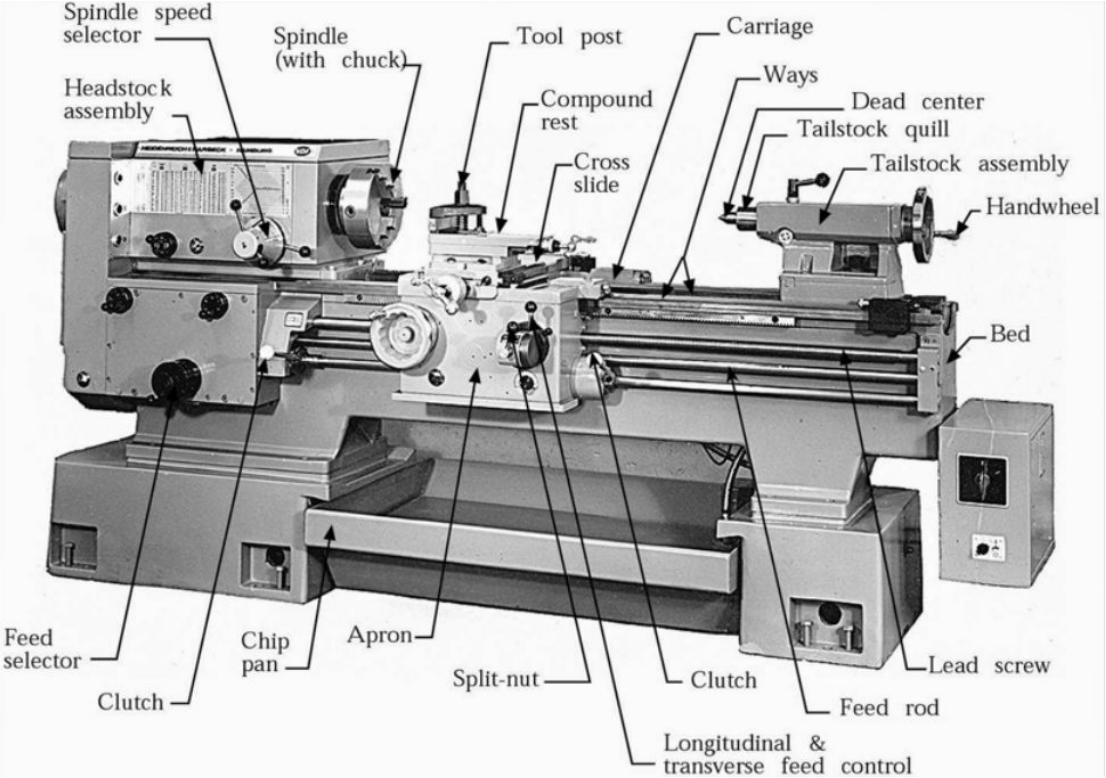


Design and Machining

John R. Leeman

GEARS 2023

LEEMANGEOPHYSICAL LLC
CONSULTING & INSTRUMENTATION

Image: crossmotormodification.tk

Machining is generally a subtractive process that can involve cutting tools or abrasives to remove material, often precisely

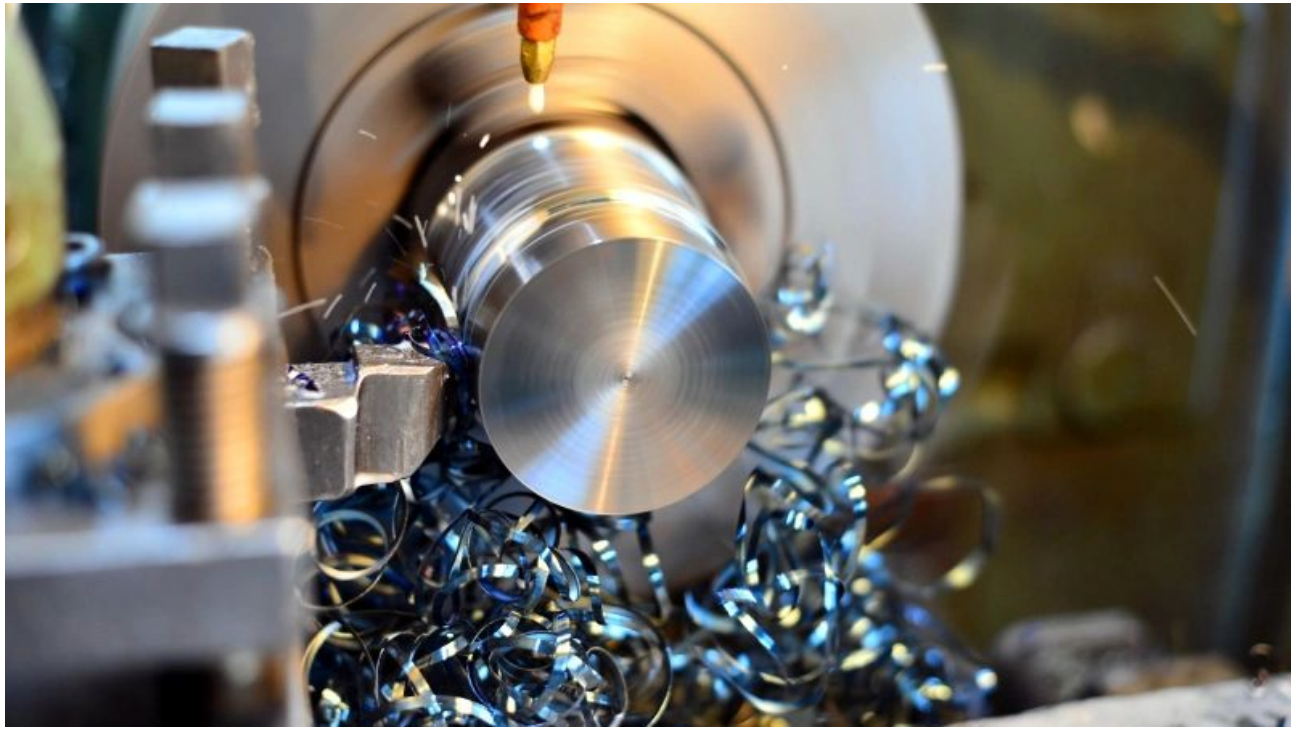
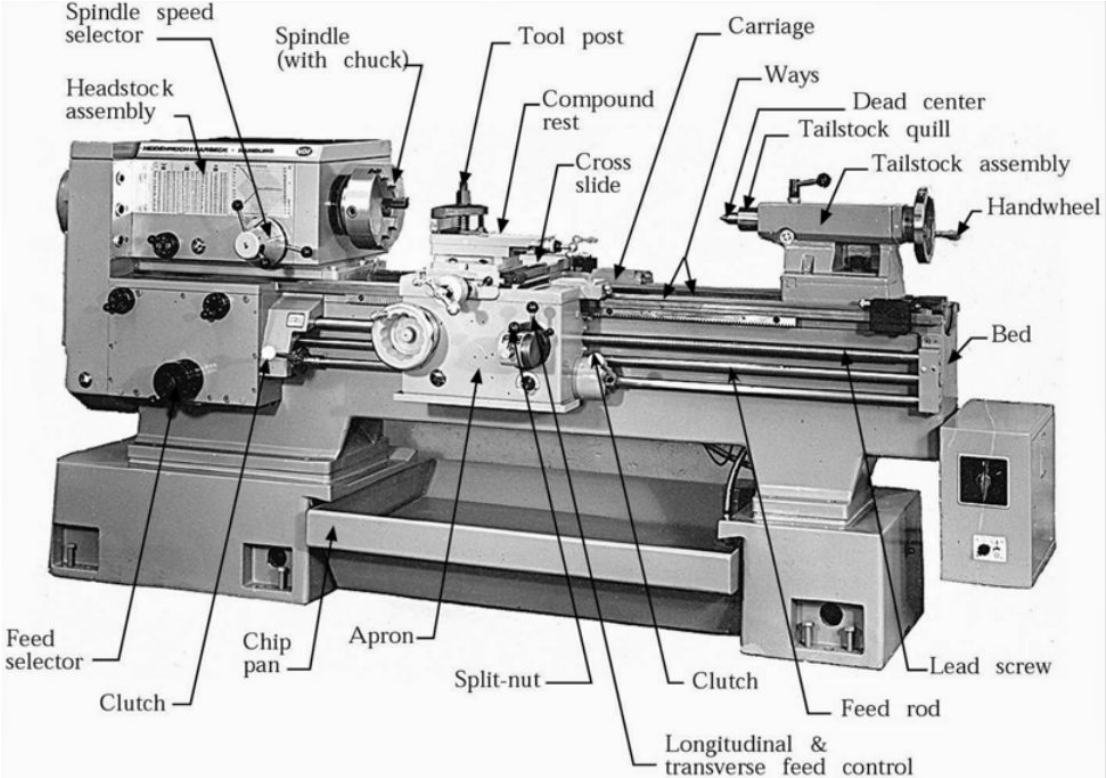


Image: Hackaday

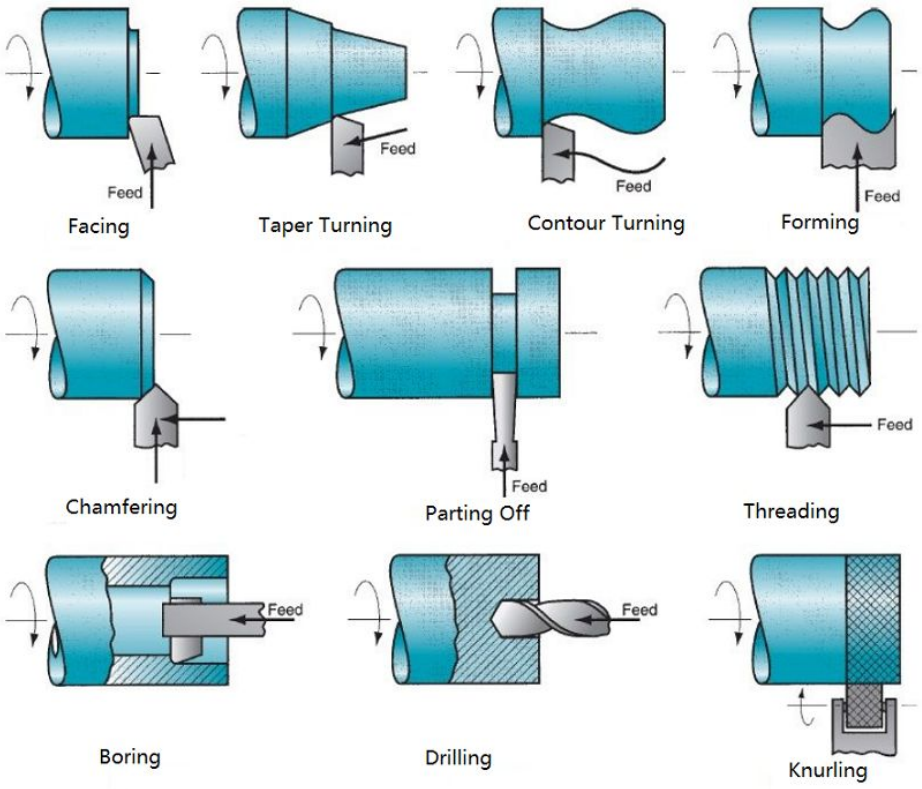
Lathes rotate the work and use stationary cutting tools



LEEMAN GEOPHYSICAL LLC
CONSULTING & INSTRUMENTATION

Image: crossmotormodification.tk

Lathes rotate the work and use stationary cutting tools



LEEMAN GEOPHYSICAL LLC
CONSULTING & INSTRUMENTATION

Image: cncmachining

Limitations of turning operations

- Can only turn radially symmetric parts
- Can’t bore inside a part without a tool entry/exit path
- Part deflection on small diameters
- Stickout limitations
- Holding for 2nd operation/back side work
- Wasted stock for workholding
- Custom/expensive tooling possible

Image: okorder.com

Milling turns the cutter while holding the work stationary and is better suited for non-symmetric parts

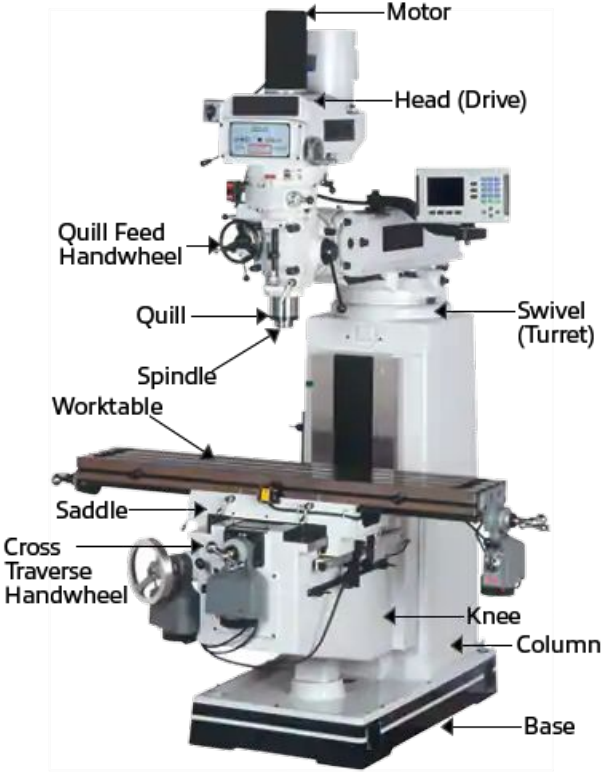


Image: MSC Industrial

Milling operations are much different from lathe, and generally more cartesian

LEEMAN GEOPHYSICAL LLC
CONSULTING & INSTRUMENTATION

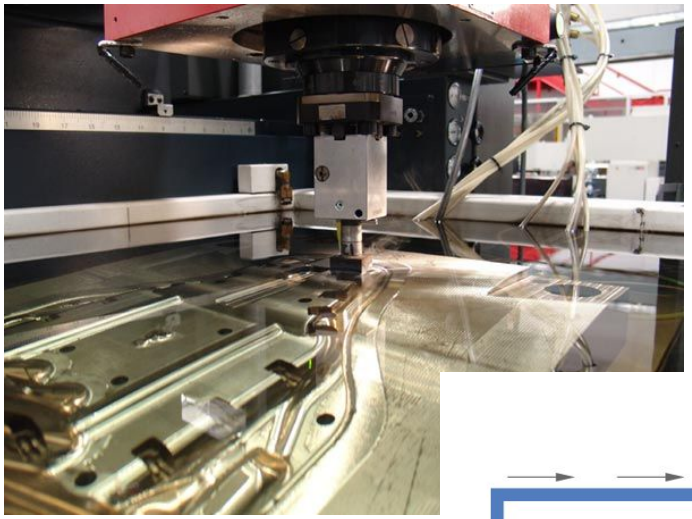
Image: Madhav Univ.

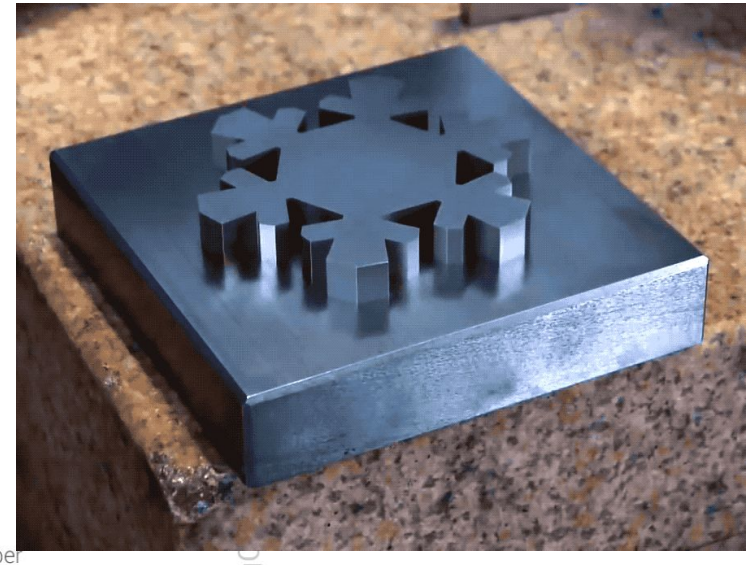
If you need things really flat or they are very hard, abrasion is next

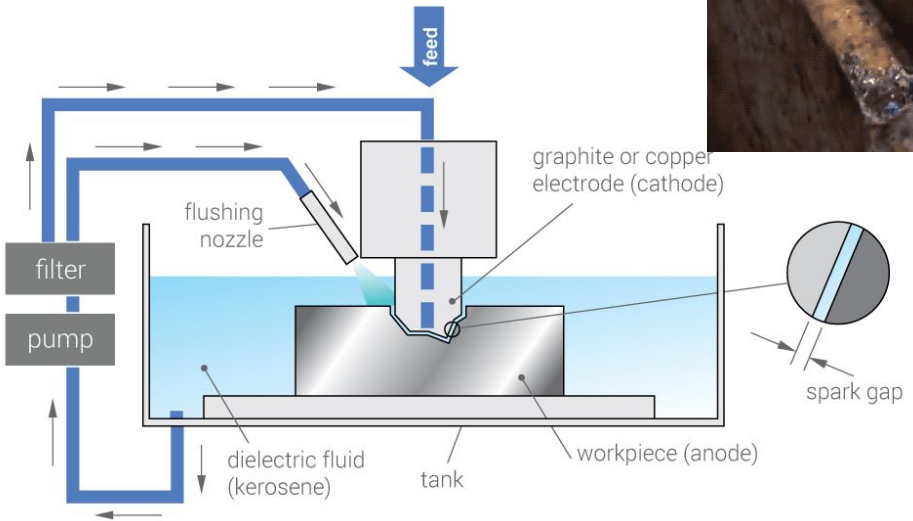
LEEMAN GEOPHYSICAL LLC
CONSULTING & INSTRUMENTATION

Images: Amazon, Clausing, Vintage Machinery

For ultra precision work the EDM is best







LEEMANGEOPHYSICAL LLC
CONSULTING & INSTRUMENTATION

Images: WikiPedia, Engineeringclicks, Wired

Waterjet is one of the fastest and most versatile tools if available

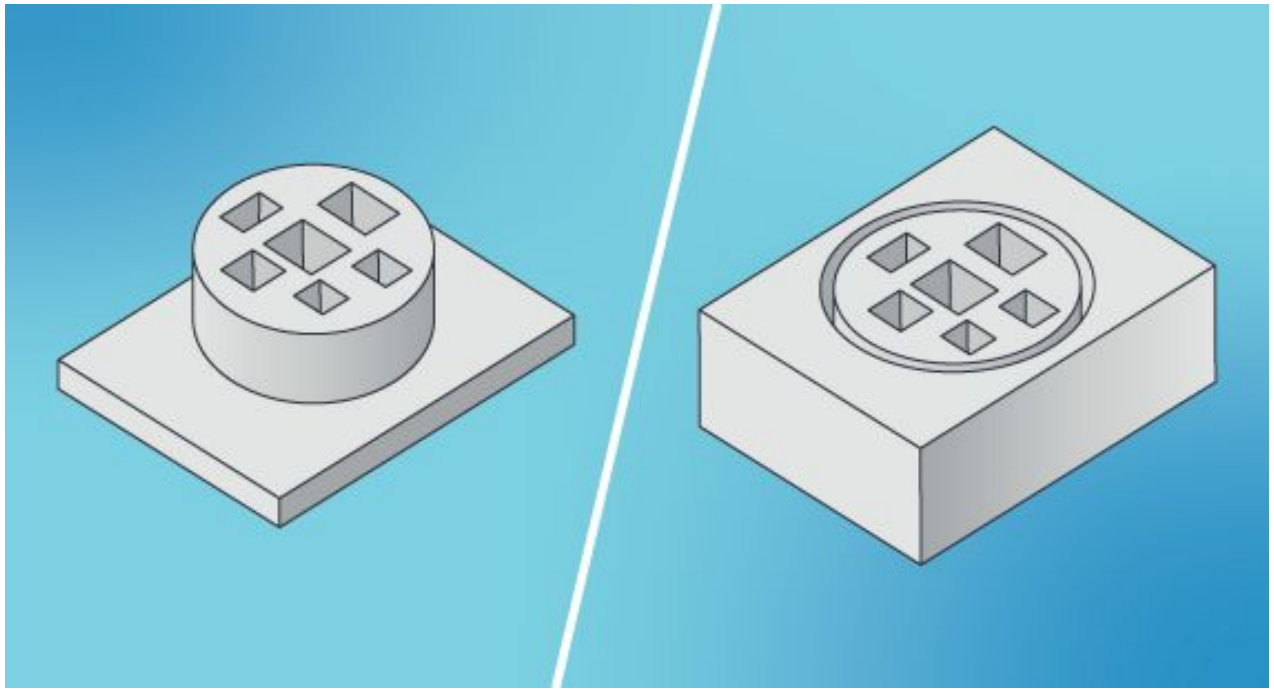
LEEMANGEOPHYSICAL LLC
CONSULTING & INSTRUMENTATION

A few things you shouldn’t do when designing parts

LEEMANGEOPHYSICAL LLC
CONSULTING & INSTRUMENTATION

Image: Pixels

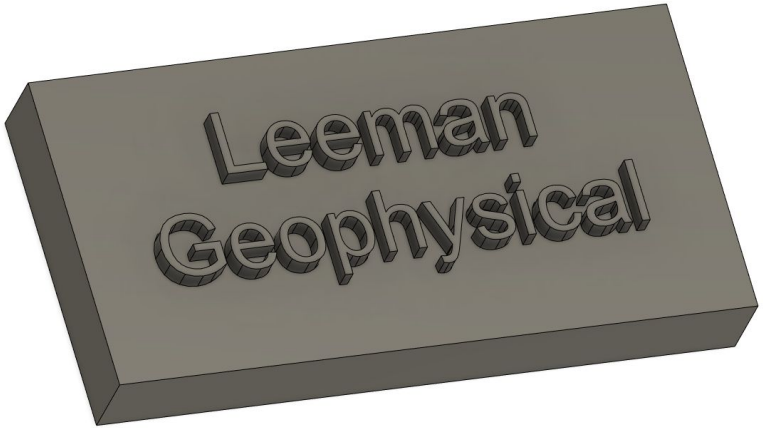
Avoid unnecessary machining



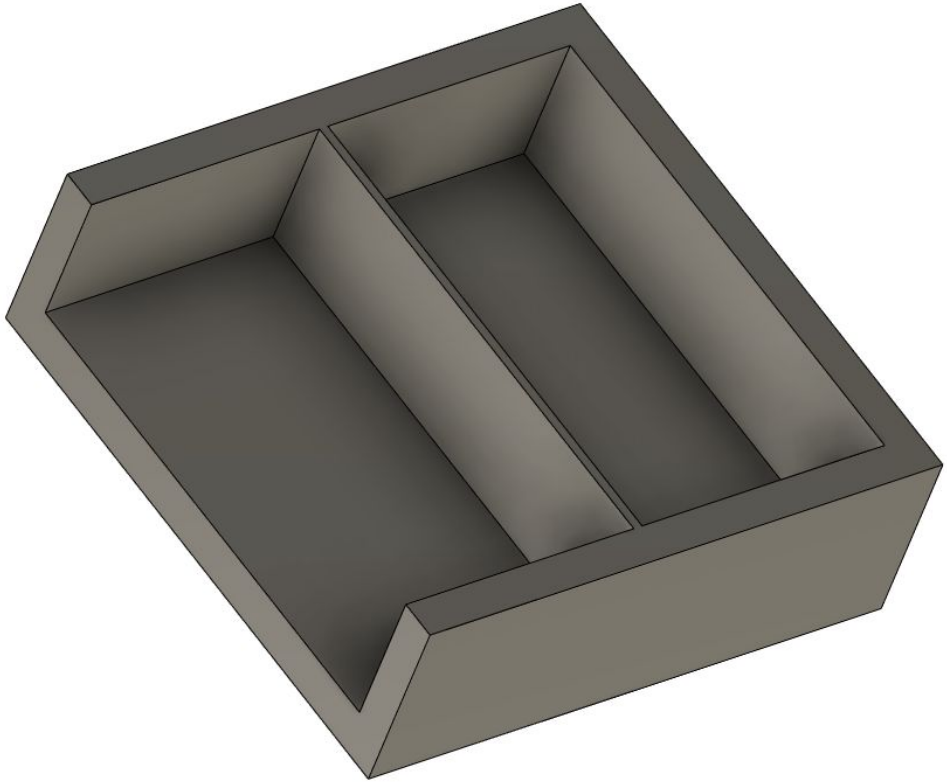
LEEMANGEOPHYSICAL LLC
CONSULTING & INSTRUMENTATION

Image: Protolabs

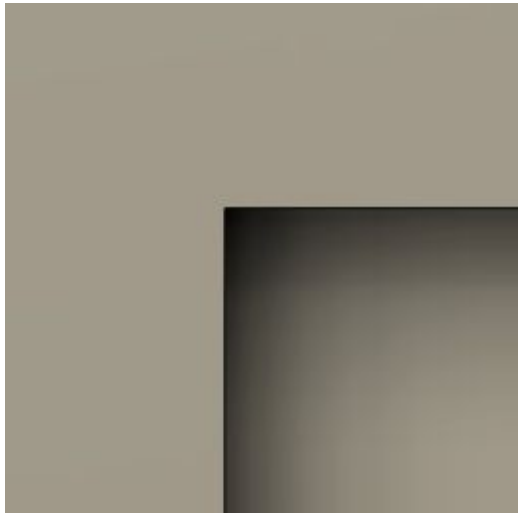
Avoid small or raised text

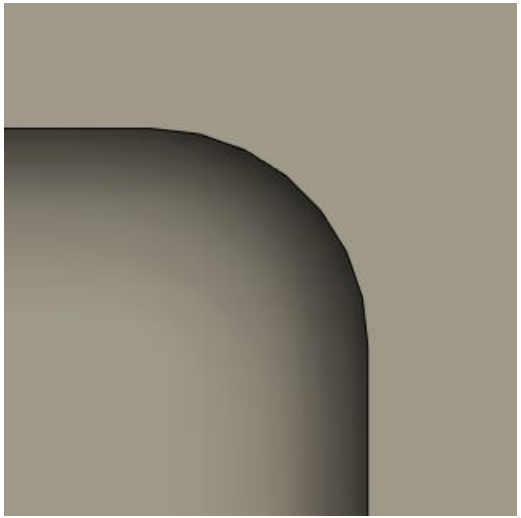


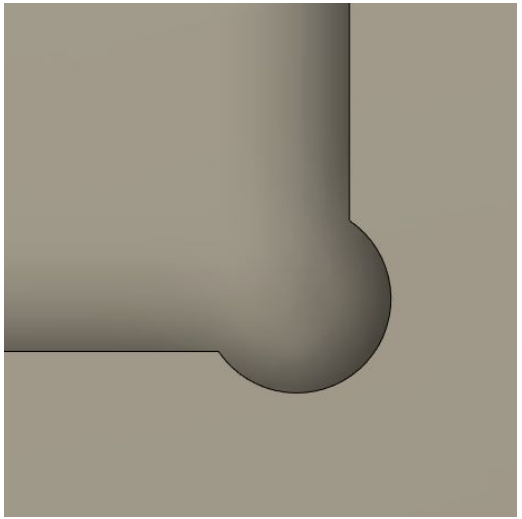
Avoid tall thin walls



Avoid sharp internal corners

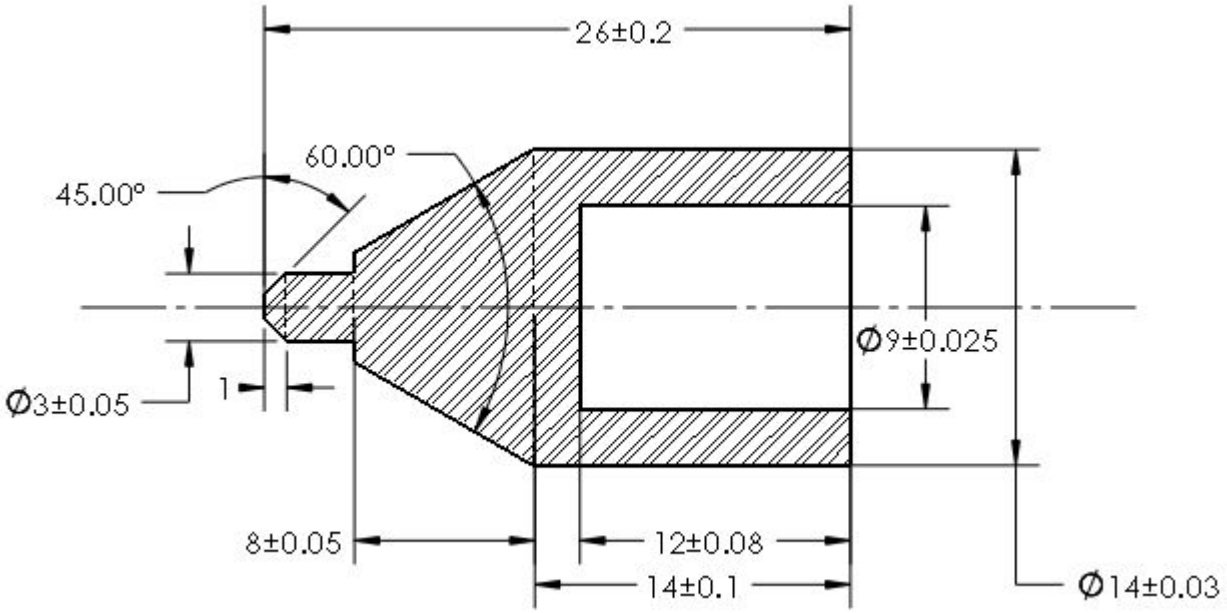






LEEMANGEOPHYSICAL LLC
CONSULTING & INSTRUMENTATION

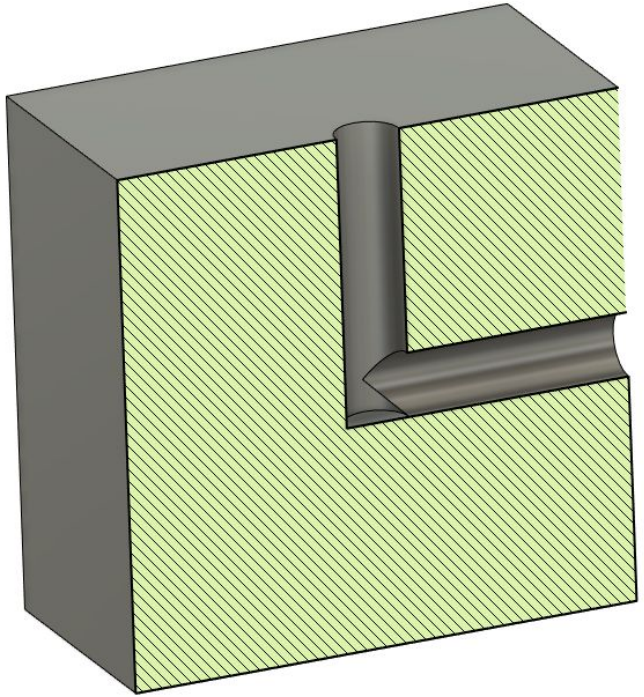
Specify tolerances always



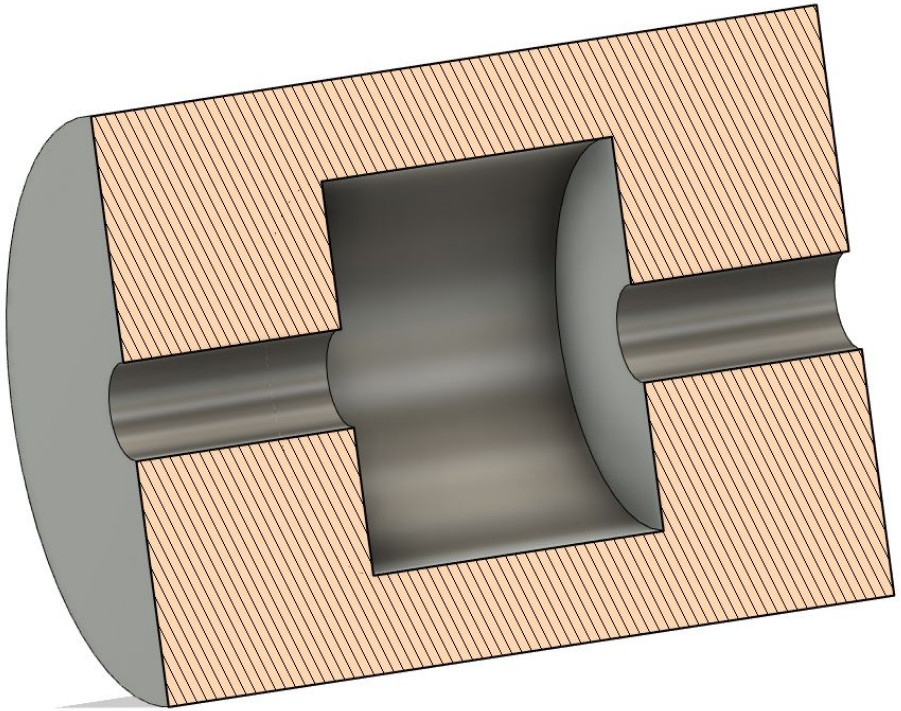
LEEMAN GEOPHYSICAL LLC
CONSULTING & INSTRUMENTATION

Image: Solidworks

Consider intersection of holes and if they can be simplified

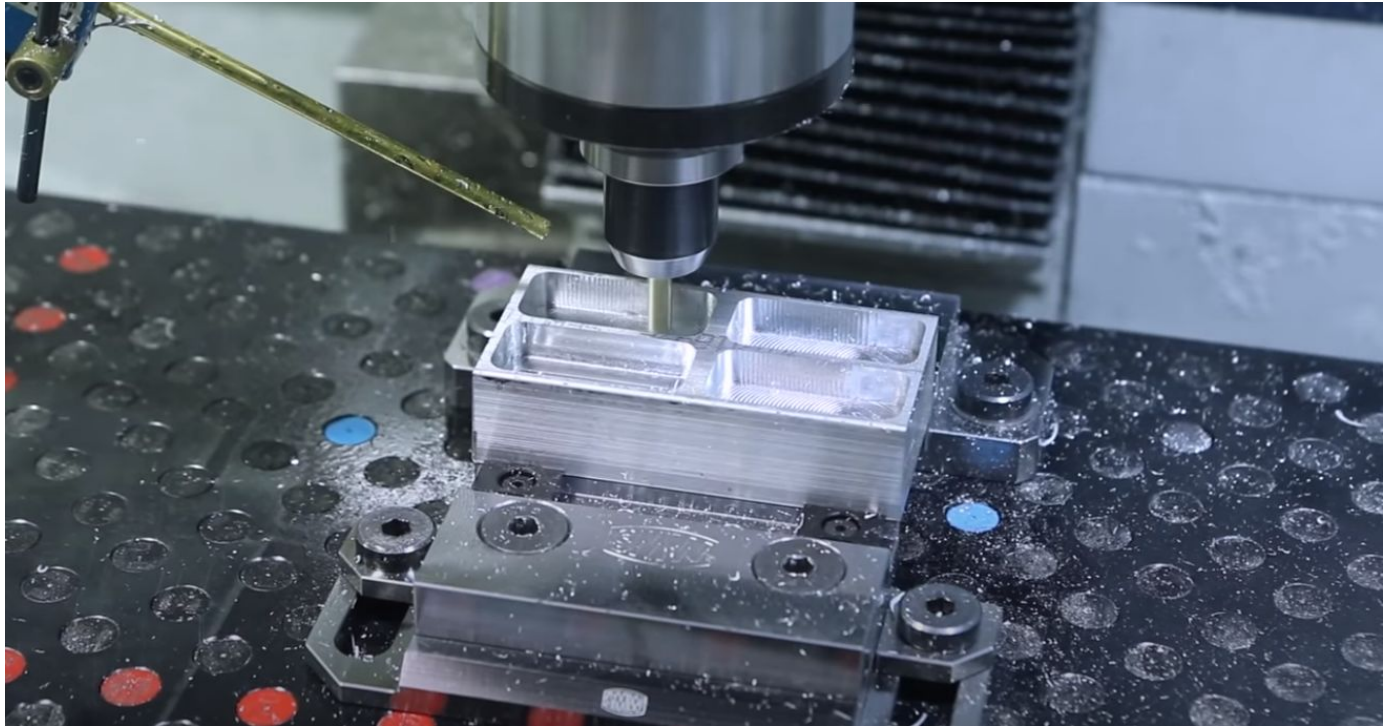


We can’t teleport tools into work



LEEMANGEOPHYSICAL LLC
CONSULTING & INSTRUMENTATION

Consider how many clampings are required



LEEMANGEOPHYSICAL LLC
CONSULTING & INSTRUMENTATION

Image: NYCCNC

Watch the diameter/depth ratio

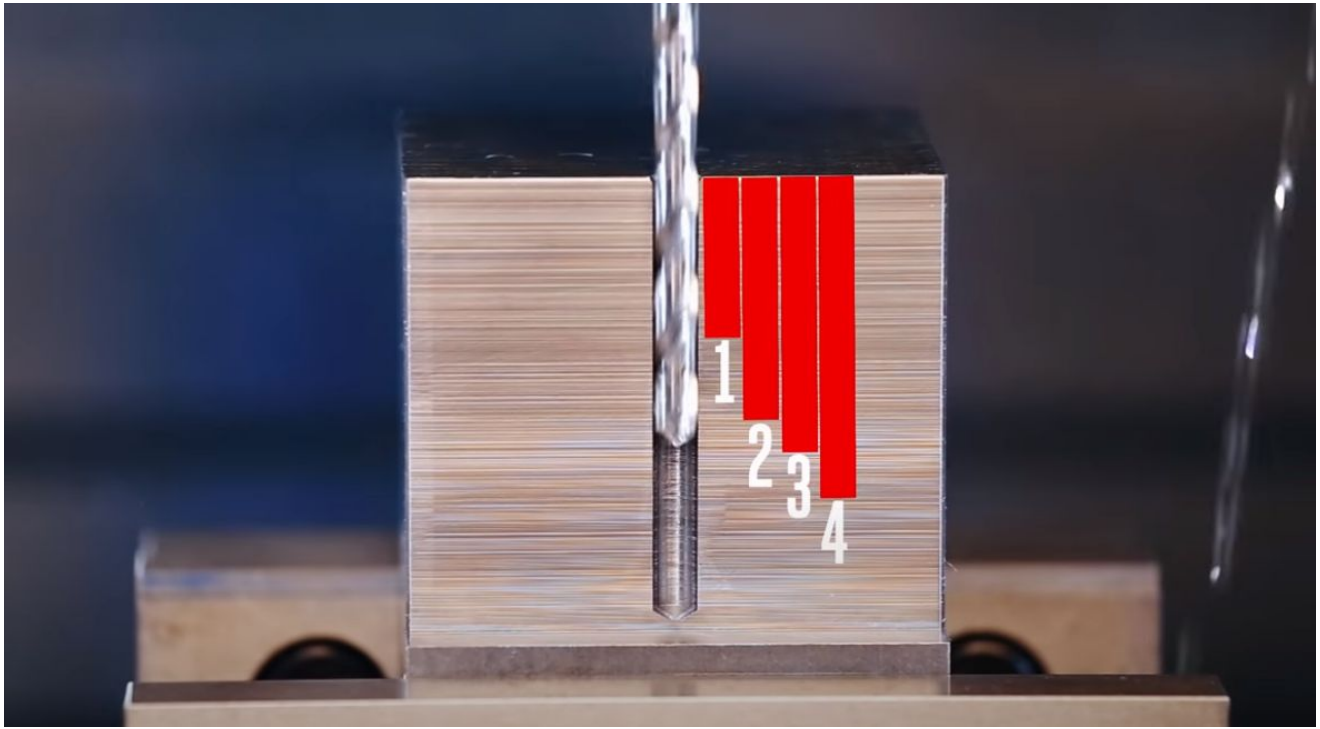


Image: Haas

Dimension so your machinist doesn't have to do math

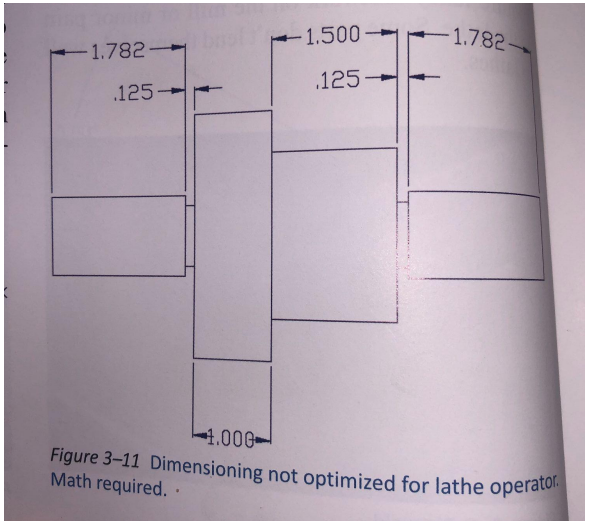


Figure 3–11 Dimensioning not optimized for lathe operator. Math required.

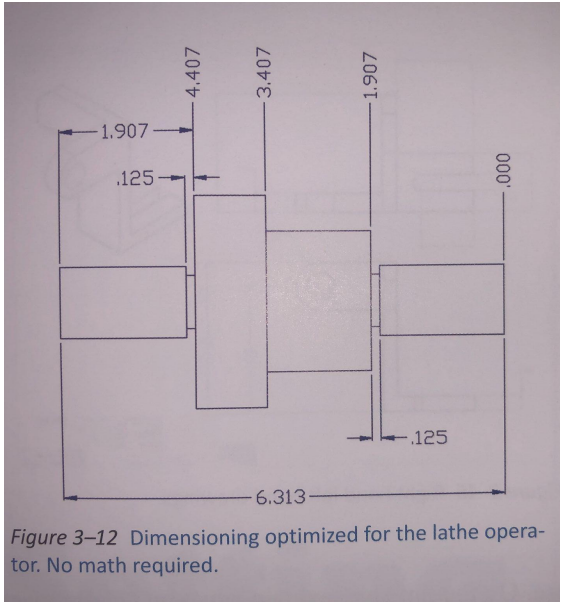


Figure 3–12 Dimensioning optimized for the lathe operator. No math required.

LEEMAN GEOPHYSICAL LLC
CONSULTING & INSTRUMENTATION

Image Concept: Tom Lipton

Dimension so your machinist doesn't have to do math

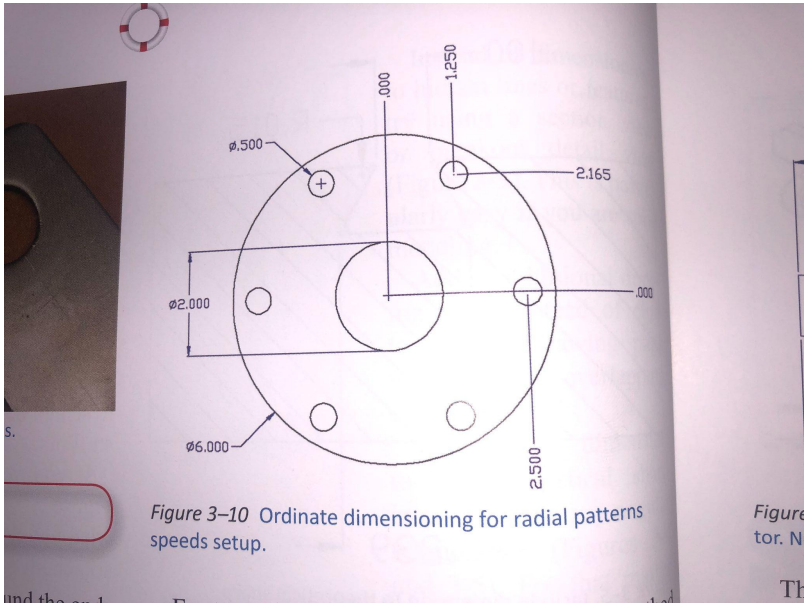


Figure 3–10 Ordinate dimensioning for radial patterns speeds setup.

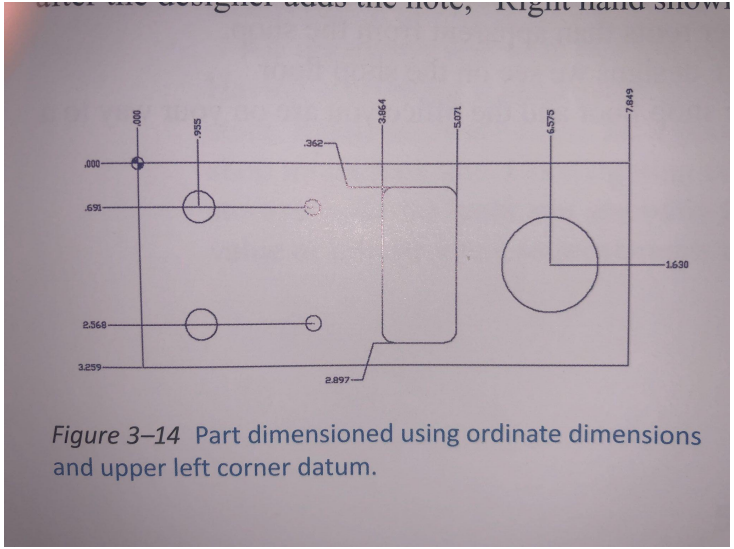


Figure 3–14 Part dimensioned using ordinate dimensions and upper left corner datum.

LEEMAN GEOPHYSICAL LLC
CONSULTING & INSTRUMENTATION

Image Concept: Tom Lipton

Draw in a sensible orientation

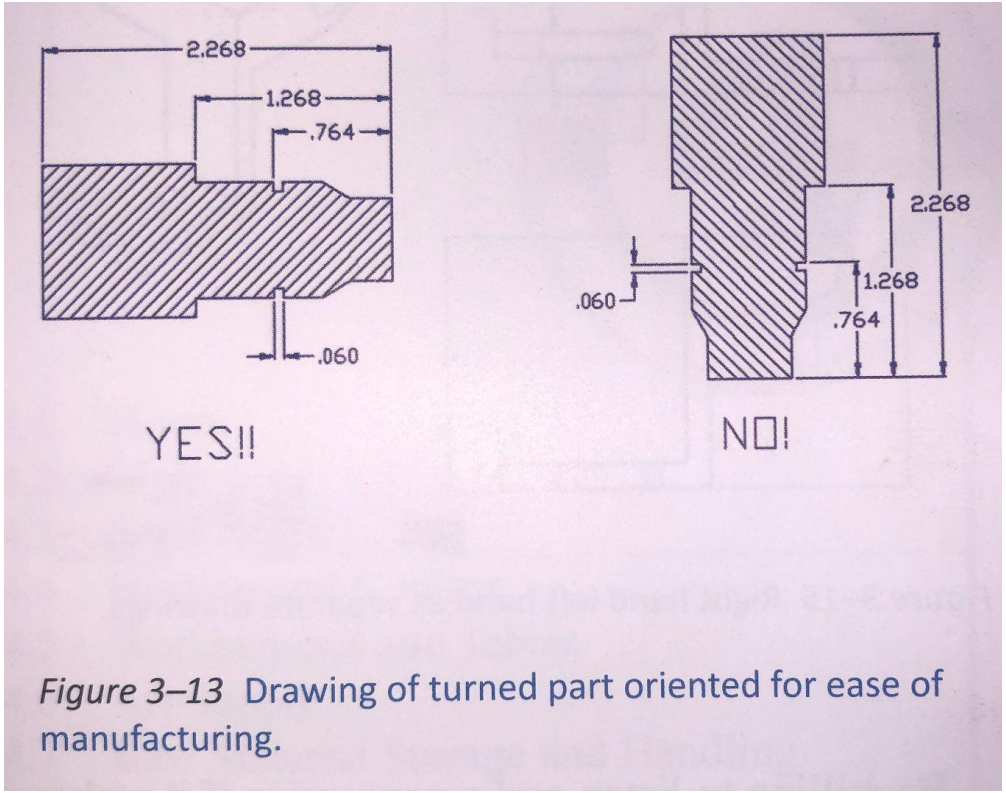


Figure 3–13 Drawing of turned part oriented for ease of manufacturing.

LEEMAN GEOPHYSICAL LLC
CONSULTING & INSTRUMENTATION

Image Concept: Tom Lipton

Consider radiusing in a way to make any misalignment less obvious

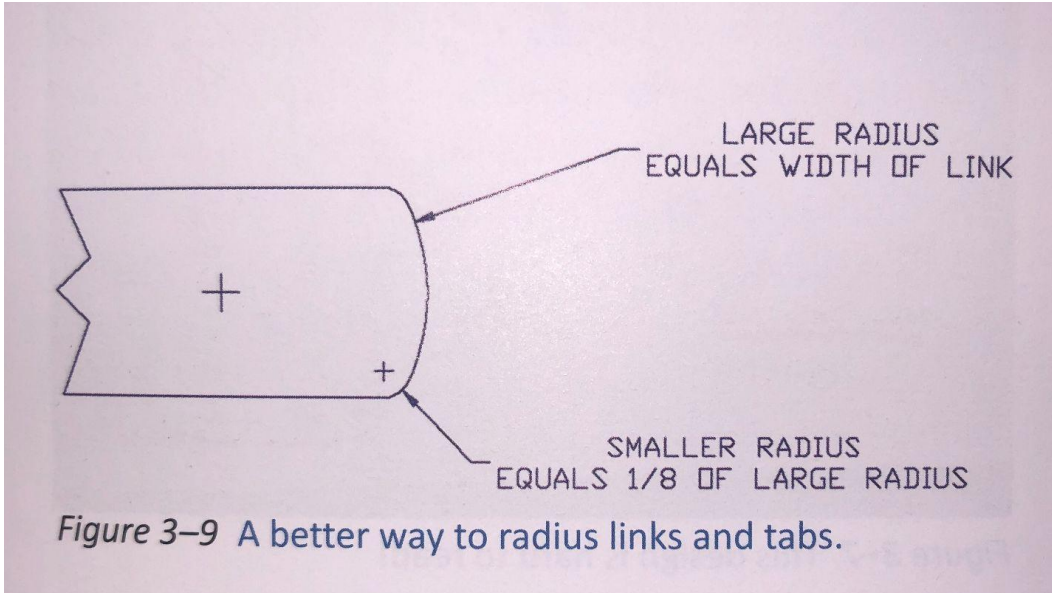
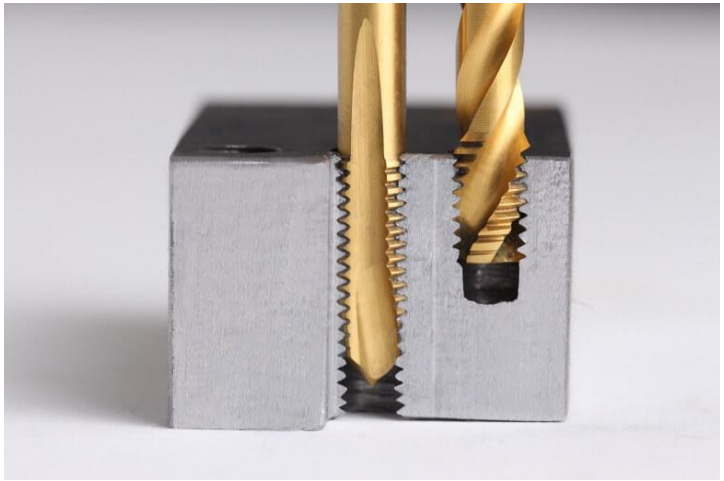


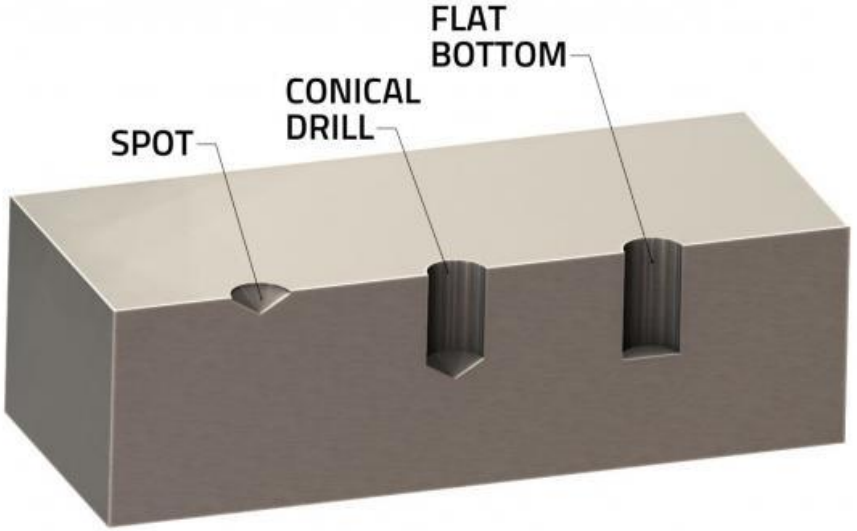
Figure 3–9 A better way to radius links and tabs.

LEEMAN GEOPHYSICAL LLC
CONSULTING & INSTRUMENTATION

Image Concept: Tom Lipton

Avoid blind holes or square bottom holes if possible





LEEMAN GEOPHYSICAL LLC
CONSULTING & INSTRUMENTATION

Images: Threadingtoolsguide.com, PH Tools

Avoid mixing metals unless you know what you're doing

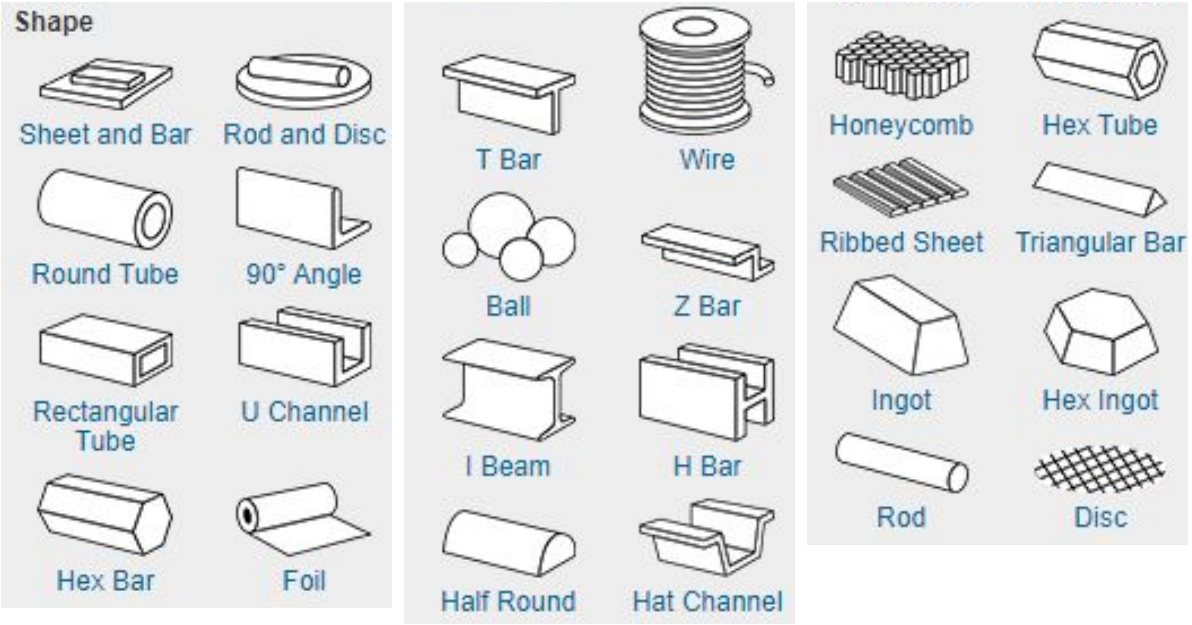
Anodic (Corrodes) \ Cathodic	Magnesium & Alloys	Zinc & Alloys	Aluminum & Alloys	Cadmium	Steel (Carbon)	Cast Iron	Stainless Steels	Lead, Tin & Alloys	Nickel	Brasses, Nickel-Silvers	Copper	Bronzes, Cupro-Nickels	Nickel Copper Alloys	Nickel-Chrome Alloys	Titanium	Silver	Graphite	Gold	Platinum
Magnesium & Alloys																			
Zinc & Alloys																			
Aluminum & Alloys																			
Cadmium																			
Steel (Carbon)																			
Cast Iron																			
Stainless Steels																			
Lead, Tin & Alloys																			
Nickel																			
Brasses, Nickel-Silvers																			
Copper																			
Bronzes, Cupro-Nickels																			
Nickel Copper Alloys																			
Nickel-Chrome Alloys																			
Titanium																			
Silver																			
Graphite																			
Gold																			
Platinum																			

GALVANIC CORROSION RISK

LEEMANGEOPHYSICAL LLC
CONSULTING & INSTRUMENTATION

Image: Belmont Metals, StrutX

Can you start with material closer to shape?



LEEMANGEOPHYSICAL LLC
CONSULTING & INSTRUMENTATION

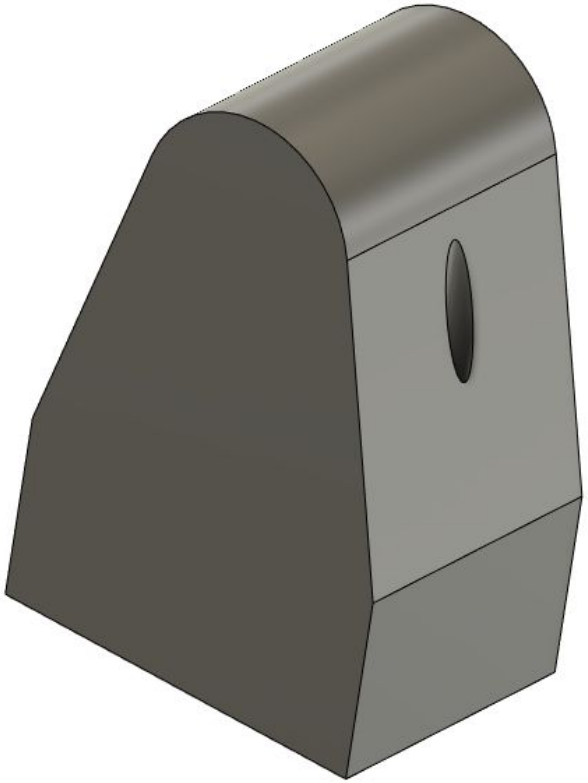
Image: McMaster-Carr

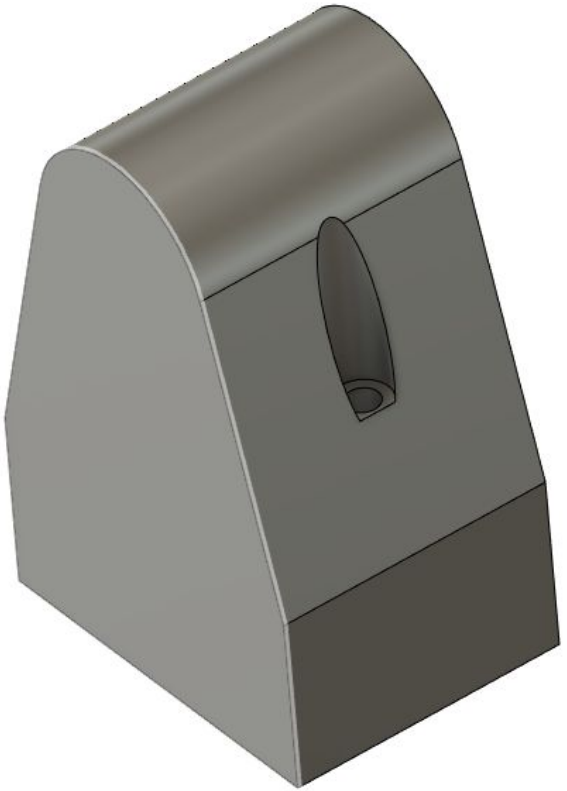
What about finish?

LEEMANGEOPHYSICAL LLC
CONSULTING & INSTRUMENTATION

Image: Protolabs

Avoid drilling on angled surfaces





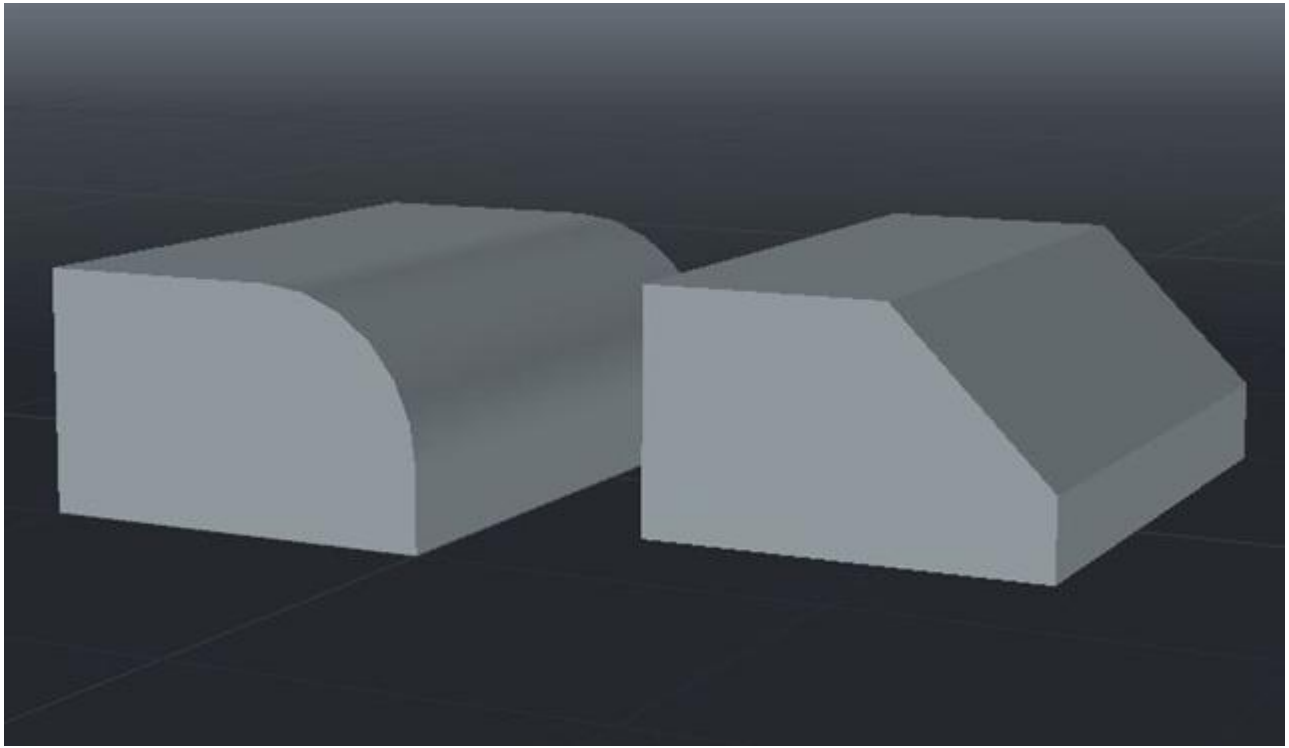
LEEMANGEOPHYSICAL LLC
CONSULTING & INSTRUMENTATION

Use standard drill sizes when possible

#10	0.1935	4.9149
#9	0.1960	4.9784
5 mm	0.1969	5.0000
#8	0.1990	5.0546
5.1 mm	0.2008	5.1000
#7	0.2010	5.1054
13/64 in	0.2031	5.1594
#6	0.2040	5.1816
5.2 mm	0.2047	5.2000
#5	0.2055	5.2197
5.3 mm	0.2087	5.3000
#4	0.2090	5.3086
5.4 mm	0.2126	5.4000
#3	0.2130	5.4102
5.5 mm	0.2165	5.5000
7/32 in	0.2188	5.5563
5.6 mm	0.2205	5.6000
#2	0.2210	5.6134
5.7 mm	0.2244	5.7000
#1	0.2280	5.7912
5.8 mm	0.2284	5.8000
5.9 mm	0.2323	5.9000
A	0.2340	5.9436
15/64 in	0.2344	5.9531
6 mm	0.2362	6.0000
B	0.2380	6.0452
6.1 mm	0.2402	6.1000

Image: CustomPartNet

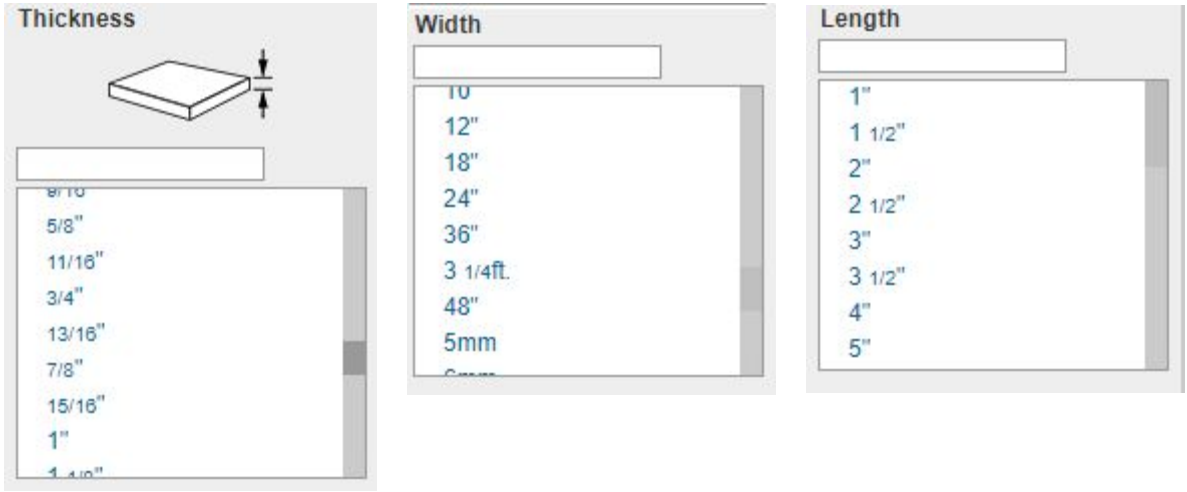
Chamfer instead of fillet when possible



LEEMANGEOPHYSICAL LLC
CONSULTING & INSTRUMENTATION

Image: engineering.com

Fit inside standard STOCK dimensions



LEEMAN GEOPHYSICAL LLC
CONSULTING & INSTRUMENTATION

Image: McMaster-Carr