Nuts & Bolts Lesson

Nuts and bolts belong to a family of devices called fasteners. There are many ways to make two or more pieces come together and stay together but we'll be focusing on nuts and bolts as they apply to your Vex robot.

Below you can see many different types of bolt head designs. Keep in mind that these are only a few of hundreds of different designs that could be used.

Your Vex robot mainly uses a type of SOCKET head screws - the button head screw. See if you can find it!

List some reasons why you think there might be so many different types of screw heads.

Try to list some advantages and disadvanteges of using one over the other.

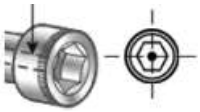
Some common SOCKET screw head types


Standard


Drilled Head


Flat


Low-Profile


Vented


Button


Flange Socket


Flange Button

Some common CAP screw head types


Standard Hex


Self Sealing Hex


Serrated Flange Hex


Flange 12 point


Heavy Hex
(Head is 1/8” wider than standard hex)


Flange Hex


Drilled Hex


High Hex

Nuts & Bolt Properties

Why do you think there are different material types?

Why do you think there are different finish types?

Some Material Type	**Some Finishes**	**Some Classes**
Steel	Plain	Class 8.8
Stainless Steel	Zinc-Plated	Class 10.9
Brass	Cadmium-Plated	Class 12.9
Nylon 6/6	Nickel-Chrome Plated	Not Rated
Silicon Bronze	Black-Oxide	
A286 Super Alloy	Blue-Coated	
	Ultra Corrosion-Resistant Coated	

Material – The choice of what material to use is a design choice. It all depends on what environment the bolt will be used in, strength required, and cost.

Finish - The finish is also a design choice and dependent on the environment, properties of the finish, and cost.

Class - The class of the bolt is related to the material properties of the bolt. For example, if steel is chosen then there are different classes of steel. Usually as the class increases the bolt becomes stronger and also more expensive.

Where Nuts & Bolts get Complicating

Nuts and bolts have been pretty simple so far. The problem with such simple devices is that sometimes it is easy to get TOO comfortable with them – that's when things go terribly wrong.

Normally, a bolt will thread right into a mating piece of metal or a nut and things go just fine. For thing to work just fine, the nut (or mating surface) and bolt have to have the same thread design. If the design of either one don't match then you can ruin the thread design on either of the pieces or even both of the pieces. If this happens, a special tool is used to fix the problem IF there isn't too much damage.

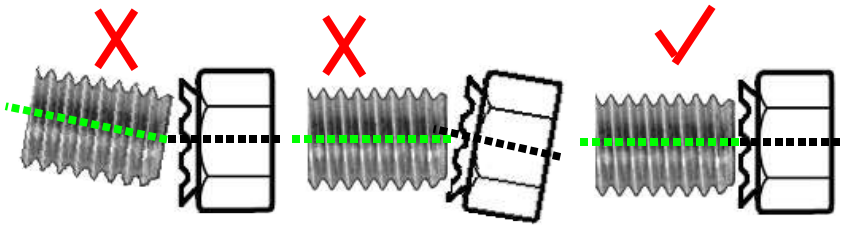
Common problems:

Stripped threads – this means that the treads of the bolt or nut have been removed to a point where they no longer work properly.

Cross-threading – this is a term used when either the wrong bolt or nut was used or the bolt started off at an angle to the threaded piece causing the threads to be ruined.

How to avoid these problems:

- Always make sure that the nut and bolts have the same thread design and diameter.
- Always make sure that the bolt or nut are started by hand first and you have spun the nut or bolt at least 2 revolutions by hand before using a tool.
- Always try to start the nut or bolt when it is perpendicular to the mating surface.



Nut & Bolt Threads

The language used for specifying the nut and bolt threads tends to be the most confusing but it is simple because it is geometry and mathematics.

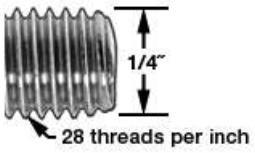
For example:
The 1/4" - 20 bolt – just tells somebody that the bolt has a diameter of 1/4" and has 20 threads per inch. That bolt should only be used with a mating nut that is also 1/4"-20.

They usually make two types of screws for each diameter, the fine pitch (has more threads per inch) and the coarse pitch (has fewer threads per inch). For example, the 1/4" diameter bolt also comes in the 1/4"-28 fine pitch variety.

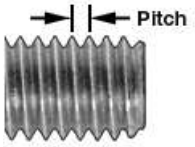
Can you come up for some reasons why there are different pitches?

Are the threads/inch and the thread pitch related? If so, how?

Selecting the Right Thread Size



Inch fasteners are specified with a size and the number of threads. For example, 1/4"-28 indicates a 1/4" diameter screw with 28 threads per inch.



Metric fasteners are specified with a thread pitch instead of a thread count. The thread pitch is the distance between threads.

Inch Thread Size	**Metric Thread Size**	**Metric Thread Pitch**
#0-80	M1.6	.35 mm
#1-72	M2	.4 mm
#2-56	M2.5	.45 mm
#3-48	M2.6	.5 mm
#4-40	M3	.7 mm
#4-48	M4	.8 mm
#5-40	M5	1 mm
#6-32	M6	1.25 mm
#6-40	M8	1.5 mm
#8-32	M10	1.75 mm
#8-36	M12	2 mm
#10-24	M14	2.5 mm
#10-32	M16	3 mm
#12-24	M18	3.5 mm
1/4"-20	M20	and so on...
1/4"-28	and so on...	
and so on...		

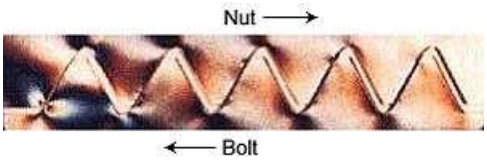
Notes about the differences:

Coarse pitch hardware is less expensive to manufacture than fine pitch.
Coarse pitch hardware threads together faster than fine pitch threads.
Coarse pitch hardware doesn't need to thread as deep for a good fit as fine pitch.
Coarse pitch hardware is less likely to cross-thread.
Coarse pitch hardware is less likely to strip.

Fine pitch bolts can thread into thinner materials than coarse.
Fine pitch bolts have higher tensile strength than coarse pitch hardware.
Fine pitch bolts are less likely to loosen under vibrations.
Fine pitched hardware is easier to torque for a preload than coarse pitch.

Thread Styles

 Right Handed Tightens in clockwise direction. Most common fastener.	 Left Handed Tightens in counter-clockwise direction.	 Self Locking Nylon patch makes threads more resistant to loosening.



Thread	%	%Sum
1	34%	34%
2	23%	55%
3	16%	71%
4	11%	82%
5	9%	91%
6	7%	98%

(Notes – there are some great geometry and mathematics lessons here to show why one is stronger than the other considering the area of engagement; the circumference and pitch angle; the number of threads and lead; why one is easier to torque, wedge examples – lot's of good things)

You are now an expert about threads and diameter. There is only 1 more piece missing about specifying what type of bolt you want, the **length**.

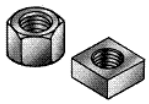
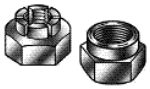
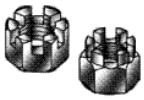
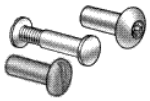
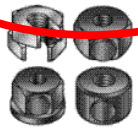
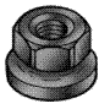
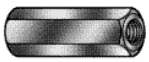
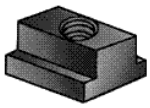
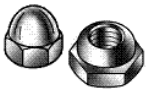
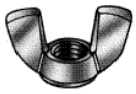
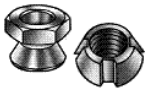
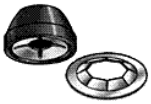
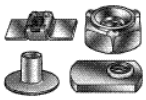
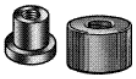
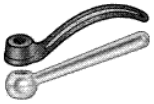
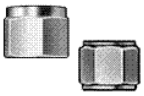
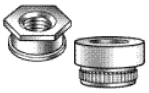
Length is measured from under the head for all cap screws, except flat head screws which are measured from the top of the head.

Example:

A 1/2” x 1/4”-20 bolt means that it is 1/2” long, 1/4” in diameter, and has 20 threads per inch. You might also see it as 1/4”-20 x 1/2” but the diameter is usually written before the hyphen leading to the thread pitch. With some experience it becomes easy.

Some Common Nuts

Nut Type — **This is where we'll be focusing our attention**

 Machine Screw and Hex Nuts	 Locknuts	 Slotted Nuts	 Barrel Nuts (Binding Barrels)
 Quick-Threading Nuts	 Flange Nuts	 Coupling Nuts	 T-Slot Nuts
 Acorn Nuts	 Wing Nuts	 Thumb Nuts	 Tamper-Resistant Nuts
 Push Nuts and Retainers	 Weld Nuts	 Allen Nuts	 General Purpose Acme Nuts
 Strut Channel Nuts	 Slip Joint Nuts	 Handle Nuts	 Binding Nuts
 Regulator and Welding Hose Fitting Nuts	 Speed Nuts	 Captive Nuts	 Thin Nuts with Specialty Threads

	* Hex Thin Nuts-Also known as Jam Nuts. Choose a small height nut to jam against another nut to prevent loosening. * Small Pattern Nuts-Choose a short and wide nut to fit into tight spaces. * Hex Heavy Nuts-Choose a wide and tall nut for added strength and thread engagement. The extra width of the nut increases bearing surface.
	Hex with Tooth Washer: Also known as **Keps** and K Lock Nuts. Washer is free-spinning and bites into the nut and base metal to resist loosening due to vibration.
	Hex with Conical Washer: Also known as Keps and K Lock Nuts. They have a flat rim and lock using tension. Ideal for use with soft and thin materials, they resist loosening without marring the material.

	Hex with Protective Cap: A nylon 6/6 cap covers exposed threads for safety and appearance. Seals internal and external pressures up to 90 psi.
	Flat Square Nut: Also known as Machine Screw Square nuts. Square shape provides broader surface for wrench engagement. Nuts are flat on the top and bottom.
	Rounded Square Nut: In addition to a large bearing surface, square nuts provide a positive grip for hand wrenches.

Material Type
- Steel
- Stainless Steel
- Aluminum
- Brass
- Bronze
- Ceramic
- Hastelloy
- Nickel-Copper Alloy 400 (Monel)
- Plastic
- Titanium

Grade/Class
- Grade 2
- Grade 5
- Grade 8
- Grade 9(L9)
- Class 4
- Class 5
- Class 6
- Class 8
- Class 10
- Not Rated

Finish
- Plain
- Zinc-Plated
- Black
- Cadmium-Plated
- Nickel-Plated
- Blue-Coated
- Ultra-Coated
- Galvanized

Nuts are specified by 3 things
1) Width of nut
2) Height of nut
3) Inside thread of nut

Width of nut

Height of Nut

That's it for specifying a nut!

Using this information for the Vex robots:
1) Make sure you use the correct bolts and the correct nuts.
2) Make sure that you thread the connection by hand first before using tools to prevent cross-threading and thread stripping.
3) Make sure you use the allen wrench to just tighten the connection so that it is a snug fit. Finish tightening by using the wrench to turn the nut.
4) Make sure you use the wrench to loosen the nut before using the allen wrench otherwise the hexagonal socket will get stripped. After the nut is loose you can turn the allen wrench.
5) Make sure you turn the bolt clockwise to tighten and counterclockwise to loosen. The same for the nut.

Remember: Righty, tighty – Lefty, loosie.