Drawing True Threads Using DeltaCad®

Written by DCUG member - "i44troll" - February 2011

This tutorial was created as the result of a request made by DCUG member "jcamp0712".

"Need suggestion on drawing a threaded rod showing the size, pitch and number per inch of the threads, i.e. 1/4-20 coarse 2 inch machine screws or a 1/2" threaded rod. Thanks."

INTRODUCTION

Most draftsmen wouldn't bother with drawing true threads within their drawings simply because it takes time and will sometimes clutter the drawing. If you decide to go the easy route you can draw threads that can be portrayed easily in several acceptable ways including short and long alternating lines to represent the length of the threads on the part. This is outside the scope of this tutorial, therefore if you choose to go the simple route I will leave that up to the good folks at *Google* to show you the way.

So, why would anybody want to draw true threads?
I like to draw everything as close to realism as possible because I like my students to be able to see the part "come off the page", so-to-speak, as they create the part. Other than that, I can "visualize" whether or not a part will work when I draw actual thread geometry.....make sense? Then again, I love to draw and create new plans and ideas, therefore, in my opinion a new idea deserves the BEST I can give it, and I love to see creations that are thoughtfully planned.

HOW TO DRAW TRUE THREADS

Before we start drawing anything, we need to get some important information from two different sources. This information is VITAL to the correct creation of true threads.
The main two sources are....

1. ***Machinery's Handbook*** --or-- visit **"EngineersEdge"** for an online chart.
2. ***Thread Wire Chart*** (PDF) from a Van Keuren thread wire set.

*We will use the *Machinery Handbook* (See Figure 1 on page 2 of this tutorial) to give us information on the Major nominal (average) diameter of the portion of the part needing threads and the nominal pitch diameter as well. In this tutorial we will create 1/2"-13 2A threads (1/2" diameter/13 threads per inch/"2A" class of fit). This is a very common thread diameter and pitch that is found within my lab at work so it works well for teaching students how to use thread wires.

** I like to use the thread wire chart to give me the information needed to create the geometry of the given thread. There may be other people that use a different method like "best wire size" which is taken directly from the *Machinery's Handbook*. Both methods work the same, but I prefer to use the Van Keuren method because the information is easier for me to work with, takes less math, and I find the *Machinery's Handbook* difficult at times to locate needed information while my thread wire chart is always in a handy location in my top box.

Wires are great to use in drawings because we can use "circles" to represent the wires, and that works perfectly when drawing true threads using the three wire method of measurement as shown in this illustration.
(See figure 2 on page 2 of this tutorial)

Figure 1

Nominal Size, Threads per Inch, and Series Designation[a]	Class	Allow-ance	Major Diameter Max[d]	Major Diameter Min	Major Diameter Min[e]	Pitch Diameter Max[d]	Pitch Diameter Min	UNR Minor Dia.[c] Max (Ref.)	Class	Minor Diameter Min	Minor Diameter Max	Pitch Diameter Min	Pitch Diameter Max	Major Diameter Min
⅜-28 UN	2A	0.0011	0.3739	0.3674	—	0.3507	0.3471	0.3313	2B	0.336	0.345	0.3518	0.3564	0.3750
	3A	0.0000	0.3750	0.3685	—	0.3518	0.3491	0.3324	3B	0.3360	0.3426	0.3518	0.3553	0.3750
⅜-32 UNEF	2A	0.0010	0.3740	0.3680	—	0.3537	0.3503	0.3368	2B	0.341	0.349	0.3547	0.3591	0.3750
	3A	0.0000	0.3750	0.3690	—	0.3547	0.3522	0.3378	3B	0.3410	0.3469	0.3547	0.3580	0.3750
⅜-36 UNS	2A	0.0010	0.3740	0.3685	—	0.3560	0.3528	0.3409	2B	0.345	0.352	0.3570	0.3612	0.3750
⅜-40 UNS	2A	0.0009	0.3741	0.3690	—	0.3579	0.3548	0.3443	2B	0.348	0.354	0.3588	0.3628	0.3750
0.390-27 UNS	2A	0.0011	0.3889	0.3822	—	0.3648	0.3612	0.3448	2B	0.350	0.359	0.3659	0.3706	0.3900
⁷⁄₁₆-14 UNC	1A	0.0014	0.4361	0.4206	—	0.3897	0.3826	0.3511	1B	0.360	0.376	0.3911	0.4003	0.4375
	2A	0.0014	0.4361	0.4258	0.4206	0.3897	0.3850	0.3511	2B	0.360	0.376	0.3911	0.3972	0.4375
	3A	0.0000	0.4375	0.4272	—	0.3911	0.3876	0.3525	3B	0.3600	0.3717	0.3911	0.3957	0.4375
⁷⁄₁₆-16 UN	2A	0.0014	0.4361	0.4267	—	0.3955	0.3909	0.3616	2B	0.370	0.384	0.3969	0.4028	0.4375
	3A	0.0000	0.4375	0.4281	—	0.3969	0.3935	0.3630	3B	0.3700	0.3800	0.3969	0.4014	0.4375
⁷⁄₁₆-18 UNS	2A	0.0013	0.4362	0.4275	—	0.4001	0.3958	0.3701	2B	0.377	0.390	0.4014	0.4070	0.4375
⁷⁄₁₆-20 UNF	1A	0.0013	0.4362	0.4240	—	0.4037	0.3975	0.3767	1B	0.383	0.395	0.4050	0.4131	0.4375
	2A	0.0013	0.4362	0.4281	—	0.4037	0.3995	0.3767	2B	0.383	0.395	0.4050	0.4104	0.4375
	3A	0.0000	0.4375	0.4294	—	0.4050	0.4019	0.3780	3B	0.3830	0.3916	0.4050	0.4091	0.4375
⁷⁄₁₆-24 UNS	2A	0.0011	0.4364	0.4292	—	0.4093	0.4055	0.3868	2B	0.392	0.402	0.4104	0.4153	0.4375
⁷⁄₁₆-27 UNS	2A	0.0011	0.4364	0.4297	—	0.4123	0.4087	0.3923	2B	0.397	0.406	0.4134	0.4181	0.4375
⁷⁄₁₆-28 UNEF	2A	0.0011	0.4364	0.4299	—	0.4132	0.4096	0.3938	2B	0.399	0.407	0.4143	0.4189	0.4375
	3A	0.0000	0.4375	0.4310	—	0.4143	0.4116	0.3949	3B	0.3990	0.4051	0.4143	0.4178	0.4375
⁷⁄₁₆-32 UN	2A	0.0010	0.4365	0.4305	—	0.4162	0.4128	0.3993	2B	0.404	0.411	0.4172	0.4216	0.4375
	3A	0.0000	0.4375	0.4315	—	0.4172	0.4147	0.4003	3B	0.4040	0.4094	0.4172	0.4205	0.4375
½-12 UNS	2A	0.0016	0.4984	0.4870	—	0.4443	0.4389	0.3992	2B	0.410	0.428	0.4459	0.4529	0.5000
	3A	0.0000	0.5000	0.4886	—	0.4459	0.4419	0.4008	3B	0.4100	0.4223	0.4459	0.4511	0.5000
½-13 UNC	1A	0.0015	0.4985	0.4822	—	0.4485	0.4411	0.4069	1B	0.417	0.434	0.4500	0.4597	0.5000
	2A	0.0015	0.4985	0.4876	0.4822	0.4485	0.4435	0.4069	2B	0.417	0.434	0.4500	0.4565	0.5000
	3A	0.0000	0.5000	0.4891	—	0.4500	0.4463	0.4084	3B	0.4170	0.4284	0.4500	0.4548	0.5000
½-14 UNS	2A	0.0015	0.4985	0.4882	—	0.4521	0.4471	0.4135	2B	0.423	0.438	0.4536	0.4601	0.5000
½-16 UN	2A	0.0014	0.4986	0.4892	—	0.4580	0.4533	0.4241	2B	0.432	0.446	0.4594	0.4655	0.5000

Figure 1 - Thread Chart from the *Machinery's Handbook*

Three wire method of checking pitch diameter of screw threads.

M=Measurement over wires.

E=Pitch diameter of thread.

D=Basic major or outside diameter.

W=Wire diameter.

P=Thread pitch

M=E+Const.

E=M-Const

Const.=3W-86603p(found in chart)

The maximum and minimum pitch diameter(E) for each class of thread can be found in machinerys hand book
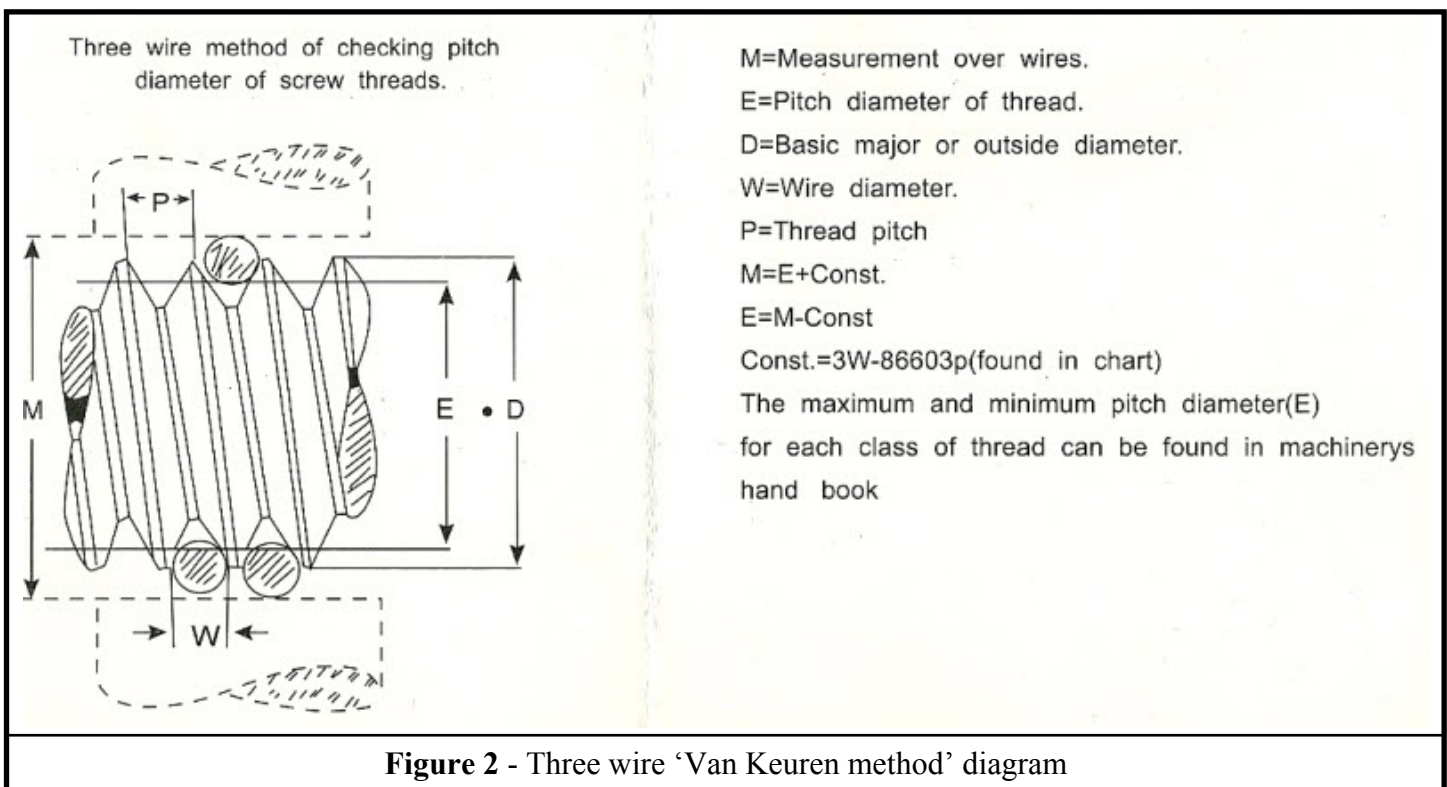
Figure 2 - Three wire 'Van Keuren method' diagram

The information provided on the wire chart (figure 3 on page 3 of this tutorial) will give us the information need-ed to draw the geometry of true threads. Thread wires are cheap to buy, but are considered to be the most accu-rate way to measure threads, therefore it should be assumed that we can get the same "accurate" results if we use them to define the dimensions of our thread drawings as well.

THREAD CHART
FOR ALL U.S.60° THREADS

Select the proper wire size for either the number of threads per inch(US) or thread pitch (metric)

Measured pitch dia (E) equals measurement over wires (M) minus decimal in"CONST"column

Note:Basic P.D.equals basic major diameter plus decimal in "ADD"coiumn minus decimal in "CONST"column

THREADS PER IN.	WIRE SIZE	ADD	CONST	THREADS PER IN.	WIRE SIZE	ADD	CONST
48	.018	.02243	.03596	11 1/2	.055	.03321	.08969
44	.018	.01956	.03432	11	.055	.02722	.08627
40	.018	.01611	.03235	10	.055	.01345	.07840
36	.018	.01190	.02994	9	.063	.02061	.09277
32	.024	.02464	.04494	8	.072	.02656	.10775
28	.024	.01787	.04107	7 1/2	.081	.04093	.12753
27	.024	.01587	.03993	7	.081	.02649	.11928
24	.029	.02385	.05092	6	.092	.02341	.13166
20	.029	.01122	.04370	5 1/2	.108	.04845	.16654
18	.032	.01180	.04789	5	.120	.05689	.18679
16	.040	.02528	.06587	4 1/2	.127	.04421	.18855
14	.040	.01175	.05814	4	.143	.05011	.21249
13	.045	.01842	.06838	3 1/2	.185	.12199	.30756
12	.055	.03870	.09283	3	.185	.04982	.26632

Figure 3 - Thread Chart

To complete this tutorial, it is assumed that you have used ***DeltaCad*** enough to be familiar with the standard features of each tab. Specifically the ability to use the "base point" feature within the SELECT tab and the ability to copy and paste selected elements in a controlled manner.

Once again, to teach the use of those functions would be outside of the scope of this tutorial.

STEP 1 - GATHERING THE INFORMATION

Since we are going to draw 1/2"-13 2A threads we need to gather all the information from our sources before we start.

This is what we'll need......

1. Major Outside Diameter (nominal) (from machinery handbook)
2. Pitch Diameter (nominal) (from machinery handbook)
3. Thread Wire Size (from wire chart)
4. Number Value in the CONST. Column based on wire size to get the "measurement over the wires" (from the Wire Chart)

The best way to define "CONST." which is an abbreviation for "CONSTANT" is to state that "regardless of the diameter of the part being threaded the physical profile of the threads remain the same as long as the TPI (Threads Per Inch) remain the same. Therefore we know that the math (more specifically, trigonometry) used to produce the measurement over the wires (MOW) is "CONSTANT", that is, "stays the same" regardless of the size of the threaded diameter".

I should also define "nominal" as well since that word encompasses such a broad definition. Machinists will use the word nominal to refer to the average of two numbers. On a blueprint there is always two numbers to represent a dimension, those two numbers define a minimum and maximum allowance. So, the nominal of 1.500 +/- .005 = 1.500 because it is the average of the minimum (1.495), and the maximum (1.505) allowance. (1.495 + 1.505)/ 2 = 1.500

So, according to our sources, this is what we have......

1. Major Outside Diameter (nominal) = .4876min / .4985max (add together and divide by 2 for nominal) = .4931 nominal , (that is the "average of the two")
2. Pitch Diameter (nominal) = .4435min / .4485max (add together and divide by 2 for nominal) = .4460 nominal
3. Thread Wire Size = .045
4. Number Value in the CONST. Column based on wire size = .06838

A little know-how and a good spreadsheet, like *Microsoft-Excel,* can take away all your headaches if you know how to use it properly.

Anyone interested in a spreadsheet that includes gearing formulas and MOW (threadwire) calculations can contact me, via PM, through our forums (username "i44troll") . -- Please include your preferred Email address that you want those files sent to. TY.

NOW WE CAN DRAW!!

WOOHOO!!

STEP 2 - Create a few threads FIRST

Follow these steps.....

1) Draw an angled line 60° at any length (not too long though).

2) At the base of that line draw another angled line at 120° (same length).

3) Now "select" (from the select tab) both lines.

----STAY WITHIN THE SELECT TAB----

4) Click the **COPY** button (it should turn RED).

5) Select the "move selected objects" button.

6) Type "**1/13,0**", then press "enter" 3 times to copy and move the selected lines incrementally 1/13 of an inch to the right with each press of the "enter" key.

> **NOTE: "1/13"** is your **X** value, "**0**" is your **Y** value.
> (The "move selected objects" button must have **X and Y** values to work, and they must be separated using a comma.)

WHY AM I USING 1/13 FOR X? Remember our threads are 13 threads PER INCH, so we are copying a single thread and moving it the distance of the thread pitch every time we hit the "Enter" key, which is 1/13th of an inch (if **COPY** is selected). **Y** is equal to "**0**" because we want to copy/paste horizontally without going up or down.
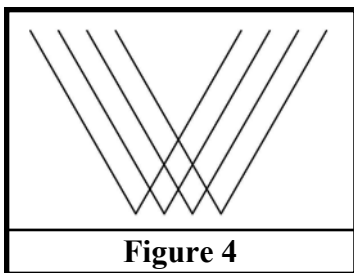
Figure 4

You should now have a drawing that looks like figure 4 if you followed each step above.

Gee, the lines look a little exaggerated don't they? Well, they are, but we didn't know how long they were supposed to be otherwise we could have made them to length.

Don't worry about it. It doesn't matter anyway! Let's go to the next step.

STEP 3 - Create the Wires to Fit the "V" Threads

This is where your thread wire information is going to come in handy.
Follow these directions.........

1) Move the first line parallel .045 (this is the same size as the diameter of your wire)

The parallel line that was just created is the red one as shown in figure 5.

- For a video tutorial on this, please see the "**Drawing a circle tangent to two lines**" in our **Video Tutorials** sub-forum.

2) Go to the "circle" tab

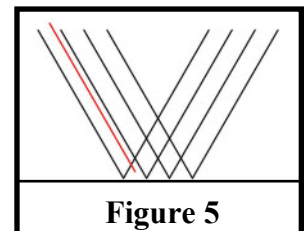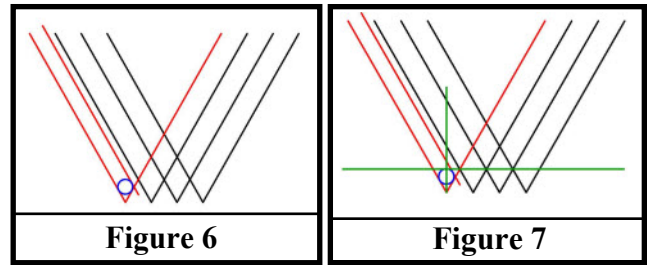**3)** Select "draw a circle tangent to three lines"

Figure 5

The three red lines shown in Figure 6 represent the ones you should use.

The circle will be created automatically once the third line is selected. That circle represents the "wire" used to measure the pitch of the thread which is the only way we can determine the correct placement of the threads.

Figure 6　　**Figure 7**

5) Now draw a line straight up from the convergence of the two lines directly beneath the circle and draw a horizontal line that is tangent to the top of our circle, which we will use to determine the "measurement over the wires". - Both of those newly added lines are represented by the green lines as shown in Figure 7.

STEP 4 - Creating the Line Representing "Measurement Over The Wires"

I guess I could have called it something else but this line is the most important line needed to set the boundaries of our threads. From this line we are going to define the centerline of our part so that we can mirror the top side after it is finished to the bottom side without having to draw everything over again.

Remember when we gathered our information at the beginning? There are two numbers that we need from that information so that we know what to make the "Measurement Over The Wires". Those two numbers are derived from......

1) the Pitch Diameter (nominal) = .4435min/.4485max (*add together and divide by 2 for nominal*) = .4460 nominal (average of both numbers)

AND........

2) the Number Value in the CONST. Column, based on wire size, is .06838

According to our thread wire chart M=E+CONST. This formula simply means "the measurement OVER the wires is equal to the pitch diameter plus the number in the CONST column that relates to the wire size used for the chosen thread pitch".

We find that value to be .4460 + .06838 = .5144 (rounded up)

Now, remember I said that we are looking for the centerline of the diameter we want to thread so that we can mirror the finished threads thus saving quite a bit of drawing time. All we have to do is divide .5144 by 2 to get that centerline.

Thus, **.5144/2=.2572**

Let's use that result to offset the horizontal line that was created tangent to the top of the circle. (See figure 9)

The next major step will be to create a line to show where our major diameter will be, but before we do that let's clean up some lines that are no longer needed and shorten the ones that we know are a bit too long.

We will always be able to shorten our lines to meet the MOW line created because those lines will end up being shorter still after we place the line representing the major diameter.
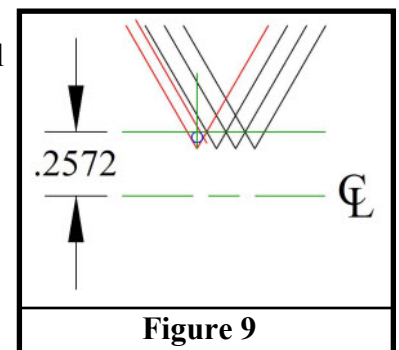
Figure 9

Make your drawing look like figure 10 by deleting two lines and shortening the others.

Now we are ready to draw the line representing the major diameter.

Figure 10
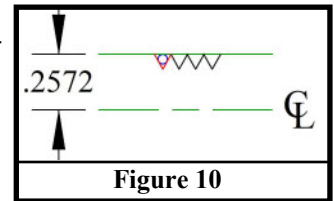
STEP 5 - Creating the Line Representing the "Major Diameter"

__*From this point on we should understand that any reference to "flat crest" (see inset) will relate to "major diameter" as well, since they are both one and the same.*

It is my understanding that after one of our major world wars (WWI or WWII ?) that thread nomenclature changed dramatically so that we no longer use "sharp-V threads as a standard (If there is anyone out there reading this post that knows more about this please feel free to comment). Therefore, it is certain that all thread forms have some type of flat crest instead of a sharp "V" shape. Regardless of whether my understanding is based on truth, it just makes sense to me to create threads with a flat crest because "sharp threads are very weak along that sharp edge and they provide little or no added strength. If we maintain the correct major diameter we'll find that our threads will never have a sharp "V" shape, but will always be created with a nice flat crest.

According to the information we obtained at the beginning, we know that the Major Diameter for 1/2"-13 2A threads is .4931. We can therefore divide that number by 2 to get .2466 and offset our centerline by that same value to find find out just where our flat crest should be, as indicated in figure 11.

Now all we have to do is cut the line into segments and trim them to the lines that form our 60° threads. Figure 12 shows what you're drawing should look like following this step of this tutorial. (Note the flattened thread points both in the drawing and the photo.)


Figure 11

Figure 12
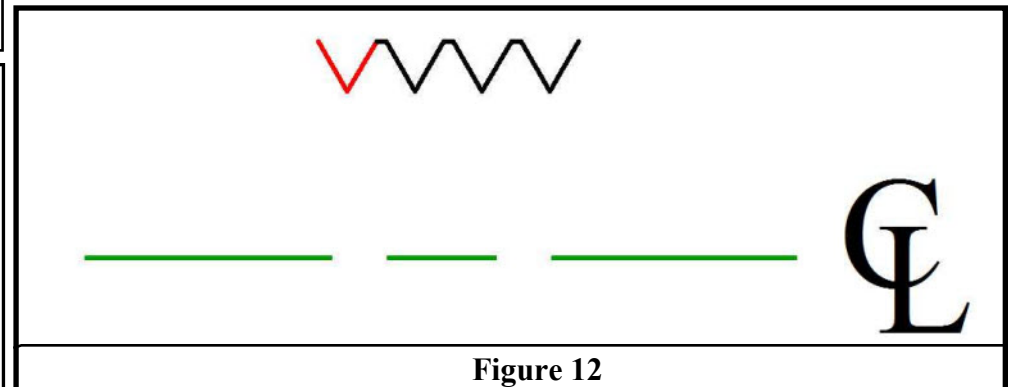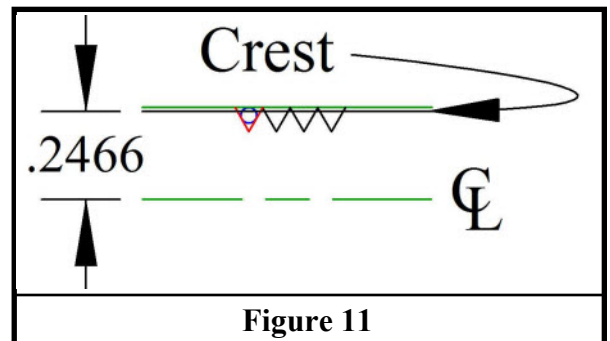
STEP 6 - Mirroring the top threads to the bottom

Now that where here you'll see why we did the top half first. Mirroring makes this so much easier I can't imagine doing it without it!

Follow these instructions closely.....
1) Go to the SELECT tab
2) Select the top threads only
3) Click the COPY button so that it turns RED
4) click on the "mirror selected objects" button
5) Select the centerline
6) CLICK OFF THE COPY BUTTON **(very important!)**
7) Click on the "move selected objects" button
8) Type "**1/13/2,0**" and press ENTER.
__**What does typing "1/13/2,0" do?** It moves the selected threads that are at the bottom 1/2 the distance of the thread pitch. Figure 13 shows what you will see when finished.

Figure 13
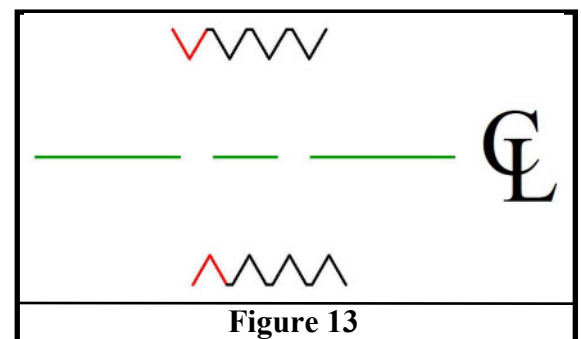
STEP 7 - Joining The Top and Bottom Lines
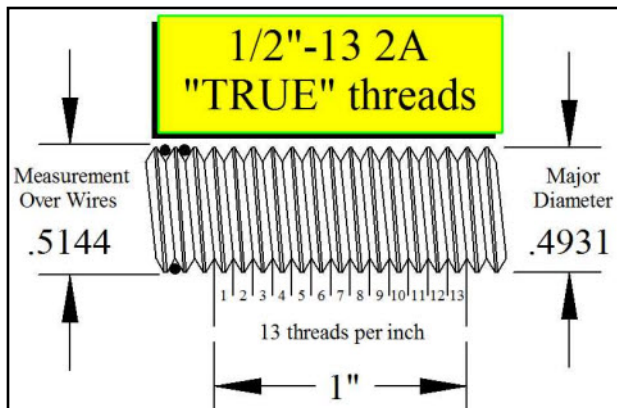
Now we can simply join the top and bottom threads together to get a true thread drawing. Still, the outcome may not be what you would expect, but we'll go over that next.

These procedures work for any diameter and pitch of thread. All that is needed are the four values for:

- Major Outside Diameter -
- Pitch Diameter -
- Thread Wire Size -
- Number Value in the CONST. Column -
(3 x Wire size - .86603 x Pitch)

STEP 8 - "So what's wrong with this thread?"

So far, there is nothing dimensionally wrong with the threads, but there is something that is aesthetically wrong!

The threads measure perfect in every way.... But, when you look at the root of the thread, it appears crooked. The reason it appears crooked is because the line representing the root cut of the thread is much shorter than the lines representing the outer crest of the threads, thus creating a much more pronounced angle than the others. This "visual" problem is nearly unnoticeable when large diameter fine threads are drawn, but when small diameter course threads are drawn it looks very awkward. If you look closely at the blue line in figure 14, you can clearly see a difference between the lines.
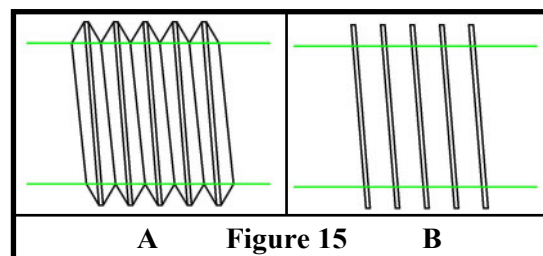

Figure 14
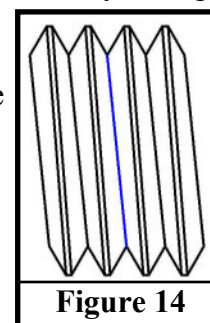
There is a solution to this problem that involves a bit of tweaking, but is well worth it if this bothers you every time you look at your drawing. The results will straighten the crooked lines and preserve the integrity of the thread dimensions. As a matter of fact, after I changed the original drawing, there was a slight change of only .0002 difference in the measurement over wires between the two drawings . You sacrifice perfect 60° threads but the discrepancy is nearly unnoticeable.

Here's how to do it......

First, draw lines at the root of the thread on both sides. (Figure 15 A)

Second, delete everything except the lines connecting the crest of the threads. (Figure 15 B)

A   **Figure 15**   B

Third, place points in the center of each thread opening. (red dots were used here since the points vanished during conversion) (Figure 16 A)

Fourth and last, replace the lines previously deleted joining them to the newly created points. (Figure 16 B) (red dots were used here since the points vanished during conversion)
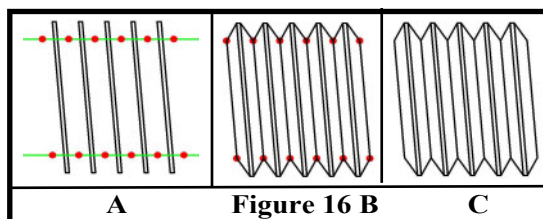
A   **Figure 16 B**   C

Once the temporary lines and the points are deleted you'll have perfectly dimensioned and aesthetically appealing threads. (Figure 16 C)

You'll benefit by saving your threads as a symbol files. Take a few moments to create them, that way you'll never have to create those threads again! -- If I can clarify anything a bit better, please let me know and I'll be glad to do it. Member: "i44troll" @ the DCUG site.