.

Table of Other Materials (and a timeline) The table at right is a list of certain other materials used on job sites and their typical dimensions. The order of the materials is not random. Generally, this is the order in which they are added to the house. Many more materials are used in the construction of a house, of course, but this will help you in identifying certain materials during certain phases of construction and in knowing what their dimensions might be. For a more complete timeline see the How-To article titled Timeline.

Almost every day on a construction site it’s likely you’ll probably want to know how to measure and mark accurately. We hope you’ll use the information above to learn ahead of time how to be not just accurate but also efficient. We’re counting on you.

Other Materials

Name	Actual Height	Actual Thickness	Typical Lengths
Concrete footer	8 "	16 "	2 - 48 '
Concrete foundation	8 - 9 '	8 "	2 - 48 '
Steel I-beam	8 "	4 "	40 - 48 '
Sill plate	5-1/2 "	1-1/2 "	16 '
Floor joist I-beam	9-1/2 "	2-1/2 "	30 '
Rim joist	9-1/2 "	1-1/4 "	12 '
Floor decking	4 '	3/4 "	8 '
OSB	4 '	7/16 "	8 or 9 '
Housewrap film	9 '	0.17 mm	150 '
Vinyl corner post	5 "	5 "	10 '
Vinyl starter strip	2-3/4 "	<= 1/2 "	12 ' 6 "
Vinyl J-channel	1-3/4 by 1 "	1 " top	12 ' 6 "
Vinyl siding		<= 5/8 "	12 ' 6 "
Vinyl soffit	11-1/2 "	<= 1/2 "	12 '
Drywall (wall)	4 '	1/2 "	8 - 16 '
Drywall (ceiling)	4 '	5/8 "	8 - 16 '
Window buck MDF	5-1/2 "	3/4 "	16 '
Door/window trim	2-1/4 "	<= 5/8 "	7 or 16 '
Baseboard	3-1/4 "	<= 3/8 "	16 '
Shower tile	3-7/8 "		3-7/8 "
Floor tile	11-3/4 "		11-3/4 "

We thank you for volunteering to help build a house, and we hope you find the experience pleasurable and educational and worthwhile. Your hard work and earnestly accurate efforts will help a deserving family afford a house you built, and that is always worthwhile.

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