NEWSLETTER FOR MANUFACTURING COMMUNITY

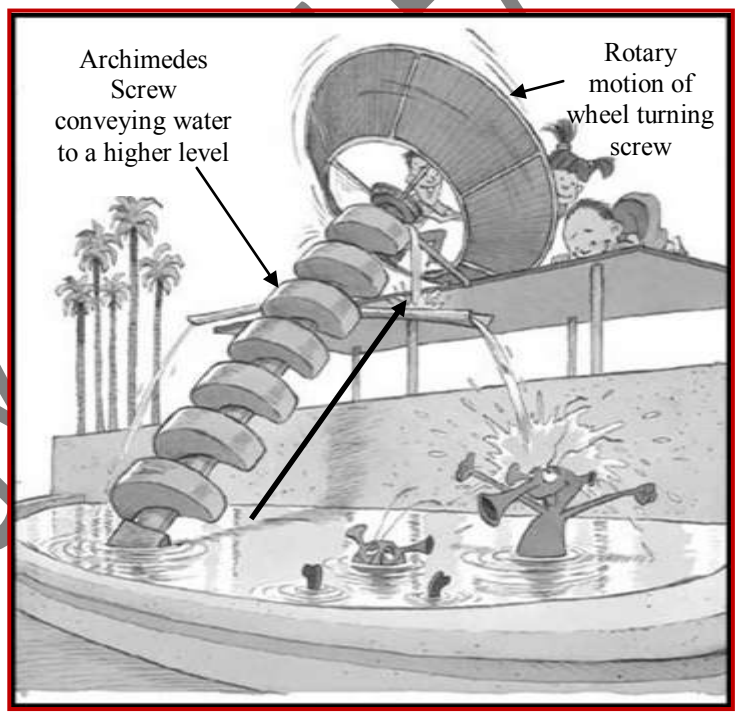
Maintenance Circle

Word for the day: **THREADS – PART ONE**

Even for a joke, none of us would like to be called a "loose" by our closest friends, colleagues or children. If someone remarks that some screw is loose in our head, our anger is guaranteed to hit the roof and they better be prepared to face the consequences. Well, digging little deep into the remark, they did not specify what type of screw was loose. Whether it had a metric or inch thread? They should have also mentioned the screw head for us to get a spanner, an Allen key or a screw driver for tightening!!

This week, let us try getting our head screws tightened a little bit by exploring some fundamentals of the threads. It is hard to imagine an equipment or a product without some screw holding some things tightly together. The screw can be as big as one meter (3.33 feet) diameter holding various pillars of big bridges or 0.3 millimeter holding the spring inside a beautiful wrist watch!!

History approximates that around 200 B.C. (2209 years ago as of today), wooden screws were made to lift many objects to high points. Of course, none of us can forget the revolutionary invention of "conveying" screw by Archimedes. It was used for innumerable purposes from carrying water to lifting objects. But it was not until end of 14th century when metal screws were made, usually by hand. So most of the screws were never similar and did not fit the purpose. Rapid industrialization during 18th century paved way for producing screws using special purpose machines and lathes. Stephen Finch & Christopher Walker are considered to be the innovators of manual and fully automatic lathes that could produce screws with different specifications. Take a look at the adjacent picture for understanding. It was one the greatest inventions which is still used in many industries for conveying different materials. But our interest in this article is limited to what is generally called as "fastening screws."



So, what is a screw (bolt)?
For this article, a screw – can also be addressed as bolt, technically – is defined as a continuous profile generated on a circular metal rod that when either pierced into a softer object or inserted into a female NUT converts a rotary motion into sliding motion creating a force that will hold intermediate object together. Refer to the following picture showing a nut & bolt for understanding. If a nut or bolt is fixed, other one will start moving in or out. This will either tighten or loosen the intermediate held object. The amount of force exerted by "tightening" nut-bolt assembly depends on many factors, some of which we will explore in proceeding paragraphs. The thread profile is very similar to a coil spring. If you hold it in hand and rotate, it will either move forward or backward depending on the direction. The coil represents bolt or "male" thread and two fingers represent "nut" or female thread. With this background let us understand some technicalities of a typical thread.

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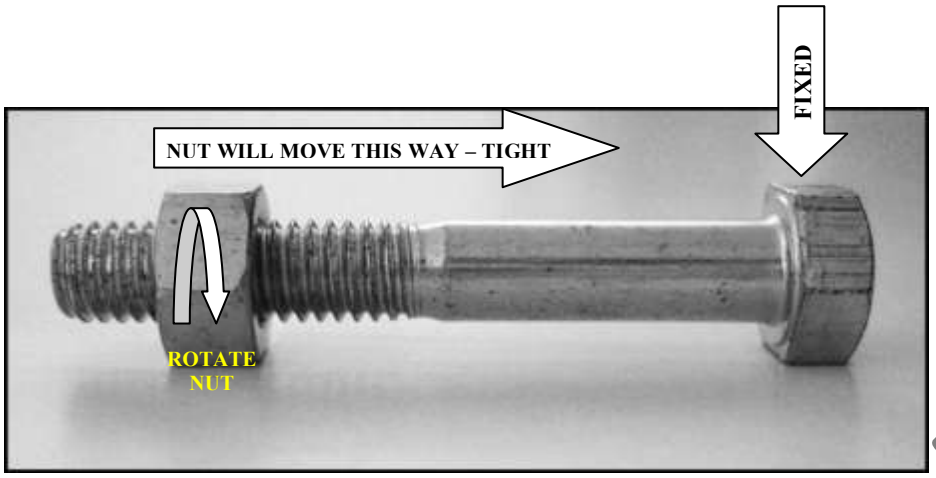
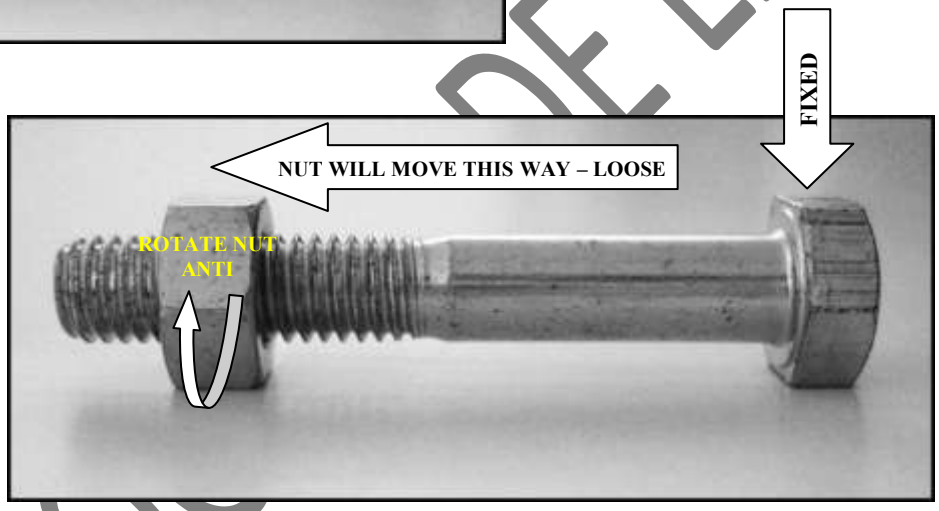


The turning – rotary – motion of nut is converted into a sliding motion which either tightens or loosens the held object

If the nut can no longer slide but is made to turn further, it tightens further exerting more force on held object up to certain limit, called torque limit, beyond which either threads wear out or nut breaks or object gets damaged



A thread profile on a round rod or hole can be generated using many methods, some of which include special purpose thread rolling machine, lathe and tap / die set. Independent of the process used, there are some international standards that have been agreed upon to produce threads anywhere. This standard makes threads highly interchangeable anywhere in the world. The thread has various parameters as shown in picture below. Each of these parameters influences various functionalities of a thread. Let us understand what each parameter mean and how it influences the intended end use.

MAJOR DIAMETER - The higher or outer most diameter of a bolt after the thread profile is generated. The diametric distance between two highest points – crests – is the measure of major diameter. It can be easily measured using a vernier caliper or even a small precision scale. For a bolt, higher the major diameter, higher will be its strength (what "strength" means will be explained little later).

MINOR DIAMETER - The lowest or inner most diameter of a bolt after the thread profile is generated. The depth of thread profile determines minor diameter. Ideally, minor diameter is equal to major diameter – 2 x profile depth. We will look at how to determine minor a bit later, since it is quite difficult to measure this diameter using conventional measuring instruments.

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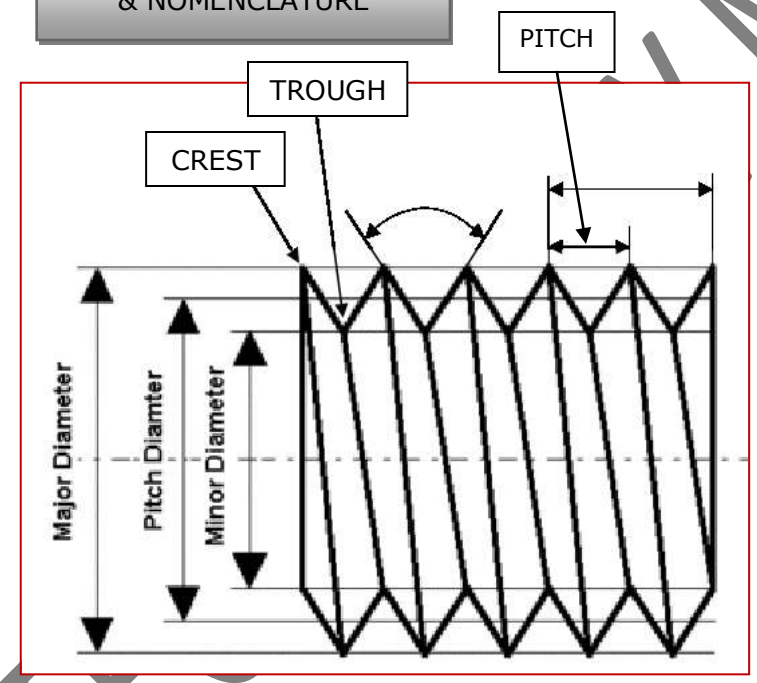
PITCH DIAMETER – The mean diameter measured (calculated) in the centre of thread profile. This dimension will be useful when selecting a nut-bolt combination. Dissimilar pitch diameter components do not match and can cause problem while fastening, resulting in worn out threads, loose connections and safety hazards. A centimeter and inch thread, for example, may look very similar to naked eyes but does not match. If they are forced to fit into each other, thread will be damaged.

PITCH – The distance between two high – crest – or two low – trough – points on a thread profile. Depending on the pitch, a thread will be categorized as "coarse" or "fine" type. Basically, shorter the pitch, finer will be the thread. Also, the pitch – apart from profile angle – determines the travel length of thread. For one complete rotation, a larger pitch thread will travel longer than a shorter pitch thread. For precision adjustment fixtures like position adjusting stoppers, hydraulic pressure setting nuts, flow control valves in pneumatic systems, measuring instruments, watch parts have fine pitch threads. Mechanical fly presses, plumbing bolts, fastening devices have coarse pitch threads.

THREADS PER UNIT LENGTH – This parameter depends on the pitch of a thread profile. This is the count of number of threads – actually number of high or low points – per unit length, which is usually inch or centimeter.

BASIC THREAD PROFILES & NOMENCLATURE



Thread "inclination": If it is inclined left, it is termed as RIGHT HAND THREAD. If it is inclined right, it is termed as LEFT HAND THREAD. ***Details in the article.***

CREST – The highest point of thread diameter

TROUGH – The lowest point of thread diameter

Major Diameter – The outer most diameter of a thread, between crests

Minor Diameter – The inner most diameter of a thread, between troughs

Pitch Diameter – Mean diameter of a thread

PITCH – The distance between two similar points, usually between two "crests" or two "troughs"

Profile Angle – The opening angle which determines the strength of thread and varies with type of thread

Threads per unit length – Number of thread per unit length – centimeter or inch – which determines whether it is a coarse or fine thread

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THREAD DIRECTION – The direction in which thread profile is generated determines how it "loosens" or "tightens." Looking at the thread along centre-line, if threads are "inclined" left it is termed as RIGHT HAND THREAD. This thread profile, when rotated clockwise from "head" side will move inward. If the threads are "inclined" right, it will move outward on clockwise rotation. The rotating components need threads "opposite" to its direction of rotation. For example, a flywheel which frequently rotates in clock wise rotation needs left hand thread to prevent loosening during rotation.

PROFILE ANGLE - The "opening" angle between two thread profiles is called profile angle and plays a very vital role in determining the thread strength. A larger profile angle makes thread more smooth to rotate, but reduces load withstanding capacity of the bolt. For example, the thread profile on very popular bench vice has almost 90 degree profile angle and is able to hold objects very tightly. Similarly, the thread on a screw jack has similar profile angle and can lift heavy objects with ease.

From the above explanations, it is quite evident that all parameters are interdependent and when combined in certain format produce threads that suit specific applications. Also, the material used for thread manufacturing plays a vital role in determining its strength. A bolt made from steel is obviously stronger than the one made from brass or aluminum.

The thread profile of a bolt is used either to hold something together as in flange joints or retain some weight as in the eye bolt of a hoist. In either case, as the bolt is tightened it is subjected to "tensile" or pulling force. As long as this force is less than so called "ultimate tensile strength" of the bolt material, no damage can occur. From basics of material science, it is quite evident that the "ultimate tensile strength" of steel or its grades is much higher than that of aluminum or brass or other "soft" materials.

There are many different types of threads manufactured for variety of applications. Also the "head" portion – used for loosening or tightening - of thread will be of different shapes to suit end use. Although the hexagonal head is most common, many other interesting shapes are also produced. Similarly, the "nut" also will have different shapes. The following picture library displays some commonly used bolt and nut shapes. In part two of this article, we will discuss different types of threads and how they are specified. This will help in differentiating so many thread profiles that we come across in our daily life. We will also explain common do's & don'ts that can save us from many major problems. In fact, in TPM practice, a great amount of emphasis is given on "tightening" standards of a bolt-nut to reduce or eliminate many problems. The importance of proper bolt-nut selection & tightening is not only limited to mechanical equipments. Beyond this for example, loose bolt-nut assembly can create a major catastrophe in electrical connections. All this and more, we will understand in part two.

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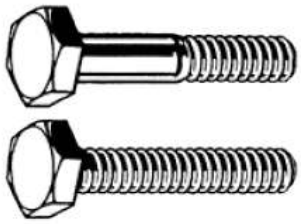
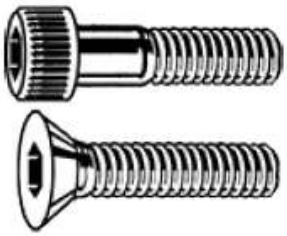
THREAD – BOLT – PROFILES IMAGE LIBRARY

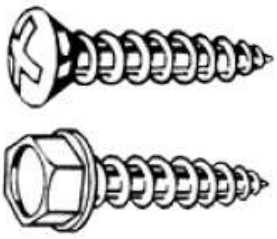


Hex Bolts
Bolts with a hexagonal head with threads for use with a nut or tapped hole. Abbreviated HHMB or HXBT.



Socket Screws
Socket screws, also known as Allen Head, are fastened with a hex Allen wrench.

Machine Screws
Screws with threads for use with a nut or tapped hole. Abbreviated MS

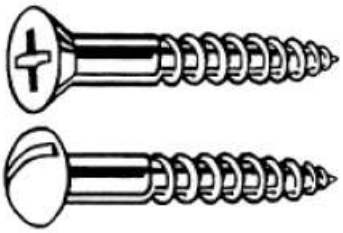


Sheet Metal Screws
Fully threaded screws with a point for use in sheet metal. Abbreviated SMS

Self Drilling SMS
A sheet metal screw with a self drilling point.

Set Screws
Machine screws with no head for screwing all the way into threaded holes.

Hanger Bolts
Hanger bolts have wood thread on one end and machine thread on the other end



Wood Screws
Screws with a smooth shank and tapered point for use in wood. Abbreviated WS

Carriage Bolts
Bolts with a smooth rounded head that has a small square section underneath.

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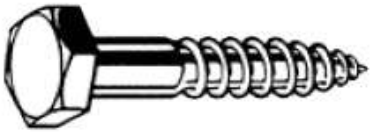
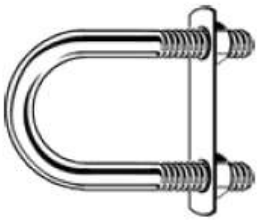


Lag Bolts
Bolts with a wood thread and pointed tip. Abbreviated Lag.

Eye Bolts
A bolt with a circular ring on the head end. Used for attaching a rope or chain.

Eye Lags
Similar to an eye bolt but with wood threads instead of machine thread.



U-Bolts
Bolts in U shape for attaching to pipe or other round surfaces. Also available with a square bend.

J-Bolts
J shaped bolts are used for tie-downs or as an open eye bolt.

NUT PROFILES IMAGE LIBRARY

Hex
A six sided nut. Also referred to as a Finished Hex Nut.

Nylon Insert Lock
A nut with a nylon insert to prevent backing off. Also referred to as a Nylock.

Jam
A hex nut with a reduced height.

Nylon Insert Jam Lock
A nylock nut with a reduced height.

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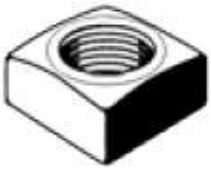
Wing
A nut with 'wings' for hand tightening.

Cap
A nut with a domed top over the end of the fastener.

Acorn
Acorn nuts are a high crown type of cap nut, used for appearance.

Flange
A nut with a built in washer like flange.

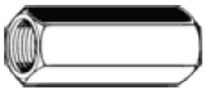
Tee
A nut designed to be driven into wood to create a threaded hole.



Square
A four sided nut.

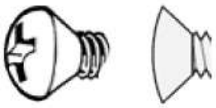
Prevailing Torque Lock
A non-reversible lock nut used for high temperature applications.

K-Lock or Kep
A nut with an attached free-spinning external tooth lock washer.



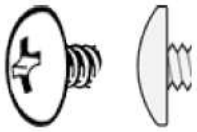
Coupling
Coupling nuts are long nuts used to connect pieces of threaded rod or other male fasteners.

Flat
A countersunk head with a flat top.
Abbreviated FH

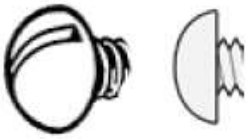


Oval
A countersunk head with a rounded top.
Abbreviated OH or OV

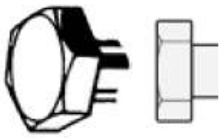
Pan
A slightly rounded head with short vertical sides.
Abbreviated PN



Truss
An extra wide head with a rounded top.



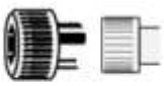
Round
A domed head.
Abbreviated RH



Hex
A hexagonal head
Abbreviated HH or HX

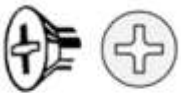
Hex Washer
A hex head with built in washer.

Slotted Hex Washer
A hex head with built in washer and a slot.



Socket Cap
A small cylindrical head using a socket drive.

Button
A low-profile rounded head using a socket drive.



Phillips and Frearson
An X-shaped drive.
Abbreviated PH

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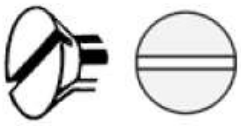
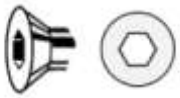


Slotted
A slot in the head.
Abbreviated SL

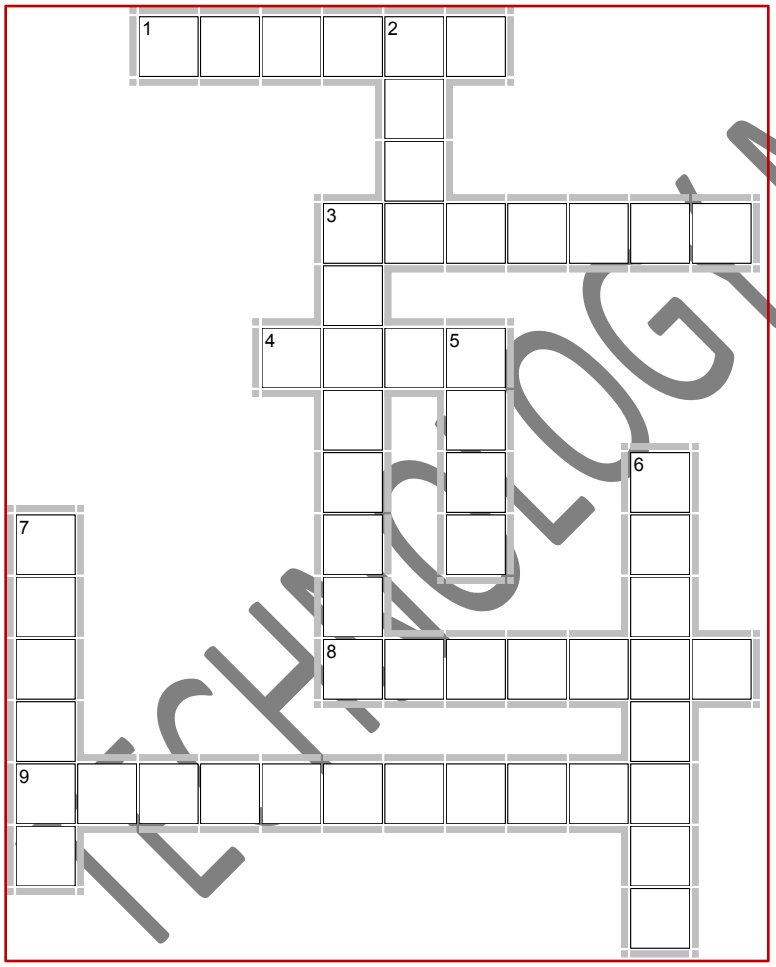
Combination
A combination of slotted and Phillips drives.
Abbreviated combo



Socket, Hex or Allen
A hexagonal hole for use with an Allen wrench.

Readers, thought you got your head nuts tightened by now? Well, you are not done yet. Tweak your head a little more and solve the Techuzzle below.

Happy solving!!



Across

1. Opposite of Fine?
3. This angle means a lot to thread
4. This nut does not fly!!
8. This is what you use to tight a hexagon "head"
9. This "head" is definitely "sunk" in some place

Down

2. This screw driver is my favorite star!!
3. Philips does not make screw driver for this "head"
5. This screw is not for rubbing!!
6. This is the key for tightening a socket screw
7. Nylon lock to secure a bolt