#### A Brief Introduction to Engineering Graphics

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#### Opening comments

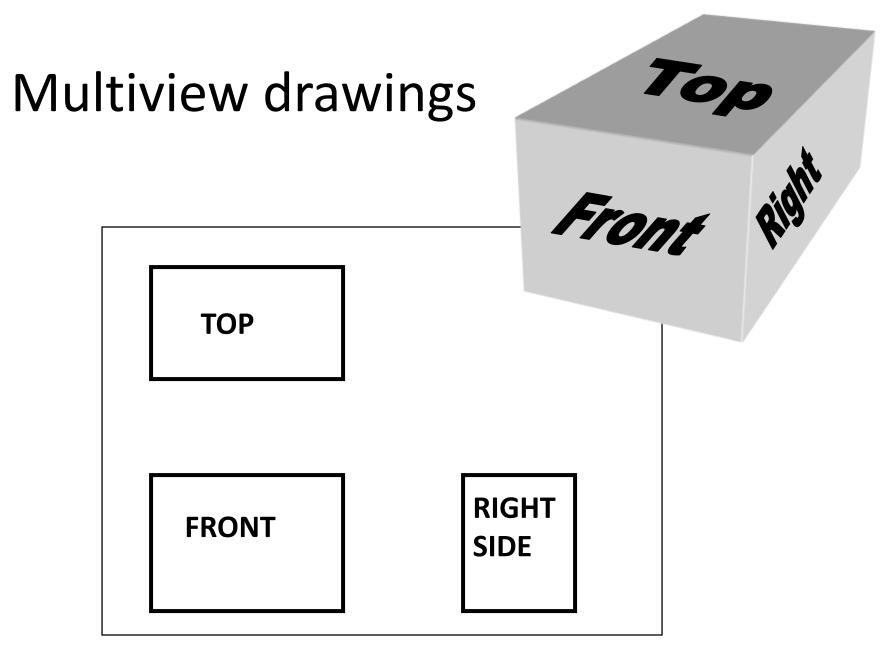
- Engineering graphics is the method for documenting a design
- Mechanical engineering students must be familiar with standards of engineering graphics as it is expected in industry
- This set of slides introduces some of the basics, but is not comprehensive
- For more, see
  - Engineering Graphics section on the Resources page of the course ME2011 website
  - Any engineering graphics textbook

#### Documenting a part requires...

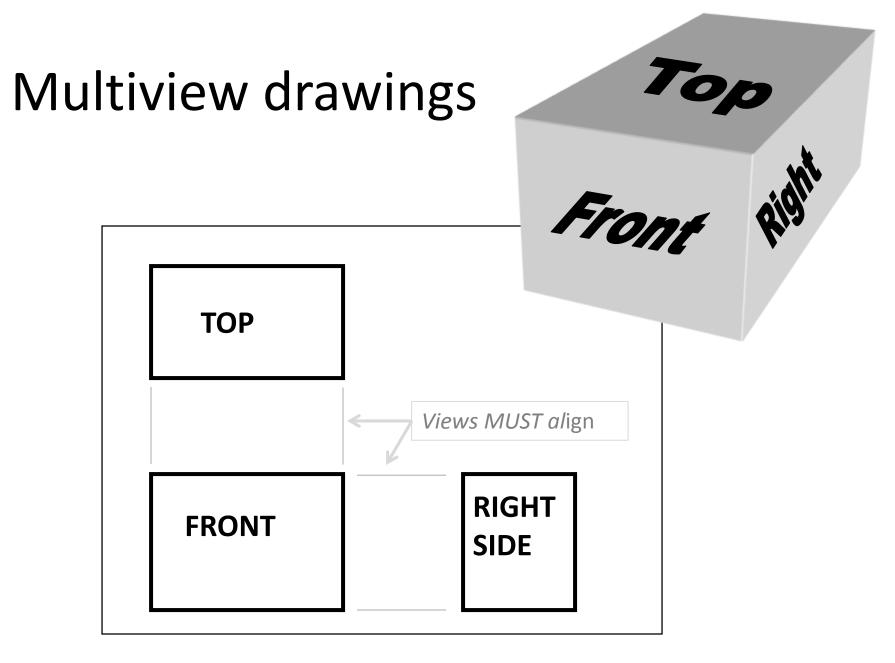
- 1. SHAPE
- 2. SIZE
- 3. MATERIAL
- 4. TOLERANCE
- 5. FINISH

#### Engineering drawings

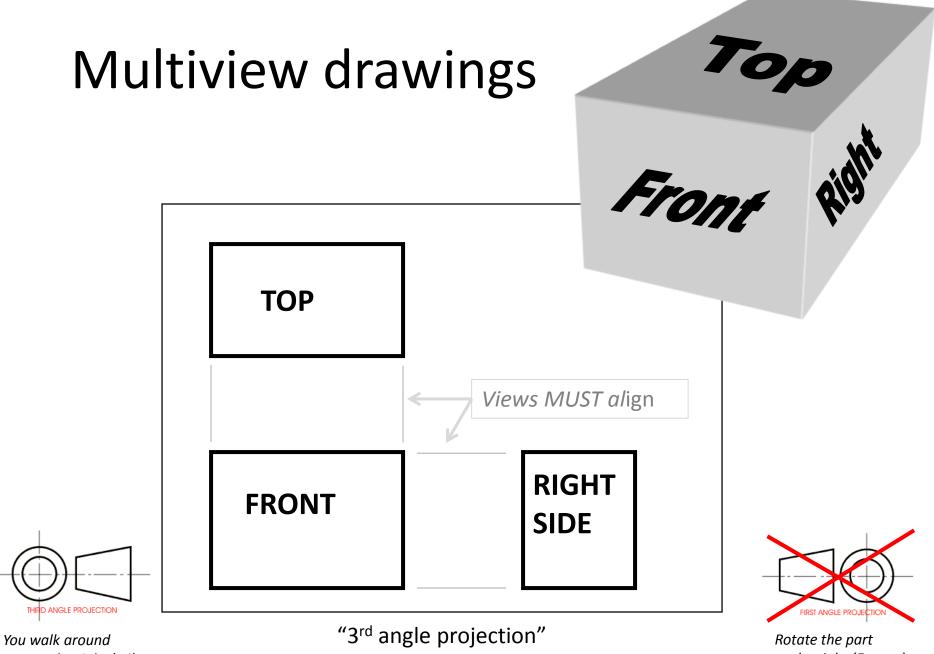
- Universal language
- Conventions (drawing grammar) simplify communication; your drawing is at risk if you defy
- CAD packages make formal drawing easy...if you follow the conventions
- The machinist will laugh at you behind your back if you show up with a non-standard drawing



"3<sup>rd</sup> angle projection"



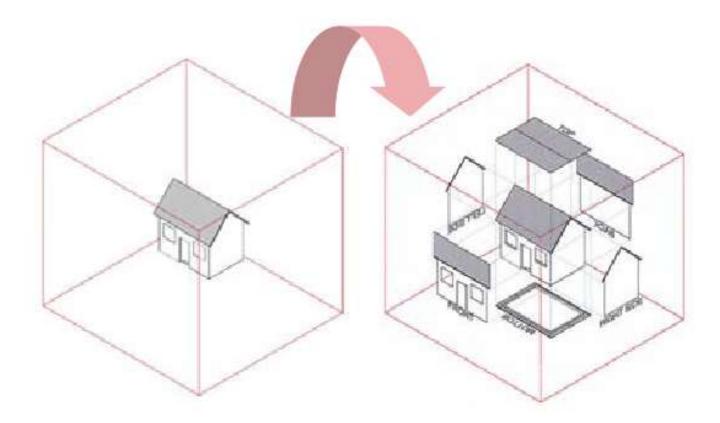
"3<sup>rd</sup> angle projection"



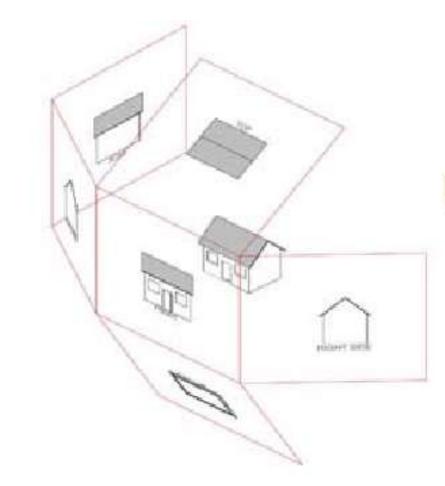
part to the right (US)

to the right (Europe)

#### The Glass Box:



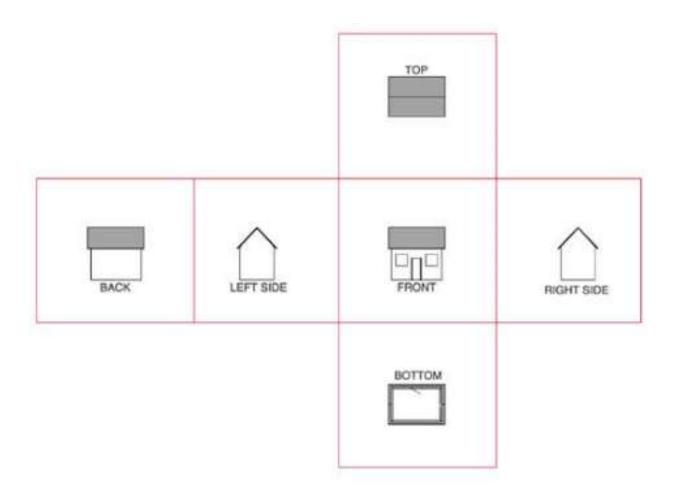
## Alignment & Orientation are preserved...



#### Unfolding the "Glass Box"

Bertoline, Engineering Graphics

#### Six Principle views: obey layout



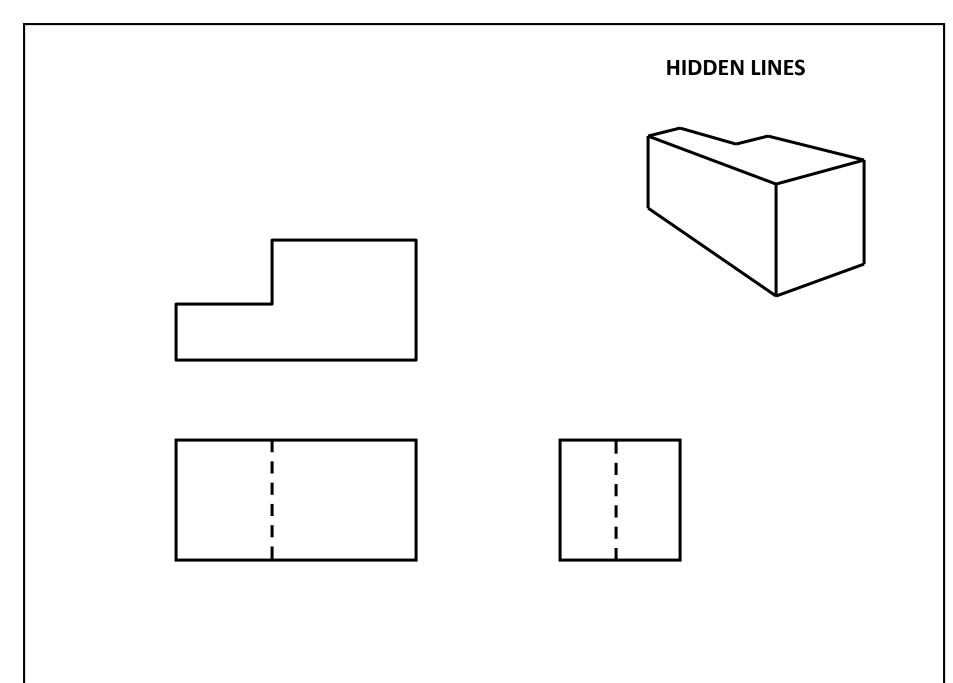
#### Basic lines (the "alphabet of lines")

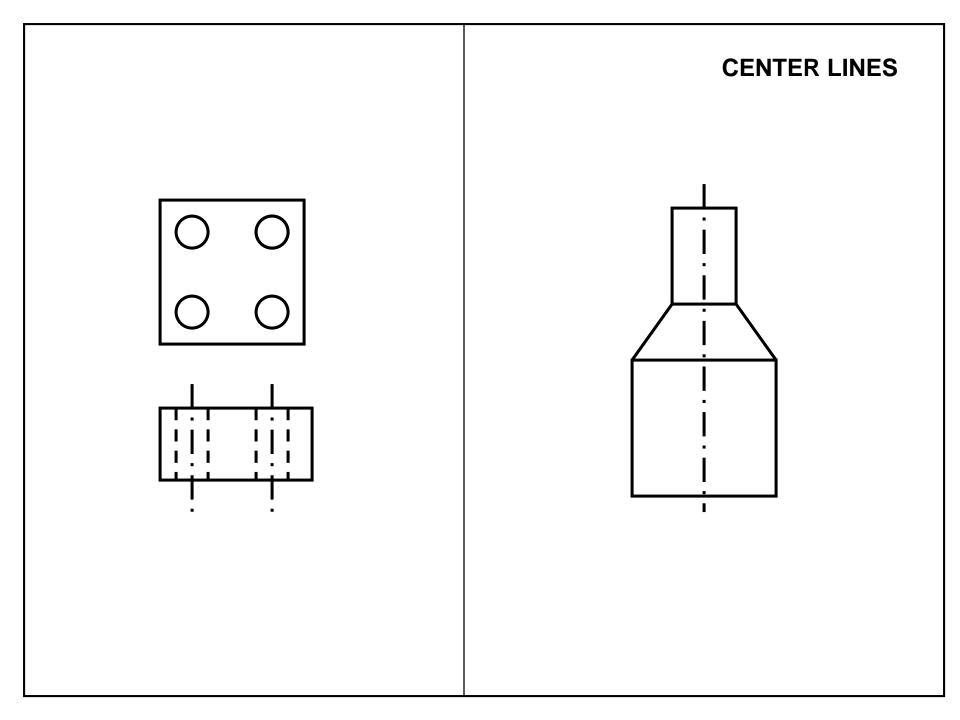
**Object line** 

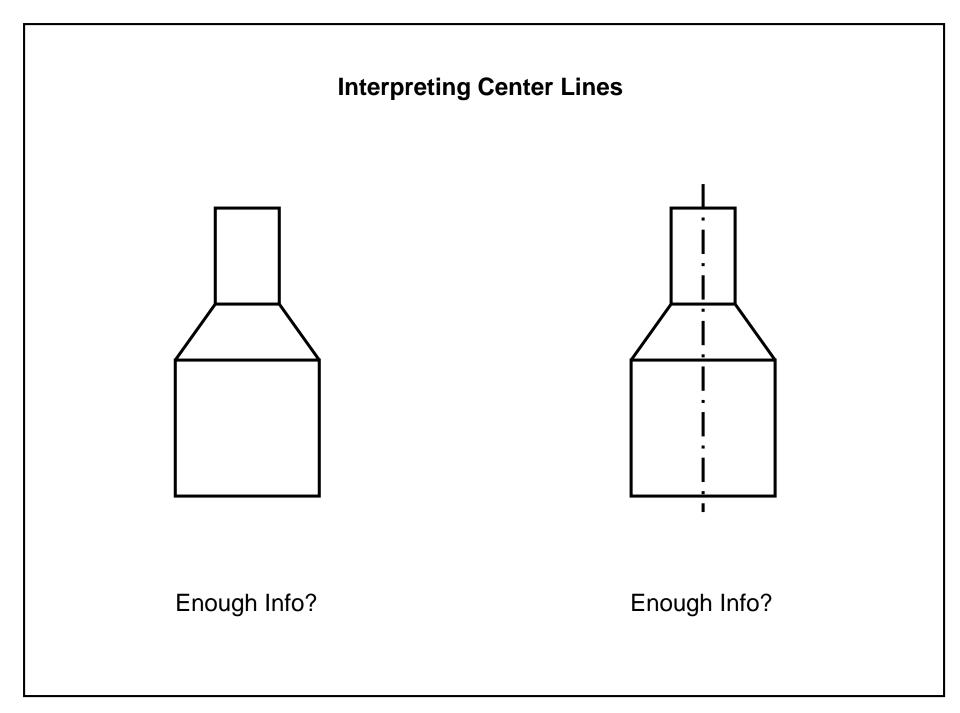
Hidden line

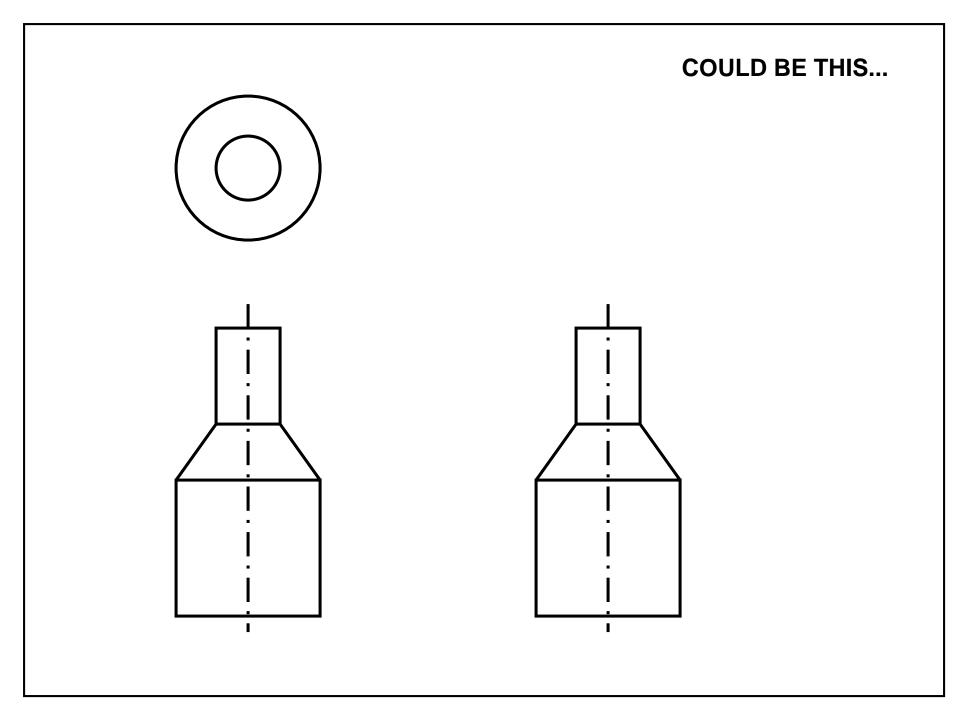
**Center line** 

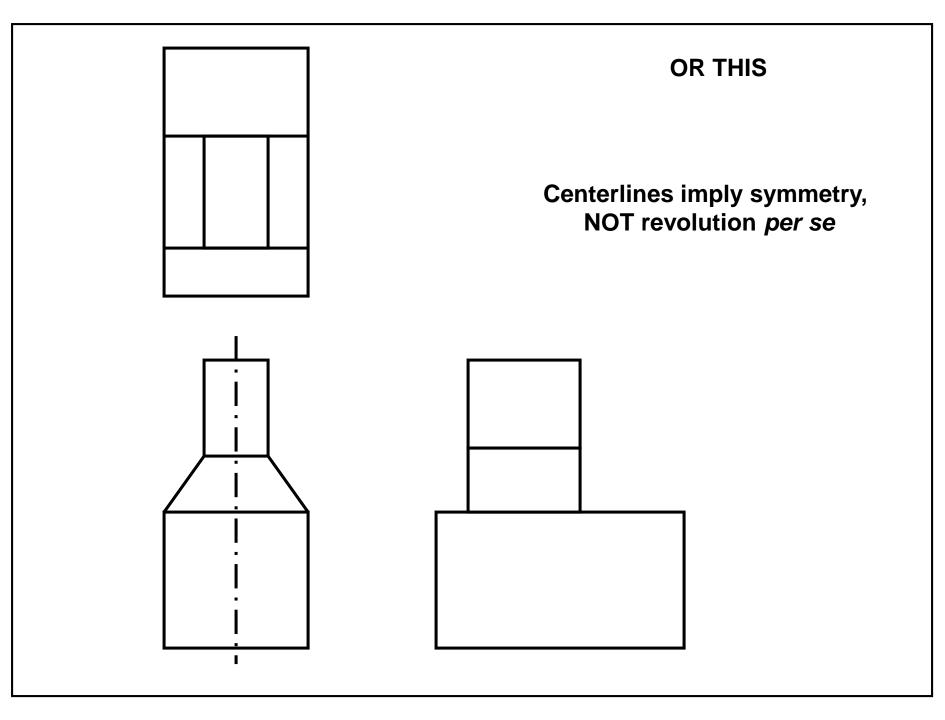
**Dimension line** 



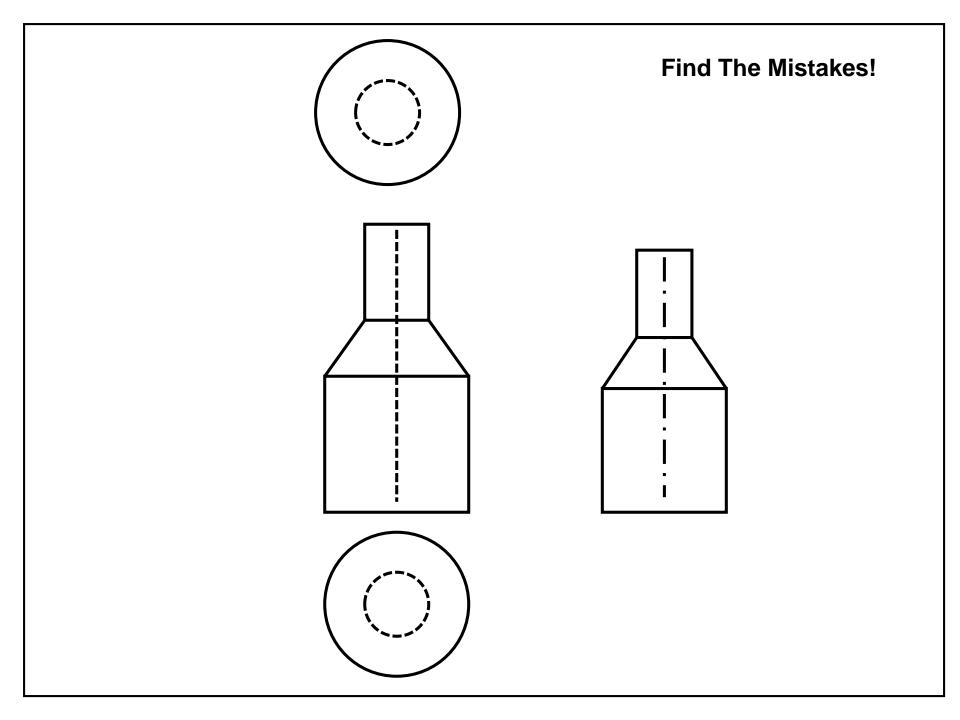


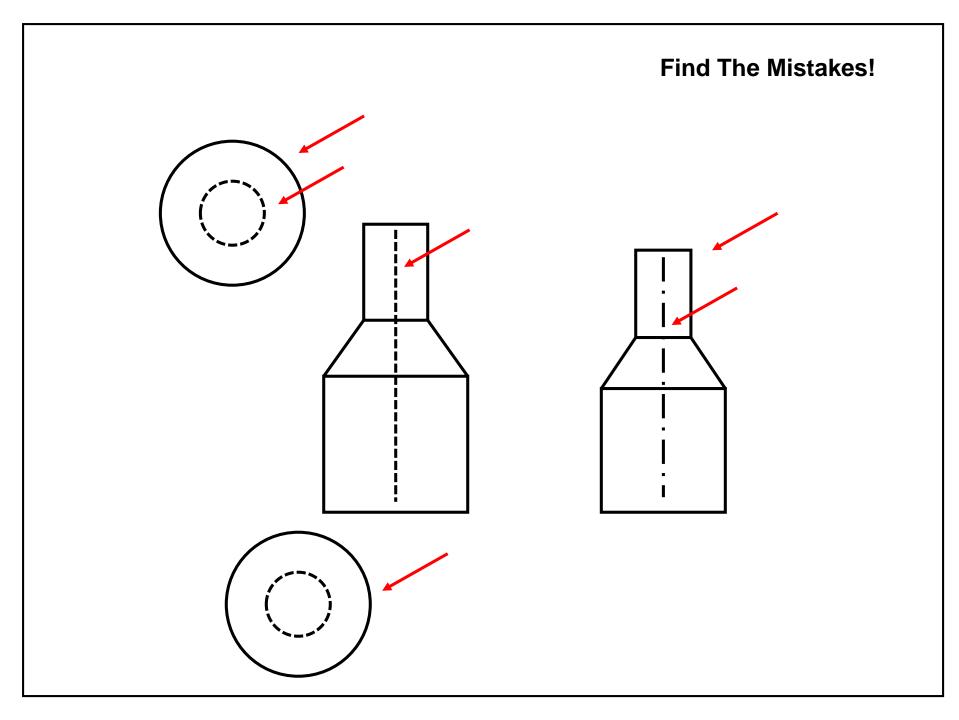


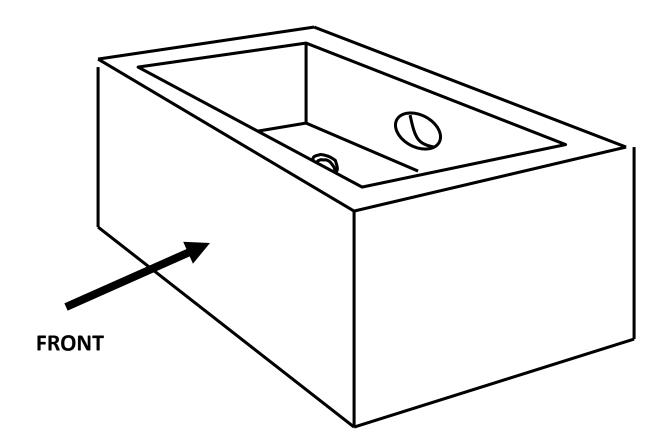


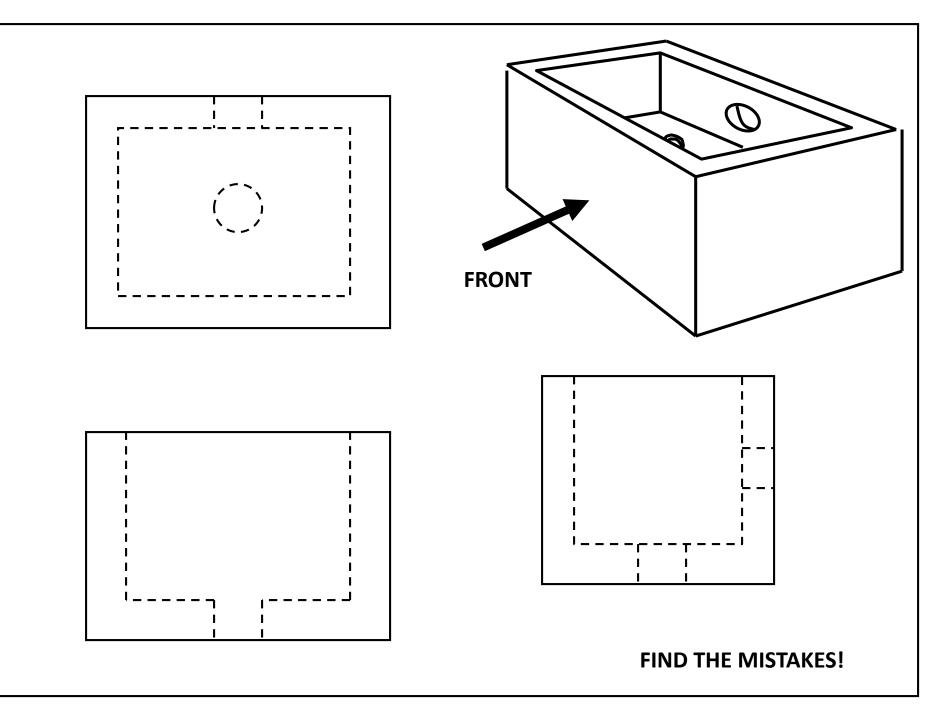


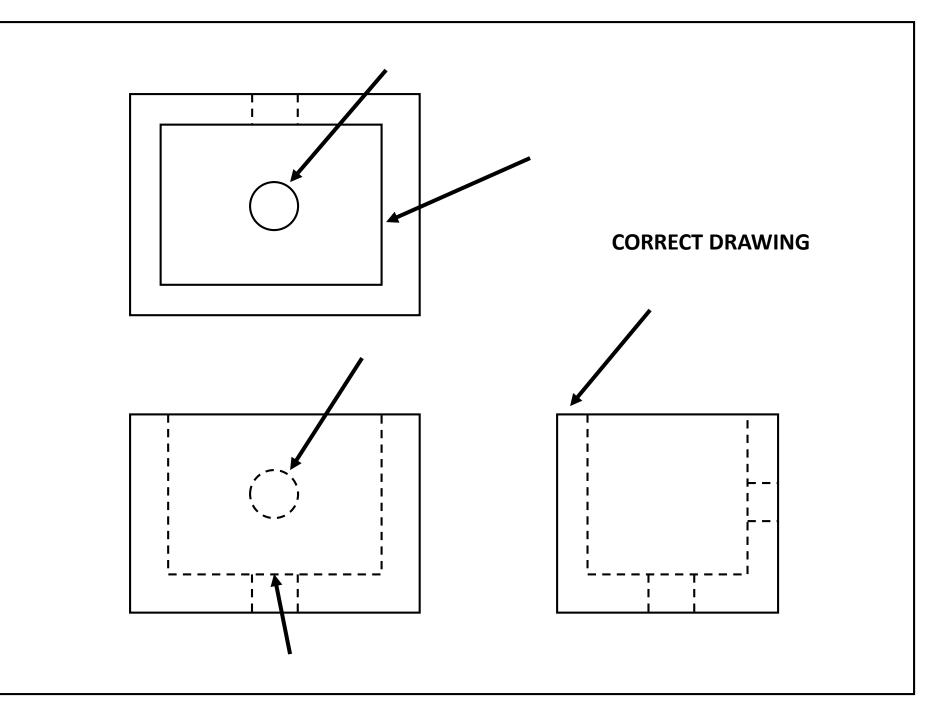
# HERE, ONLY 2 VIEWS NEEDED (Correct drawing)

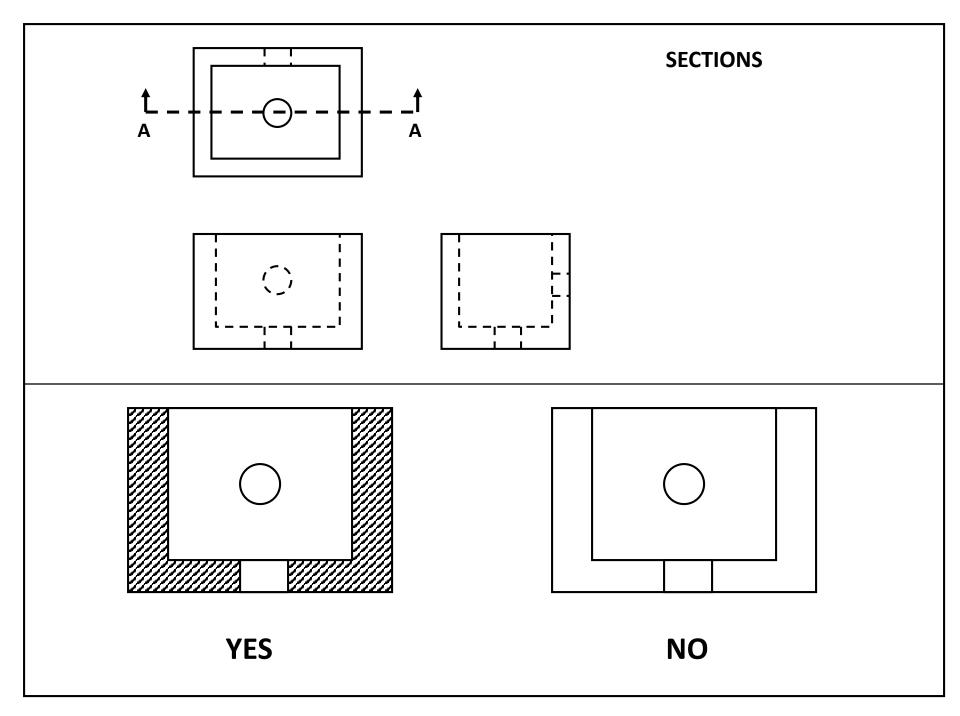




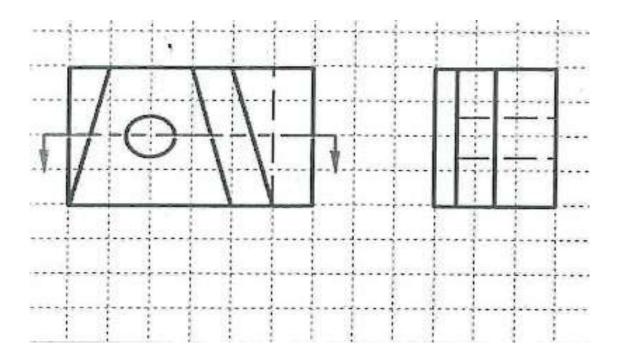




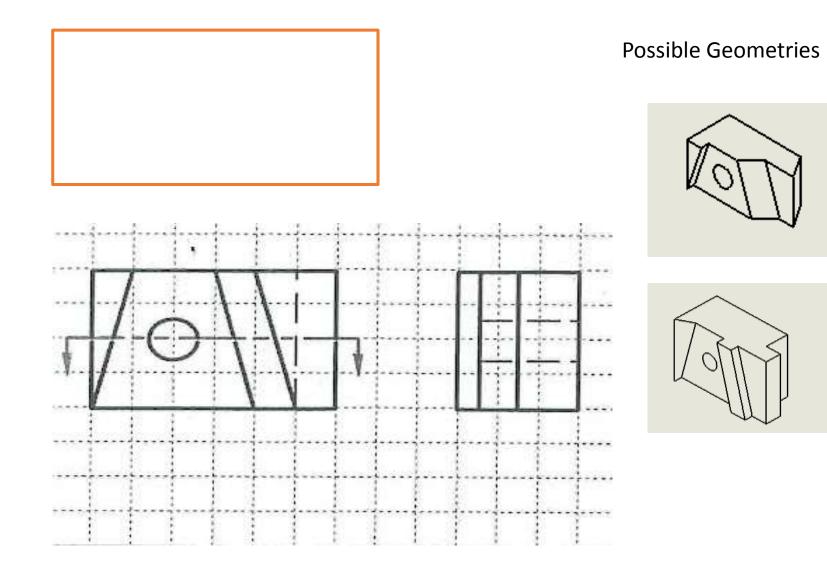




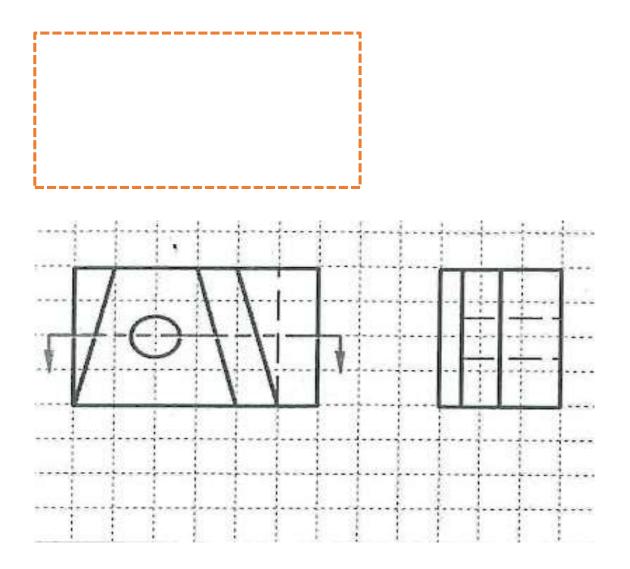




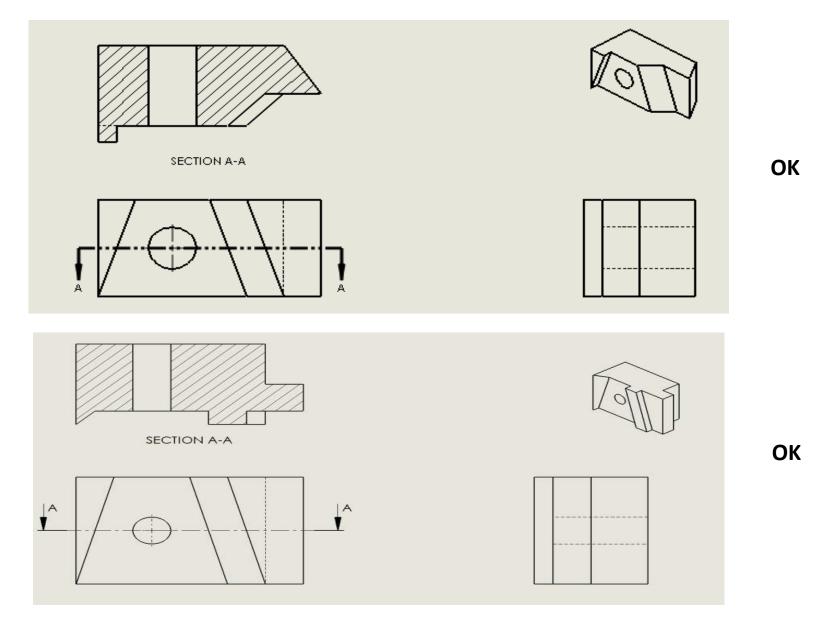
Working with person sitting next to you copy this and draw the **TOP VIEW** 



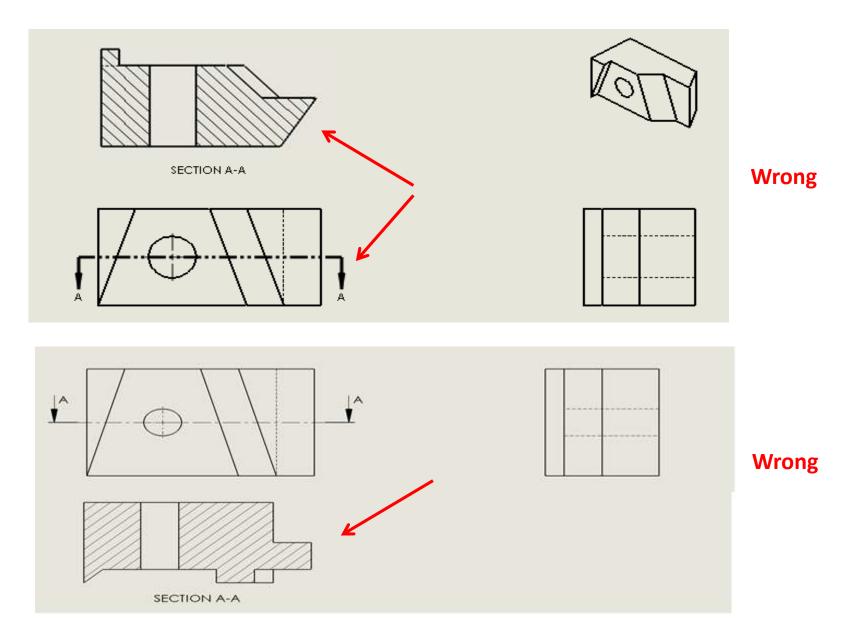
Working with person sitting next to you copy this and draw the **TOP VIEW** 



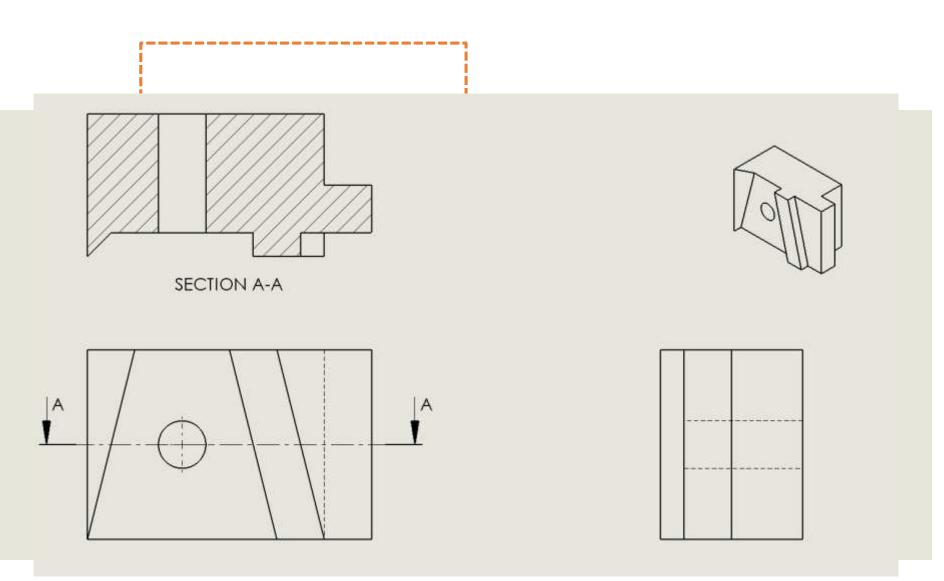
Working with person sitting next to you, sketch the Section View



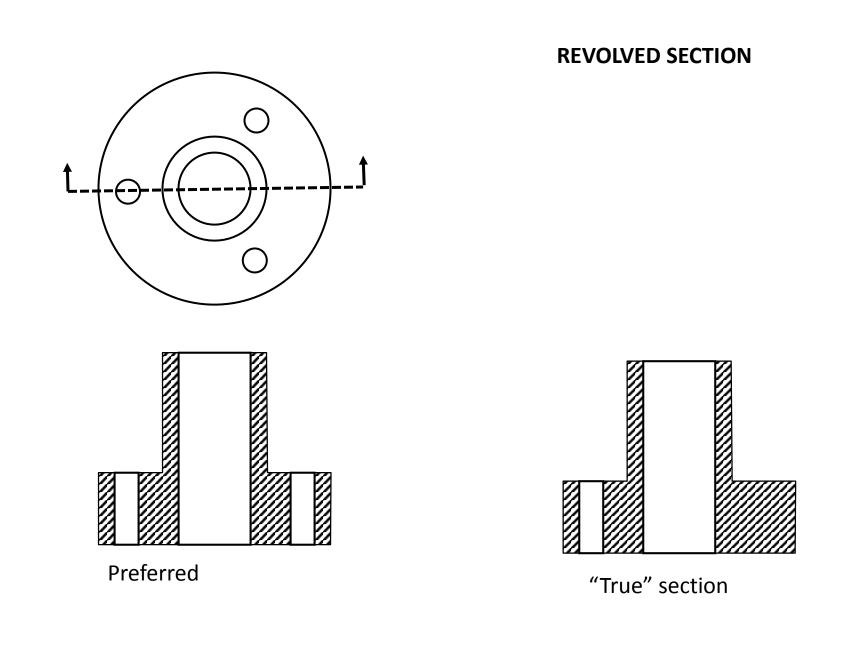
Correct Section Views



Working with person sitting next to you, Find the MISTAKES



Working with person sitting next to you, sketch the Section View



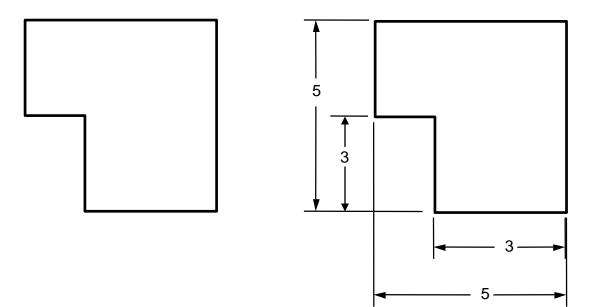
### DIMENSIONING



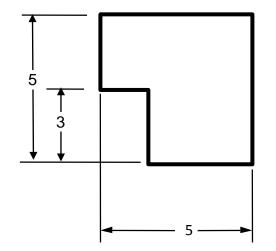
4. TOLERANCE AND FINISH

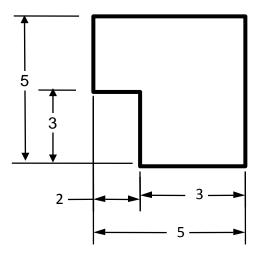
#### Dimensioning

- Conventions exist for choice and placement
- Not too many and not too few
- Never should measure off drawing with a ruler

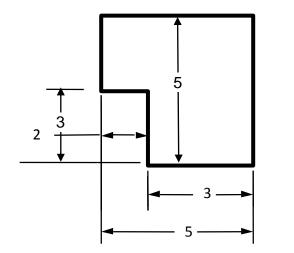


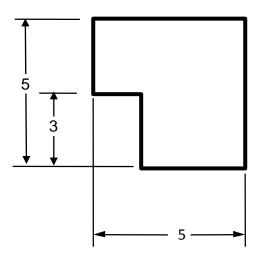
#### **Under/Over Dimensioning**



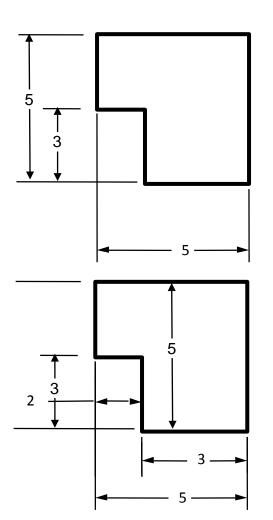


#### Dimensioning rules: ...find the mistakes.





#### **Dimensioning guidelines**



1. Don't overdefine or underdefine the object. [MOST IMPORTANT]

2. Dimension to the visible contour or shape of the feature / Don't dimension to hidden lines.

4. Don't dimension to object lines (model edges), use extension lines.

5. Don't overlap a dimension and the model.

Place dimensions away

from the model's surface.

6. Don't cross extension lines if possible.

7. Group dimensions when possible unless it become difficult to read.

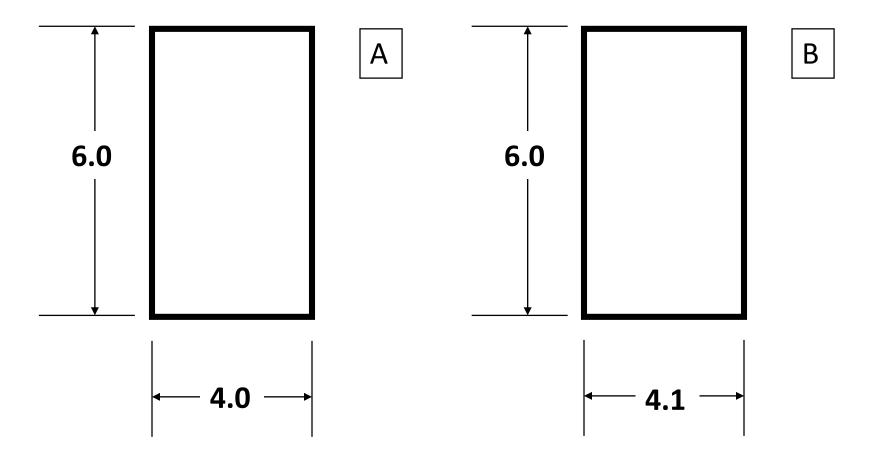
8. Place dimensions on the side of the view were adjacent views exist

(for easy referencing).

#### **Design Detail**

1/2" thick aluminum block

Which is more expensive: A or B and why?

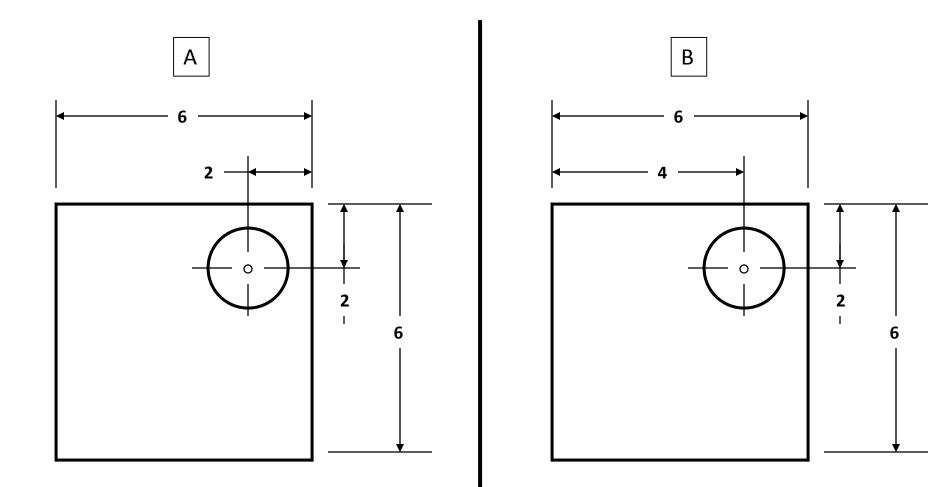


#### www.mcmaster.com

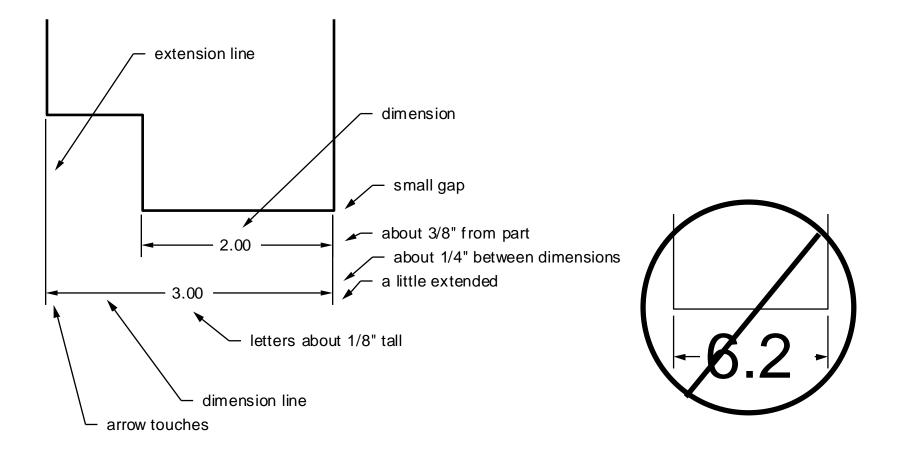


#### **Dimensioning Choices & Design Intent**

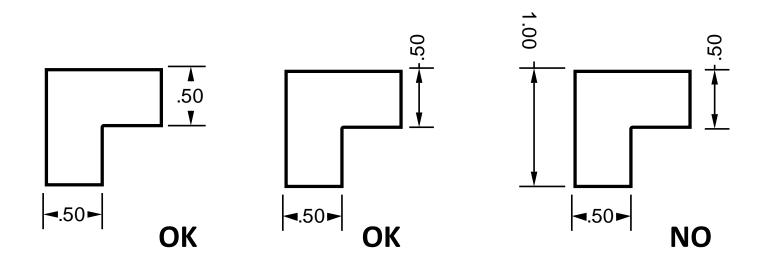
If change width of block to 8, what happens to the hole location?



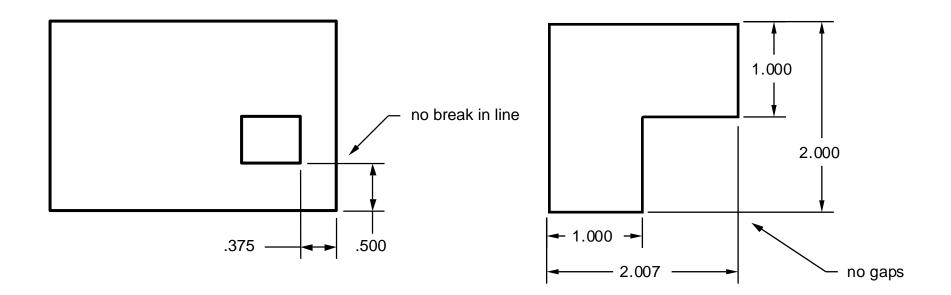
#### **Placement conventions**



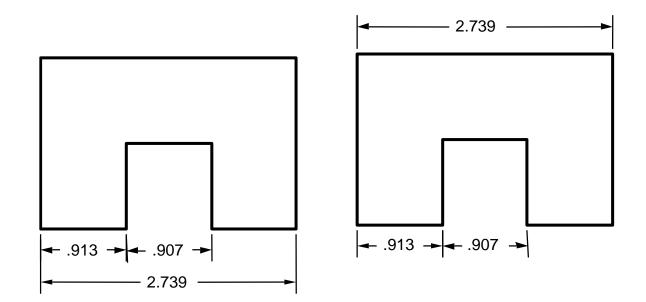
#### Lettering: 1 or 2 directions only



#### **Extension Lines**

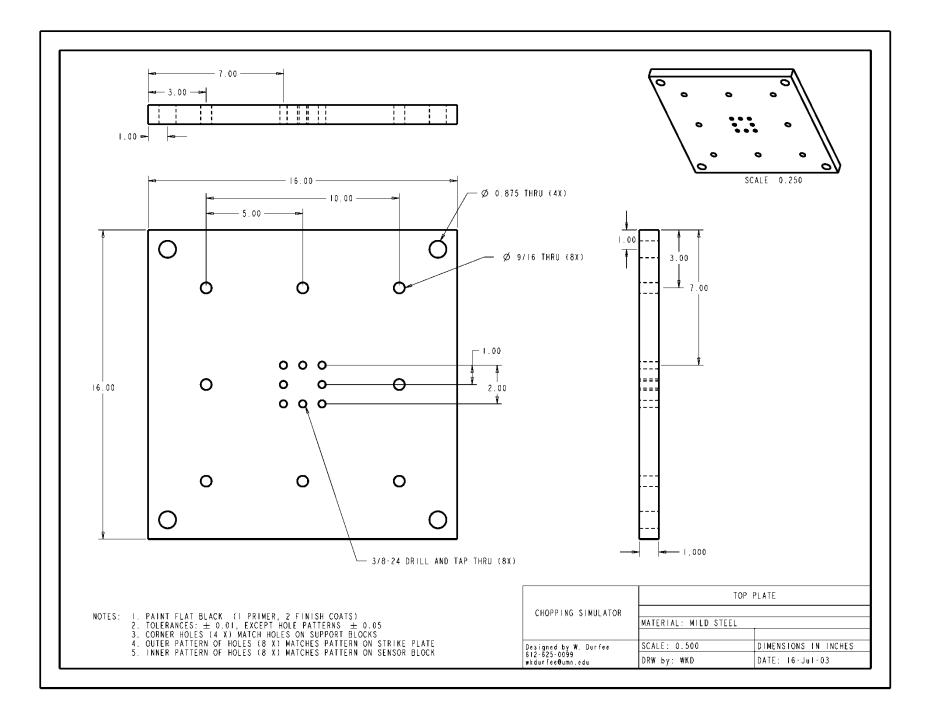


#### All on one side

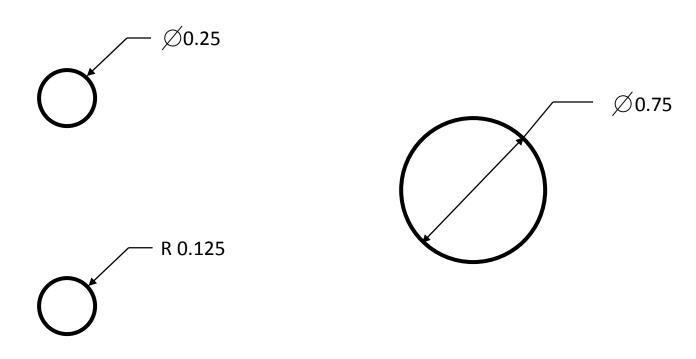


YES

NO

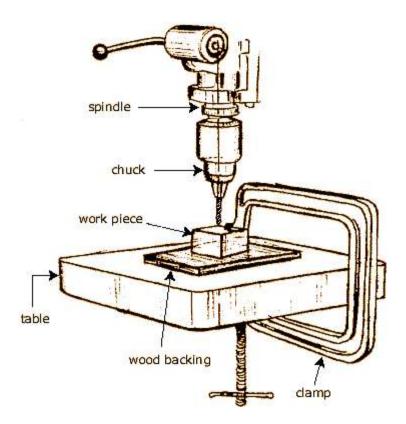


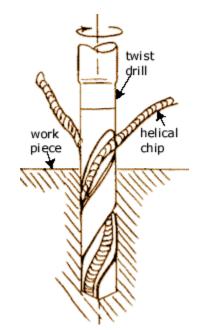
#### **Dimensioning Rounds**



Place dimension on view that shows the circle Show diameter rather than radius

## TOLERANCES





www.efunda.com/processes/machining/drill.cfm

www.efunda.com/processes/machining/drill\_press.cfm

#### Tolerances

- Matter because parts cannot be made to an exact dimension
- Must specify dimension tolerance so that every part A fits every part B
- Higher tolerance = higher cost
- A ½ inch hole made on an ordinary drill press gives you a hole in the range 0.496 to 0.504 (+/- 0.004).
  For higher precision, drill undersize and use a reamer...but it will cost you more and take longer to fabricate.



#### <sup>1</sup>/<sub>2</sub> inch drill bit: +/- .0040

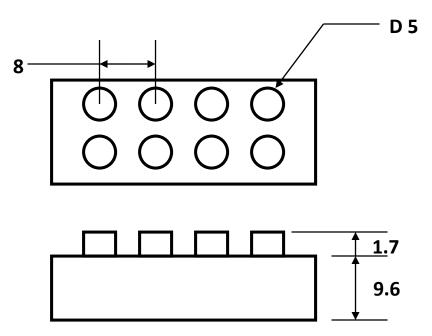


#### <sup>1</sup>/<sub>2</sub> inch reamer: +.0003, -.0000

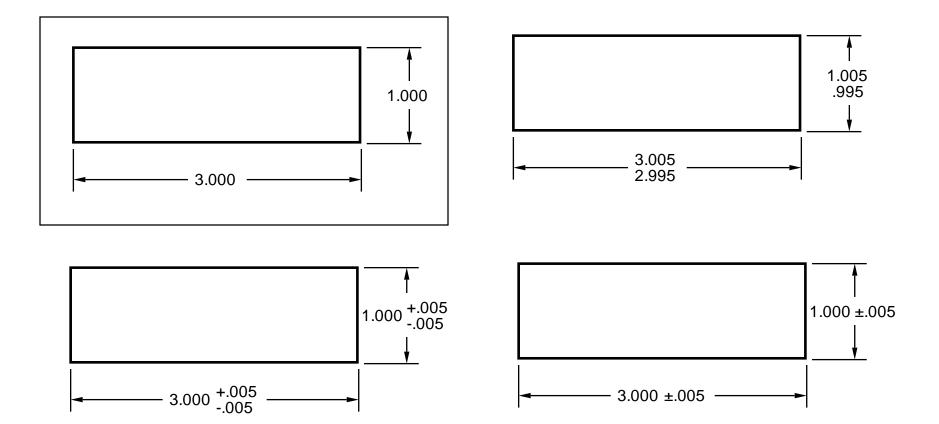
## LEGOS !



- You can combine six 8-stud bricks of the same color 102,981,500 different ways
- 91% of all households with children in Denmark own LEGO products
- During the period 1949-1990, 110,000,000,000 (110 billion) LEGO elements were molded
- Bayer Corporation's Polymers Division is the official supplier of ABS plastic to the LEGO group.
- Exact specifications of the Bayer resin supplied to the LEGO Group are a closely held secret.
- Dimension tolerance of mold is 0.005 mm (0.0002 inch)!



#### **Representing tolerances**



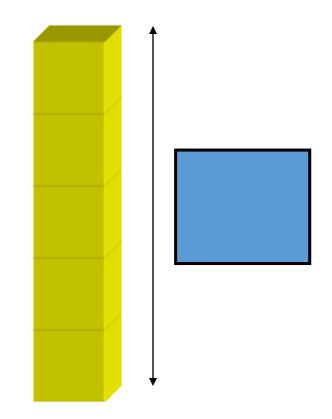
## Tolerance stack-up

What is min and max height of stack?

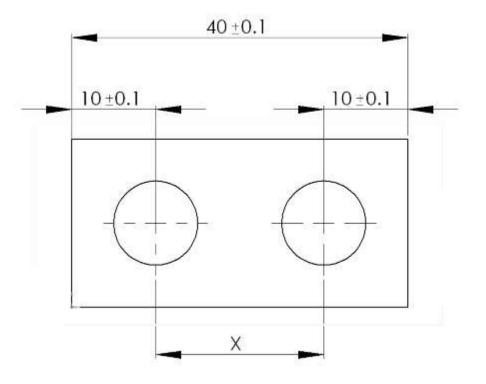


3.0 ±.05

5 high stack



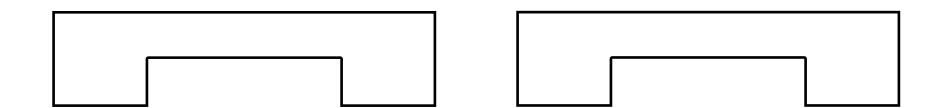
## **Tolerance Stacking**

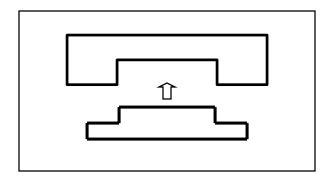


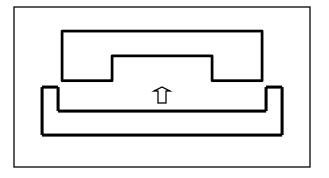
What's the tolerance (+/-) on dimension x?



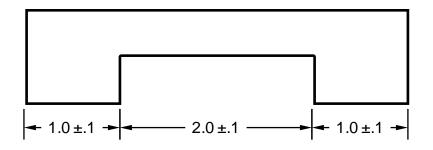
#### Chain or Baseline Dimensioning? ... You decide

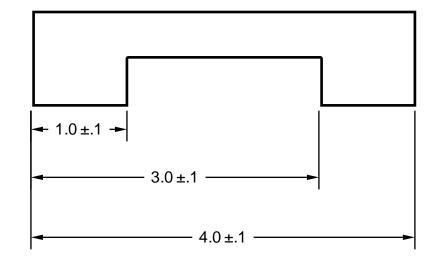


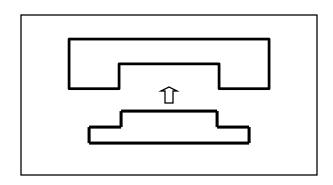


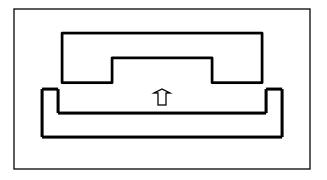


# Chain or Baseline Dimensioning



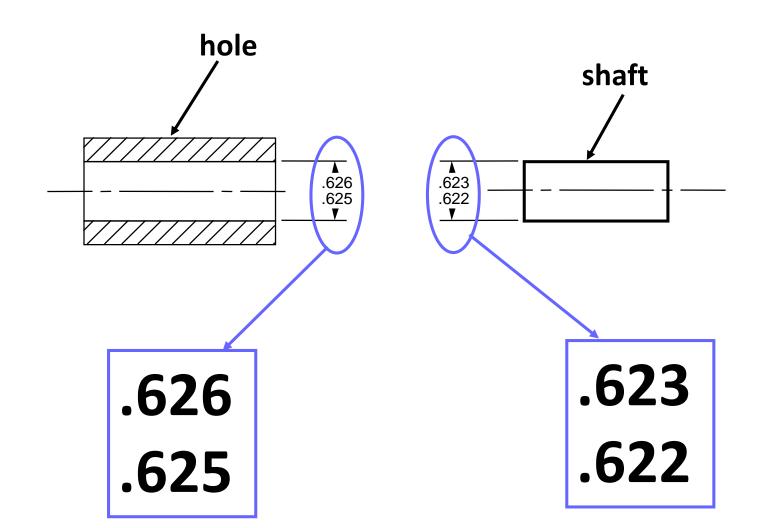


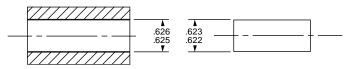




## Holes and shafts

- 1. Will all shafts fit into all holes?
- 2. What is maximum clearance?





## ANSI standards for shaft & holes

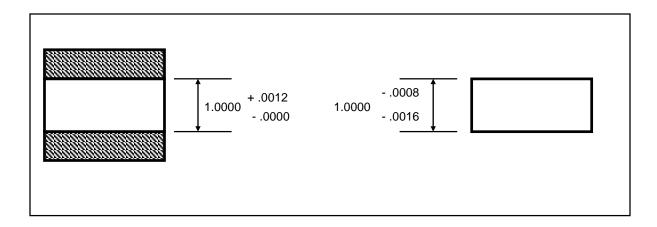
Clearance	Sha	Shaft smaller than hole for all shafts and holes					
Interference	Sha	Shaft larger than hole for all shafts and holes					
Transition	Sm	Smallest shaft fits in largest hole					
Running/Sliding		RC1 (fit together, no play) to RC9 (fit loosely)					
Force/shrink		FN1 (light drive and pressure) to FN5 (high stresses and pressures)					
and others		Like Locational, etc.					
·							
Daalahala		Line neminal size of hole on starting naint					

Basic hole	Use nominal size of hole as starting point
Basic shaft	Use nominal size of shaft as starting point

### Preferred Fit Example...

		Ru	nning	and	Slidin	g Fits	s - An	erica	n Nat	ional	Stan	dards			
	RC 5 RC 6	}	Mediun	n runnin	<b>gs fits</b> a	re intend	led for h	igher run	ning spe	eds, or h	eav y jou	rnal pres	sures or	both	
	RC 7	}			ts are int ncounter						ntial, or w	here larç	ge tempe	erature va	ariation
	RC 8 RC 9	}			fits are the exte			where wi	de comm	nercial to	lerances	may be	necessa	iry, toget	her wit
1	С	lass R	C5	С	lass R	C6	С	lass R	C7	С	ass R	C8	С	lass R	C9
Nominal Size Range, Inches	of nce	10010200	id ard nits	of nce	100000000	idard nits	of nce	120200	dard nits	of nce		ndard nits	of nce		dard nits
Over To	Limits of Clearance	Hole H8	Shaft e7	Limits of Clearance	Hole H9	Shaft e8	Limits of Clearance	Hole H9	Shaft d8	Limits of Clearance	Hole H10	Shaft e9	Limits of Clearance	Hole H11	Shaf
0-0.12	0.6 1.6	+0.6 - 0	- 0.6 - 1.0	0.6	+ 1.0	- 0.6	1.0 2.6	+ 1.0	- 1.0 - 1.6	2.5 5.1	+1.6	- 2.5 - 3.5	4.0 8.1	+2.5	- 4.0
0.12-0.24	0.8 2.0	+0.7	- 0.8 - 1.3	0.8	+ 1.2	- 0.8 - 1.5	1.2 3.1	+1.2	- 1.2 - 1.9	2.8 5.8	+1.8	- 2.8 - 4.0	4.5 9.0	+3.0	- 4.5
0.24-0.40	1.0 2.5	+0.9	- 1.0 - 1.6	1.0 3.3	+ 1.4	- 1.0 - 1.9	1.6 3.9	+1.4	- 1.6 - 2.5	3.0 6.6	+2.2	- 3.0	5.0 10.7	+3.5	- 5.0
0.40-0.71	1.2 2.9	+1.0	- 1.2 - 1.9	1.2 3.8	+ 1.6	- 1.2	2.0 4.6	+1.6	- 2.0 - 3.0	3.5 7.9	+2.8	- 3.5	6.0 12.8	+4.0	- 6.0 - 8.5
0.71-1.19	1.6 3.6	+1.2	- 1.6	1.6 4.8	+ 2.0	- 1.6 - 2.8	2.5 5.7	+2.0	- 2.5 - 3.7	4.5 10.0	+3.5	- 4.5	7.0 15.5	+ 50 - 0	- 7.0
1.19-1.97	2.0 4.6	+1.6	- 2.0 - 3.0	2.0 6.1	+ 2.5	- 2.0 - 3.6	3.0 7.1	+2.5	- 3.0 - 4.6	5.0 11.5	+4.0	- 5.0	8.0 18.0	+6.0	- 8.0
1.97-3.15	2.5 5.5	+1.8	- 2.5	2.5 7.3	+3.0	- 2.5 - 4.5	4.0 8.8	+3.0	- 4.0 - 5.8	6.0 13.5	+4.5	- 6.0 - 9.0	9.0 20.5	+7.0	- 9.0

## "Basic Hole" Tolerancing Example



Drawing shows 1 in. nominal, ANSI RC4 clearance fit

"Basic Hole" means smallest possible hole = nominal, then size shaft for clearance

RC4 clearance = [0.0008, 0.0028] = [smallest hole-largest shaft,

largest hole - smallest shaft]

# Title block information for tolerance

ALL DIMENSIONS IN INCHES

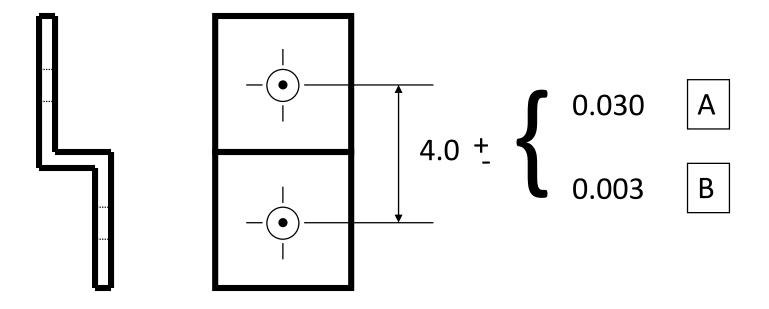
HOLD ALL DIMENSIONS TO ± 0.010 UNLESS SPECIFIED

Dimension	<b>Tolerance</b>
X.X	± 0.1
X.XX	± 0.05
X.XXX	$\pm 0.001$

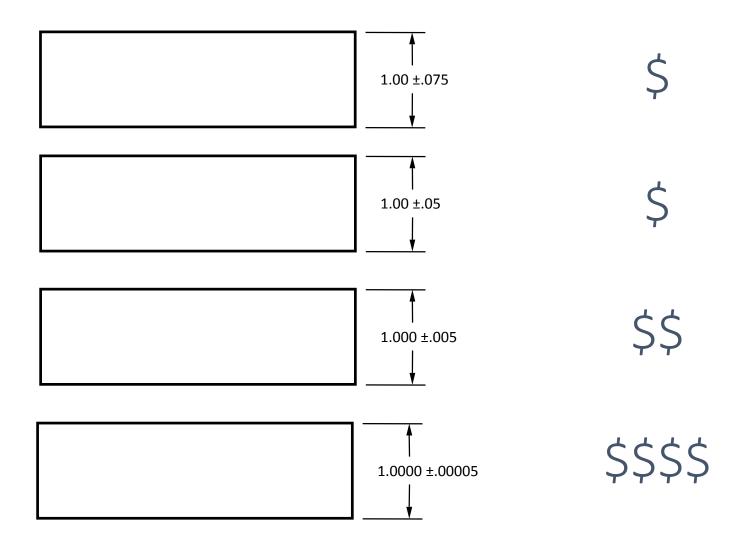
#### **Design Detail**

#### Bent aluminum sheet, 1/16" thick

A or B: Which is more expensive and why?



#### Tolerance vs. Cost

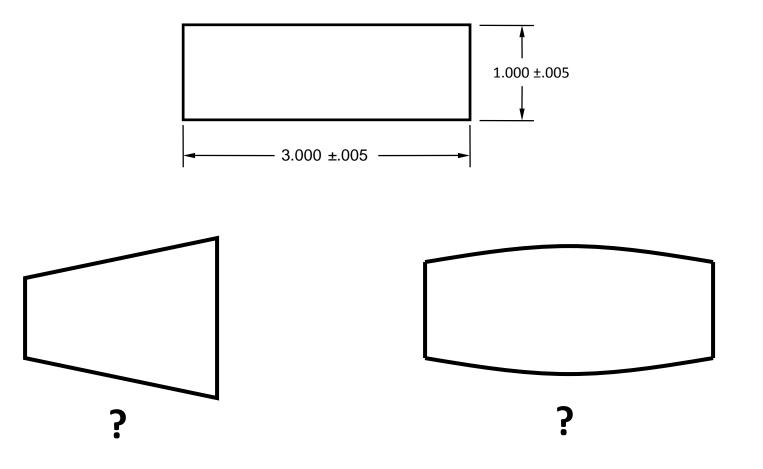


### Manufacturing Tolerances

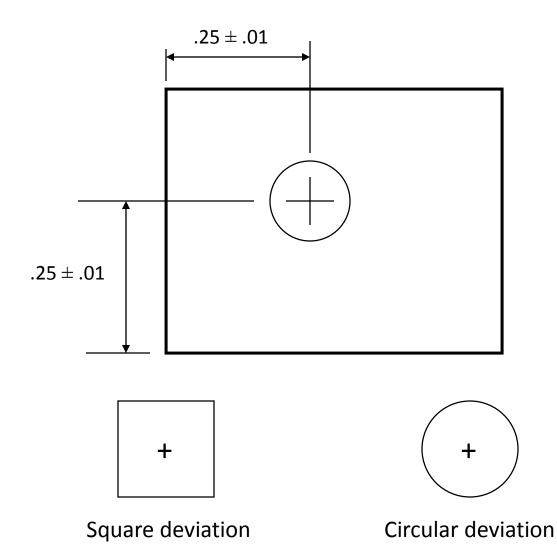
Size (in.)	Total Tolerance (in.)								
0.000-0.599	0.00015	0.0002	0.0003	0.0005	0.0008	0.0012	0.002	0.003	0.005
0.600-0.999	0.00015	0.00025	0.0004	0.0006	0.001	0.0015	0.0025	0.001	0.006
1.000-1.499	0.0002	0.0003	0.0005	0.0008	0.0012	0.002	0.003	0.005	0.008
1.500-2.799	0.00025	0.0004	0.0006	0.001	0.0015	0.0025	0.004	0.006	0.010
2.800-4.499	0.0003	0.0005	0.0008	0.0012	0.002	0.003	0.005	0.008	0.012
4.500-7.799	0.0004	0.0006	0.001	0.0015	0.0025	0.004	0.006	0.010	0.015
7.800-13.599	0.0005	0.0008	0.0012	0.002	0.003	0.005	0.008	0.012	0.025
Operation									
Lapping/Honing									
Grinding/Burnishing									
Broaching									
Reaming									
Turning/Boring									
Milling									
Stamping/Punching									

### Geometric Dimensioning and Tolerancing (GD&T)

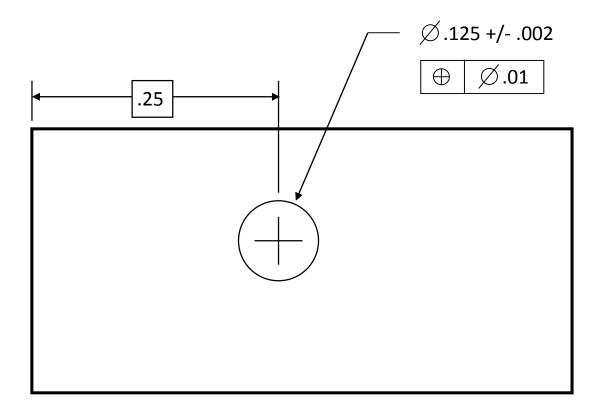
#### Traditional tolerancing is ambiguous



## Ambiguity...

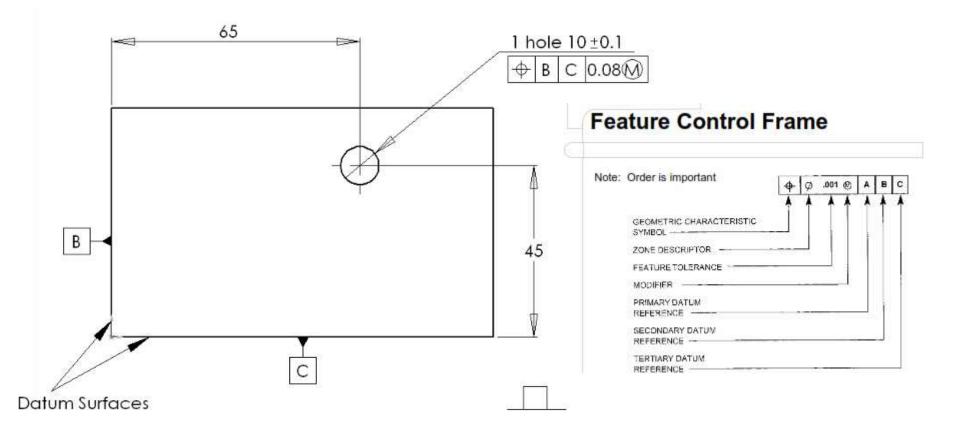


#### Geometric Dimensioning and Tolerancing



- Ideal position of hole. .25, is marked with box and no +/- notation.
- Feature control box shows how close hole is to exact; within circular tolerance zone with diameter .01

#### Geometric Dimensioning and Tolerancing



#### **GD&T** Resources

0	TYPE OF TOLERANCE	CHARACTERISTIC	SYMBOL
		STRAIGHTNESS	-
FOR		FLATNESS	0
PEA IURES	FORM	CIRCLE ARITY (ROUNDWESS)	0
		CYLINOHICITY	N
FOR INDIVIDUAL OR RELATED TRAFURES	Contras - 1	PROFILE OF A LINE	0
	PHOHLE	PROFILE OF A SURFACE	
FOR RELATED FEATURES		ANGULARITY	14
	ONIENTATION	PERPENDICULAIIITY	1
		PARALLELISH	11
		POSITION	Ф
	LOCATION	CONCENTRICITY	0
	langelen 1	CIRCULAK RUNOUT	1
	RUNOUT	TOTAL ISUNOUT	200

#### ME2011 website:

https://sites.google.com/a/u mn.edu/me2011/resources

• Efunda tutorial:

http://www.efunda.com/de signstandards/gdt

## **Threaded Fasteners**

What they are and how to indicate on a drawing

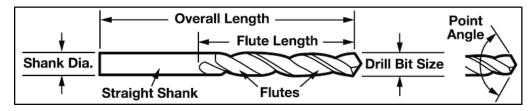
### **Threaded Fasteners**

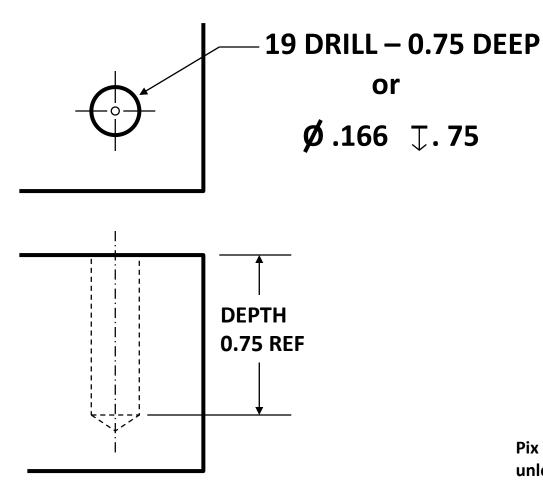
- Holes
- Threads
- Threaded fasteners





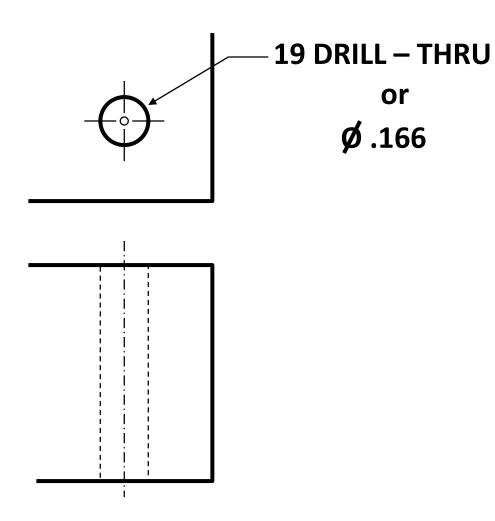
## Holes

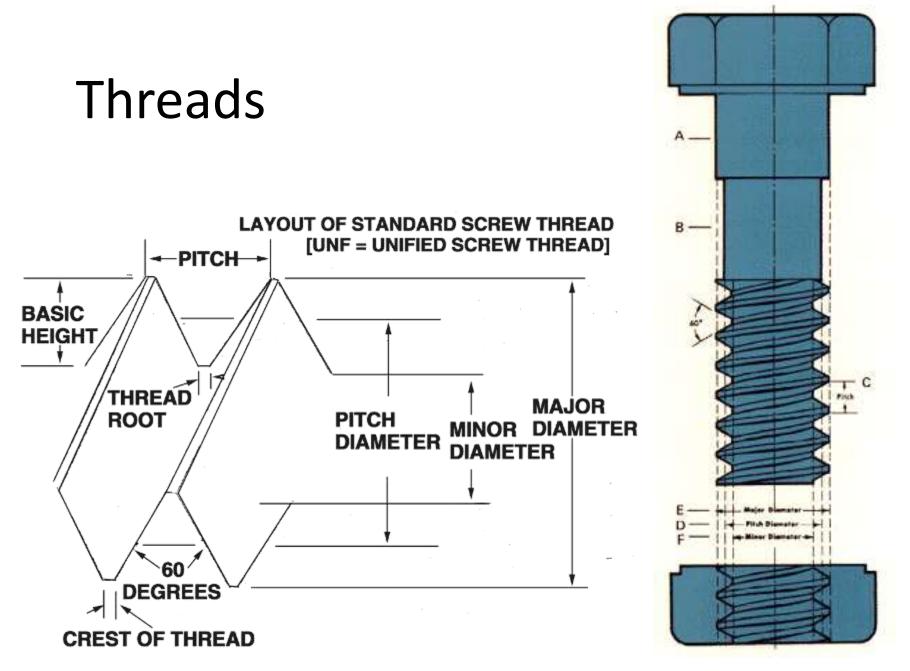




Pix from www.mcmaster.com unless noted

#### Thru holes



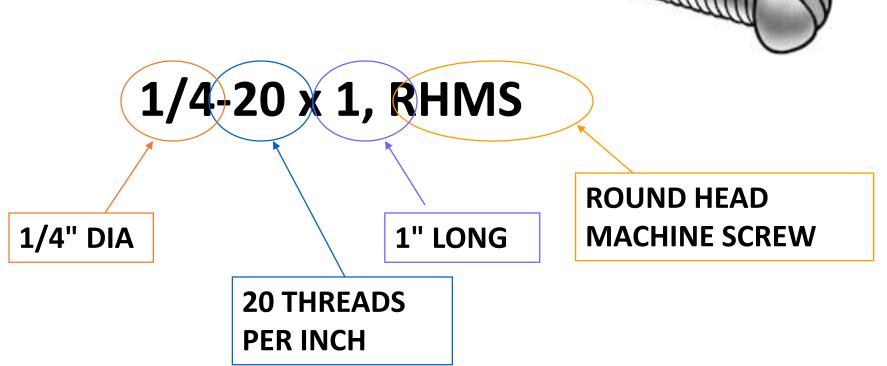


http://www.machinist.org/harvard\_cotreau/mshop6.html

http://www.americanfastener.com/technical/thread\_terminology.asp

#### Threaded Fasteners (screws, bolts)

 Specify diameter, thread, length, head



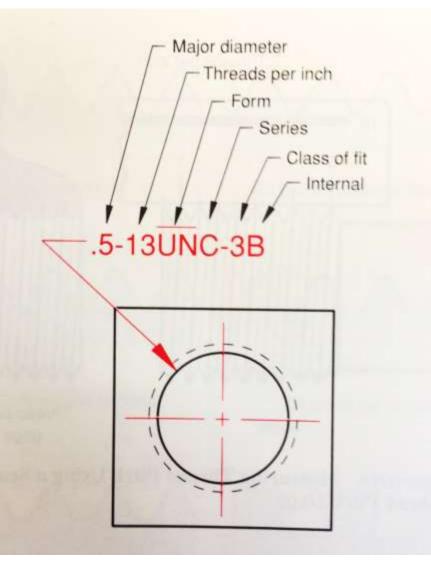
Common screw thread sizes Unified Thread Standard

- 2-56
- 4-40
- 6-32
- 8-32
- 10-24

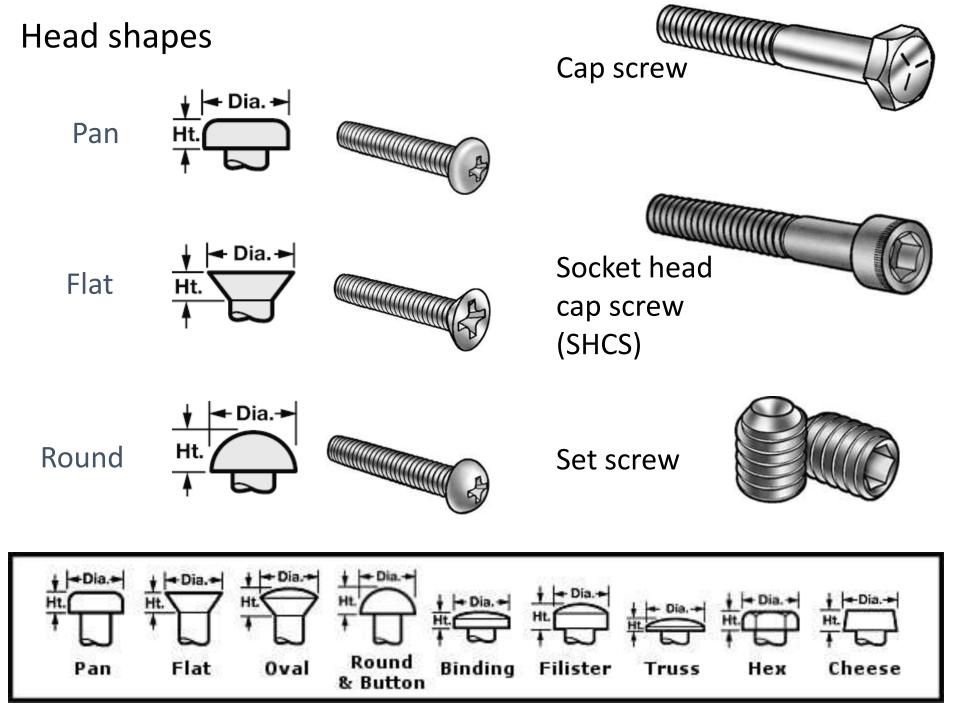
- 1/4-20
- 3/8-16
- 1/2-13
- 5/8-11
- 3/4-10

#### DIA. = (N\*.013) + .060 (inches)

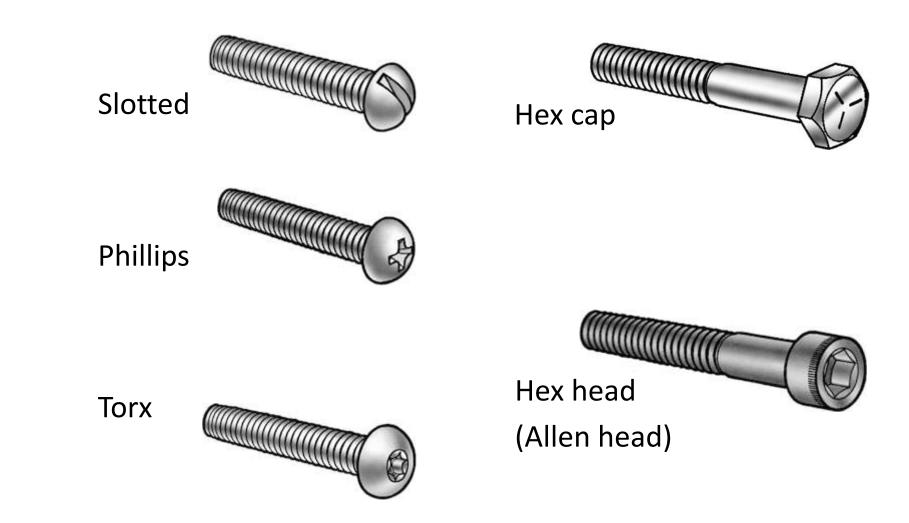
## Alternate Thread Callout



UNC	Means Unified National Coarse
UNF	Means Unified National Fine
UNEF	Means Unified Extra Fine Series
UN	Means Uniform Pitch Series
UNM	Means Unified Miniature Series
NC	Means National Coarse Series
NF	Means National Fine Series
UNR	Means Unified National Round

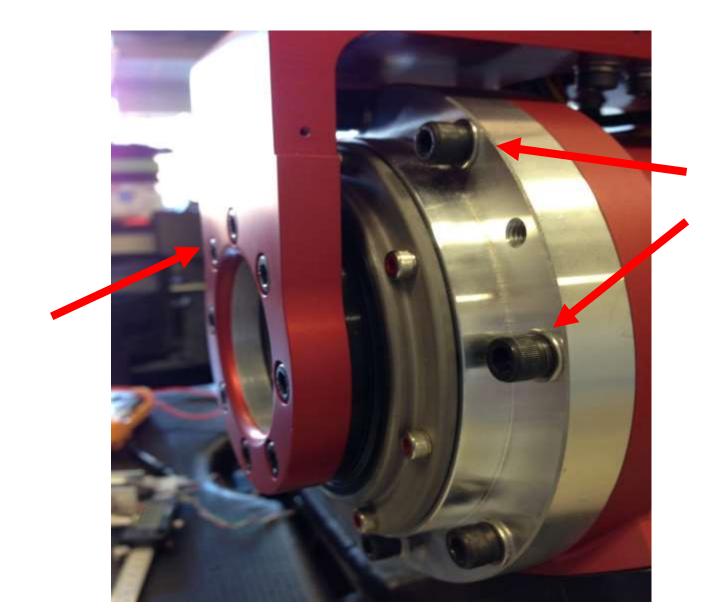


#### Driving a fastener

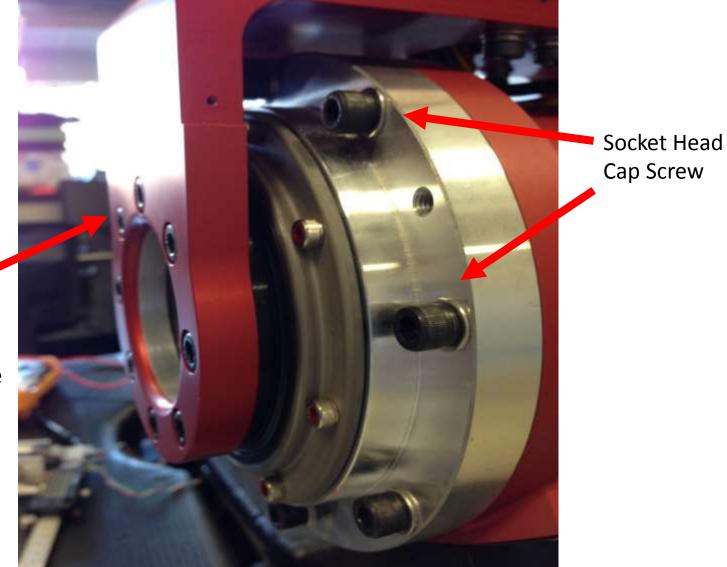


21   21 <t< th=""><th>CAD Theolarisal drawings and 3-0 module available for flams with this symbol.</th><th>Machine Screws</th><th></th></t<>	CAD Theolarisal drawings and 3-0 module available for flams with this symbol.	Machine Screws	
μ   μ			
III → III → III → III → III → III → IIII → IIIII → IIIIII	Lg Oty PerPkg Lg Oty PerPkg Lg O	Pkg. Pkg. Qty. ParPkg Lg. Qty. ParPkg.	
Image: Image	10-24 (Cont.) 9021642554 17.12 67 50 9021640504 182.4 1147 1 4* 100 9021642554 17.12 67 50 9021640504 182.4 1147 1 4* 100 9021642614 116 6* 25 9021640544 596 1144 1	(Cont.) 100 90276A546 \$3.71 1701 100 90276A582 \$9.48 100 90276A548 4.16 21 100 90276A581 11.96	
1   1	67 100 90276A265A 10.32 12:24 67 100 90276A269A 13.27 107 90276A287 3.36 204 10-32 100 90276A289A 13.27 107 90276A289 2.92 204	100_9027645514 5.22 2147 100_9027645934 14.70 100_9027645934 5.75 57 50.9027645954 9.33	
3"   100   90276A533   9.38     1/4"   100   90276A533   4.10     5/16"   100   90276A533   4.10     5/16"   100   90276A533   4.10     5/16"   100   90276A533   4.10     5/16"   100   90276A533   2.30     1/2"   100   90276A534   3.08     1/2"   100   90276A541   3.76     1/2"   100   90276A543   3.03     1/2"   100   90276A543   3.03     1/2"   100   90276A543	<sup>4</sup> N <sup>4</sup> 100 90276A826 161 W <sup>4</sup> 100 90276A293 283 3° 1 W <sup>4</sup> 100 90276A827 152 N <sup>4</sup> 100 90276A294 297 392° 1 N <sup>4</sup> 100 90276A828 2.07 1° 100 90276A296 3.47 4° 1	100 90276A6544 6.93 9' 50 90276A6034 14.23 100 90276A6074 8.10	
$\frac{1}{1} \underbrace{1}_{0} $	W 100 90276A930 169 116 100 90276A299 4.42 gr W 100 90276A331 2.03 27 100 90276A301 5.31 er	100, 9027646734 12,73 0/ 50 902764619 5.30 50 9027642704 7.97 1/ 1/00 90276422 12,41 50 902764274 9.81 1/ 1/00 902764424 12,83	
$\frac{1}{\sqrt{1}} \underbrace{1}{\sqrt{1}} \underbrace{1} \underbrace{1} \underbrace{1} \underbrace{1} $	17 100 902164033 2.35 2* 00 902164365 0.38 12* 1 114* 100 902164034 3.52 12* 00 902164353 0.38 12* 1 114* 100 902164033 2.59 14* 100 902164533 4.10 15*	100 902264557 4.03 9 50 902264532 8.97 100 902264550 5.26 9 50 902264384 12.62 100 902264561 5.52	
1   1	104* 100 900 F64336 2.69 Mv* 100 900 F64534 7.25 114* 104* 100 900 F6433 3.55 Mv* 100 900 F64515 2.30 2* 100 900 F6433 3.55 Mv* 100 900 F64515 2.30 2* 100 900 F64515 2.30 4*-16	50, 902 76A663 2.81 6 25 902 76A644A 9.33 50, 902 76A664 7.71 6 25 902 76A640A 10.78	
1/1/2   1/1/2 <td< th=""><th>214* 100 9023640846 53 14* 100 902364540 3.09 2* 1 214* 100 90236438414 6.95 14* 100 902364541 3.76 7* 100 9023643924 6.95 1* 100 902364542 3.10 4**</th><th>100 90226A578 5.83 1' 25 90276A712 11.21 100 90226A580 6.70 1'6<sup>y</sup> 25 90276A716 9.10</th><th>3″100<b>90276A305▲</b> 9.38</th></td<>	214* 100 9023640846 53 14* 100 902364540 3.09 2* 1 214* 100 90236438414 6.95 14* 100 902364541 3.76 7* 100 9023643924 6.95 1* 100 902364542 3.10 4**	100 90226A578 5.83 1' 25 90276A712 11.21 100 90226A580 6.70 1'6 <sup>y</sup> 25 90276A716 9.10	3″100 <b>90276A305▲</b> 9.38
All productions as stores bots, have a factor final stores on auth and another on auth and a factor of a fa	2 100 900 JEAD464 9.72 W 100 900 JEAD44 9.00 104 1	100 902 m 503 8.32 3" 10 90276A7244 5.20	TRACT TRACT
100   100   100   100   900   100   100   900   100   100   900   100   100   900   1	Also known as stove bolts, these zinc-plated steel round healt screws come w		
m   bit	5-40 B-32 (Cont.) 10-24 (C	Itý Per Pikg Lg Qtý Per Pikg. Cont3 597-207/Cont3	
min 100   90277480   2.56   11   100   902776A539   2.82     Min 100   902776A539   2.80   3.09   3.40   100   90276A534   3.09     Min 100   902776A53   9.50 </th <th>№     100     90232A473     3.79     10-24     2"     10       Ψ     100     90232A475     3.85     №     100     90232A500     3.00     2%"     10       Ψ     100     90232A475     3.85     №     100     90232A500     3.00     2%"     10       Ψ     100     90232A476     3.57     %"     100     90232A505     2.81     2"     10</th> <th>00 902324516 5.00 1/4 100 902324546 5.67 00 9023245204 7.37 144 100 902324546 6.48 00 9023245204 7.37 144 100 902324548 7.03</th> <th></th>	№     100     90232A473     3.79     10-24     2"     10       Ψ     100     90232A475     3.85     №     100     90232A500     3.00     2%"     10       Ψ     100     90232A475     3.85     №     100     90232A500     3.00     2%"     10       Ψ     100     90232A476     3.57     %"     100     90232A505     2.81     2"     10	00 902324516 5.00 1/4 100 902324546 5.67 00 9023245204 7.37 144 100 902324546 6.48 00 9023245204 7.37 144 100 902324548 7.03	
Round Head Phillips   Main and screw have a tricker head thm pan head, providing a deeper this and a finite beaning surface. Length three three and this is a heave at field that is a heave at field to be in the dealing surface. Length three three and the main and three three and the main as a heave at field to be in the dealing surface. Length three three and the main as a heave at field to be in the dealing surface. Length three three and the main as a heave at field to be in the dealing surface. Length three three and the main as a heave at field to be in the dealing surface. Length three three and the main as a heave at field to be in the dealing surface. Length three three and the main as a heave at field to be in the deal to be intered. The deal to be intered at the deal to be int	1/4* 100 90232A408 3.19 4/4* 100 90232A539 1.27 4/4* 10 3/4* 100 90232A490 3.75 1* 100 90232A540 3.50 1/2* 10 7* 100 90232A490 4.05 11/4* 100 90232A547 3.82 1/4* 10	00 90222A530 4.57 3* 106 90222A5564 8.97 00 90232A537 4.57 4* 100 90222A5564 13.00 0 90222A538 4.64 4*	사망 같은 것 같은 것은 것 같이 있다. 그는 것 같은 것은 것 같은 것 같은 것 같은 것 같은 것 같은 것 같은
Lg     Opsile     Per / Rig     Composition     State / State		00. 902324540 4.98 3 50 500 500 500 1.54	CD y constants
640   -60 cmw   340   -70 os   640   700   9173 Model   622   700   9173 Model   623   623   700   9173 Model   624   700   9173 Model	is measured from under freed. Sizes marked with a 4 have at least 11/2" of threa Pkg. Pkg. Pkg.		
Win 100   9377 JARG5   6.46   Win 100   9177 JARG5   6.48   Win 100   9177 JARG5   6.48   Win 100   9177 JARG5   6.48   Win 100   9177 JARG5   2.48   Win 100   9177 JARG5   6.53   11/s"   1000   902 76 A5 43   5.003     Win 100   9177 JARG5   9.48   Win 100   9177 JARG5   4.43   Win 100   9177 JARG5   6.54   Yin 100   9177 JARG5   9.37   10/s"   902 76 A5 44   S.003     Win 100   9177 JARG5   9.48   Win 100   9177 JARG5   6.48   Yin 100   9177 JARG5   9.37   10/s"   9.37   10/s"   9177 JARG5   9.	18-8 Stainless Steel 18-8 St 0-80-#1 Drive 3-40-#1 Drive 6-32 (Co	tainless Steel (Cont.) Cont.) 10-24-72 Drave	
3 <sup>w</sup> 100   91773A101   810   1 <sup>w</sup> 100   91773A101   230   w <sup>w</sup> 100   91773A101   530   920   937   930   93773A100   9377   937	Me* 100 91771A054 6.77 Me* 100 91773A084 6.72 Me* 1 We* 100 91773A055 5.00 Me* 100 91773A096 7.16 Me* 1 We* 100 91773A057 6.46 Me* 100 91773A096 7.16 Me* 1 We* 100 91773A057 6.46 Me* 100 91773A096 8.19 Me* 1	100_91773A145_2.72_%%_100_91773A240_4.26 100_91773A146_2.74_%%_100_91773A245_4.62	
mv   100   917/14mes   8.69   mv   100   917/34mes   8.70     mv   100   917/34mes   8.69   mv   100   917/34mes   8.71     mv   100   917/34mes   8.29   mv   100   917/34mes   8.62     mv   100   917/34mes   8.64   7   100   917/34mes   8.62     mv   100   917/34mes   8.64   7   50   917/34mes   8.64     mv   100   917/34mes   8.65   21//   50   917/34mes   2.94     mv   100   917/34mes   8.64   7   50   917/34mes   2.94     mv   100   917/34mes   8.64   7   50   917/34mes   2.94     mv   100   917/34mes   8.64   7   50   917/34mes   4.24     mv   100   917/34mes   3.33   mv   100   917/34mes   4.24     mv   100   917/34mes   3.33   mv   100   917/34mes   4.24     mv	44 100 91773A071 8 10 1 100 91773A101 12.07 44 17 100 91773A101 12.07 44 17 100 91773A107 10.92	100 91773A151 3.30 44" 100 91773A245 5.33 100 91773A152 3.40 1" 100 91773A247 6.19	
r*   50   917714115   6.811   Wur 100   917734109   2.51   2*   00   917734154   6.52   4.5   7*   50   9177342544   7.93   3.31     **   100   917734066   9.02   Wur 100   917734110   2.72   50   917734154   6.22   4*   10   9177342544   7.93   3.44     Wu 100   917734066   9.02   Wur 100   917734113   2.93   0.32   62   4*   10   9177342544   3.44     Wu 100   917734066   9.02   Wur 100   917734110   3.30   Wur 100   917734125   4.22     Wu 100   917734066   9.02   Wur 100   917734126   4.24   4.44 <td< th=""><th>%** 100 01773A165 8.66 %** 100 01773A105 2.49 144 1 %* 100 01773A166 8.66 %** 100 01773A106 2.33 144 1 %* 100 01773A168 9.29 %** 100 01773A107 2.41 195 1</th><th>100 91773A155 4.13 110' 100 91773A251 8.37 100 91773A157 4.76 110' 100 91773A252 9.52</th><th>134</th></td<>	%** 100 01773A165 8.66 %** 100 01773A105 2.49 144 1 %* 100 01773A166 8.66 %** 100 01773A106 2.33 144 1 %* 100 01773A168 9.29 %** 100 01773A107 2.41 195 1	100 91773A155 4.13 110' 100 91773A251 8.37 100 91773A157 4.76 110' 100 91773A252 9.52	134
W* 100   91773A066   9.02   W* 100   91773A173   5.93   W* 100   91773A174   4.22     W* 100   91773A076   9.65   Iff. 100   91773A176   3.30   W* 100   91773A176   4.24     W* 100   91773A116   0.53   Iff. 100   91773A176   3.30   W* 100   91773A176   4.24     W* 100   91773A116   0.59   Iff. 100   91773A119   3.20   W* 100   91773A126   4.24     W* 100   91773A116   0.51   Iff. 100   91773A119   3.21   W* 100   91773A126   4.26     W* 100   91773A116   0.51   91773A119   4.22   W* 100   91773A126   4.26     W* 100   91773A126   4.20   W* 100   91773A126   4.26   W* 100   91773A126   4.26     W* 100   91773A126   100   91773A126   4.26   W* 100   91773A126   4.26   W* 100   91773A126   4.26     W* 100   91773A126   100   91773A126   4.26   W* 100   91773A126   5.39     W* 100   91773A	T 50 91773A175 881 0 10 91773A109 2.61 200 1 T-72-40 2000 10 10 10 91773A109 2.61 200 1	100 01773A169 6.52 230" 50 01773A2664 7.89 100 01773A1614 9.64 3" 50 01773A2574 9.33 50 01773A2614 8.22 4" 10 01773A2614 3.44	
r   50   517/14/16   0.01   1/1/2 100   01/2 1/2 1/2 1/2 1/2 1/2 1/2 1/2 1/2 1/2	W 100 91773A066 9.02 W 100 9173A113 2.93 W 1 W 100 91773A068 9.66 * 100 91773A115 3.38 W 1 9 100 91773A070 10.53 1 0 91773A117 4.22 94 1	100 917734199 3.30 W* 100 917734825 4.22 100 917734190 3.31 9W* 100 917734826 4.24	
	256-01/20010 0071 449-01 000 017730110 4.72 497.1 256-01/2000 017730100 017730101 0.18 497.1 567.100 017730101 0.18 497.1	100 91773A192 3.41 92 150 91773A820 4.73 100 51773A194 3.73 92 100 51773A830 5.16 100 91773A196 4.12 92 100 51773A831 5.33	
THE PART OF THE PA	1/4 100 51773A077 2.44 1 6.0 51773A246 9.30 74 Net 100 51773A078 2.57 6.00 50 200m Wet 100 51773A078 2.57 Wet 100 91773A123 6.09	100 91773A198 4.96 1* 100 91773A833 6.19 100 91773A199 5.01 1/4* 100 91773A834 7.19	McMaster-Carr
10/ 100 917714001 3.39 W/ 100 91734126 6.58 W/ 100 917140201 6.70 11// 100 917740186 8.37 W/ 100 917714001 3.39 W/ 100 917134126 6.14 10// 100 917140201 6.56 1% 100 917740187 8.52	107 100 91774001 318 W 100 97774426 558 107 1 W 100 91774013 330 W 100 97774428 514 107 1 W 100 91774404 294 W 100 977744128 514 107 1	100 917734200 E.70 146" 100 917734136 8.37 100 917234204 7.56 146" 100 917724437 9.62 100 917334205 8.58 2* 100 917724438 0.62	www.mcmastar.com
Wr     100     917714406     2.94     4/r     100     917714406     2.94     4/r     100     917714406     2.94     1/r     100     9177142014     10.91     9177142014     10.91     9177142014     10.91     9177142014     8.04     0     9177142014     8.04     0     9177142014     8.04     0     9177142014     8.04     0     9177142014     8.04     0     9177142014     8.04     0     9177142014     8.04     0     9177142014     8.04     0     9177142014     8.04     0     9177142014     8.04     0     9177142014     8.04     0     9177142014     8.04     0     9177142014     8.04     0     9177142014     8.04     0     9177142014     8.04     0     9177142014     8.04     0     9177142014     8.04     0     9177142014	7/ 100 91771A085 2.94 1* 100 91771A133 12.04 2/1/ 1 1* 100 91771A187 1.17 6-32-#2 Duve	100_97773A2004_10.31_207_160_91773A040A_13.59 60_91773A2094_6.86_3*_60_91773A041A_8.04 10_97773A253A_3.41	www.mcmaster.com

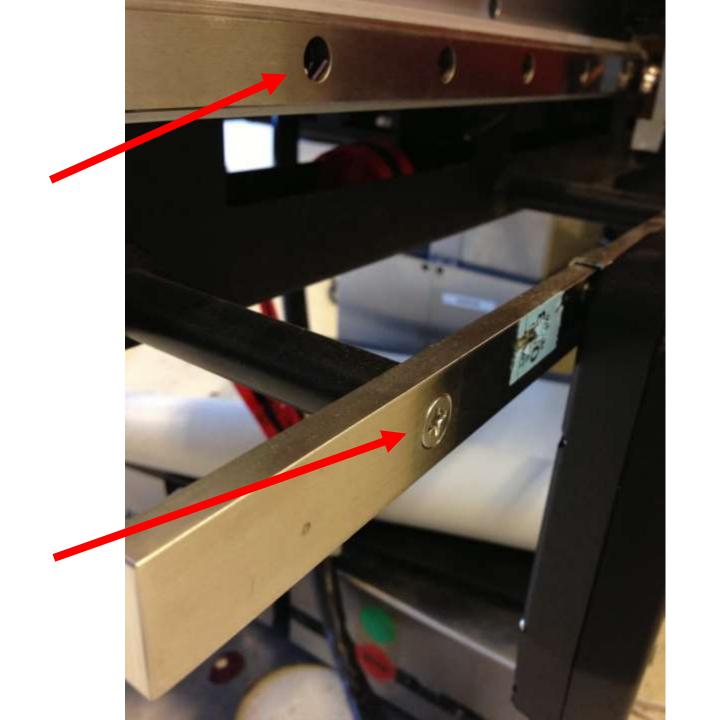
#### Name the Fastener:



#### Name the Fastener:

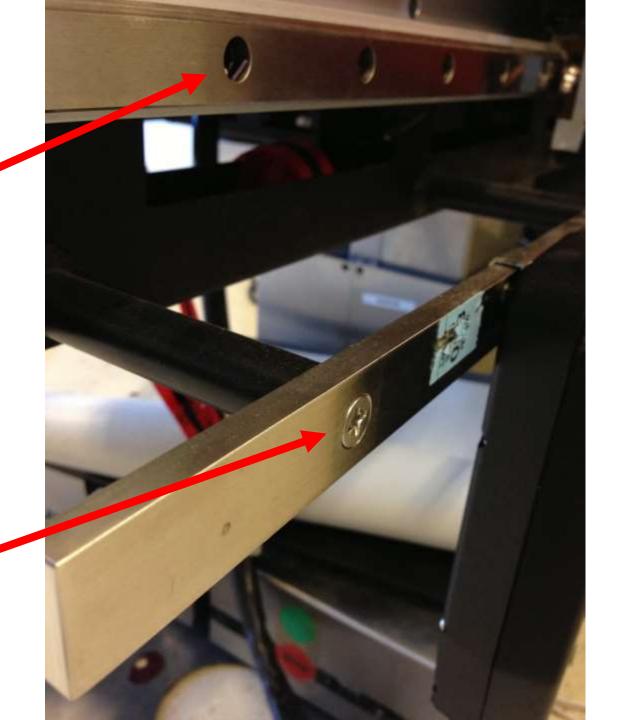


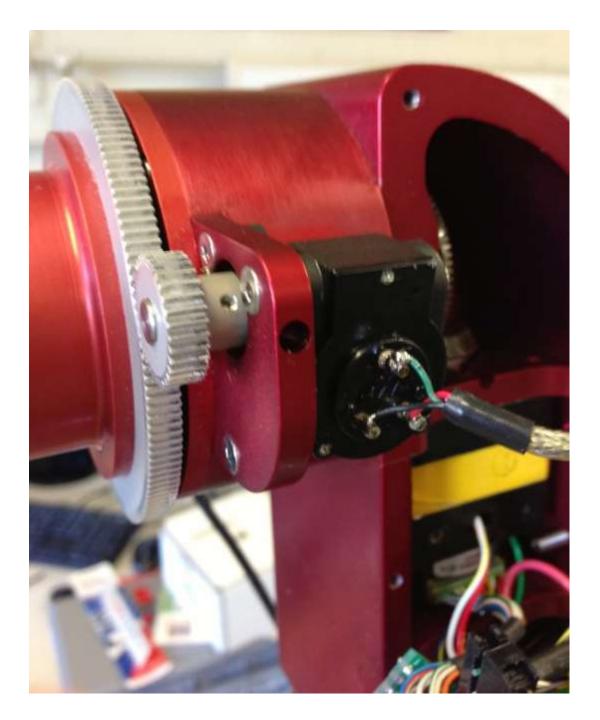
Socket Head Cap Screw with counterbore

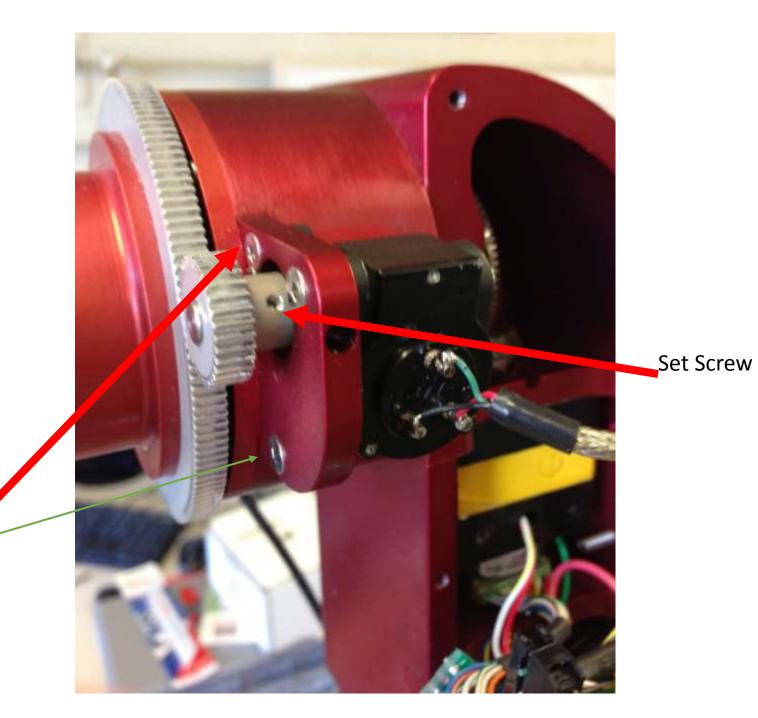


Socket Head Cap Screw with counterbore

Phillips Flat Head Screw with countersink

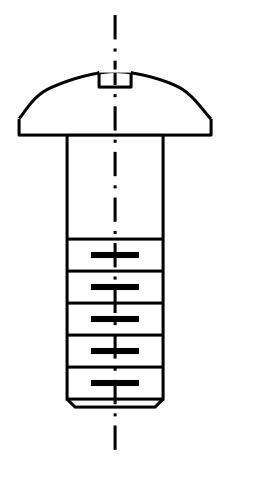


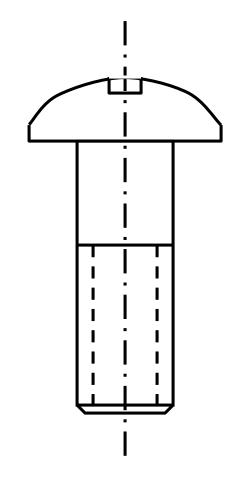




Countersunk, Phillips Flat head

### **Convention for screws**

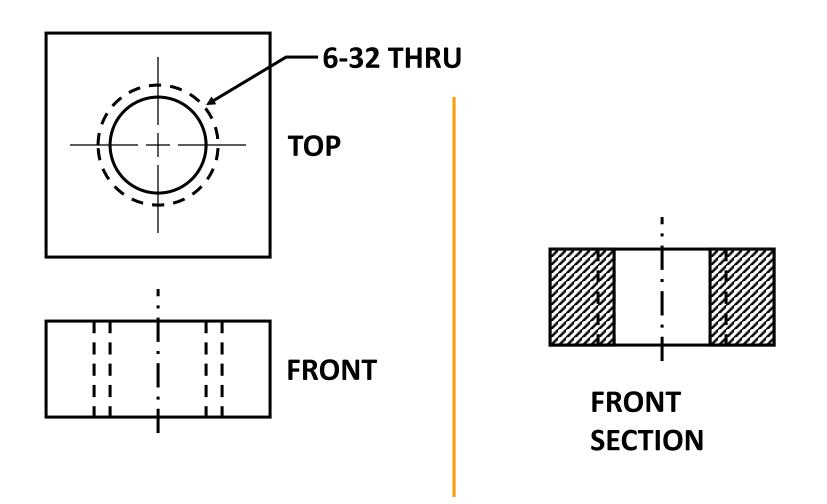




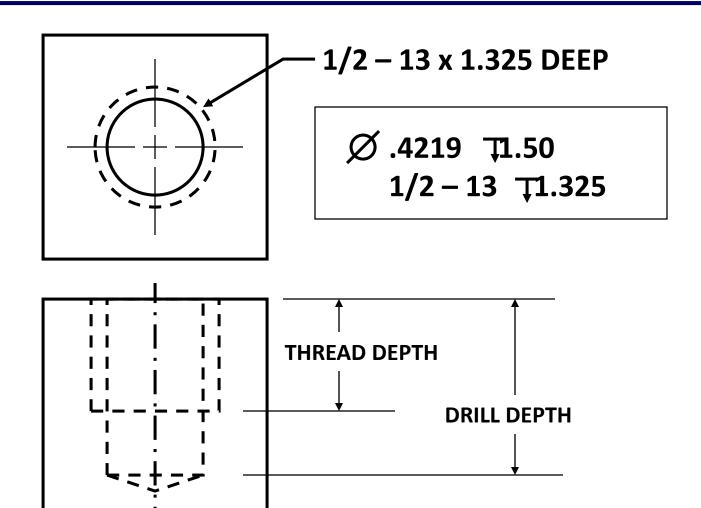
"SCHEMATIC"



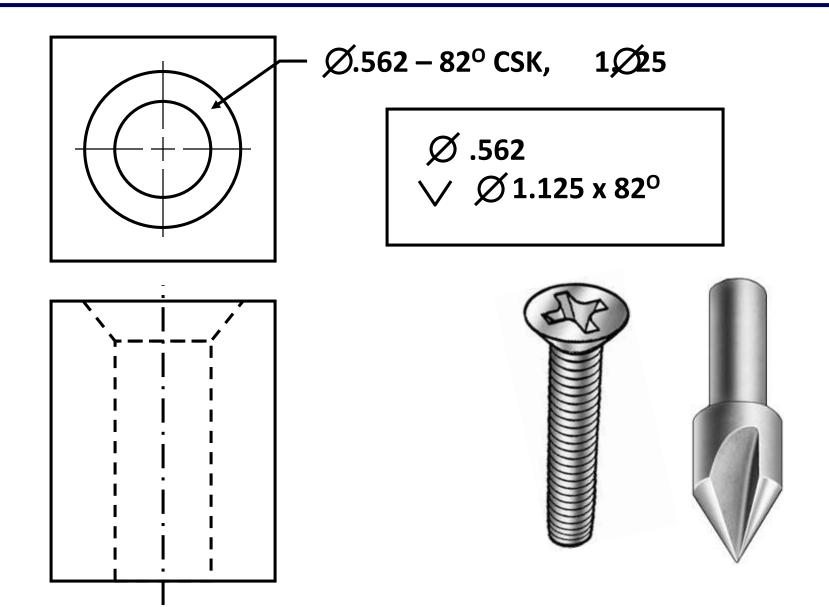
## **Convention for threaded holes**



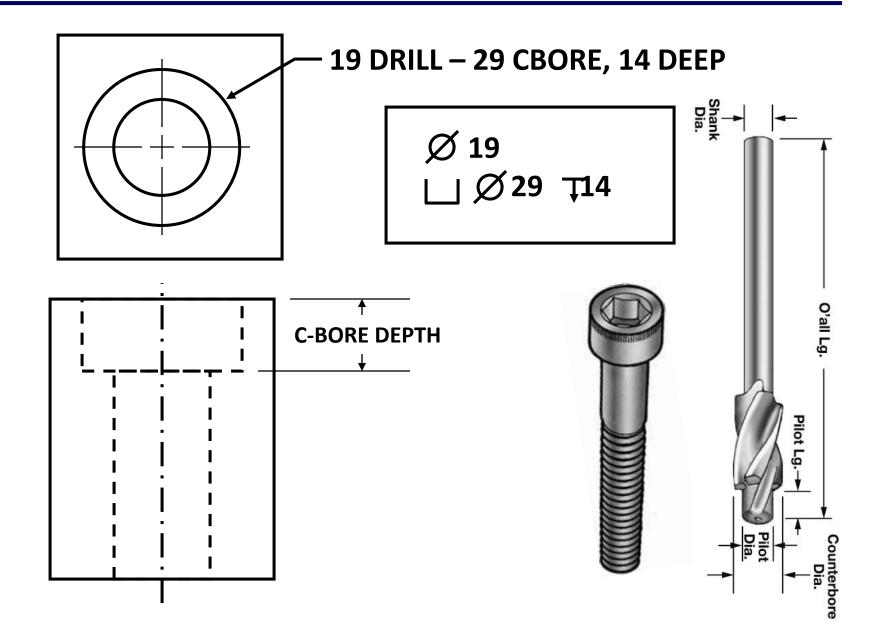
### Blind threaded holes

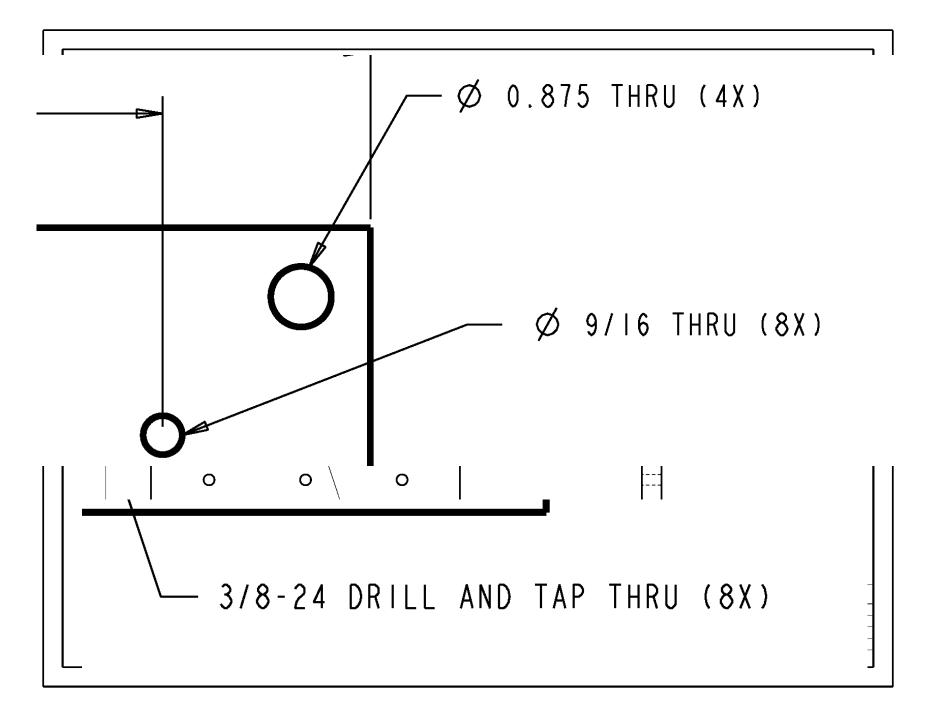


#### **Countersunk holes**



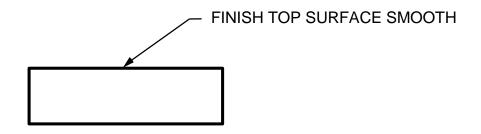
### **Counterbored holes**

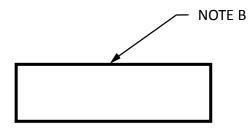




#### Other Items for Drawings

### Leaders & notes





# TITLE BLOCKS

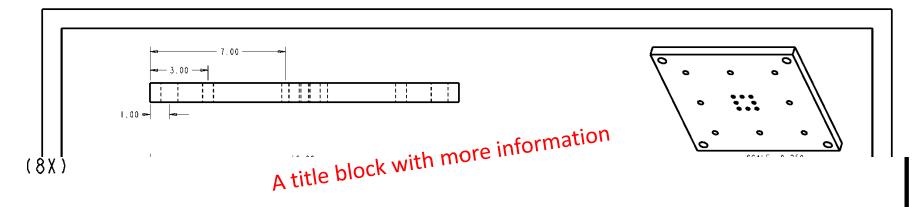
- Basic
  - Title
  - Name
  - Date
  - Units
- Optional
  - Company name, sheet number, scale, tolerances, material, finish....
- Follow your company standards

#### 10/2/2014 **ALL DIMENSIONS IN INCHES**

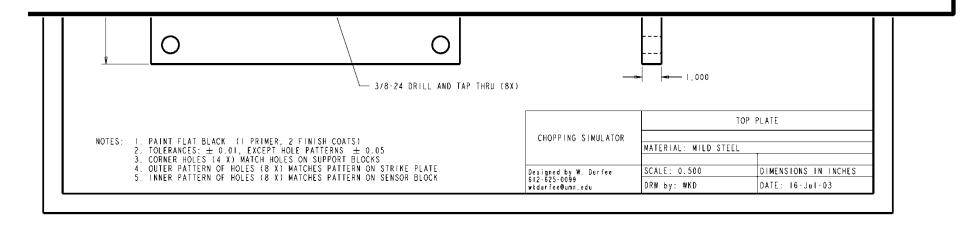
W. DURFEE

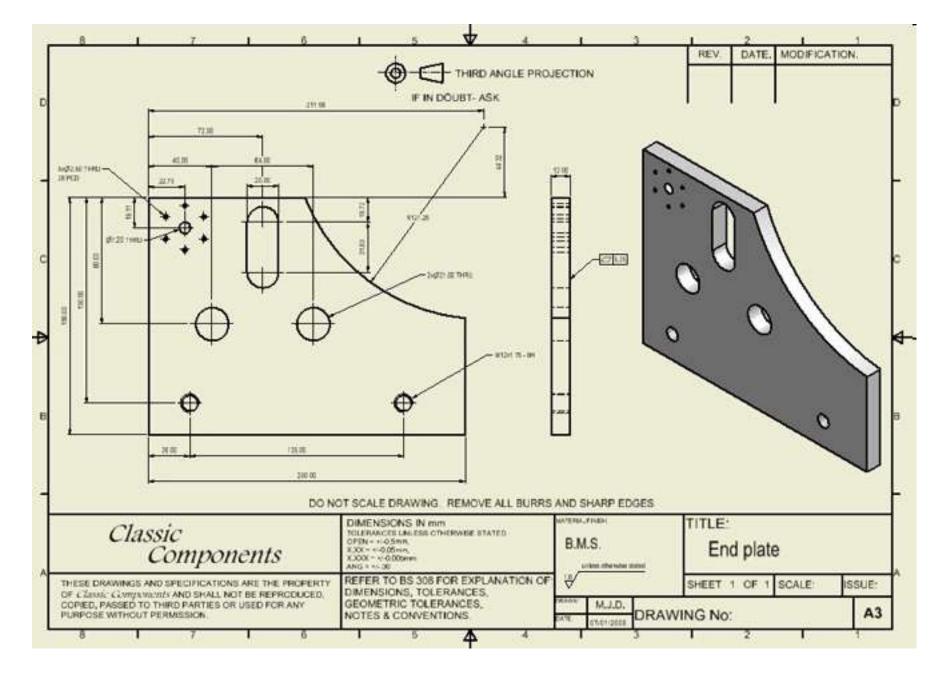
**MY PART** 

A basic title block



	TOP PLATE		
CHOPPING SIMULATOR	MATERIAL: MILD STEEL		
Designed by W. Durfee 612-625-0099 wkdurfee@rumn.edu	SCALE: 0.500 DRW by: WKD	DIMENSIONS IN INCHES DATE: 16-Jul-03	





#### A title block using a company template

www.classic-components.co.uk

## **Production Drawings**

Many types of drawings can be produced from the CAD database

