



FIRST Team 1334

OTHS Red Devil Robotics



FASTENERS AND FASTENING SYSTEMS

This handout is intended for the use of students involved with FIRST Robotics. Suggestions for revisions and corrections should be sent to George Chisholm, mentor of Team 1334, Oakville Trafalgar High School Robotics at georgechisholm@sympatico.ca

Machine screws and bolts are very similar. Machine screws are small. Bolts are bigger but there is overlap.

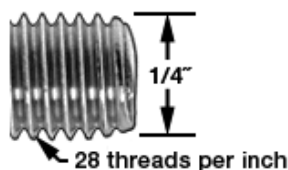
They are specified using several identifying features – imperial, metric, thread form, diameter, length, head shape, drive system and strength

Imperial Threads (inches) are specified by diameter and number of threads per inch. Sometimes NC (National Coarse) or NF (National Fine) is also included in the description. Fine threads are less common but are stronger and less subject to loosening under vibration. Under $\frac{1}{4}$ inch diameter a number is used. They go down to a 000 but the smallest used in FIRST is #2. Odd numbers are rare. #12 is not used much as it is very close to $\frac{1}{4}$ ". The number is a gauge number rather than a measurement in units. An external thread as on a bolt is sometimes called a male thread. An internal thread as on a nut is sometimes called a female thread.

#10-24 means #10 diameter, 24 threads per inch and, according to the chart on the next page, it's National Coarse.

$\frac{1}{4}$ -28NF means $\frac{1}{4}$ " diameter, 28 threads per inch and it's National Fine. Generally if NF isn't stated, it's NC. Occasionally you will see UNC or UNF which means Unified National Coarse and Unified National Fine. They're pretty much the same as NC and NF.

There are other thread forms as well. Square threads and Acme threads are used in power transmission. Buttress threads are stronger in one direction than the other and are used in vises. Pipe threads (NPT) are tapered so that the piece of pipe will lock into the fitting to give a seal.



As you can see from the above diagram a 1/4" thread is 1/4" outside diameter.

So how do we make these threads? The easiest way is to buy a bolt or nut with the correct thread already on it or we can use threaded rod. We can also cut internal and external threads on the lathe but this is not easy and should be avoided. The most common way is to use a **Tap** to cut internal threads or a **Die** for external threads.



Die

Used for cutting external threads. Available in National Fine, National Coarse and Metric.

One side has more taper or incomplete teeth. This is the side that goes onto the piece to be threaded first.

Come in sets – National Coarse from 1/4" up, National Fine from 1/4" up, Number from #4 to #12 NC and NF and Metric

Die Stock or Wrench

Used to hold the die. The tapered side goes out



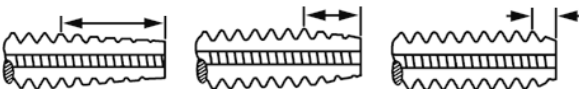
Tap

Used for cutting internal threads Available in National Fine, National Coarse and Metric.

Starting Tap has lots of taper to make it easy to start the thread – not commonly used

Plug Tap has some taper and is used for most holes

Bottoming Tap has very little taper and is used to thread close to the bottom of a blind hole (one that doesn't go through). They break a lot more easily.





Tap Wrench
Used to hold the tap

Taps and Dies are, for our purposes, used by hand and must always be used with a cutting agent such as Cool Tool so they don't break.

If you are making a 1/4 " internal thread the hole you start with can't be 1/4" or the tap won't have any material to cut as the 1/4" refers to the outside diameter of the male thread. We have to drill a smaller hole so that we can cut threads in the material. The chart on the next page tells us what the tap drill size will be for each thread. National

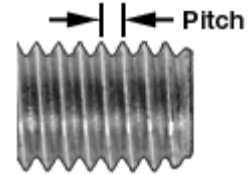
Fine threads are closer together which means that the "V" is narrower which means it isn't as deep which means we need a slightly bigger tap drill.

Size	Outside dia	Threads/inch NC	Tap drill	Threads/inch NF	Tap drill
#2	0.086"	56	#50	64	#50
#3	0.099"	48	#47	56	#45
#4	0.112"	40	#43	48	#42
#6	0.138"	32	#36	40	#33
#8	0.164"	32	#29	36	#29
#10	0.190"	24	#25	32	#21
#12	0.216"	24	#16	28	#14
1/4	0.250"	20	#7	28	#3
5/16	0.312"	18	F	24	I
3/8	0.375"	16	5/16	24	Q
7/16	0.438"	14	U	20	25/64
1/2	0.500"	13	27/64	20	29/64



Drill Sizes Note that drills come in three imperial size ranges (and one metric). The most common by far are **Fractional Drills**. They start at 1/16" and go up from there by multiples of 1/64". So a set would go 1/16, 5/64, 3/32, 7/64, 1/8, 9/64, 5/32 etc. Sometimes we need drill sizes that are between these sizes. **Number Drills** fill in the gaps in the smaller size. They start at #1 and get smaller as the number gets bigger – don't ask why. A standard set goes from #1 to #60. **Letter Drills** fill in the gaps in larger sizes. They start with A and get bigger up to Z. The only overlap is an E drill which is 0.250" which we all know is 1/4". Notice that the chart above uses all three size ranges. We are careful not to leave the number and letter drills out as they disappear and are much more expensive than fractional drills. Drills are also available in **Long Series**. We keep them locked up as they break easily and are more expensive than the standard length which is called **Jobber Series**.

Metric Threads Yes, Canada is officially a metric country but most fasteners etc are still imperial and FIRST stuff is usually imperial as it comes from the US. M8 means diameter 8 mm. The smallest is M1. Thread is specified by pitch, or the distance from one thread to the next. There is, however, more than one series: coarse and fine as with imperial threads. As an example M8 coarse has a pitch of 1.25mm. M8 fine pitch has a pitch of 0.75mm or 1.0mm. If the designation doesn't state, then it's coarse. M8 is coarse. M8X0.75 or M8X1 is used if it isn't coarse.



As we use metric threads so little in FIRST chart of sizes isn't included here. All the sizes – both imperial and metric – and drill sizes – fractional, letter, number and metric are on posters in the shop.

Machine Screws and Bolts

For our purposes they're the same thing. **Machine Screws** are tightened with a **Screwdriver** or **Allen Key**. **Bolts** require a wrench. This table shows the different types of **Screwdrivers** which are used with **Machine Screws**.



Robertson or Square Recess

Canadian Invention
Several sizes – yellow, green, red, black, double black



**Slot**

Tend to strip easily.
Avoid if at all possible

**Phillips**

Tend to strip easily.
Avoid if at all possible

**Allen (hex key)**

Metric or Imperial
Ball end are handy but don't get as good a grip
T-handle work best

**Torx**

Tend to be used in automotive

This table shows different common **Wrenches** which are used with **Bolts** and **Nuts**

**Open End Wrench**

Imperial and Metric

**Box End Wrench**

Stronger
Imperial and Metric

**Combination Wrench**

¼", 3/8" and ½" square drive

**Socket and Ratchet****Socket**

Standard, Deep, Flex and Hex shown
Imperial and Metric

**Nut Driver**

Handy
Imperial and Metric

**Adjustable Wrench** (Crescent Wrench)



Monkey Wrench

Included this because people refer to a monkey wrench. Rarely used. Not very strong

Pipe Wrench

Only for bars and pipes without a hex end

Machine Screws, Bolts and Nuts come in a variety of head shapes and drive types and are specified by thread and length.

#10-32 x 2" RHMS means #10 diameter, 32 threads per inch (which is National Coarse) and 2" (from the under side of the head) long **Round Head Machine Screw**. The length is the part of the fastener that will be in the pieces being fastened.



Socket Head Cap Screws (SHCS)

Usually use a hex key or Allen Key. Start at #2 diameter and go up from there.

Usually black in colour



Hex Head Bolts

Usually start at 1/4" and go up
The little lines on the head indicate the grade or strength of the bolt

Black or silver in colour

Wrench size = bolt diameter plus 3/16"



Round Head Machine Screws (RHMS)

Flat Head Machine Screws (FHMS)

Usually start at #4 and go up

Usually Robertson Head (square) in Canada

Can be Slot or Phillips

Usually silver in colour

Set screws or Grub screws

Usually start at #4 and go up

Usually hex or Allen key

Usually black in colour

Shoulder Bolts or Stripper Bolts

Specified by Shoulder diameter and length





Usually hex or Allen key
Usually silver and black in colour

Threaded Rod

Specified by diameter and thread
Cut to desired length

Nuts



Hex Nut

Specified by the thread eg ¼-20
From ¼ up, the distance across the flats is 3/16 bigger – in this case ¼ + 3/16 = 7/16

Two hex nuts can be jammed together to lock them on the bolt

Wing Nut

As above



Lock Nut – tends to scar the surface.
Not commonly used by FIRST

As above



Nylock – a favourite as they don't vibrate loose but they do take longer to run down a long thread as you need a wrench to do it.

Washers



Flat Washer

Specified by the thread they fit. A ¼" washer does not have a ¼" hole. The hole is somewhat bigger.



Spring Lock Washer – tends to scar the surface. Not commonly used by FIRST



Star or Tooth Lock Washers – tend to scar the surface. Not commonly used by FIRST

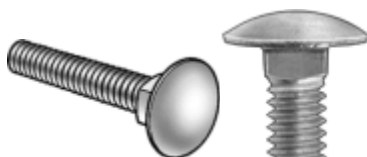
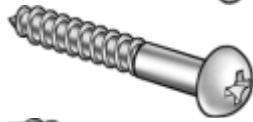
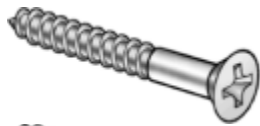


Threaded Fasteners for Wood

Wood Screws have a very coarse thread and are pointed for screwing in to wood. Most we buy here are Robertson (square recess). Cheaper ones are



Phillips (cross). Older ones are Slot. They are sold by the gauge diameter, length and head shape. The length is the part that is in the wood. #10 – 2” FHWS is #10 diameter, 2” long Flat Head Wood Screw



Flat Head Wood Screw (FHWS)
Round Head Wood Screw (RHWS)
 Oval Head Wood Screw
 Usually start at #4 and go up
 Usually Robertson Head (square) in Canada
 Can be Slot or Phillips
 Usually silver in colour
 Available in brass
Pan Head Wood Screw
 Usually start at #4 and go up
 Usually Robertson Head (square) in Canada
 Can be Slot or Phillips
 Usually silver in colour
 Virtually the same as self tapping sheet metal screws
Lag Bolt
 Usually start at 1/4" and go up
 Silver in colour
 Wrench size = bolt diameter plus 3/16"

Carriage Bolt
 Usually start at 1/4" and go up
 Silver in colour
 The square bit under the head is meant to grip in the wood.
 A hole the diameter of the bolt must be drilled through both pieces of wood being fastened
 Uses a washer and machine nut



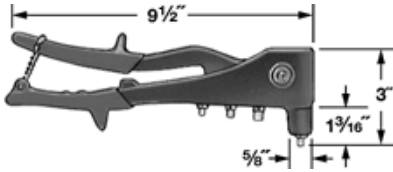
Other Fasteners



Pop Rivets

Used to join sheet metal and/or thin plastic.

Easy to remove by drilling out the pin
Must be used in pairs (at least)



Rivet Nuts (Rivnuts)

Work similar to pop rivets but allow a machine screw to be threaded into them. No access hole required behind them to tighten the nut.

