

Turks Head Knots Using a Board Jig

The method of using a board jig (a “former”) to make a Turks Head knot of B bights and $B+1$ leads is described in a video by Kevin Gagne. He describes the making of a knot with 7 bights and 8 leads. See <https://youtu.be/gxDuomjdvsM>.

Such a board jig is particularly useful whenever the knot is to be placed on a tube or stick for which the ends of the tube or stick are not accessible, such as a tube on a bicycle. In this case, the board can be placed on the tube, and any wraps that would normally be around the board by itself are done around both the board and the tube. Then when the board is slid out, the knot is right there where you want it, and can be tightened up, with additional passes if desired, and finished off.

We wondered whether it might be possible to use such a board jig to make longer Turks Head knots—with B bights and more than $B+1$ leads. It *is* possible. It turns out that it is easy to make a knot with B bights and $nB+1$ leads, where n is a positive integer. These notes describe how that may be achieved. We were motivated by a desire to put long knots on some of the tubes of a bicycle frame.

We use the following terms:

- **standing end:** The starting end of the cord. In our illustrations we usually show this end at the left for both the front and the back of the board jig. (When we turn over the board, we rotate it about its horizontal axis, so it appears upside down.)
- **working end:** The other end of the cord, usually shown with a fid. This is the end that is threaded through the knot when making it.
- **bight:** This is where the cord reverses from left to right at each end of the knot. Any knot will be characterized by its number of bights, denoted by B . The knot will have the same number of bights at each end.
- **passes:** The number of times that the cord is threaded through the knot. When making a knot with a jig, we usually stop after one pass, since it is easier to add passes after the knot is in place on a stick or tube. When illustrating the knot itself in these notes we often add a second pass (if the cord is long enough) for clarification.
- **leads:** Any knot will also be characterized by its number of leads (denoted by L), which is the number of times a single pass wraps around whatever the knot is tied on. It is also the number of times the cord would be cut through if one side of the knot were sliced through from one end to the other, ignoring any additional passes that may have been added. The length of a knot will be proportional to the number of leads, so the number of leads may, in theory, be used to estimate the length of the knot:

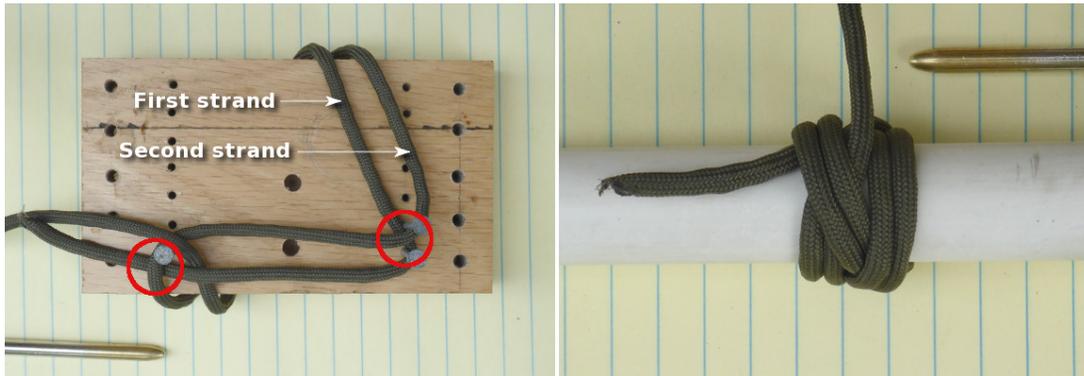
$$\text{length of knot} = \text{fudge factor} \times \text{number of leads} \times \text{cord thickness} \times \text{number of passes}$$

However, the fudge factor is not easy to determine accurately. See the end of our discussion for a better way to estimate the knot length.

- **strand:** The piece of cord starting at the standing end of the knot, passing through the other end, and returning to the standing end. Therefore half a strand just goes from one end of the knot to the other end.
- **segment:** The part of a strand that passes over either the front or the back of the board jig.

Knots with B bights and B+1 leads (n = 1)

We start by reviewing a simple Turks Head knot—one with **2 bights** and **3 leads**. Of course this can be made using Gagne’s board jig. Our duplicate version is illustrated here:



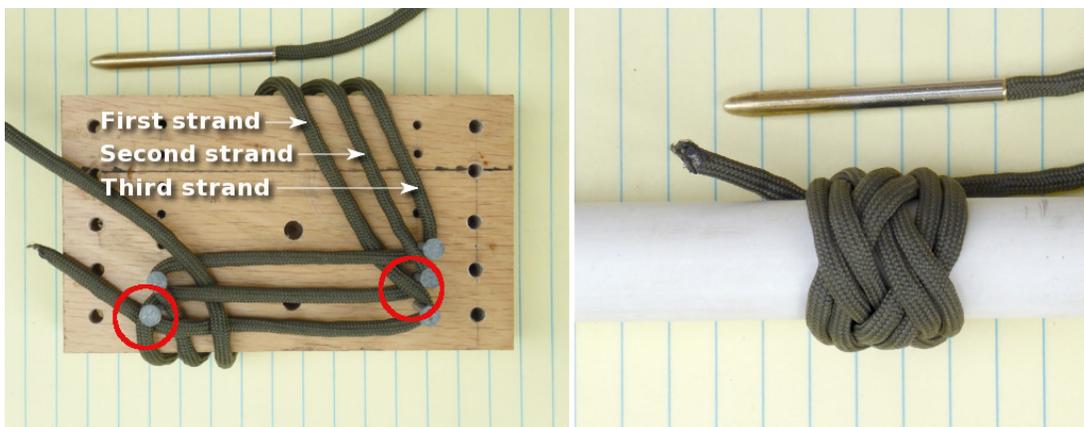
On the jig

Finished knot on a pipe

Note that on the jig, the *second strand* goes *over* the *first strand* in both places shown under the red circles. This must occur whenever the number of bights in the knot is *even*. If the number of bights is *odd*, the *second strand*, while still going *over* the first strand at the left peg, must go *under* the *first strand* at the right pegs, as shown below. After this first key step, we just weave, alternately under or over, opposite to whatever the previous strand did.

Although hard to believe, the knot on the jig is complete for one pass of the cord. The number of pegs on the right is equal to the number of bights in the knot. (On the left, we need only one less peg than the number of bights.) When we removed the pegs (here we used nails), slid the board out and put the knot on a pipe, we added a second pass. We can see that there are three leads.

Here, simply for comparison, is a similar knot of 3 bights and 4 leads:



On the jig

Finished knot on a pipe

Note that in this case, the second strand, after going *over* the standing end at the lower left peg, goes *under* the first strand before rounding peg#2 at the lower right of the jig (red circle), since the number of bights is *odd*. Again a second pass was added when the knot was transferred to the pipe. We can see that there are four leads in this knot.

Knots with B bights and $2B+1$ leads ($n = 2$)

Below is an illustration of how this board jig may be used to create a knot with **2 bights** and **5 leads**. For this, we have used 8-32 machine screws instead of nails for the pegs, since we will need to turn the board over when we thread the jig and we don't want the nails to fall out. We have used hardwood (here oak, but other hardwoods will work) for the board. The outer sets of holes (drilled with a #29 drill) were tapped with an 8-32 tap, and hold the screws just fine.



Front of jig

Back of jig

On a pipe

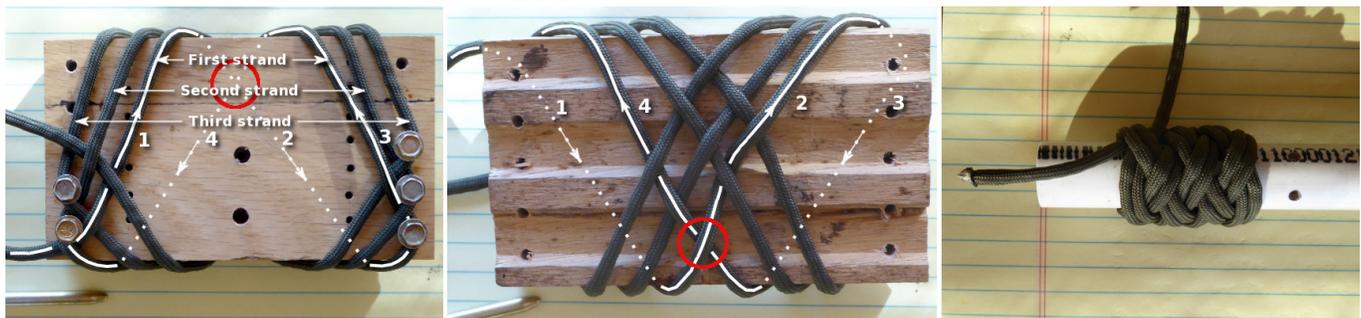
For this knot we have marked and numbered the segments of the first strand. Here there are two points to notice. First, in the left photo, at the crossing above the lower right peg, the *second* strand crosses *over* the *first* strand. This should be the case for all knots with $n > 1$, for either *even* or *odd* numbers of bights.

Second, in the center photo (which is upside down because we have rotated the board around its horizontal axis), at the crossing under the red circle, the fourth segment of the first strand crosses *over* the second segment. This is the case whenever the number of bights is *even*. (There are 2 bights in this knot.) When the number of bights is *odd*, it's the other way: The fourth segment should cross *under* the second. Note that the number of pairs of cord (here 2) on the board is the value of n .

In the right photo, we can see clearly that there are 5 leads.

There is a good check **when a knot on the jig is complete**, as it is for these photos. If you follow the cord from beginning to end, it should alternate between *over* and *under*. You should not have two *unders* (or two *overs*) in a row. If it doesn't alternate, you have made a mistake, and need to start over.

To illustrate, we have a look at a knot with **3 bights** and **7 leads**:



Front of jig

Back of jig

On a pipe

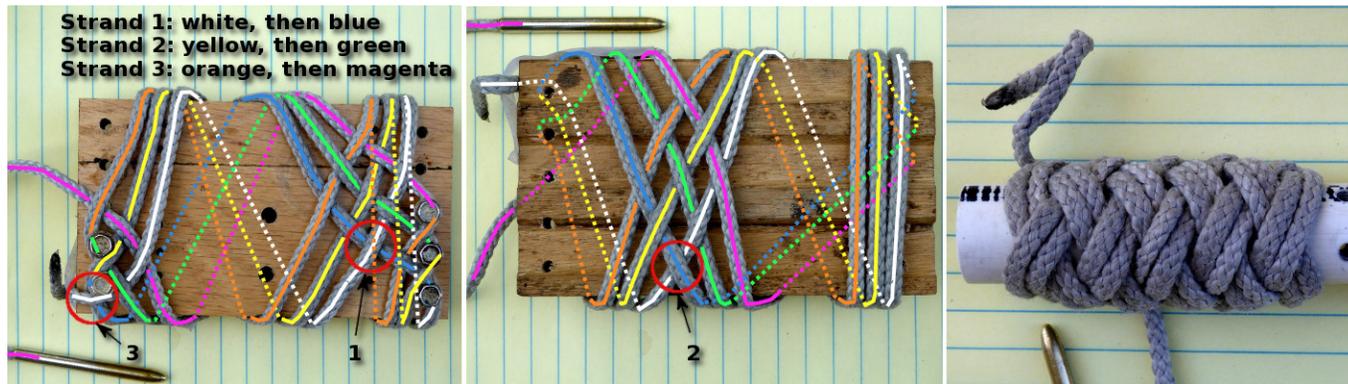
Here, in the left photo, above peg#1 at the lower right, the *second* strand again crosses *over* the *first* strand, even though this knot has an *odd* number of bights.

However in the center photo, if we look carefully at the crossing under the red circle, we see that the fourth segment of the first strand crosses *under* the second segment, as it should if the number of bights is *odd*. Here the number of triplets on the board (two) is the value of n .

Also in the right photo, we see that there are indeed seven leads.

A knot with B bights and $3B+1$ leads ($n=3$)

We look here at a trickier knot, one with **3 bights** and **10 leads**. Here are the relevant photos:



Front of jig

Back of jig

On a pipe

It is trickier for two reasons. The first is that it is a knot with an *odd* number of bights, and the second is that it has a value of n that is greater than 2. (Note there are *three* groups of three strands each at the top and bottom of each photo of the board. The number of such groups is the value of n .) It is key to get the crossings right in this first strand. If you get them right, the crossings of the subsequent strands are easy, and **when the knot is complete**, *each* crossing will alternate between *over* and *under*, as described above.

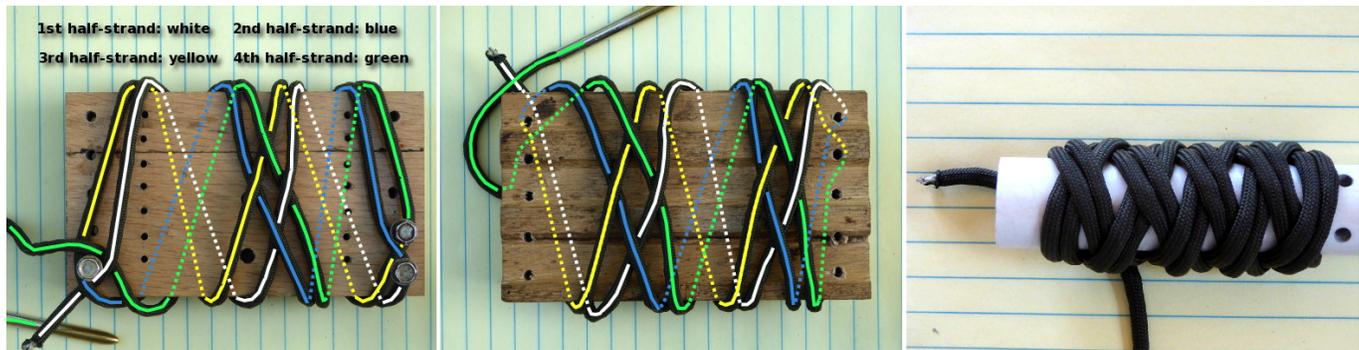
In both the left and center figures, we have put red circles around the key crossings of this first strand. Thus, the second half of the first strand must go *under* the first half (**1**), then *over* the first half (**2**), then *under* the first half (**3**)—*i.e.*, alternating. The crossings of subsequent strands are then determined by what the *previous* strand did. Just do the *opposite* of what the previous strand did. (You must follow the previous strand as you wind a new strand.)

While you are making the knot on the jig, there will be times when you must do two *overs* (or two *unders* in a row. For this knot, this first occurs when the second strand crosses *over* the first strand just above peg#1 on the right (yellow over blue) and then crosses *over* the first strand again (green over white) on the front of the board. Then it crosses *under* the second strand on the front of the board and then *under* the first strand on the back of the board. However, at this point, the knot is not complete. These situations should disappear by the time the knot is complete. If they don't disappear, you have made a mistake. The second half of the last strand should always alternate between *under* and *over*.

The knot is complete as shown on the board, so the pegs can be removed and the board replaced by the pipe (or stick) on which you want to place the knot. Note the completed knot on the pipe. We have added a second pass. It clearly has 10 leads. If you are placing the knot on a tube for which the ends are not accessible (*e.g.*, a bicycle tube), lay the jig on the tube and wind the cord around both the jig and the tube. Add any additional passes after you remove the jig board.

A knot with B bights and $4B+1$ leads ($n=4$)

Here's a knot with **2 bights** and **9 leads**:



Front of jig

Back of jig

On a pipe

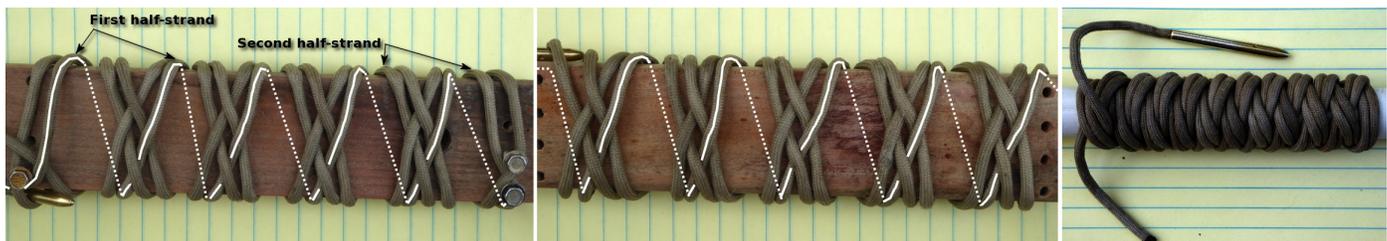
This knot, like the previous one, is about the longest knot that we can form on this small board. If we want longer knots, we can just use a longer board, so there will be room for more leads. (See the next section.) This knot is pretty complex, but it is simpler than the previous knot since it has an *even* number of bights.

In fact, it is especially easy to make a knot—of any length—with an *even* number of bights, since for the first *three* half-strands, *every* crossing is *over*. You just have to wrap the cord around the board for the first one-and-a-half strands. After that, just pay attention to the *previous* strand, and make every crossing *opposite* to the previous strand's crossing. The last half-strand, as you head back to the standing end, should alternate between *under* and *over*. And when the knot is complete, be sure to check that the crossings alternate between *under* and *over*, as described earlier.

For the 2-bight knot shown here, the four segments shown as dashed white lines are on the back of the board—again upside down, since we rotated the board about its horizontal axis. See the center photo. The key point is that segment 6 crosses *over* segment 2 on the back of the board. This crossing is circled in red, and is the first crossing of the first strand. As with previous examples, this must be the case whenever the number of bights is *even*.

A knot with B bights and $10B+1$ leads ($n=10$)

Here we illustrate a long knot with **2 bights** and **21 leads**. We use a longer narrower board. It's maple. The peg holes are easily threaded for 8-32 machine screws. Here's what it looks like:



Front of jig

Back of jig

On a pipe

Here the board is only $1\frac{3}{4}$ inches high, room enough for up to four pegs, so it's limited to a 4-bight knot. It's 7 inches between the left and right peg holes. The first half-strand is marked in white. Can you pick out the third and fourth half-strands? Each of the first three always crosses *over* the previous half-strand. There are 10 strand pairs at the top and bottom of each view of the jig. This is the value of n . With this technique, the crossings fall in place naturally on both the front and back of the board.

This is clearly an excellent way to create a long Turks Head knot, especially if the number of bights is *even*.

As a final illustration, we made this beautiful knot using the full capacity of our long narrow board jig. It has **4 bights** and **17 leads**:



Front of jig

Back of jig

On a pipe

If you count the groups of four (there are four bights) along either the top or the bottom edge of the board you will see that there are four groups, so $n = 4$. The lines on the paper are separated by 0.345 inches, so you can see that the knot itself is slightly over 4 inches long (12 lines on the paper). Adding another wrap of the cord around the board would increase n to 6, resulting in a 25-lead knot, which would be $25/17$ times as long, or nearly 6 inches. This is a good technique for predicting both the length of the desired knot and the length of cord needed to make it. Just make a test knot (we could have used one with $n = 2$) and go from there.

Note that in the left photo above, we have marked the first half-strand—it’s the white one. Also in this photo, the fid is shown starting a second pass of the knot. The cord goes around the back of the board, from the upper left to the lower left, before reaching the fid. I’ve found that it helps avoid mistakes if the start of a second pass (say one additional wrap around the board and whatever additional tube on which you are placing your knot) is done before removing the board. It is crucial to get this first pass exactly right. I’ve also found that the knot seems easier to align along the length of the knot if the second pass is placed (as shown) to the right of the first pass, *i.e.*, headed toward the center of the knot. It’s difficult to align a knot with only one pass, since at that stage it’s pretty much of a mess.

Also the easiest stage to align the knot so the crosses and overlaps don’t spiral around the tube or stick is when the second pass is complete. The rest of the second pass and any additional passes are best made after the knot is placed on the tube or pipe or stick. The photo of the knot on the pipe shows two passes. We added the rest of the second pass after the knot was transferred to the pipe.

To make a 4-bight knot, all you need to do is to add two additional strands to the 2-bight knot, always using the previous strand to determine whether you should cross *over* or *under*. Of course you will need a cord of twice the length, and probably a longer board. You can make very long knots, but it takes lots of time and enormous patience to keep the kinks out of the cord and avoid mistakes. I’ve found that a “locking forceps” is useful for doing the final tightening.

Feel free to write to me, at drip@ucsc.edu, if you have any comments or suggestions. You can grab the most recent copy of these notes from https://scott.physics.ucsc.edu/pdf/jig_for_turks_head_knots.pdf.

