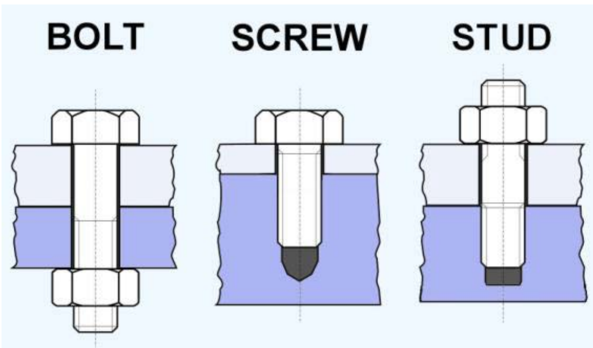
EML2322L Fastener Reference Guide

Introduction

Fasteners are connective hardware that can easily be installed and removed with common hand tools. *Bolts*, *screws*, *nuts*, and *rivets* are typical examples of fasteners. The difference between a *bolt*, *screw*, and a *stud* is determined by its use.

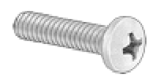
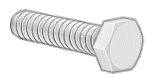
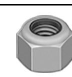
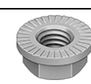


Bolts are headed fasteners with external threads that meet an exacting, uniform thread specification such that they can accept a standardized nut. In the most general sense, screws are headed, externally-threaded fasteners that can cut their own internal threads when installed. In mechanical and aero-space design applications (which are what we care about as design engineers), screws are identical to bolts, but do not require nuts, as they instead screw into threaded holes previously created in work-pieces. Studs are externally threaded headless fasteners with which one end usually mates with a threated component and the other end typically mates with a standardized nut.

Purpose

The ONLY purpose of fasteners is to clamp parts together. Standard fasteners are NOT intended to be used to for positioning or pivoting; that is the function of dowel pins, locating shoulders, and piloting diameters. However, due to the short-term nature of prototyping, these uses may be allowed in some situations (like in DML). ***Be aware that in real life such improperly designed joints WILL loosen and fail.*** Furthermore, the threaded portion of a fastener should NEVER be loaded in shear, as doing so tremendously reduces the load carrying capacity and fatigue resistance of the threaded assembly.

Common Fastener Head, Nut, and Washer Types

Fastener	*Name*	*Tighten With*
	flat head (slotted)	slotted head screwdriver
	pan head (Phillips)	Phillips head screwdriver
	hex head	wrench, socket wrench
	button head cap screw	Allen/hex wrench
	set screw	Allen/hex wrench
	socket head	Allen/hex wrench
	shoulder screw	Allen/hex wrench
	stud	wrench, socket wrench
	rivet	rivet gun
	hex nut	wrench, socket wrench
	Nyloc nut	wrench, socket wrench
	serrated flange nut	wrench, socket wrench
	flat washer	-
	NORD-LOCK washer	-
	Belleville disc spring	-
	split lock washer	-

Nuts and Washers

Most nuts used in this lab are hex nuts or nylon ring elastic stop nuts. Serrated and nylon insert nuts are designed to resist loosening under vibration. We also have an assortment of washers. The two purposes of washers are to ensure a flat bearing surface and to distribute the fastener's clamping force over a larger bearing surface. NORD-LOCK and split lock washers are designed to resist loosening from vibration. Belleville disc spring washers are used under bolt heads to maintain tension in another attempt at preventing loosening.

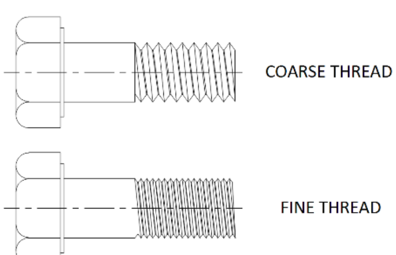
Thread Classes & Types

There are two general *classes* of fasteners: *standard* (i.e. *imperial*) and *metric*. Most imperial fastener sizes are stocked in lab for common use, as well as metric fasteners for use with the OTS electric motors used for the course projects.

Regardless of the country of origin, there are two types of threads commonly used by design engineers: coarse and fine. The differences are the *thread pitches* and *minor diameters.* Always select the TPI that gives the weaker part of the joint (material or fastener) the geometric advantage. Fine threads are stronger when the female thread is strong relative to the male thread; coarse threads are stronger when the female thread is weak relative to the male thread. ***There is only always one correct choice of thread pitch for any given application.*** The fastener lecture notes cover this selection in detail.

Coarse vs. Fine Thread Example

The following image shows two threads of the same diameter with different thread pitches.



The coarse threaded fastener has a smaller minor diameter, decreasing tensile strength, and increasing the shear area of the threads, giving the strength advantage to the female threads.

Fastener Torque

When it comes to fasteners, it is important to understand the consequence of over-tightening versus under-tightening fastener joints. Un-intuitively, it is actually better to over-tighten a bolted joint than to under-tighten it. ***Proper installation torque is what keeps a properly designed fastener assembly tight.***

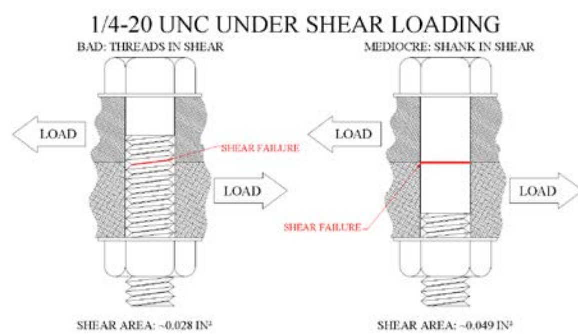
To calculate desired fastener torque:

$$\sigma_t = 0.9 \times \sigma_y$$
$$F_i = \sigma_t \times A_t$$
$$T = 0.2 \times F_i \times d$$

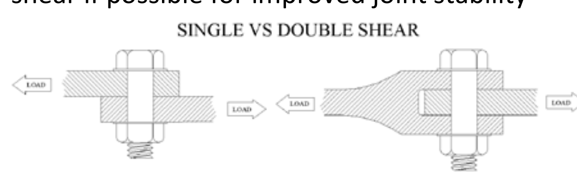
Where σ_y is the ultimate yield strength; A_t is the tensile stress area; F_i is the desired preload (installation force); d is the nominal fastener diameter; and T is the measured installation torque

General Use Guidelines

1. Understand when attaching two parts together with fasteners, one must have a clearance hole (i.e. **both parts cannot be threaded**)
2. Imperial fastener sizes smaller than ¼" are referred to by a numeric designation (i.e. #10, #6, and #4); and these are very different from M10, M6, and M4 metric fastener designations
3. NEVER load fastener threads in shear as this significantly weakens the strength of the joint and guarantees premature fastener failure



4. Always use double shear joint design over single shear if possible for improved joint stability



General Use Guidelines (continued)

5. When designing for fasteners use fine threads in stronger female materials and coarse threads in weaker female materials
6. Fine threaded screws/bolts are stronger than coarse threaded bolts, and coarse threaded nuts are stronger than fine threaded nuts
7. Always select fasteners, clearance drills, and tap sizes off of the [Tap and Drill Chart] since these are established industry standards
8. Use close-fit clearance holes for applications requiring higher positional accuracy (i.e. motor mounting holes in a motor mounting bracket)
9. Use free-fit clearance holes for applications not requiring higher positional accuracy (i.e. 80/20 mounting bracket attachment holes)
10. For ease of manufacturing, it is advantageous to use thru-bolted holes vs. blind tapped holes when ease of assembly in not a major concern
11. Allow clearance for the tip of the tap when tapping blind holes; tap drill deeper than the desired final thread depth by an amount equal to the major diameter of the fastener
12. Always allow adequate clearance around fastener joints for installation tools (wrenches, sockets, screwdrivers, Allen wrenches)
13. Always design threaded features with AT LEAST 5 threads of engagement; better yet, design for 2X the major diameter for full strength (i.e. 0.5" of useable thread depth for a ¼-20 UNC screw); if not permissible, use a normal nut or rivet nut instead to provide proper thread engagement
14. Whenever possible, avoid designing parts requiring fasteners smaller than #6 (imperial) and M4 (metric), as doing so requires small, fragile tap drills and taps which easily break, especially when working with tougher materials
15. Use dowel pins, feature shoulders, and piloting diameters to locate parts and resist applying lateral / transverse shear loads to fasteners
16. Understand that properly computed and measured installation torque (tensile preload) is what keeps properly designed fastener assemblies tight during use, and what allows them to achieve their calculated service life

Useful Fastener Resources

1. [Introduction to Fasteners]
2. [Drill & Tap Chart]
3. [Common Drill Sizes Chart]
4. [Advanced Fastener Notes]

Application Examples (thread notes and BOM)

1.	(4) #10 close fit *clearance holes:*	*Ø 0.196" THRU;* *4 PLACES*
2.	(2) ¼" free fit: clearance holes:	*Ø0.266" THRU;* *2 PLACES*
3.	(3) 6mm threads thru an aluminum workpiece:	*Ø 5.00 THRU;* *M6x1.0 THRU;* *3 PLACES*
4.	(7) #10 blind threads 0.5" deep in aluminum:	*Ø 0.157" 0.7 DP;* *10-24 UNC 0.50 DP;* *7 PLACES*
5.	(3) #10 threads thru *a steel workpiece:*	*Ø 0.170" THRU;* *10-32 UNF THRU;* *3 PLACES*

6. BOM fastener descriptions require 3 pieces of info (thread spec, fastener length, head type):

   10-24 x 0.75" UNC socket head cap screw
   10-32 x 1.25" UNF hex head cap screw
   M10x1.50 x 20 flat head cap screw