

Saturday, February 6, 2016 7:08 AM

**TITAN ROBOTICS CLUB
TEAM 492**



TITAN ROBOTICS ADVISORY COMMITTEE (TRAC)

ROBOTICS DESIGN AND FABRICATION REFERENCE NOTEBOOK

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Hole and Drill Sizes

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HOLE AND DRILL SIZES

- A. HOLE SIZE REFERENCE**
- B. COUNTERSINK FASTENER REFERENCE**
- C. FRACTIONAL DRILL SIZE EQUIVALENTS**
- D. NUMBERED DRILL SIZES (INCHES)**
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Hole Size Reference

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	Close Fit			Clearance			Loose Fit		
Fastener Size	Close Fit	Closest Drill Size	Closest Fractional	Close Fit	Closest Drill Size	Closest Fractional	Close Fit	Closest Drill Size	Closest Fractional
4	0.116	#33	1/8	0.129	#29	0.140	0.136	#29	9/64
6	0.144	#27	5/32	0.150	#20	0.172	0.170	#18	11/64
8	0.170	#18	11/64	0.177	#11	0.203	0.194	#10	13/64
10	0.196	#9	3/16	0.201	7/32	0.229	0.221	#2	7/32
1/4	0.257	F	1/4	0.266	K	0.291	0.281	K	9/32
5/16	0.323	P	21/64	0.332	11/32	0.354	0.344	S	11/32

	PEM Fasteners		Rivnut Fasteners	
Fastener Size	Closest Drill Size	Decimal Equiv	Closest Drill Size	Decimal Equiv
4	#19	0.166	--	--
6	3/16	0.1875	17/64	0.2656
8	#3	0.213	17/64	0.2656
10	1/4	0.25	19/64	0.2969
1/4	11/32	0.34375	25/64	0.3906
5/16	Z	0.413	17/32	0.5313

Drill and Tap Size Reference

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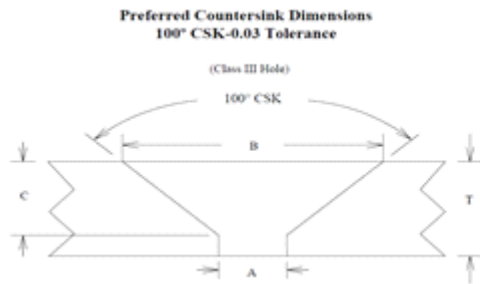


Fastener Size	UNC T/in	Drill Size	Dec Equiv	UNF T/in	Drill Size	Dec Equiv
0	N/A	N/A		80	3/64	0.04688
1	64	#53	0.0595	72	#53	0.0595
2	56	#50	0.07	64	#50	0.07
3	48	#47	0.0785	56	#45	0.082
4	40	#43	0.089	48	#42	0.0935
5	40	#38	0.1015	44	#37	0.104
6	32	#36	0.1065	40	#33	0.113
8	32	#29	0.136	36	#29	0.136
10	24	#25	0.15	32	#21	0.159
1/4	20	#7	0.201	28	#3	0.213
5/16	18	F	0.257	24	I	0.272

Countersink Fastener Reference

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Fastener Size	A		B		C		Min "T"
	Min	Max	Min	Max	Min	Max	
4	0.136	0.147	0.225	0.253	0.033	0.049	0.065
6	0.161	0.172	0.280	0.308	0.045	0.062	0.078
8	0.192	0.203	0.335	0.365	0.055	0.073	0.089
10	0.218	0.229	0.390	0.420	0.068	0.085	0.101
1/4	0.279	0.291	0.515	0.545	0.094	0.112	0.128
5/16	0.342	0.354	0.645	0.677	0.112	0.140	0.156

Fractional Drill Size Equivalents

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Frac	Decimal	Frac	Decimal	Frac	Decimal	Frac	Decimal
1/64	0.015625	17/64	0.265625	33/64	0.515625	49/64	0.765625
1/32	0.03125	9/32	0.28125	17/32	0.53125	25/32	0.78125
3/64	0.046875	19/64	0.296875	35/64	0.546875	51/64	0.796875
1/16	0.0625	5/16	0.3125	9/16	0.5625	13/16	0.8125
5/64	0.078125	21/64	0.328125	37/64	0.578125	53/64	0.828125
3/32	0.09375	11/32	0.34375	19/32	0.59375	27/32	0.84375
7/64	0.109375	23/64	0.359375	39/64	0.609375	55/64	0.859375
1/8	0.125	3/8	0.375	5/8	0.625	7/8	0.875
9/64	0.140625	25/64	0.390625	41/64	0.640625	57/64	0.890625
5/32	0.15625	13/32	0.40625	21/32	0.65625	29/32	0.90625
11/64	0.171875	27/64	0.421875	43/64	0.671875	59/64	0.921875
3/16	0.1875	7/16	0.4375	11/16	0.6875	15/16	0.9375
13/64	0.203125	29/64	0.453125	45/64	0.703125	61/64	0.953125
7/32	0.21875	15/32	0.46875	23/32	0.71875	31/32	0.96875
15/64	0.234375	31/64	0.484375	47/64	0.734375	63/64	0.984375
1/4	0.250	1/2	0.500	3/4	0.750	1	1.000

Pasted from <<http://www.newmantools.com/decinch.htm#fralink>>

Numbered Drill Sizes (inches)

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No.	Size of No. in Decimals	No.	Size of No. in Decimals	No.	Size of No. in Decimals	No.	Size of No. in Decimals
1	0.2280	21	0.1590	41	0.0960	61	0.0390
2	0.2210	22	0.1570	42	0.0935	62	0.0380
3	0.2130	23	0.1540	43	0.0890	63	0.0370
4	0.2090	24	0.1520	44	0.0860	64	0.0360
5	0.2055	25	0.1495	45	0.0820	65	0.0350
6	0.2040	26	0.1470	46	0.0810	66	0.0330
7	0.2010	27	0.1440	47	0.0785	67	0.0320
8	0.1990	28	0.1405	48	0.0760	68	0.0310
9	0.1960	29	0.1360	49	0.0730	69	0.02925
10	0.1935	30	0.1285	50	0.0700	70	0.0280
11	0.1910	31	0.1200	51	0.0670	71	0.0260
12	0.1890	32	0.1160	52	0.0635	72	0.0250
13	0.1850	33	0.1130	53	0.0595	73	0.0240
14	0.1820	34	0.1110	54	0.0550	74	0.0225
15	0.1800	35	0.1100	55	0.0520	75	0.0210
16	0.1770	36	0.1065	56	0.0465	76	0.0200
17	0.1730	37	0.1040	57	0.0430	77	0.0180
18	0.1695	38	0.1015	58	0.0420	78	0.0160
19	0.1660	39	0.0995	59	0.0410	79	0.0145
20	0.1610	40	0.0980	60	0.0400	80	0.0135

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Letter Drill Sizes (inches)

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Letter	Decimal	Letter	Decimal
A	0.234	N	0.302
B	0.238	O	0.316
C	0.242	P	0.323
D	0.246	Q	0.332
E	0.250	R	0.339
F	0.257	S	0.348
G	0.261	T	0.358
H	0.266	U	0.368
I	0.272	V	0.377
J	0.277	W	0.386
K	0.281	X	0.397
L	0.290	Y	0.404
M	0.295	Z	0.413

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Monday, January 1, 2018 10:02 AM

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Material Specifications

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MATERIAL SPECIFICATIONS

- A. SHEET METAL THICKNESS GAUGES**
- B. BEND RADIUS FOR ALUMINUM**
- C. GUIDE TO ALUMINUM**
- D. WHAT IS 80/20?**
- E. PVC PIPE REFERENCE DIMENSIONS**

Sheet Metal Thickness Gauges

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Sheet Metal Thickness Gauges

[Steel data](#) from [Caloritech](#), for heavier gauges also from [Engineer's Edge](#). Aluminum data from Festiva Tech.

Gauge (ga)	Standard Steel Thickness (inches)	Galvanized Steel Thickness (inches)	Aluminum Thickness (inches)
3	0.2391		0.2294
4	0.2242		0.2043
5	0.2092		0.1819
6	0.1943		0.1620
7	0.1793		0.1443
8	0.1644		0.1285
9	0.1495	0.1532	0.1144
10	0.1345	0.1382	0.1019
11	0.1196	0.1233	0.0907
12	0.1046	0.1084	0.0808
13	0.0897	0.0934	0.0720
14	0.0747	0.0785	0.0641
15	0.0673	0.0710	0.0571
16	0.0598	0.0635	0.0508
17	0.0538	0.0575	0.0453
18	0.0478	0.0516	0.0403
19	0.0418	0.0456	0.0359
20	0.0359	0.0396	0.0320
21	0.0329	0.0366	0.0285
22	0.0299	0.0336	0.0253
23	0.0269	0.0306	0.0226
24	0.0239	0.0276	0.0201
25	0.0209	0.0247	0.0179
26	0.0179	0.0217	0.0159
27	0.0164	0.0202	0.0142
28	0.0149	0.0187	0.0126
29	0.0135	0.0172	0.0113
30	0.0120	0.0157	0.0100

Pasted from <<http://www.unc.edu/~rowlett/units/scales/sheetmetal.html>>

Bend Radius for Aluminum

Thursday, December 21, 2017 9:53 PM

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APPROXIMATE MINIMUM RADII FOR 90° COLD BEND

Where range is shown, use smaller radius with extreme caution.

ALLOY	TEMPER	RADII' For Various Thicknesses Expresses in Terms of Thickness "t"							
		1/64 Inch	1/32 Inch	1/16 Inch	1/8 Inch	3/16 Inch	1/4 Inch	3/8 Inch	1/2 Inch
1100	-O	O	O	O	O	O	O	O	1t-2t
	-H12	O	O	O	O	O-1t	O-1t	O-1t	1t-3t
	-H14	O	O	O	O	O-1t	O-1t	O-1t	2t-3t
	-H16	O	O	O-1t	1/2t-1-1/2t	1t-2t	1-1/2t-3t	2-1/2t-3-1/2t	3t-4t
	-H18	O-1t	1/2-1-1/2t	1t-2t	1-1/2t-3t	2t-4t	2t-4t	3t-5t	3t-6t
Alclad	-O	O	O	O	O	O-1t	O-1t	1-1/2t-3t	3t-5t
	-T3	1t-2t	1-1/2t-3t	2t-4t	3t-5t	4t-6t	4t-6t	5t-7t	5-1/2t-8t
	-T4	1t-2t	1-1/2t-3t	2t-4t	3t-5t	4t-6t	4t-6t	5t-7t	5-1/2t-8t
2014	-T6	2t-4t	3t-5t	3t-5t	4t-6t	5t-7t	6t-10t	7t-10t	8t-11t
	-O ²	O	O	O	O	O-1t	O-1t	1-1/2t-3t	3t-5t
2024	-T3 ²³	1-1/2t-3t	2t-4t	3t-5t	4t-6t	4t-6t	5t-7t	6t-8t	6t-9t
	-36 ²	2t-4t	3t-5t	4t-6t	5t-7t	5t-7t	6t-10t	7t-10t	8t-11t
	-T42	1-1/2t-3t	2t-4t	3t-5t	4t-6t	4t-6t	5t-7t	6t-8t	6t-9t
	-T81	3-1/2t-5t	4-1/2t-6t	5t-7t	6-1/2t-8t	7t-9t	8t-10t	9t-11t	9t-12t
	-T86	4t-5-1/2t	5t-7t	6t-8t	7t-10t	8t-11t	10t-13t	10t-13t	1t-2t
	-O	O	O	O	O	O	O	O	1t-2t
3003	-H12	O	O	O	O	O-1t	O-1t	O-1t	1t-3t
	-H14	O	O	O	O-1t	O-1t	1/2t-1-1/2t	1t-2-1/2t	1-1/2t-3t
	-H16	O-1t	O1t	1/2t-1-1/2t	1t-2t	1-1/2t-3t	2t-4t	1-1/2t-4t	3t-5t
	-H18	1/2t-1-1/2t	1t-2t	1-1/2t-3t	2t-4t	3t-5t	4t-6t	4t-7t	5t-8t
	-O	O	O	O	O	O-1t	O-1t	1/2t-1-1/2t	1t-2t
5052	-H32	O	O	O	O-1t	O-1t	1/2t-1-1/2t	1t-2t	1-1/2t-2-1/2t
	-H34	O	O	O-1t	1/2t-1-1/2t	1t-2t	1-1/2t-3t	2t-3t	2-1/2t-3-1/2t
	-H36	O-1t	1/2t-1-1/2t	1t-2t	1-1/2t-3t	2t-4t	2t-4t	2-1/2t-5t	3t-5-1/2t
	-H38	1/2t-1-1/2t	1t-2t	1-1/2t-3t	2t-4t	3t-5t	4t-6t	4t-7t	5t-8t
	-O	O	O	O	O	O-1t	O-1t	1/2t-2t	1t-1-1/2t
6061	-T4 ²	O-1t	O-1t	1/2t-1-1/2t	1t-2t	1-1/2t-3t	2t-4t	2-1/2t-4t	3t-5t
	-T6 ²	O-1t	1/2t-1-1/2t	1t-2t	1-1/2t-3t	2t-4t	3t-4t	3-1/2t-5-1/2t	4t-6t
7075	-O	O	O	O-1t	1/2t-1-1/2t	1t-2t	1-1/2t-3t	2-1/2t-4t	3t-5t
	-T6 ²	2t-4t	3t-5t	4t-6t	5t-7t	5t-7t	6t10t	7t-11t	7t-12t

1. Minimum permissible radius over which sheet or plate may be bent varies with nature of forming operation, type of forming equipment, and design and conditions of tools. Minimum working radius for a given material or hardest alloy and temper for a given radius can be ascertained only by actual trial under contemplated conditions of fabrication. Where range is shown, use a smaller radius with extreme caution.

2. Alclad sheet can be bent over slightly smaller radii than the corresponding tempers of the uncoated alloy.

3. Immediately after quenching, this alloy can be formed over appreciable smaller radii. 4217661360076962

Guide to Aluminum

Saturday, December 9, 2017 8:39 AM

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Next to steel, Aluminum is the most commonly used and commercially available metal. Its light weight and high strength-to-weight ratio make it a good choice for everything from aircraft to flashlights to jigs to just about anything else you can make out of metal.

Pure aluminum, primarily seen in the 1xxx series of wrought aluminum alloys, has little strength, but possesses high electrical conductivity, reflectivity, and corrosion resistance. For this reason, a wide variety of aluminum alloys have been developed.

OnlineMetals.com currently stocks eight alloys of aluminum in various shapes and sizes:

- [1100 Aluminum](#) (available in Sheet)
- [2011 Aluminum](#) (available in Hex, Round)
- [2024 Aluminum](#) (available in Hex, Plate, Rectangle, Round, Sheet, Square, Tube)
- [3003 Aluminum](#) (available in Sheet)
- [5052 Aluminum](#) (available in Sheet)
- [5086 Aluminum](#) (available in Sheet, Plate)
- [6060 Aluminum](#) (available in Rectangle, Rectangle Tube, Round, Sheet, Square, Square Tube, Tube)
- [6061 Aluminum](#) (available in Angle, Channel, Hex, I-Beam, Pipe, Plate, Rectangle, Rectangle Tube, Round, Sheet, Square, Square Tube, Tube)
- [6063 Aluminum](#) (available in Angle, Channel, Pipe, Rectangle, Rectangle Tube, Round, Square Tube, Tube)
- [6101 Aluminum](#) (available in Pipe, Rectangle)
- [6262 Aluminum](#) (available in Hex, Round)
- [7075 Aluminum](#) (available in Hex, Plate, Rectangle, Round, Sheet, Square)

Aluminum Comparison

Sunday, December 24, 2017 6:55 AM

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	Ultimate (PSI)	Yeild (PSI)	Corrosion Resistance	Formable	Machinable	Weldable
<u>1100 Aluminum</u>	18,000	13,800	Superior	Superior		Highly
<u>2011 Aluminum</u>	55,000	43,000	Low		Excellent	Average
<u>2024 Aluminum</u>	70,000	50,000	Low		Average	Low
<u>3003 Aluminum</u>	22,000	21,000	Superior	Highly		Highly
<u>5052 Aluminum</u>	33,000	28,000				
<u>5086 Aluminum</u>	42,000	30,000				
<u>6060 Aluminum</u>	32,000	24,000				
<u>6061 Aluminum</u>	45,000	40,000				
<u>6063 Aluminum</u>	27,000	21,000				
<u>6101 Aluminum</u>	32,000	28,000				
<u>6262 Aluminum</u>	31,900	27,600				
<u>7075 Aluminum</u>	83,000	73,000				

1100 Aluminum

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1100-H14 Aluminum Sheet is known for its superior corrosion resistance, formability, conductivity and high weldability.

It is not often used as a high strength or hardness item like the 2024 alloy; rather it is used for chemical equipment, decorative trim and heat exchangers. It is nonmagnetic and not heat treatable.

1100-H14 Aluminum

Minimum Properties	Ultimate Tensile Strength, psi	18,000
	Yield Strength, psi	13,800
	Brinell Hardness	32
	Rockwell Hardness	--
Chemistry	Aluminum (Al)	99-99.95%
	Silicon (Si)	0-1%
	Iron (Fe)	0-1%
	Copper (Cu)	0.05%- 0.2%
	Zinc (Zn)	0-0.1%
	Manganese (Mn)	0 - 0.05%
	Residuals	0-.15%

2011 Aluminum

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2011 is the most machinable of the commonly available aluminum alloys. Machining this alloy can produce excellent surface finishes on your product, and small, broken chips.

Weldability, strength, and anodizing response are all rated as average at best, and this alloy does not have a high degree of corrosion resistance.

If the ability to make your part quickly is important to you, and strength is not the primary desire, 2011 represents a good choice if you're using aluminum.

2011-T3 Aluminum

Minimum Properties	Ultimate Tensile Strength, psi	55,000
	Yield Strength, psi	43,000
	Brinell Hardness	95
	Rockwell Hardness	B60
Chemistry	Aluminum (Al)	91.2 - 94.6%
	Bismuth (Bi)	0.2 - 0.6%
	Copper (Cu)	5.0 - 6.0%
	Iron (Fe)	0.7% max
	Magnesium (Mg)	2.1 - 2.9%
	Lead (Pb)	0.2 - 0.6%
	Silicon (Si)	0.4% max

2024 Aluminum

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Copper is the main alloying ingredient in 2024. It is very strong compared to most aluminum alloys, and has average machinability, but the copper component of this alloy makes it susceptible to corrosion (many items in this alloy are produced with a clad surface to protect the underlying material.) In addition, 2024 is not considered to be weldable.

Finally, the fatigue resistance of 2024 make it a primary choice when the application is expected to be under stress or strain for prolonged periods. It is commonly used in aerospace applications.

2024-T3 Aluminum

Minimum Properties	Ultimate Tensile Strength, psi	70,000
	Yield Strength, psi	50,000
	Brinell Hardness	120
	Rockwell Hardness	B75
Chemistry	Aluminum (Al)	90.7 - 94.7%
	Chromium (Cr)	0.1% max
	Copper (Cu)	3.8 - 4.9%
	Iron (Fe)	0.5% max
	Magnesium (Mg)	1.2 - 1.8%
	Manganese (Mn)	0.3 - 0.9%
	Silicon (Si)	0.5% max

3003 Aluminum

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Aluminum Sheet 3003 H14 Bare is an excellent choice for chemical equipment and general sheet metal projects due to its superior corrosion resistance and good workability. Aluminum 3003 H14 bare sheet works well in fabrication and decorative architectural uses because it is highly workable, formable, and weldable, while being capable of withstanding outdoor weather.

3003-H14 Aluminum

Minimum Properties	Ultimate Tensile Strength, psi	22,000
	Yield Strength, psi	21,000
	Brinell Hardness	40
	Rockwell Hardness	--
Chemistry	Aluminum (Al)	96.8-99%
	Manganese (Mn)	1-1.5%
	Iron (Fe)	0-0.7%
	Silicon (Si)	0- 0.6%
	Copper (Cu)	0.05-0.2%
	Zinc (Zn)	0 - 0.1%
	Residuals	0-0.15%

5052 Aluminum

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5052 is the alloy most suited to forming operations, with good workability and higher strength than that of the 1100 or 3003 alloys that are commercially available.

5052 is not heat-treatable, but is stronger than most of the 5xxx series of alloys. It has very good corrosion resistance, and can be easily welded. 5052 is not a good choice for extensive machining operations, as it has only a fair machinability rating.

5052-H32 Aluminum

Minimum Properties	Ultimate Tensile Strength, psi	33,000
	Yield Strength, psi	28,000
	Brinell Hardness	60
Chemistry	Aluminum (Al)	95.7 - 97.7%
	Chromium (Cr)	0.15 - 0.35%
	Copper (Cu)	0.1% max
	Iron (Fe)	0.4% max
	Magnesium (Mg)	2.2 - 2.8%
	Manganese (Mn)	0.1% max
	Silicon (Si)	0.25% max

5086 Aluminum

Saturday, December 9, 2017 8:40 AM

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5086-H32 Aluminum Sheet is frequently found in marine applications, with higher strength capacity than Aluminum Alloy 5052 or Aluminum Alloy 5083. Aluminum Alloy 5086 has superior corrosion resistance and good formability. Aluminum Alloy 5086 is non-magnetic and heat treatable

5086-H32 Aluminum

Minimum Properties	Ultimate Tensile Strength, psi	42,000
	Yield Strength, psi	30,000
	Brinell Hardness	80
Chemistry	Aluminum (Al)	93 - 96.3%
	Magnesium (Mg)	3.5-4.5%
	Manganese (Mn)	0.2-0.7%
	Iron (Fe)	0-0.5%
	Silicon (Si)	0-0.4%
	Chromium (Cr)	0.05-0.25%
	Zinc (Zn)	0-0.25%
	Titanium (Ti)	0-0.15%
Copper (Cu)	0-0.1%	

6060 Aluminum

Saturday, December 9, 2017 8:40 AM



6060 Aluminum is a medium strength alloy more closely related to 6063 than to 6061 but will have more magnesium than 6063. This alloy is mainly found in Europe with metric sizes and is commonly heat treated to a temper with higher strength but low ductility. 6060 alloy is very good for anodizing

The main alloy ingredients of 6060 aluminum are magnesium and silicon.

6060-T6 Aluminum

Physical and Mechanical Properties	Ultimate Tensile Strength, psi	32,000
	Yield Strength, psi	24,000
	Brinell Hardness	60
	Rockwell Hardness	--
Chemistry	Aluminum (Al)	97.9 - 99.3%
	Magnesium (Mg)	0.35-0.6%
	Silicon (Si)	0.3-0.6%
	Iron (Fe)	0.1-0.3%
	Zinc (Zn)	0 -0.15%
	Manganese (Mn)	0-0.1%
	Titanium (Ti)	0- 0.1%
	Copper (Cu)	0-0.1%
Chromium (Cr)	0-0.50%	

6061 Aluminum

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TEAM 492



6061 Aluminum is, by most any measure, the most commonly used aluminum alloy. It is specified in most any application due to its strength, heat treatability, comparatively easy machining, and weldability. If that were not enough, it is also capable of being anodized, adding a layer of protection for finished parts.

The main alloy ingredients of 6061 aluminum are magnesium and silicon.

6061-T6 Aluminum

Physical and Mechanical Properties	Ultimate Tensile Strength, psi	45,000
	Yield Strength, psi	40,000
	Brinell Hardness	95
	Rockwell Hardness	B60
Chemistry	Aluminum (Al)	95.8 - 98.6%
	Chromium (Cr)	0.04 - 0.35%
	Copper (Cu)	0.15 - 0.40%
	Iron (Fe)	0.70%
	Magnesium (Mg)	0.8 - 1.2%
	Manganese (Mn)	0.15% max
	Silicon (Si)	0.4 - 0.8%
	Zinc (Zn)	0.25%

6063 Aluminum

Saturday, December 9, 2017 9:27 AM

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6063 is often called architectural aluminum for two reasons - first, it has a surface finish that is far smoother than the other commercially available alloys, and second, its strength is significantly less (roughly half the strength of 6061), making it suited for applications where strength is not the foremost consideration.

6063 is rated as "Good" for forming and cold working operations, "Excellent" for anodizing, and "Fair" for machining.

6063-T52 Aluminum

Minimum Properties	Ultimate Tensile Strength, psi	27,000
	Yield Strength, psi	21,000
	Brinell Hardness	60
Chemistry	Aluminum (Al)	97.5% max
	Chromium (Cr)	0.1% max
	Copper (Cu)	0.1% max
	Iron (Fe)	0.35% max
	Magnesium (Mg)	0.45 - 0.90%
	Manganese (Mn)	0.1% max
	Silicon (Si)	0.2 - 0.6%

6101 Aluminum

Saturday, December 9, 2017 9:27 AM

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6101 is best suited for applications involving moderate strength and maximum electrical conductivity. It is similar to alloy 6063, but with minor chemistry changes which enhance electrical conductivity. Although slightly lower in conductivity than alloy 1350, it offers greater strength. Its most typical application is bus bar.

6101-T6 Aluminum

Physical and Mechanical Properties	Ultimate Tensile Strength, psi	32,000
	Yield Strength, psi	28,000
	Brinell Hardness	71
	Electrical Conductivity	57% IACS
Chemistry	Aluminum (Al)	97.6%
	Chromium (Cr)	0.03%
	Copper (Cu)	0.10%
	Iron (Fe)	0.50%
	Magnesium (Mg)	0.35 - 0.80%
	Manganese (Mn)	0.03% max
	Silicon (Si)	0.3 - 0.7%
	Boron (Si)	0.06%

6262 Aluminum

Saturday, December 9, 2017 9:28 AM

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6262 was designed as an aluminum alloy for operations where significant machining is required. It contains lead and bismuth to help with chip creation and breakage, as well as to partially lubricate the cutting tool. It is generally regarded as having good strength and corrosion resistance. Finished parts can be produced with a high level of polishing.

6262-T6511 Aluminum

Minimum Properties	Ultimate Tensile Strength, psi	31,900
	Yield Strength, psi	27,600
	Brinell Hardness	71
Chemistry	Aluminum (Al)	94.6 - 97.8%
	Chromium (Cr)	0.04 - 0.14%
	Copper (Cu)	0.15 - 0.40%
	Iron (Fe)	0.7% max
	Magnesium (Mg)	0.8 - 1.2%
	Manganese (Mn)	0.15% Max
	Bismuth (Bi)	0.4 - 0.7%
	Silicon (Si)	0.4 - 0.8%
	Lead (Pb)	0.4 - 0.7%

7075 Aluminum

Saturday, December 9, 2017 9:28 AM

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7075 is the other "aircraft grade" aluminum that is carried by OnlineMetals. Its principal alloying ingredients are zinc and copper, which make it one of the highest-strength aluminum alloys that are available. In fact, its typical strength in the T6 temper is higher than most mild steels.

7075 also has average-to-good ratings for machinability, corrosion resistance, and anodizing response. Like 2024, however, it is not considered to be weldable.

7075-T6 Aluminum

Physical and Mechanical Properties	Ultimate Tensile Strength, psi	83,000
	Yield Strength, psi	73,000
	Brinell Hardness	150
	Rockwell Hardness	B87
Chemistry	Aluminum (Al)	87.1 - 91.4%
	Zinc (Zn)	5.1 - 6.1% max
	Copper (Cu)	1.2 - 2.0%
	Chromium (Cr)	0.18 - 0.28%
	Iron (Fe)	0.5 max
	Magnesium (Mg)	2.1 - 2.9%
	Manganese (Mn)	0.3% max

What is 80/20?

Thursday, January 11, 2018 7:17 PM

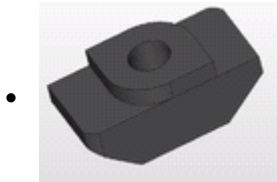


80/20 is a [framing system](#) using [extruded](#) beams of [6105-T5 aluminum alloy](#). The integral [T-slots](#) create the foundation for the profile's assembly technology. Accessories are also available, which are specific to each framing system. Many of these accessories are made in-house, while most of the specialty products, such as panels and casters, are made by third party companies.

Profiles

Both metric and inch (fractional) profiles are available.

Profile type	Profile name	Profile size	Distance from edge of profile to centerline of T-slot
fractional	10 series	1"	0.5"
	15 series	1.5"	0.75"
metric	20 series	20 mm	10 mm
	25 series	25 mm	12.5 mm
	30 series	30 mm	15 mm
	40 series	40 mm	20 mm
	45 Series	45 mm	22.5 mm



CAD model of a rotating [T-nut](#) used with aluminum T-slots/ T-track/ extrusions

Uses

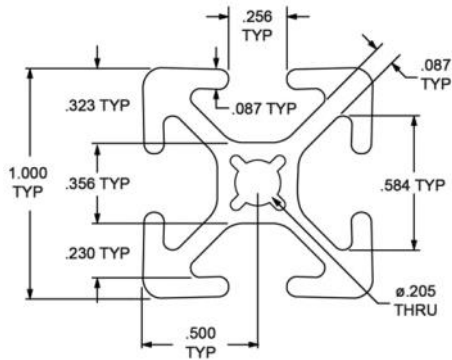
When making a structure that requires substantial structural integrity, is not under high vibrating loads or forces and does not have to be super-precise then aluminium extrusions are the way to go. (Here we are talking about precision under 0,1mm (0.03")). Most common uses are for enclosures, guards, working stations, machine structures. There are also a lot of industrial machines that have their entire frame built out of these profiles. In automation and mechatronics they are also common.

From <[https://en.wikipedia.org/wiki/80/20_\(framing_system\)](https://en.wikipedia.org/wiki/80/20_(framing_system))>

80/20 Extrusions

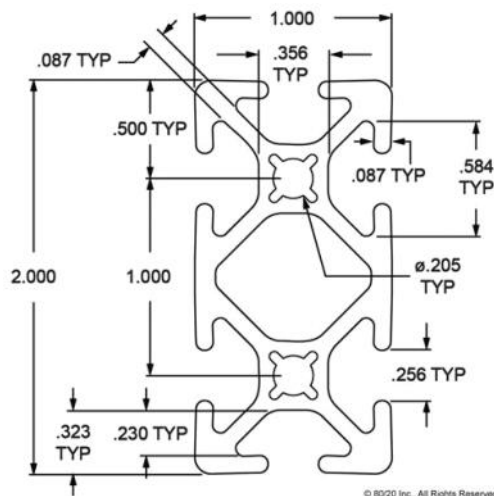
Thursday, January 11, 2018 6:53 PM

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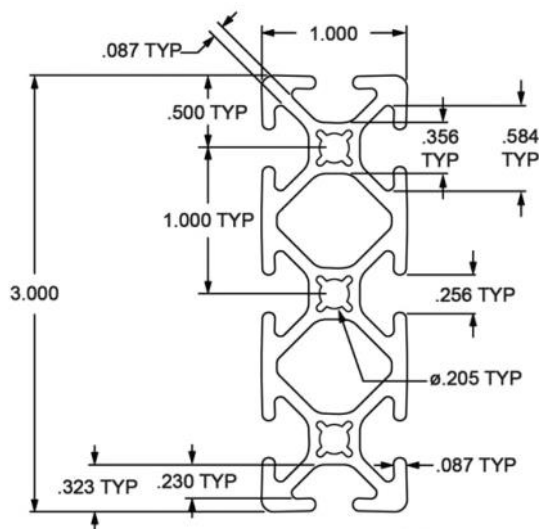
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Series	10
Length	per inch
Material	Aluminum
Grade	6105-T5
Finish	Anodize #204-R1
Yield Strength	35,000 psi
Modulus of Elasticity	10,200,000 Lbs / Sq. In.
Weight lbs	0.0424 per inch



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Series	10
Length	per inch
Material	Aluminum
Grade	6105-T5
Finish	Anodize #204-R1
Yield Strength	35,000 psi
Modulus of Elasticity	10,200,000 Lbs / Sq. In.
Weight lbs	0.0763 per inch



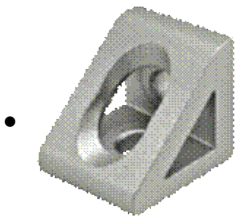
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Series	10
Length	per inch
Material	Aluminum
Grade	6105-T5
Finish	Anodize #204-R1
Yield Strength	35,000 psi
Modulus of Elasticity	10,200,000 Lbs / Sq. In.
Weight lbs	0.1101 per inch

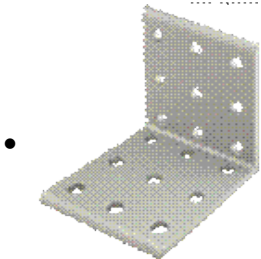
Plates and Brackets (Page 1)

Thursday, January 11, 2018 6:57 PM

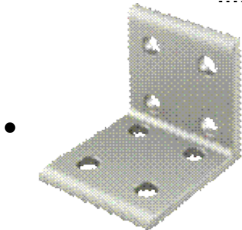
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TEAM 492



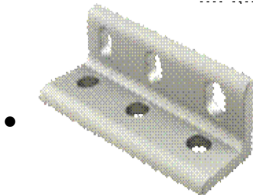
- [10 Series 2 Hole - Gusseted
Inside Corner Bracket](#)
[Part Number: 4132](#)
\$3.95



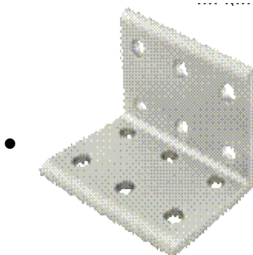
- [10 Series 18 Hole - Inside
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[Part Number: 4017](#)
\$7.95



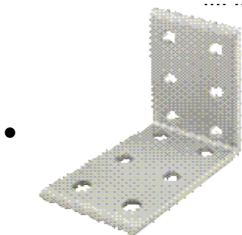
- [10 Series 8 Hole - Inside
Corner Bracket](#)
[Part Number: 4114](#)
\$5.35



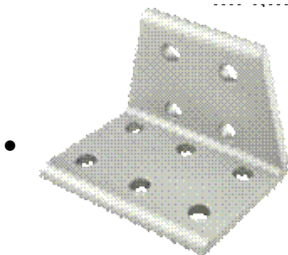
- [10 Series 6 Hole - Wide Slotted
Inside Corner Bracket](#)
[Part Number: 4266](#)
\$7.65



- [10 Series 12 Hole - Wide Inside
Corner Bracket](#)
[Part Number: 4016](#)
\$6.60



- [10 Series 12 Hole - Tall Inside
Corner Bracket](#)
[Part Number: 4014](#)
\$6.60

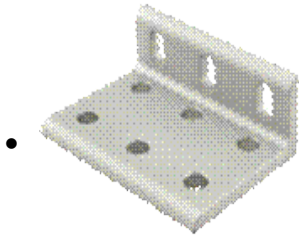


- [10 Series 10 Hole - Inside
Corner Bracket](#)
[Part Number: 4020](#)
\$8.95

Plates and Brackets (Page 2)

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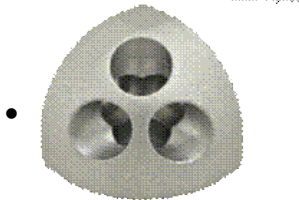
TITAN ROBOTICS CLUB
TEAM 492



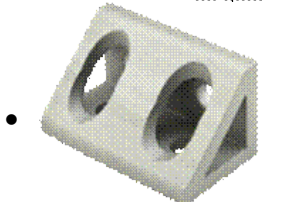
- [10 Series 9 Hole - Slotted Inside Corner Bracket](#)
[Part Number: 4251](#)
\$9.30



- [10 Series 10 Hole - Inside Corner Bracket](#)
[Part Number: 4020-Black](#)
\$9.97



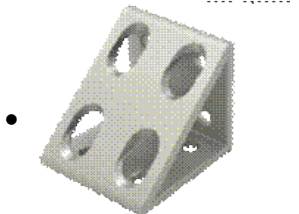
- [10 Series 3 Way - Rounded Corner Connector](#)
[Part Number: 4041](#)
\$19.95



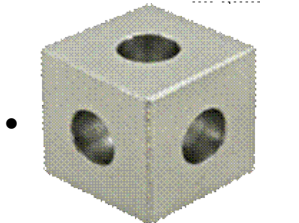
- [10 Series 4 Hole - Wide Gusseted Inside Corner Bracket](#)
[Part Number: 4134](#)
\$5.65



- [10 Series 4 Hole - Tall Gusseted Inside Corner Bracket](#)
[Part Number: 4136](#)
\$5.65



- [10 Series 8 Hole - Gusseted Inside Corner Bracket](#)
[Part Number: 4138](#)
\$7.45

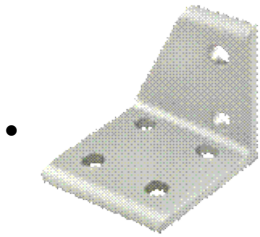


- [10 Series 3 Way - Squared Corner Connector](#)
[Part Number: 4042](#)
\$17.85

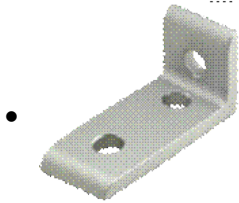
Plates and Brackets (Page 3)

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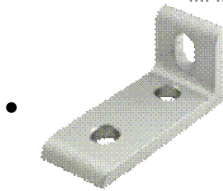
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TEAM 492



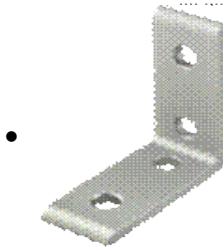
[10 Series 6 Hole - Right Aligned Inside Corner Bracket](#)
[Part Number: 4121](#)
\$6.55



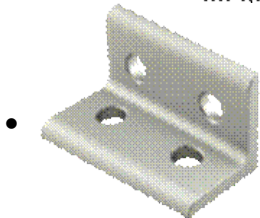
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[Part Number: 4176](#)
\$3.85



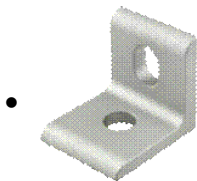
[10 Series 3 Hole - Slotted Inside Corner Bracket](#)
[Part Number: 4250](#)
\$4.50



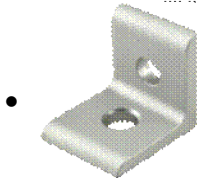
[10 Series 4 Hole - Tall Inside Corner Bracket](#)
[Part Number: 4115](#)
\$4.05



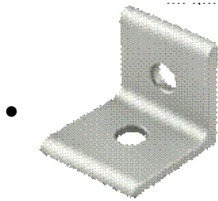
[10 Series 4 Hole - Wide Inside Corner Bracket](#)
[Part Number: 4113](#)
\$4.05



[10 Series 2 Hole - Slotted Inside Corner Bracket](#)
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\$3.55



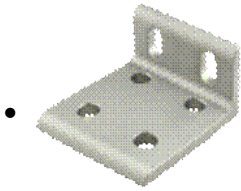
[10 Series 2 Hole - Inside Corner Bracket](#)
[Part Number: 4119](#)
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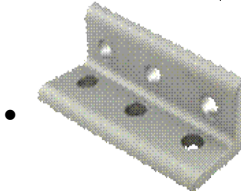
[10 Series 2 Hole - Lite Inside Corner Bracket](#)
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Plates and Brackets (Page 4)

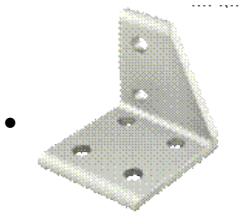
Thursday, January 11, 2018 7:13 PM



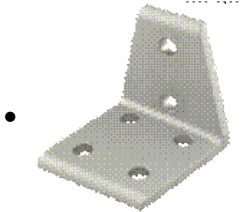
[10 Series 6 Hole - Wide 2x4
Slotted Inside Corner Bracket](#)
[Part Number: 4286](#)
\$6.90



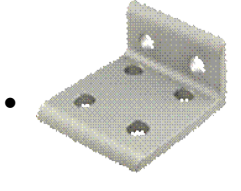
[10 Series 6 Hole - Wide 3x3
Inside Corner Bracket](#)
[Part Number: 4015](#)
\$5.20



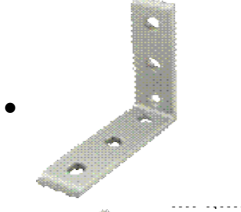
[10 Series 6 Hole - Left Aligned
Inside Corner Bracket](#)
[Part Number: 4122](#)
\$6.55



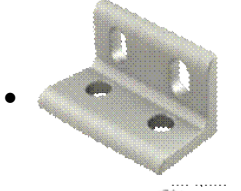
[10 Series 6 Hole - Center
Inside Corner Bracket](#)
[Part Number: 4111](#)
\$6.90



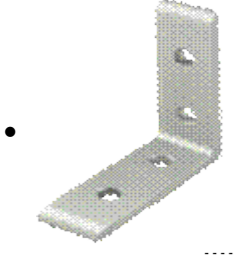
[10 Series 6 Hole - Wide 2x4
Inside Corner Bracket](#)
[Part Number: 4175](#)
\$5.40



[10 Series 6 Hole - Tall Inside
Corner Bracket](#)
[Part Number: 4013](#)
\$5.20



[10 Series 4 Hole - Wide Slotted
Inside Corner Bracket](#)
[Part Number: 4260](#)
\$5.60



[10 Series 4 Hole - Tall Lite
Inside Corner Bracket](#)
[Part Number: 4101](#)
\$4.10

PVC Pipe Reference Dimensions

Friday, March 15, 2013 9:02 AM

**TITAN ROBOTICS CLUB
TEAM 492**



PVC and CPVC Pipes - Schedule 40					
Nominal Pipe Size	Outside Diameter	Minimum Wall Thickness	Nominal Inside Diameter	Weight	
<i>(inches)</i>	<i>(inches)</i>	<i>(inches)</i>	<i>(inches)</i>	<i>(lb/100 ft)</i>	
				PVC	CPVC
1/2	0.84	0.109	0.622	16	17
3/4	1.05	0.113	0.824	21	23
1	1.315	0.133	1.049	32	34
1 1/4	1.66	0.14	1.38	43	46
1 1/2	1.9	0.145	1.61	51	55
2	2.375	0.154	2.067	68	74
2 1/2	2.875	0.203	2.469	107	118
3	3.5	0.216	3.068	141	154
4	4.5	0.237	4.026	201	220
5	5.563	0.258	5.047	273	
6	6.625	0.28	6.065	353	386
8	8.625	0.322	7.981	539	581
10	10.75	0.365	10.02	755	824
12	12.75	0.406	11.938	1001	1089
PVC and CPVC Pipes - Schedule 80					
Nominal Pipe Size	Outside Diameter	Minimum Wall Thickness	Nominal Inside Diameter	Weight	
<i>(inches)</i>	<i>(inches)</i>	<i>(inches)</i>	<i>(inches)</i>	<i>(lb/100 ft)</i>	
				PVC	CPVC
1/2	0.84	0.147	0.546	20	22
3/4	1.05	0.154	0.742	27	30
1	1.315	0.179	0.957	41	44
1 1/4	1.66	0.191	1.278	52	61
1 1/2	1.9	0.2	1.5	67	74
2	2.375	0.218	1.939	95	102
2 1/2	2.875	0.276	2.323	145	156
3	3.5	0.3	2.9	194	209
4	4.5	0.337	3.826	275	305
5	5.563	0.375	4.813	387	
6	6.625	0.432	5.761	542	582
8	8.625	0.5	7.625	805	883
10	10.75	0.593	9.564	1200	1309
12	12.75	0.687	11.376	1650	180



TOOL AND TOOL ACCESS

- A. SAE HEX ALLEN WRENCH REFERENCE**
- B. METRIC ALLEN WRENCH REFERENCE**
- C. SAE SOCKET WRENCH ACCESS REFERENCE**
- D. METRIC SOCKET WRENCH ACCESS REFERENCE**
- E. SAE NUTDRIVER ACCESS REFERENCE**
- F. OPEN END WRENCH CLEARANCE**
- G. 12-POINT BOX END WRENCH CLEARANCE**
- H. ADJUSTABLE WRENCHES**
 - I. DRIVERS**
- J. PLIERS**
- K. VISE GRIP PLIERS**
- L. CUTTERS**
- M. FILE**
- N. PUNCHES**
- O. DEBURRING TOOL**
- P. CHAIN BREAKER TOOL**
- Q. HAMMERS AND MALLOTS**
- R. TAPS, DIES & TAP HANDLES**
- S. MEASURING**
- T. SQUARES**

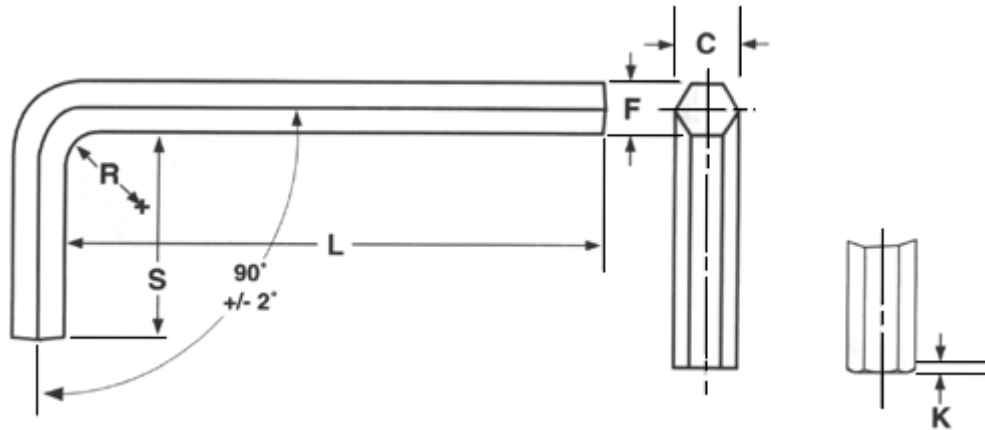
SAE Hex Allen Wrench Reference

Friday, March 15, 2013 1:05 PM

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TEAM 492



Hex Wrench



Nominal Key Size	F		C		S		L				R	K
	Hexagon Width Across Flats		Hexagon Width Across Corner		Length of Short Arm		Length of Long Arm				Radius of Bend	Chamfer
	Max	Min	Max	Min	Max	Min	Short Series		Long Series			
							Max	Min	Max	Min	Min	Max
0.028	0.0280	0.0275	0.0314	0.0300	0.312	0.125	1.312	1.125	2.688	2.500	0.062	0.003
0.035	0.0350	0.0345	0.0393	0.0378	0.438	0.250	1.312	1.125	2.766	2.578	0.062	0.004
0.050	0.0500	0.0490	0.0560	0.0540	0.625	0.438	1.750	1.562	2.938	2.750	0.062	0.006
1/16	0.0625	0.0615	0.0701	0.0680	0.656	0.469	1.844	1.656	3.094	2.906	0.062	0.008
5/64	0.0781	0.0771	0.0880	0.0859	0.703	0.516	1.969	1.781	3.281	3.094	0.078	0.008
3/32	0.0937	0.0927	0.1058	0.1035	0.750	0.562	2.094	1.906	3.469	3.281	0.094	0.009
7/64	0.1094	0.1079	0.1238	0.1210	0.797	0.609	2.219	2.031	3.656	3.469	0.109	0.014
1/8	0.1250	0.1235	0.1418	0.1390	0.844	0.656	2.344	2.156	3.844	3.656	0.125	0.015
9/64	0.1406	0.1391	0.1593	0.1566	0.891	0.703	2.469	2.281	4.031	3.844	0.141	0.016
5/32	0.1562	0.1547	0.1774	0.1745	0.938	0.750	2.594	2.406	4.219	4.031	0.156	0.016
3/16	0.1875	0.1860	0.2135	0.2105	1.031	0.844	2.844	2.656	4.594	4.406	0.188	0.022
7/32	0.2187	0.2172	0.2490	0.2460	1.125	0.938	3.094	2.906	4.969	4.781	0.219	0.024
1/4	0.2500	0.2485	0.2845	0.2815	1.219	1.031	3.344	3.156	5.344	5.156	0.250	0.030
5/16	0.3125	0.3110	0.3570	0.3531	1.344	1.156	3.844	3.656	6.094	5.906	0.312	0.032
3/8	0.3750	0.3735	0.4285	0.4238	1.469	1.281	4.344	4.156	6.844	6.656	0.375	0.044
7/16	0.4375	0.4355	0.5005	0.4944	1.594	1.406	4.844	4.656	7.594	7.406	0.438	0.047
1/2	0.5000	0.4975	0.5715	0.5650	1.719	1.531	5.344	5.156	8.344	8.156	0.500	0.050
9/16	0.5625	0.5600	0.6420	0.6356	1.844	1.656	5.844	5.656	9.094	8.906	0.562	0.053
5/8	0.6250	0.6225	0.7146	0.7080	1.969	1.781	6.344	6.156	9.844	9.656	0.625	0.055
3/4	0.7500	0.7470	0.8580	0.8512	2.219	2.031	7.344	7.156	11.344	11.156	0.750	0.070
7/8	0.8750	0.8720	1.0020	0.9931	2.469	2.281	8.344	8.156	12.844	12.656	0.875	0.076
1	1.0000	0.9970	1.1470	1.1350	2.719	2.531	9.344	9.156	14.344	14.156	1.000	0.081

Pasted from <<http://www.americanfastener.com/fasteners/sockets.asp>>

Metric Hex Allen Wrench Reference

Monday, January 12, 2015 9:43 PM

TITAN ROBOTICS CLUB
TEAM 492

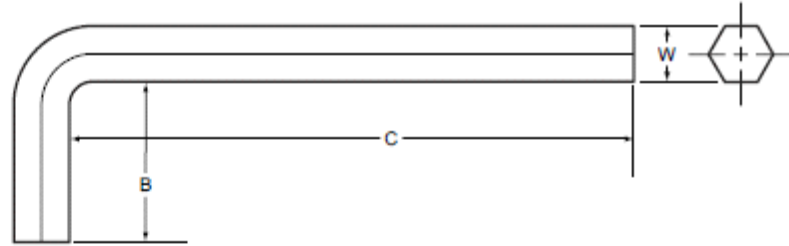


These UNBRAKO keys are made to higher requirements than ISO or DIN keys, which may not properly torque Class 12.9 cap screws. The strength and dimensional requirements are necessary to properly install the products in this catalog.

Material: ANSI B18.3.2.M alloy steel

Dimensions: ANSI B18.3.2.M

Similar Specifications: DIN 911, ISO 2936



METRIC KEY APPLICATION CHART

size W	socket cap screws		socket cap screws	flat head socket cap screws	button head shoulder screws	socket set screws
	std. head height	low head				
0.7 0.9 1.3						M1.6 M2 M2.5
1.5 2.0 2.5	M1.6/M2 M2.5 M3		M3 M4	M3 M4		M3 M4 M5
3.0 4.0 5.0	M4 M5 M6	M4 M5 M6	M5 M6 M8	M5 M6 M8	M6 M8 M10	M6 M8 M10
6.0 8.0 10.0	M8 M10 M12	M8 M10 M12	M10 M12 M16	M10 M12 M16	M12 M16 M20	M12 M16 M20
12.0 14.0 17.0	M14 M16 M20	M16 M20 M24	M20 M24		M24	M24
19.0 22.0 27.0	M24 M30 M36					
32.0 36.0	M42 M48					

DIMENSIONS

MECHANICAL PROPERTIES

key size W		B nominal	C nominal		torsional shear strength minimum		torsional yield strength minimum	
max.	min.		short arm	long arm	N-m	In-lbs.	N-m	In-lbs.
0.711 0.889 1.270	0.698 0.876 1.244	5.5 9 13.5	31 31 42	*69 71 75	0.12 0.26 0.73	1.1 2.3 6.5	0.1 0.23 .63	0.9 2. 5.6
1.500 2.000 2.500	1.470 1.970 2.470	14 16 18	45 50 56	78 83 90	1.19 2.9 5.4	10.5 26 48	1.02 2.4 4.4	9. 21 39
3.000 4.000 5.000	2.960 3.960 4.960	20 25 28	63 70 80	100 106 118	9.3 22.2 42.7	82 196 378	8. 18.8 36.8	71 166 326
6.000 8.000 10.000	5.960 7.950 9.950	32 36 40	90 100 112	140 160 170	74 183 345	655 1,620 3,050	64 158 296	566 1,400 2,620
12.000 14.000 17.000	11.950 13.930 16.930	45 55 60	125 140 160	212 236 250	634 945 1,690	5,610 8,360 15,000	546 813 1,450	4,830 7,200 12,800
19.000 22.000 24.000	18.930 21.930 23.930	70 80 90	180 *200 *224	280 *335 *375	2,360 3,670 4,140	20,900 32,500 36,600	2,030 3,160 3,560	18,000 28,000 31,500
27.000 32.000 36.000	26.820 31.820 35.820	100 125 140	*250 *315 *355	*500 *630 *710	5,870 8,320 11,800	51,900 73,600 104,000	5,050 7,150 10,200	44,700 63,300 90,300

All dimensions in millimeters.
*Non-stock sizes

SAE Socket Wrench Access Ref

Friday, March 15, 2013 12:51 PM

TITAN ROBOTICS CLUB
TEAM 492



Socket Wrench Access Requirement (Dia)		
Socket Size	Socket End	Base End
1/4	0.380	0.453
9/32	0.417	0.453
5/16	0.449	0.449
11/32	0.496	0.496
3/8	0.553	0.553
7/16	0.656	0.656
1/2	0.691	0.691
9/16	0.756	0.756
5/8	0.837	0.837
11/16	0.909	0.909
3/4	0.988	0.988



Size [in]	Nut End Outside Diameter [in]	Drive end Outside Diameter [in]	Nut Depth [in]	Overall Length [in]
3/16	5/16	15/32	9/64	63/64
7/32	23/64	15/32	11/64	63/64
1/4	3/8	15/32	3/16	63/64
9/32	7/16	15/32	5/32	63/64
5/16	15/32	15/32	5/32	63/64
11/32	33/64	33/64	11/64	63/64
3/8	43/64	43/64	11/64	63/64
7/16	5/8	5/8	15/64	63/64
1/2	45/64	45/64	9/32	63/64
9/16	47/64	47/64	21/64	63/64

Pasted from <http://www.protoindustrial.com/en/industrial-tools/Expert/Hand-Sockets/Sockets/0577274f-7902-451b-883a-07f031e951b5_Expert-1%7c4%22-Drive-Sockets---12-Point/>

Metric Socket Wrench Access Ref

Thursday, May 09, 2013 6:53 PM

TITAN ROBOTICS CLUB
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Size [mm]	Nut End Outside Diameter [in]	Drive end Outside Diameter [in]	Nut Depth [in]	Bolt Clearance Depth [in]	Overall Length [in]
4	5/16	15/32	11/64	1/2	7/8
4.5	5/16	15/32	11/64	1/2	7/8
5	5/16	15/32	11/64	1/2	7/8
5.5	21/64	15/32	11/64	1/2	7/8
6	3/8	15/32	7/32	1/2	7/8
7	27/64	15/32	1/4	9/16	7/8
8	15/32	15/32	19/64	35/64	7/8
9	33/64	33/64	23/64	35/64	7/8
10	37/64	37/64	23/64	35/64	7/8
11	5/8	5/8	23/64	35/64	7/8
12	21/32	21/32	23/64	35/64	7/8
13	11/16	11/16	23/64	35/64	7/8
14	3/4	3/4	23/64	9/16	7/8
15	13/16	13/16	23/64	17/32	7/8

Pasted from <<http://www.protoindustrial.com/en/industrial-tools/Proto/Hand-Sockets/Socket/dff7efb6-c8d2-4f1d-9e80-3e1c6aded93f> Proto%20ae-1%7c4%22-Drive-Metric-Sockets---12-Point/>

Combination Wrench Access Ref

Thursday, May 09, 2013 6:58 PM

TITAN ROBOTICS CLUB
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Size [in]	Outside Head Width 1 [in]	Outside Head Width 2 [in]
1/4	39/64	27/64
9/32		29/64
5/16	45/64	33/64
11/32	25/32	17/32
3/8	13/16	39/64
7/16	15/16	43/64
1/2	1-5/16	49/64
9/16	1-3/16	3/4
5/8	1-21/64	15/16
11/16	1-29/64	1-1/64
3/4	1-37/64	1-3/32
13/16	1-11/16	1-11/64
7/8	1-13/16	1-1/4
15/16	1-29/32	1-27/64
1	2-1/64	1-13/32

Pasted from <http://www.protoindustrial.com/en/industrial-tools/Proto/Wrenches/Combination-Wrenches/90c3103a-763c-4ae8-9e8a-687bb37dedb1_Proto%20ae-Satin-Combination-Wrenches---12-Point/>

SAE Nutdriver Access Ref

Thursday, May 09, 2013 7:08 PM

TITAN ROBOTICS CLUB
TEAM 492



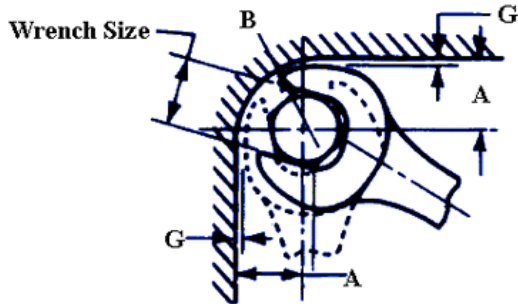
Size [in]	Shank Length [in]	Handle Length [in]	Overall Length [in]
3/16	3-11/64	4-15/64	7-3/8
9/32	3-13/64	4-15/64	7-3/8
1/4	3-3/16	4-15/64	7-3/8
5/16	3-5/32	4-1/4	7-3/8
11/32	3-3/16	4-15/64	7-3/8
3/8	3-13/64	4-1/4	7-3/8
7/16	3-5/32	4-1/4	7-3/8
1/2	3-11/64	4-15/64	7-3/8

Pasted from <http://www.protoindustrial.com/en/industrial-tools/BlackhawkByProto/Screwdrivers-%26-Hex-Keys/Nut-Drivers/8ed8d16b-939f-4de7-9a2f-ba7d4bb823f9> Blackhawk%e2%84%a2-by-Proto%c2%ae-Standard-Nutdrivers/>

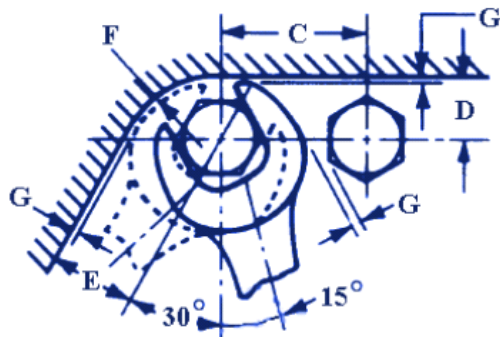
Open End Wrench Clearance

Sunday, December 24, 2017 7:11 AM

TITAN ROBOTICS CLUB
TEAM 492



90 Degree Installation



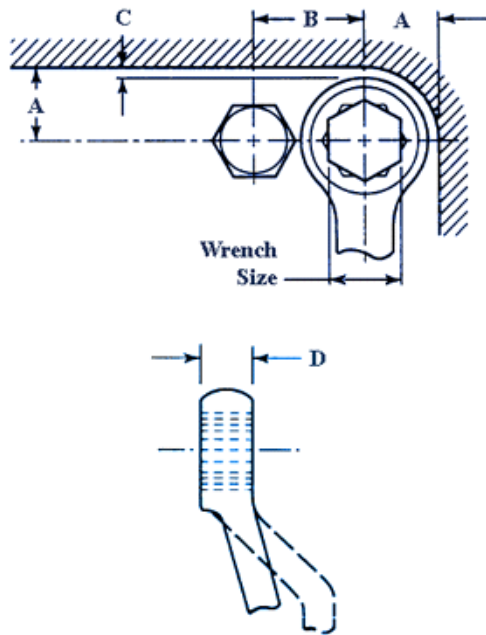
120 Degree + Installation

Wrench Size	Bolt Center Wall Clearance Min	Wall Radius Max	Min Bolt Spacing	Bolt Center Wall Clearance Min	Bolt Center Wall Clearance Max	Wall Rad Max	Ref Wrench End Clearance	Wrench Thickness or Width Max
	A	B	C	D	E	F	G	H
3/16	.250	.250	.430	.190	.270	.230	.030	.172
1/4	.280	.340	.530	.270	.310	.310	.030	.203
5/16	.380	.470	.660	.280	.390	.390	.050	.203
11/32	.420	.500	.750	.340	.450	.450	.050	.203
3/8	.420	.500	.780	.360	.450	.520	.050	.219
7/16	.470	.590	.890	.420	.520	.640	.050	.250
1/2	.520	.640	1.000	.470	.580	.660	.050	.266
9/16	.590	.770	1.130	.520	.660	.700	.050	.297
5/8	.640	.830	1.239	.550	.700	.700	.050	.344
11/16	.770	.920	1.470	.660	.880	.800	.060	.375
3/4	.770	.920	1.510	.670	.880	.800	.060	.375

12-Point Box Wrench Clearance

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TITAN ROBOTICS CLUB
TEAM 492



Note: All dimensions are in inches

Wrench Size	Bolt Center - Wall Clearance Min	Min Bolt Spacing	Min Recommended Wrench-Wall Clearance	Wrench Thickness Max
1/4	.270	.410	.030	.250
5/16	.300	.480	.030	.281
11/32	.300	.500	.030	.281
3/8	.340	.560	.030	.344
7/16	.400	.650	.030	.359
1/2	.450	.740	.030	.375
9/16	.500	.830	.030	.406
5/8	.560	.920	.030	.469
11/16	.590	.990	.030	.469
3/4	.660	1.090	.030	.594

Adjustable Wrenches

Sunday, December 24, 2017 8:43 AM



Adjustable Wrenches



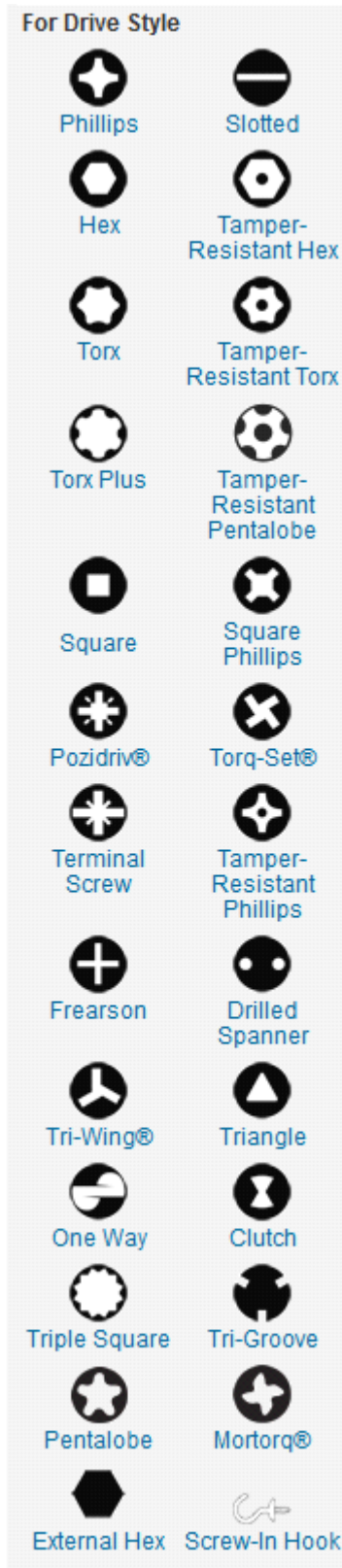
	Jaw		Chrome Plated		Black		Gray Painted
Overall Lg.	Max. Capacity	Texture		Each		Each	Each
Steel							
4"	1/2"	Smooth	5385A11	\$16.60	5386A8	\$15.63	_____
6"	3/4"	Smooth	5385A12	17.82	5386A2	16.76	_____
8"	1 1/8"	Smooth	5385A13	18.47	5386A3	16.98	_____
10"	1 5/16"	Smooth	5385A14	21.30	5386A4	20.44	_____
12"	1 1/2"	Smooth	5385A15	30.70	5386A5	30.37	_____
15"	1 11/16"	Smooth	5385A16	53.91	5386A6	51.33	_____

From <<https://www.mcmaster.com/#adjustable-wrenches/=1axw66w>>

Adjustable wrenches (also known as Crescent wrenches), as the name implies, adjustable to any size within the max jaw capacity. One of the down sides is that there is "give" to the adjustment, making them more susceptible to slipping and rounding over the fasteners. Because of this, they are generally a "second choice" when choosing tools.

Drivers

Sunday, December 24, 2017 10:19 AM



Most Common Drivers used by the team

- 1) Hex.....Used exclusively on Robot
- 2) Torx.....Primarily for Wood Screw (Favorite)
- 3) Square.....Primarily for Wood Screw (2nd Favorite)
- 4) Phillips.....Primarily for Wood Screws (3rd favorite)
- 5) Slotted (or Regular.....Primarily for Wood Screw (Least favorite)

Hex is common in high strength fasteners. It is resistant to stripping. We use internal hex fasteners, in lieu of external hex (which are more common hardware store grade fasteners)

Hex bits are available in ball-end; but should never be used with an impact driver

Stripped heads drive the order of precedence for the other 4 head types listed above.

Pliers

Sunday, December 24, 2017 10:05 AM

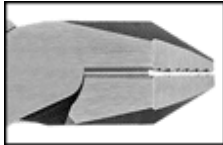


Wire Gripping and Cutting Pliers



Also known as lineman's and side-cutting pliers, these produce a deeply pointed, pinched end on the tip of the wire. Pliers with curved handle end are less likely to slip through your hands. They have spring-assisted jaws that open automatically when you release the handles. Also known as ironworkers' pliers.

Flat Jaws and Cushion Grip



Square Head

From <<https://www.mcmaster.com/#standard-length-wire-cutting-pliers/=1atqg6e>>

Slip-Joint Pliers



Curved Jaws and Plain Grip

Flat and Curved Jaws and Cushion Grip
The slip joint allows you to switch between two different jaw opening sizes and the curved jaws are good for gripping round stock, tubing, and pipe. Flat and curved jaws also have a flat area for general purpose gripping. Also known as combination jaws

From <<https://www.mcmaster.com/#standard-length-wire-cutting-pliers/=1atqgix>>

Long-Nose Pliers



Also known as needle-nose and chain-nose pliers.



Bent-Nose Pliers



Reach over and between closely spaced components.

From <<https://www.mcmaster.com/#standard-length-wire-cutting-pliers/=1atqh70>>

Vise Grip Pliers

Sunday, December 24, 2017 8:42 AM



Locking Pliers



Flat Jaws (Plain Grip Shown)



Curved Jaws (Plain Grip Shown)

Turn the pressure-adjusting screw in the handle to lock the jaws in a vise-like grip around your workpiece. These pliers stay clamped on your work to leave your hands free.

Curved jaws are good for gripping round stock, tubing, and pipe.

Pliers with lever lock release open when you press the lever.

Pliers with pull-open lock release are easier to open with one hand, giving you more control than lever-style

From <<https://www.mcmaster.com/#vise-grips/=1atxhu8>>

Locking Long-Nose Pliers



Flat Jaws and Plain Grip

Turn the pressure-adjusting screw in the handle to lock the jaws in a vise-like grip around your workpiece. These tools stay clamped on your work to leave your hands free.

Pliers with lever lock release open when you press the lever.

Pliers with pull-open lock release are easier to open with one hand, giving you more control than lever-style lock.

From <<https://www.mcmaster.com/#vise-grips/=1atxi96>>

Plier Clamps



Fixed Jaws

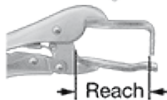


Pivoting Jaws

Turn the adjustment knob to change the opening size; squeeze the handle to lock the clamp in place

From <<https://www.mcmaster.com/#vise-grips/=1atxin5>>

Plier Clamps for Sheets



Finger-shaped clamping points get a secure grip on thin sheets and panels. Turn the knob to adjust the opening size, then squeeze the handle to lock the clamp in place

From <<https://www.mcmaster.com/#vise-grips/=1atxk8x>>

Tight-Grip Sheet Metal Benders and Crimpers



These tools lock onto your material to prevent them from opening while bending and crimping.

From <<https://www.mcmaster.com/#vise-grips/=1atxkng>>

Cutters

Sunday, December 24, 2017 8:42 AM



Wire Cutters



Cushion Grip



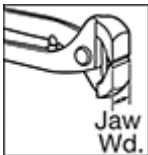
Oval Head

Also known as diagonal-cutting pliers.

Cut profile refers to the amount of pinch left on the tip of the wire after it has been cut. Pointed cutters produce a deeply pointed, pinched end. Use for electrical and general applications. Semiflush cutters are the most widely used for electronics assembly and produce a slightly pointed, pinched end. They are generally more accurate than pointed-cut tools. Flush cutters produce a cut with virtually no pinch, creating clean connections for easy soldering. Flush-cut tools don't last as long as pointed and semiflush. Spring-assisted jaws open automatically when you release the handles.

From <<https://www.mcmaster.com/#standard-length-wire-cutting-pliers/=1atqetn>>

Comfort-Grip Wire End Cutters for Hard Wire



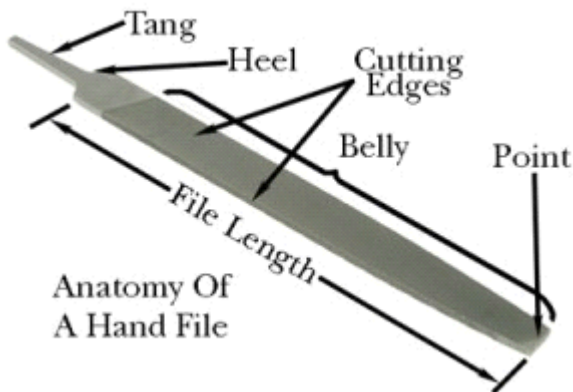
Plastic-cushioned grips make these cutters easy to hold during repeated cuts. They have hardened, precisely aligned cutting edges with a rust-resistant coating for clean, even cuts. Also known as nippers, they have wide, flat jaws that cut close to the surface.

From <<https://www.mcmaster.com/#standard-length-wire-cutting-pliers/=1atqfo6>>



Hand File Anatomy 101

There are several parts that make up a file. First, there is the TANG. This is the pointy end and is used to attach a wood or plastic handle. Some files come with handles already integrated or moulded over the tang while on others, like a Farmer's File, the tang has been flattened and widened to form a handle as part of the chisel.



At the base of the tang is the HEEL. This is where the actual body of the file begins.

The next section is the area where all the cutting action happens. This called the BELLY of the file. Some files cut from all edges, some have edges that are smooth. Some edges are flat, some tapered and some are even rounded. You can even get files where the two opposing edges are different.

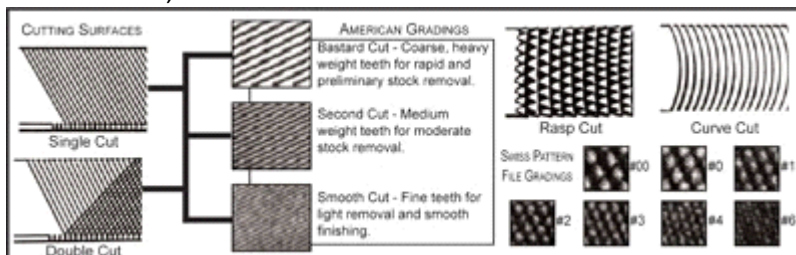
At the end farthest from the tang is the POINT. Strangely enough, this can often be quite square or anything but pointed, but it is in fact, the end you 'point' at the work you are going to be filing.

A file's size or LENGTH is measured from the base of the HEEL, to the end of the POINT. The length of the tang or handle, is not considered part of the length.

The Cutting Edges

Most *American Pattern* files are available in three grades of cut. Bastard, Second Cut and Smooth. The length of the file also affects the coarseness, regardless of the actual grade. So for example a 6" Bastard Cut is a lot finer than a 12" Bastard Cut. This is because the shorter files are generally used for finer work. Overall, the least coarse would be a 4" Smooth file and the most coarse would be a 16" Bastard file. The relationship between the grades of coarseness for each length remains the same.

Swiss Pattern files on the other hand, come in seven grades of cut, from $\emptyset\emptyset$ to No. 6 where the $\emptyset\emptyset$ represents the coarsest and 6 the finest cut. These files are used for detailed work such as by jewelers, watchmakers, model makers and tool and die makers.















From <https://www.kmstools.com/blog/hand-file-identification/>

Types of Files

Sunday, December 24, 2017 7:50 AM



There are many different types of Files, some of which you will be familiar with. Below you can see a table containing the more common Files, their shape and their main uses.

File Name	Shape	Cross-Section	Description
Hand File			The Hand File is parallel in width for its length. It is Double Cut on both faces, Single Cut on one edge, but the other edge is blank and called the Safe Edge. Used for general purposes.
Flat File			The Flat File is Double Cut on both faces and Single Cut on the edges. It tapers slightly towards the point. Used for general purposes.
Half-Round File			The Half-Round File is Double Cut on the flat side and Single Cut on the curved side. It tapers slightly towards the point in both width and thickness. Used for filing concave surfaces and internal corners.
Round File			The Round File is Double cut. It tapers slightly towards the point. Used for enlarging holes and internal corners.
Square File			The Square File is Double Cut on all sides. It tapers slightly towards the point. Used for rectangular slots, square holes and internal corners.
Three Square File			The Three Square File is Double Cut on all sides. It tapers slightly towards the point. It is triangular in section. Used for filing into internal angles.

Punches

Sunday, December 24, 2017 8:16 AM



Mechanical engineering workshops extensively use various types of punches. Few of the basic types include center punch, prick punch, pin punch and drift punch. Workshops use punches for locating centers for drawing circles, to punch holes in sheet metals, to start holes for drilling, to remove damaged rivets, bolts or pins and to transfer location of holes in patterns. Some punches used are hollow.

Classification and Use of Punches

Punches are usually classified according to the shape of their points.

- For driving out damaged rivets, bolts and pins that are bound up in holes, you should use the drive punch. The drive punch has a flat face instead of a point. The width of its face defines this type of punch, for example, 1/8-in or 1/4-in. The sides of a drive punch will taper all the way down to the face, but sometimes you may need to use a punch with a straight shank. This is called the pin or drift punch. Be careful not to use a prick or a center punch to remove bolts or pins from holes, as the point of the punch will spread the object making it even more difficult to remove.
- A center punch is useful when making large indentations in metal, such as necessary to engage a twist drill. Take care that you do not strike with so much force as to cause the end to protrude through or dimple the metal around the indentation. Usually, a center punch is heavier than a prick punch and has a point ground to an angle of 60°.
- When necessary to fit a drill-locating hole in a template, you must use a transfer punch. The transfer punch is typically about 4-inches long and has a point that initially tapers, then runs straight for a short distance. The tip of the transfer punch is similar to that of a prick punch. True to its name, the transfer punch is useful for transferring the location of holes through a pattern or a template on to the metal.

From <<https://www.apexinds.com/blog/types-punches-uses/>>

An **automatic center punch** is a [hand tool](#) used to produce a dimple in a workpiece (for example, a piece of metal). It performs the same function as an ordinary [center punch](#) but without the need for a [hammer](#). When pressed against the workpiece, it stores [energy](#) in a spring, eventually releasing it as an [impulse](#) that drives the punch, producing the dimple. The impulse provided to the point of the punch is quite repeatable, allowing for uniform impressions to be made.

From <https://en.wikipedia.org/wiki/Automatic_center_punch>

Deburring Tool

Sunday, December 24, 2017 8:40 AM



A **burr** is a raised edge or small piece of material remaining attached to a workpiece after a modification process.

There are three type of burrs that can be formed from machining operations: *Poisson burr*, *rollover burr*, and *breakout burr*. The rollover burr is the most common. Burrs may be classified by the physical manner of formation. Plastic deformation of material includes lateral flow (*Poisson burr*), bending (*rollover burr*), and tearing of material from the workpiece (*tear burr*). Incomplete cutoff of material causes a cutoff projection.

Burrs in drilled holes cause fastener and material problems. Burrs cause more stress to be concentrated at the edges of holes, decreasing resistance to fracture and shortening fatigue life. They interfere with the seating of fasteners, causing damage to fastener or the assembly itself. Cracks caused by stress and strain can result in material failure.

Burrs in moving parts increase unwanted friction and heat. Rough surfaces also result in problems with lubrication, as wear is increased at the interfaces of parts. This makes it necessary to replace them more frequently.

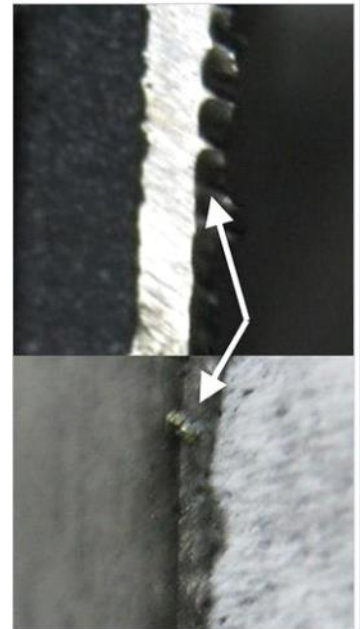
It is usually an unwanted piece of material and is removed with a **deburring tool** in a process called 'deburring'. Burrs are most commonly created by [machining](#) operations, such as [grinding](#), [drilling](#), [milling](#), [engraving](#) or [turning](#). It may be present in the form of a fine wire on the edge of a freshly sharpened tool or as a raised portion of a surface; this type of burr is commonly formed when a [hammer](#) strikes a surface. Deburring accounts for a significant portion of manufacturing costs.

From <[https://en.wikipedia.org/wiki/Burr_\(edge\)#Deburring](https://en.wikipedia.org/wiki/Burr_(edge)#Deburring)>

Manual deburring

Manual deburring is the most common deburring process because it is the most flexible process. It also only requires low cost tools and allows for instant inspection.

From <[https://en.wikipedia.org/wiki/Burr_\(edge\)](https://en.wikipedia.org/wiki/Burr_(edge))>



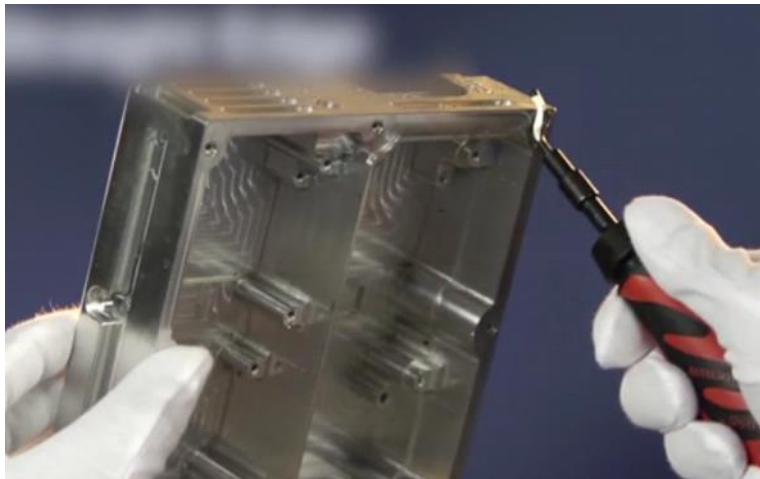
Metal burr extending beyond the edge of the cut piece, view on the cut face (top) and from the bottom (bottom)



How to use a Deburring Tool

Sunday, December 24, 2017 9:12 AM

TITAN ROBOTICS CLUB
TEAM 492



Deburring tools are incredibly useful for rounding out rough edges on almost anything. You can use a deburring tool to even out the edges of a PVC pipe or to get rid of rough spots on the edge of a piece of wood. Using a deburring tool is pretty easy, but it helps to know about the process before you get started. You might also find it helpful to know what to consider when choosing your tool and what you should do to keep yourself safe.

- 1) **Make sure that the object you are deburring is locked in place.** While some larger objects might stay put on their own, it will be difficult (and unsafe) to deburr a smaller item that is not secured in place. For example, a piece of furniture may not need to be secured, but a piece of wood or a pipe will need to be secured in place.
 - 1) Try using a vice to secure smaller items and prevent them from moving around as you deburr them.
- 2) **Place the deburring tool against the edge.** Hold the tool so that it is right up against the edge you wish to deburr. For example, if you are deburring the edge of a piece of wood, then place the tool right up against the edge.^[1]
 - 1) You do not need to press hard to deburr the item, just ensure that the tool makes contact with the edge of the object you are deburring.
- 3) **Go over the area two or three times.**^[2] To ensure that the edge is completely deburred, it may be necessary to go over it with the deburring tool two or three times. Start at one end and move all the way to the end, or select a starting point if you are deburring a circular item.^[3]
 - 1) If you are deburring a pipe or other circular area, then you may just have to let the deburring tool rotate two or three times.
 - 2) If you are deburring an edge, then you will need to drag the tool back and forth across the area two or three times.
- 4) **Check the edges to ensure all burrs have been removed.** After you have finished deburring the item, remove the tool and turn it off. Then, check the edges of the area you just deburred to ensure that you got all of the larger burrs.^[4] If there are still some burrs left, then you can always go over it again.^[5]
 - 1) You can also [sand the edges](#) of the area you just deburred to ensure that it is nice and smooth. Use a fine grit sandpaper to sand away any minor imperfections.

From <<https://www.wikihow.com/Use-a-Deburring-Tool>>

Chain Breaker Tool

Sunday, December 24, 2017 8:41 AM



Roller Chain Breakers



Most chain tools are designed for chains where the links have flat plates. For chains with complicated shaped plates designed to facilitate smooth shifting, specific chain tools are available which are identical in design and operation, but have the ears protruding into the chain shaped in cross section to fit the links of the particular chain in question precisely, so as to hold the pin in the all-important vertical alignment with the screw of the tool.

Some chain tools are better at removing pins than they are at inserting them. Once completely removed, chain pins are often very difficult to insert with a tool unless it has been specifically designed to do so. Users may overcome this limitation of some tools by never completely removing a pin that they intend to replace. They push the pin so that the chain can be broken, to shorten it for example, but so that it is firmly retained in the farthest plate. This way, even simple chain tools can press the pin back into place.

While a chain tool is required to shorten simple chains, and can often be used to reconnect them, there are fast-release chain links that allow repeated making and breaking of a chain. They are connected by hand pressure but often need a pair of needle-nosed pliers for removal. These links invariably replace a pair of *outside* plates on a chain, so joining two sets of *inside* plates. A [master link](#) on the chain which holds the pin in place with an easily removable [c-clip](#).

From <https://en.wikipedia.org/wiki/Chain_tool>

Drive out chain pins with a twist of the handle. Breakers allow you to disassemble chain in order to remove or add links.

Roller Chain Breakers

For Roller Chain Trade Size	For Roller Chain Pitch	Overall			Material	Each	Replacement Points	Each
		Lg.	Wd.					
For Single-Strand ANSI Roller Chain								
25, 35, 40, 41, 50, 60	1/4"-3/4"	10 3/4"	3 1/4"	Steel	6051K15	\$31.45	6051K22	\$2.79

From <<https://www.mcmaster.com/#chain-tools/=1atq46z>>

Hammers and Mallots

Sunday, December 24, 2017 8:44 AM



Hickory Handle



Straight
Claw



Curved
Claw

Straight claw hammers are good for ripping and prying. Curved claw hammers are used to remove nails. Serrated face prevents the head from slipping when striking. For replacement handles, see [Hickory Hammer Handles](#). From <<https://www.mcmaster.com/#nail-hammers/=1atxr4s>>

High-Visibility Polyurethane Dead Blow Hammers



These hammers are bright orange. The head is loaded with steel shot to provide a controlled, solid impact with minimal rebound, reducing worker fatigue and injuries. The faces have a hardness similar of that of a tire tread. The textured grip provides slip resistance.

From <<https://www.mcmaster.com/#dead-blow-hammers/=1atxrn4>>

Ball Peen Hammers



Hickory Handle

The flat face is slightly rounded with a beveled edge and the peen end is good for forming unhardened metal.

From <<https://www.mcmaster.com/#standard-ball-peen-hammers/=1atxsgj>>

Sheet Metal Forming Hammers



Also known as body and fender tools, these hammers are excellent for forming and repairing dents in sheet metal components. Serrated face prevents the head from slipping when striking. Fiberglass handle resists breakage if you miss your mark and has a textured grip for slip resistance.

From <<https://www.mcmaster.com/#sheet-metal-hammers/=1atxukn>>

Taps, Dies & Tap Handles

Monday, December 25, 2017 8:22 AM

**TITAN ROBOTICS CLUB
TEAM 492**



TAPS, DIES & TAP HANDLES

- A. THROUGH HOLE TAPS**
- B. BOTTOMING TAPS**
- C. DIES**
- D. TAP HANDLES**

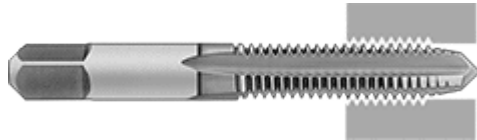
Through-Hole Tap

Sunday, December 24, 2017 10:19 AM

TITAN ROBOTICS CLUB
TEAM 492



Long-Life General Purpose Taps



For Through-Hole Threading

Coated with titanium nitride (TiN), these taps last up to two times longer than uncoated taps. Use them to thread most metals and plastics. They're also known as hand taps and are for use with a tap wrench. Taps for through-hole threading are for start-to-finish tapping of through-holes. They have a plug chamfer with 3-5 tapered threads at the tip to guide the tap into the hole, but they're not as good for starting threads.

Inch

Thread Size	Thread Lg.	O'all Lg.	Drill Bit Size	Drill Bit Size Decimal Equivalent	No. of Flutes	Thread Type	Through-Hole Threading	Each
Titanium Nitride (TiN) Coated High-Speed Steel								
4-40	9/16"	1 7/8"	43	0.089"	2	UNC	26955A13	\$8.23
4-40	9/16"	1 7/8"	43	0.089"	3	UNC	2636A41	7.89
6-32	11/16"	2"	36	0.1065"	2	UNC	26955A15	6.17
6-32	11/16"	2"	36	0.1065"	3	UNC	2636A43	6.06
8-32	3/4"	2 1/8"	29	0.136"	3	UNC	26955A17	5.63
8-32	3/4"	2 1/8"	29	0.136"	4	UNC	2636A44	6.21
10-24	7/8"	2 3/8"	25	0.1495"	3	UNC	26955A18	6.44
10-24	7/8"	2 3/8"	25	0.1495"	4	UNC	2636A45	6.38
10-32	7/8"	2 3/8"	21	0.159"	2	UNF	26955A29	6.44
10-32	7/8"	2 3/8"	21	0.159"	4	UNF	2636A452	6.38
1/4"-20	1"	2 1/2"	7	0.201"	2	UNC	26955A32	8.34
1/4"-20	1"	2 1/2"	7	0.201"	4	UNC	2636A47	6.86

From <<https://www.mcmaster.com/#standard-taps/=1atxybd>>

Bottoming Tap

Sunday, December 24, 2017 10:19 AM



Long-Life General Purpose Taps



For Closed-End Hole Threading

Coated with titanium nitride (TiN), these taps last up to two times longer than uncoated taps. Use them to thread most metals and plastics. They're also known as hand taps and are for use with a tap wrench. Taps for closed-end hole threading make threads close to the bottom of closed-end holes. They have a bottoming chamfer with 1-2 tapered threads to guide the tap into the hole, but they're not as good for starting threads.

Inch

Thread Size	Thread Lg.	O'all Lg.	Drill Bit Size	Drill Bit Size Decimal Equivalent	No. of Flutes	Thread Type	Closed-End Hole Threading	Each
Titanium Nitride (TiN) Coated High-Speed Steel								
4-40	9/16"	1 7/8"	43	0.089"	2	UNC	26955A71	\$8.23
4-40	9/16"	1 7/8"	43	0.089"	3	UNC	2636A61	7.89
6-32	11/16"	2"	36	0.1065"	2	UNC	26955A74	6.17
6-32	11/16"	2"	36	0.1065"	3	UNC	2636A63	6.06
8-32	3/4"	2 1/8"	29	0.136"	3	UNC	26955A76	5.63
8-32	3/4"	2 1/8"	29	0.136"	4	UNC	2636A64	6.21
10-24	7/8"	2 3/8"	25	0.1495"	3	UNC	26955A78	6.44
10-24	7/8"	2 3/8"	25	0.1495"	4	UNC	2636A65	6.38
10-32	7/8"	2 3/8"	21	0.159"	2	UNF	26955A86	6.44
10-32	7/8"	2 3/8"	21	0.159"	4	UNF	2636A653	6.38
1/4"-20	1"	2 1/2"	7	0.201"	2	UNC	26955A95	8.34
1/4"-20	1"	2 1/2"	7	0.201"	4	UNC	2636A67	6.86

From <<https://www.mcmaster.com/#standard-taps/=1atxzbm>>

Dies

Sunday, December 24, 2017 8:25 PM



Long-Life Dies



These dies are carbon steel. Use them to create external threads on bolts, studs, and rods made from metals and plastics. Loosen and tighten the die with the included set screw to adjust thread depth. Turn these dies by hand with a die wrench.

From <<https://www.mcmaster.com/#standard-dies/=1axufbt>>

Thread Size	Material	Part Number	Price
UNC Right-Hand Thread			
1" OD			
6-32	Carbon Steel	2576A141	15.45
8-32	Carbon Steel	2576A142	15.45
10-24	Carbon Steel	2576A143	15.45
12-24	Carbon Steel	2576A144	15.45
1/4"-20	Carbon Steel	2576A451	15.45
5/16"-18	Carbon Steel	2576A452	15.45
3/8"-16	Carbon Steel	2576A453	15.45
7/16"-14	Carbon Steel	2576A454	15.45
1/2"-13	Carbon Steel	2576A261	15.45

UNF Right-Hand Thread

1" OD			
10-32	Carbon Steel	2576A245	15.45
1/4"-28	Carbon Steel	2576A455	15.45
5/16"-24	Carbon Steel	2576A456	15.45
3/8"-24	Carbon Steel	2576A457	15.45
7/16"-20	Carbon Steel	2576A458	15.45
1/2"-20	Carbon Steel	2576A262	15.45

From <<https://www.mcmaster.com/#standard-dies/=1axufbt>>

Tap Handles

Monday, January 1, 2018 9:57 AM

**TITAN ROBOTICS CLUB
TEAM 492**



Measuring and Marking

Sunday, December 24, 2017 10:19 AM

**TITAN ROBOTICS CLUB
TEAM 492**



MEASURING AND MARKING

- A. MARKING TOOLS**
- B. MICROMETERS AND CALIPERS**
- C. CALIPER USE**
- D. THREAD GAUGE**
- E. FEELER GAUGE**

Marking Tools

Tuesday, December 26, 2017 10:38 AM

TITAN ROBOTICS CLUB
TEAM 492



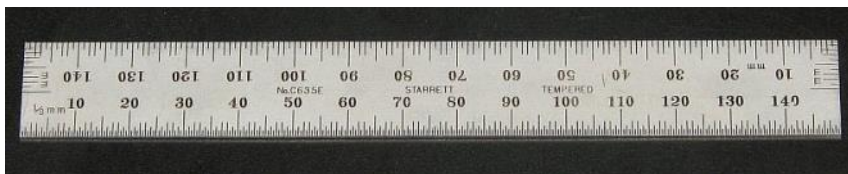
Marking Tools:

When doing precision work, a pencil, no matter how sharp, will not make a fine enough line. For marking, you can use either a scribe or a razor knife. I find it easier to get good results with a razor knife (with a blade that has been snapped off recently) but a scribe will also work well if it has a sufficiently sharp point.



Rules:

For most of the work I do, a rule (ruler) is not accurate enough. Rules are good for quick, rough measurements but not precision work. If you have very good eyesight and a rule with very fine lines, it may work well for you. I prefer dial calipers. The image below is a metric rule. This one is made of hardened steel. Many of the ones you find are stamped from stainless steel sheet stock.



From <http://www.asos1.com/metalwork/basicmetalworking01.html>

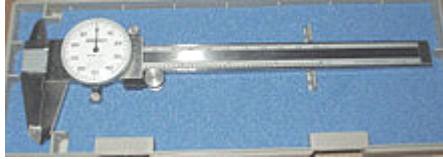
Micrometers and Calipers

Sunday, December 24, 2017 8:41 AM

TITAN ROBOTICS CLUB
TEAM 492



Dial caliper



Mitutoyo dial caliper

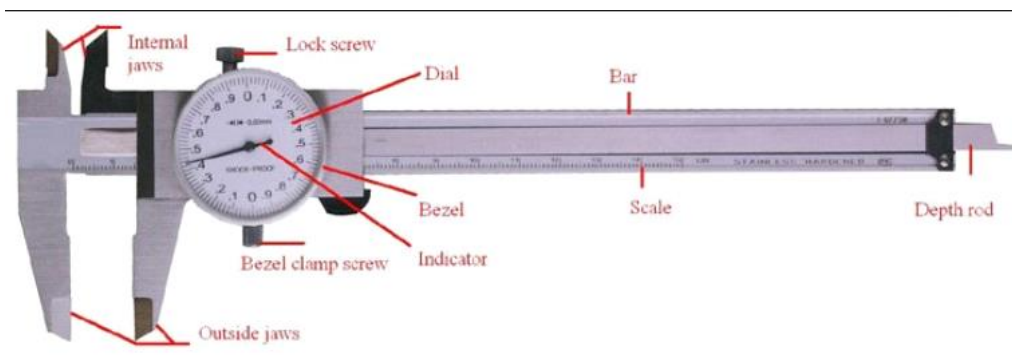
The **dial caliper** reads the final fraction of a millimeter or inch on a simple dial.
In this instrument, a small, precise [rack and pinion](#) drives a pointer on a circular [dial](#), allowing direct reading. Typically, the pointer rotates once every inch, tenth of an inch, or 1 millimeter. This measurement must be added to the coarse whole inches or centimeters read from the slide. The dial is usually arranged to be rotatable beneath the pointer, allowing for "differential" measurements (the measuring of the difference in size between two objects, or the setting of the dial using a master object and subsequently being able to read directly the plus-or-minus variance in size of subsequent objects relative to the master object). The slide of a dial caliper can usually be locked at a setting using a small [lever](#) or screw; this allows simple [go/no-go](#) checks of part sizes.



Digital caliper

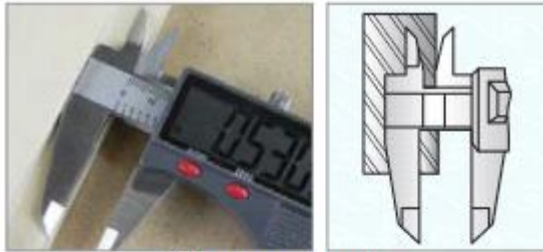
The **digital caliper** reads the final fraction of a millimeter or inch on a digital display.
A refinement now popular is the replacement of the analog dial with an [electronic digital display](#) on which the reading is displayed as a single value. Rather than a [rack and pinion](#), they have a [linear encoder](#). Some digital calipers can be switched between centimeters or millimeters, and inches. All provide for zeroing the display at any point along the slide, allowing the same sort of differential measurements as with the dial caliper. Digital calipers may contain some sort of "reading hold" feature, allowing the reading of dimensions even in awkward locations where the display cannot be seen. Ordinary 6-in/150-mm digital calipers are made of stainless steel, have a rated accuracy of 0.001 in (0.02mm) and resolution of 0.0005 in (0.01 mm).^[9]

From <<https://en.wikipedia.org/wiki/Calipers>>



Caliper use

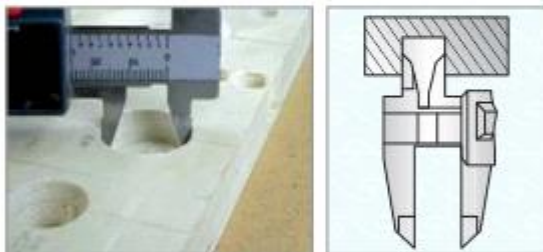
Monday, January 1, 2018 9:32 AM



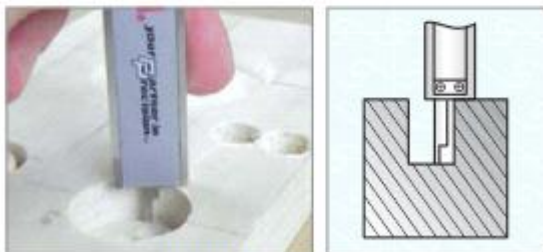
Steps Measurements



External Measurements



Internal Measurements



Depth Measurements

Patrick A. Molzahn

Figure 12-10. Four ways calipers can be used to take measurements.

Calipers are used to measure outside and inside distances, as well as depth. They come in various types.

Dial calipers have precision gears, but debris can cause problems if they get into the gears. Digital calipers have become popular in recent years, especially because they can be quickly switched from inches to millimeters.

Outside dimensions are measured using the large jaws. Inside dimensions **are** measured with the smaller, pointed jaws. Depth measurements can be taken using either the main jaw or depth probe.

From <https://www.g-w.com/pdf/sampchap/9781631260711_ch12.pdf>

The tips of both the "inside measuring" jaws and the "outside measuring" jaws are hardened steel, allowing them to be used as marking scribes.

If you are using them for scribing material, turn the locking screw on the calipers to ensure that they stay at the desired position.

Thread Gauge

Tuesday, December 26, 2017 11:56 AM

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TEAM 492



Thread gauge

A thread pitch gauge, also known as a screw pitch gauge or pitch gauge, is used to measure the pitch or lead of a screw thread.

- (i) Is used as a precision measuring instrument.
- (ii) Allows the user to determine the profile of the given thread.
- (iii) Allows to categorize the thread by shape and pitch.

From <<http://weldinginst.yolasite.com/resources/Measuring%20&%20Marking.pdf>>



Feeler Gauge

Wednesday, December 27, 2017 6:48 AM

TITAN ROBOTICS CLUB
TEAM 492



To keep the set complete, gauge leaves are riveted together in a fan design that folds up for portability. These sets are used to check gaps, alignment, and narrow slots. Each leaf is marked with thickness.

From <<https://www.mcmaster.com/#feeler-gauges/=1axu3t7>>



Squares

Sunday, December 24, 2017 9:34 AM

**TITAN ROBOTICS CLUB
TEAM 492**



SQUARES

- A. COMBINATION**
- B. MACHINIST**
- C. CARPENTER'S**

Combination Square

Sunday, December 24, 2017 8:41 AM

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TEAM 492



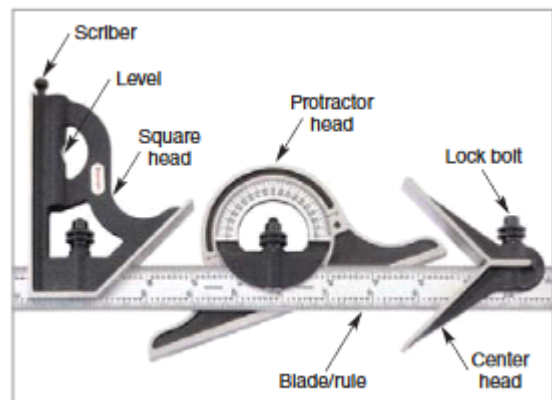
Combination square



Combination square with standard head

A combination square consisting of the rule, 45° holder, protractor and center square

A **combination square** is a [tool](#) used for multiple purposes in [woodworking](#), [stonemasonry](#) and [metalworking](#). It is composed of a [ruled](#) and one or more interchangeable heads that may be affixed to it. The most common head is the *standard* or *square* head which is used to lay out or check [right](#) and 45° angles.^[1] Invented in 1883 by [Leroy S. Starrett](#),^[2] the combination square continues to be a commonplace tool in home workshops, construction jobsites and metalworking.



The L.S. Starrett Co.

Uses

Measuring angles — A combination square can reliably measure 90° and 45° angles. The 45° angle is used commonly in creating [miter joints](#).

Determining flatness — When working with wood the first step is to designate a [reference surface](#) on a board which is known as the face side. The rest of the workpiece is measured from the face side

Measuring the center of a circular bar or [dowel](#). The rule is assembled through the center of the center square, the two cast iron legs of the center square are then placed against the outside of the bar (dowel) allowing a center line to be scribed alongside the ruler. Perform this action at two locations and the intersecting lines will approximate the center of the bar (dowel).

[Protractor](#) head allows angles to be set and measured between the base and ruler.

A rudimentary level for approximating level surfaces is incorporated in the protractor and also the 45° holder. By moving and setting the head, it can be used as a depth gauge or to transfer dimensions.

Marking the work surface; with the included Scribe Point stored in a drilled hole in the Square Base.

It is used to find the center of the round jobs.

In woodworking, the starting raw material is neither flat nor square, however, the end product such as a table must be flat and have corners and legs which are square.

In metalworking, it is useful for a wide variety of layout and setup tasks. When used correctly, a fairly high degree of precision can be achieved. One use would be setting large items at the required angle in machine vises, where the long reach of the rule and firm, heavy base aid the process.

From <https://en.wikipedia.org/wiki/Combination_square>

Machinist Square

Sunday, December 24, 2017 9:30 AM

TITAN ROBOTICS CLUB
TEAM 492

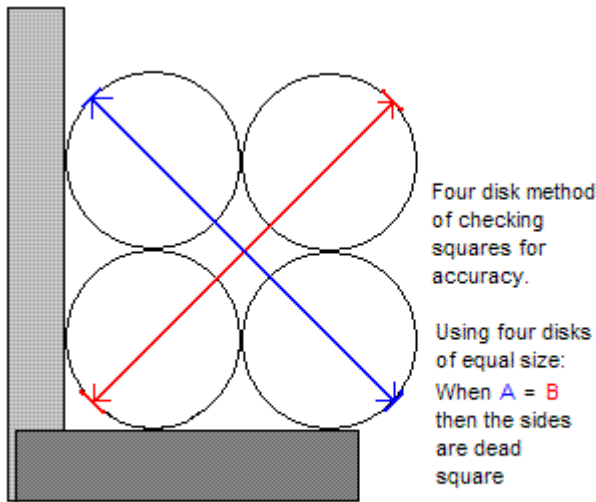


A **machinist square** or **engineer's square** is the metalworkers' equivalent of a [try square](#). It consists of a steel blade inserted and either [welded](#) or [pinned](#) into a heavier body at an angle of 90°. Usually a small notch is present at the inside corner of the square. This prevents small particles from accumulating at the juncture and affecting the square's reading.

Use

In use, the body is aligned against the one edge of the object and the blade is presented to the end or body of the object. If the end is being checked, then a strong light source behind the square will show any mismatch between the blade of the square and the end of the object. The purpose of this action is to check for [squareness](#) or to [mark out](#) the body of the workpiece.

Accuracy



Machinist squares can have a linear error of no greater than 0.0002 in/in.^[1] Squares must be occasionally checked for accuracy. The four disk method is one way to verify overall squareness. However, it cannot detect bent blades.

From <https://en.wikipedia.org/wiki/Machinist_square>

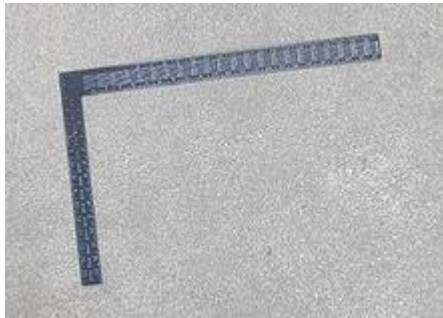
Carpenter's Square

Sunday, December 24, 2017 9:33 AM

TITAN ROBOTICS CLUB
TEAM 492



Steel square



Steel square

The **steel square** is a tool used in [carpentry](#). Carpenters use various tools to lay out structures that are square (that is, built at accurately measured [right angles](#)), many of which are made of [steel](#), but the name *steel square* refers to a specific long-armed square that has additional uses for measurement, especially of various [angles](#). Today the steel square is more commonly referred to as the **framing square** or **carpenter's square**. It consists of a long arm and a shorter arm, which meet at an angle of 90 degrees (a right angle). It can also be made of [aluminum](#) or [polymers](#), which are light and resistant to rust. The wider arm, two [inches](#) wide, is called the **blade**; the narrower arm, one and a half inches wide, the **tongue**. The square has many uses, including laying out common [rafters](#), [hip](#) rafters and [stairs](#).^[1] It has a [diagonal](#) scale, [board foot](#) scale and an [octagonal](#) scale. On the newer framing squares there are degree conversions for different pitches and fractional equivalents.

From <https://en.wikipedia.org/wiki/Steel_square>



FASTENERS

- A. THREAD TERMINOLOGY**
- B. BOLT GRADES**
- C. SOCKET ALLEN SET SCREW REFERENCE**
- D. SHOULDER SCREW REFERENCE**
- E. FLAT HEAD SCREW**
- F. BUTTON HEAD SCREW**
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- H. EXTERNAL RETAINING RING (E-RING)**
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- J. NYLOCK NUTS**
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Thread Terminology

Friday, March 15, 2013 1:11 PM

TITAN ROBOTICS CLUB
TEAM 492



	<p>A. FULL DIAMETER SHANK: Equal to major diameter of thread. Produced by cut thread or by roll thread on extruded blank. Characteristic of machine bolts and cap screws.</p>	<p>ROLLED THREAD: Threads are cold formed by squeezing the blank between reciprocating serrated dies. This acts to increase the major diameter of the thread over and above the diameter of unthreaded shank (if any), unless an extruded blank is used.</p>
	<p>B. UNDERSIZED SHANK: Equal approximately to pitch diameter of thread. Produced by roll threading a non-extruded blank. Characteristic of machine screws.</p>	<p>Classes of thread are distinguished from each other by the amounts of tolerance and allowance specified. External threads or bolts are designated with the suffix "A"; internal or nut threads with "B".</p>
	<p>C. PITCH: The distance from a point on the screw thread to a corresponding point on the next thread measured parallel to the axis.</p>	<p>CLASSES 1A and 1B: For work of rough commercial quality where loose fit for spin-on-assembly is desirable.</p>
	<p>D. PITCH DIAMETER: The simple, effective diameter of screw thread. Approximately half way between the major and minor diameters.</p>	<p>CLASSES 2A and 2B: The recognized standard for normal production of the great bulk of commercial bolts, nuts and screws.</p>
	<p>E. MAJOR DIAMETER: The largest diameter of a screw thread.</p>	<p>CLASSES 3A and 3B: Used where a closed fit between mating parts for high quality work is required.</p>
	<p>F. MINOR DIAMETER: The smallest diameter of a screw thread.</p>	<p>CLASS 4: A theoretical rather than practical class, now obsolete.</p>
	<p>LEAD: The distance a screw thread advances axially in one turn.</p>	<p>CLASS 5: For a wrench fit. Used principally for studs and their mating tapped holes. A force fit requiring the application of high torque for semi-permanent assembly.</p>
	<p>CUT THREAD: Threads are cut or chased; the unthreaded portion of shank will be equal to major diameter of thread.</p>	

Pasted from <http://www.americanfastener.com/technical/thread_terminology.asp>

Bolt Grades

Sunday, December 24, 2017 10:44 AM



Grade	Radial Bolt Markings	Material	Nominal Size Diameter/Inches	Proof Load psi	Tensile Strength minimum psi	Yield Strength minimum psi
Grade 2 No Radial Lines		Low or Medium Carbon Steel	1/4" to 3/4"	55,000	74,000	57,000
			Over 3/4" thru 1 1/2"	33,000	60,000	36,000
Grade 5 3 Radial Lines		Medium Carbon Steel	1/4" to 1"	85,000	120,000	92,000
			Over 1" thru 1 1/2"	74,000	105,000	81,000
Grade 8 6 Radial Lines		Medium Carbon Alloy Steel	1/4" thru 1 1/2"	120,000	150,000	130,000
Metric 8.8		Medium Carbon Steel	All sizes under 16mm	580	800	640
			16mm thru 72mm	600	830	660
Metric 10.9		Alloy Steel	5mm thru 100mm	830	1040	940

Alloy Steel Socket Head Screws



Fully Threaded



Partially Threaded

These screws are made from an alloy steel that's stronger than Grade 8 steel.

Length is measured from under the head.

Black-oxide steel screws are mildly corrosion resistant in dry environments.

From <<https://www.mcmaster.com/#socket-head-cap-screws/=1atqyp7>>

Standard Fastener Reference

Saturday, January 19, 2013 9:57 PM

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Fastener Size	Nylock Nut		Hex Head		Socket Head Cap Screw		Socket Head Button Screw		Flat Head Allen Screw	
	Socket Size	Width Across Corners	Socket Size	Width Across Corners	Allen Wrench Size	Dia of Head	Allen Wrench Size	Dia of Head	Allen Wrench Size	Dia of Head
4	1/4	0.268	N/A	N/A	3/32	0.183	1/16	0.213	1/16	0.255
6	5/16	0.339	N/A	N/A	7/64	0.226	5/64	0.262	5/64	0.307
8	11/32	0.374	1/4		9/64	0.27	3/32	0.312	3/32	0.359
10	3/8	0.41	5/16		5/32	0.312	1/8	0.361	1/8	0.411
1/4	7/16	0.482	7/16	0.505	3/16	0.375	5/32	0.437	5/32	0.531
5/16	1/2	0.552	1/2	0.577	1/4	0.46875	3/16	0.547	3/16	0.656

Socket Allen Set Screw Reference

Friday, March 15, 2013 12:48 PM

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TEAM 492



Socket Allen Screw				
Fastener Size	UNCT/in	Allen Wrench Size	UNF T/in	Allen Wrench Size
0	N/A	N/A	80	0.028
1	64	0.028	72	0.028
2	56	0.035	64	0.035
3	48	0.05	56	0.05
4	40	0.05	48	0.05
5	40	1/16	44	1/16
6	32	1/16	40	1/16
8	32	5/64	36	/64
10	24	3/32	32	3/32

Set Screws

Cup-Point Set Screws



Cup point set screws have a thin edge that digs into the contact surface for a secure hold on a wide range of surfaces.

Extended-Tip Set Screws



Also known as dog-point set screws, these set screws have a protruding tip that locks within a mating hole or slot to keep parts aligned.

Swivel-Tip Set Screws for Angled Surfaces



The tip swivels and tilts in all directions to apply uniform pressure to angled and uneven surfaces.

Hollow-Lock Set Screws



Also known as jam screws, these lock other screws in place, hold pins, and adjust spring tension.

Nonmarring Set Screws



Make frequent adjustments with minimal surface damage. Choose from flat-, oval-, and soft-tip set screws.

High-Hold Cone-Point Set Screws



For a secure hold on soft materials such as brass, the pointed tip wedges into the contact surface.

Easy-Adjust Ball-Point Set Screws



A ball bearing tip rolls to allow for slight adjustments without loosening the screw.

Shoulder Screw Reference

Friday, March 15, 2013 12:50 PM

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TEAM 492

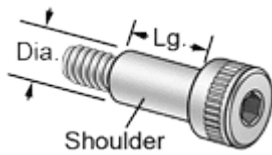


Shoulder Diameter (A)	Thread (C)	Thread Length (D)	Head Diameter (E)	Head Height (F)	Allen Wrench Size
1/8	4-40	3/32	1/4	1/8	5/64
3/16	8-32	3/16	5/16	5/32	3/32
1/4	10-24	3/8	3/8	3/16	1/8
5/16	1/4-20	7/16	7/16	7/32	5/32
3/8	5/16-18	1/2	9/16	1/4	3/16
1/2	3/8-16	5/8	3/4	5/16	1/4

Alloy Steel Shoulder Screws

Friday, May 10, 2013 6:15 PM

TITAN ROBOTICS CLUB
TEAM 492



These shoulder screws have a standard shoulder with an undersized tolerance to fit most machinery and equipment. Also known as stripper bolts, they're commonly used as a linear guide for stripper plates in punch and die mechanisms and as a bearing pin, axle, or pivot point. Screws made from alloy steel are comparable to Grade 8 screws.



For technical drawings and 3-D models, click on a part number.

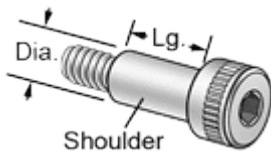
From <<https://www.mcmaster.com/#shoulder-screws/=1atrfex>>

Shoulder Lg.	Thread Size	Thread Lg.	Head Dia	Head Ht.	Finish	Tensile (Str, psi)	Min. Shear (Str, psi)	Drive Size	P/N	1-4	5-Up
5/32" Shoulder Dia.—Standard Fit (-0.004" to -0.002" Dia. Tolerance)											
1/8"	6-32	3/16"	9/32"	1/8"	Black Oxide	140,000	84,000	3/32"	91259A158	\$ 1.97	\$ 1.66
3/16"	6-32	3/16"	9/32"	1/8"	Black Oxide	140,000	84,000	3/32"	91259A159	\$ 1.98	\$ 1.67
1/4"	6-32	3/16"	9/32"	1/8"	Black Oxide	140,000	84,000	3/32"	91259A161	\$ 2.00	\$ 1.68
3/8"	6-32	3/16"	9/32"	1/8"	Black Oxide	140,000	84,000	3/32"	91259A162	\$ 2.03	\$ 1.71
1/2"	6-32	3/16"	9/32"	1/8"	Black Oxide	140,000	84,000	3/32"	91259A163	\$ 2.08	\$ 1.75
3/16" Shoulder Dia.—Standard Fit (-0.004" to -0.002" Dia. Tolerance)											
1/8"	8-32	3/16"	5/16"	5/32"	Black Oxide	140,000	84,000	3/32"	91259A164	\$ 2.01	\$ 1.69
1/4"	8-32	3/16"	5/16"	5/32"	Black Oxide	140,000	84,000	3/32"	91259A165	\$ 2.03	\$ 1.71
1/2"	8-32	3/16"	5/16"	5/32"	Black Oxide	140,000	84,000	3/32"	91259A166	\$ 2.11	\$ 1.78
3/4"	8-32	3/16"	5/16"	5/32"	Black Oxide	140,000	84,000	3/32"	91259A167	\$ 2.19	\$ 1.83
1"	8-32	3/16"	5/16"	5/32"	Black Oxide	140,000	84,000	3/32"	91259A168	\$ 2.22	\$ 1.87
1/4" Shoulder Dia.—Standard Fit (-0.004" to -0.002" Dia. Tolerance)											
1/8"	10-24	3/8"	3/8"	3/16"	Black Oxide	140,000	84,000	1/8"	91259A169	\$ 2.29	\$ 1.93
1/4"	10-24	3/8"	3/8"	3/16"	Black Oxide	140,000	84,000	1/8"	91259A533	\$ 1.08	\$ 0.92
1/4"	10-24	1/4"	3/8"	3/16"	Black Oxide	140,000	84,000	1/8"	91259A171	\$ 2.35	\$ 1.98
5/16"	10-24	3/8"	3/8"	3/16"	Black Oxide	140,000	84,000	1/8"	91259A534	\$ 1.06	\$ 0.90
3/8"	10-24	3/8"	3/8"	3/16"	Black Oxide	140,000	84,000	1/8"	91259A535	\$ 1.08	\$ 0.92
1/2"	10-24	3/8"	3/8"	3/16"	Black Oxide	140,000	84,000	1/8"	91259A537	\$ 1.09	\$ 0.93
1/2"	10-24	1/4"	3/8"	3/16"	Black Oxide	140,000	84,000	1/8"	91259A172	\$ 2.44	\$ 2.05
5/8"	10-24	3/8"	3/8"	3/16"	Black Oxide	140,000	84,000	1/8"	91259A539	\$ 1.11	\$ 0.95
3/4"	10-24	3/8"	3/8"	3/16"	Black Oxide	140,000	84,000	1/8"	91259A540	\$ 1.13	\$ 0.97
3/4"	10-24	1/4"	3/8"	3/16"	Black Oxide	140,000	84,000	1/8"	91259A173	\$ 2.50	\$ 2.10
7/8"	10-24	3/8"	3/8"	3/16"	Black Oxide	140,000	84,000	1/8"	91259A541	\$ 3.03	\$ 2.57
1"	10-24	3/8"	3/8"	3/16"	Black Oxide	140,000	84,000	1/8"	91259A542	\$ 1.20	\$ 1.02
1"	10-24	1/4"	3/8"	3/16"	Black Oxide	140,000	84,000	1/8"	91259A174	\$ 2.63	\$ 2.22
1 1/4"	10-24	3/8"	3/8"	3/16"	Black Oxide	140,000	84,000	1/8"	91259A544	\$ 1.29	\$ 1.10
1 1/2"	10-24	3/8"	3/8"	3/16"	Black Oxide	140,000	84,000	1/8"	91259A546	\$ 1.34	\$ 1.14
1 3/4"	10-24	3/8"	3/8"	3/16"	Black Oxide	140,000	84,000	1/8"	91259A102	\$ 1.60	\$ 1.36
2"	10-24	3/8"	3/8"	3/16"	Black Oxide	140,000	84,000	1/8"	91259A103	\$ 1.69	\$ 1.43

Alloy Steel Shoulder Screws (cont)m



Friday, May 10, 2013 6:15 PM



These shoulder screws have a standard shoulder with an undersized tolerance to fit most machinery and equipment. Also known as stripper bolts, they're commonly used as a linear guide for stripper plates in punch and die mechanisms and as a bearing pin, axle, or pivot point. Screws made from alloy steel are comparable to Grade 8 screws.



For technical drawings and 3-D models, click on a part number.

From <<https://www.mcmaster.com/#shoulder-screws/=1atrfex>>

Shoulder Lg.	Thread Size	Thread Lg.	Head Dia	Head Ht.	Finish	Tensile (Str, psi)	Min. Shear (Str, psi)	Drive Size	P/N	1-4	5-Up
5/16" Shoulder Dia.—Standard Fit (-0.004" to -0.002" Dia. Tolerance)											
1/4"	1/4"-20	7/16"	7/16"	7/32"	Black Oxide	140,000	84,000	5/32"	91259A574	\$ 1.24	\$ 1.06
5/16"	1/4"-20	7/16"	7/16"	7/32"	Black Oxide	140,000	84,000	5/32"	91259A175	\$ 2.35	\$ 1.98
3/8"	1/4"-20	7/16"	7/16"	7/32"	Black Oxide	140,000	84,000	5/32"	91259A576	\$ 1.29	\$ 1.10
1/2"	1/4"-20	7/16"	7/16"	7/32"	Black Oxide	140,000	84,000	5/32"	91259A578	\$ 1.28	\$ 1.09
5/8"	1/4"-20	7/16"	7/16"	7/32"	Black Oxide	140,000	84,000	5/32"	91259A580	\$ 1.29	\$ 1.10
3/4"	1/4"-20	7/16"	7/16"	7/32"	Black Oxide	140,000	84,000	5/32"	91259A581	\$ 1.35	\$ 1.15
7/8"	1/4"-20	7/16"	7/16"	7/32"	Black Oxide	140,000	84,000	5/32"	91259A582	\$ 3.13	\$ 2.67
1"	1/4"-20	7/16"	7/16"	7/32"	Black Oxide	140,000	84,000	5/32"	91259A583	\$ 1.38	\$ 1.17
1 1/4"	1/4"-20	7/16"	7/16"	7/32"	Black Oxide	140,000	84,000	5/32"	91259A585	\$ 1.50	\$ 1.28
1 1/2"	1/4"-20	7/16"	7/16"	7/32"	Black Oxide	140,000	84,000	5/32"	91259A587	\$ 1.63	\$ 1.38
1 3/4"	1/4"-20	7/16"	7/16"	7/32"	Black Oxide	140,000	84,000	5/32"	91259A589	\$ 1.67	\$ 1.41
2"	1/4"-20	7/16"	7/16"	7/32"	Black Oxide	140,000	84,000	5/32"	91259A591	\$ 1.70	\$ 1.44
3/8" Shoulder Dia.—Standard Fit (-0.004" to -0.002" Dia. Tolerance)											
1/4"	5/16"-18	1/2"	9/16"	1/4"	Black Oxide	140,000	84,000	3/16"	91259A615	\$ 1.49	\$ 1.26
5/16"	5/16"-18	1/2"	9/16"	1/4"	Black Oxide	140,000	84,000	3/16"	91259A176	\$ 2.76	\$ 2.32
3/8"	5/16"-18	1/2"	9/16"	1/4"	Black Oxide	140,000	84,000	3/16"	91259A617	\$ 1.50	\$ 1.27
1/2"	5/16"-18	1/2"	9/16"	1/4"	Black Oxide	140,000	84,000	3/16"	91259A619	\$ 1.52	\$ 1.29
5/8"	5/16"-18	1/2"	9/16"	1/4"	Black Oxide	140,000	84,000	3/16"	91259A621	\$ 1.53	\$ 1.30
3/4"	5/16"-18	1/2"	9/16"	1/4"	Black Oxide	140,000	84,000	3/16"	91259A622	\$ 1.56	\$ 1.33
7/8"	5/16"-18	1/2"	9/16"	1/4"	Black Oxide	140,000	84,000	3/16"	91259A623	\$ 4.70	\$ 3.99
1"	5/16"-18	1/2"	9/16"	1/4"	Black Oxide	140,000	84,000	3/16"	91259A624	\$ 1.57	\$ 1.33
1 1/4"	5/16"-18	1/2"	9/16"	1/4"	Black Oxide	140,000	84,000	3/16"	91259A626	\$ 1.66	\$ 1.41
1 1/2"	5/16"-18	1/2"	9/16"	1/4"	Black Oxide	140,000	84,000	3/16"	91259A628	\$ 1.70	\$ 1.44
1 3/4"	5/16"-18	1/2"	9/16"	1/4"	Black Oxide	140,000	84,000	3/16"	91259A630	\$ 1.74	\$ 1.48
2"	5/16"-18	1/2"	9/16"	1/4"	Black Oxide	140,000	84,000	3/16"	91259A632	\$ 1.86	\$ 1.58
2 1/4"	5/16"-18	1/2"	9/16"	1/4"	Black Oxide	140,000	84,000	3/16"	91259A633	\$ 1.96	\$ 1.66
2 1/2"	5/16"-18	1/2"	9/16"	1/4"	Black Oxide	140,000	84,000	3/16"	91259A634	\$ 1.99	\$ 1.69
2 3/4"	5/16"-18	1/2"	9/16"	1/4"	Black Oxide	140,000	84,000	3/16"	91259A635	\$ 2.09	\$ 1.78

Flat Head Screw

Friday, May 10, 2013 5:44 PM

TITAN ROBOTICS CLUB
TEAM 492



Socket Head Cap Screw Dimensions



Flat Head Socket Cap Screws—Use a [countersink](#) to create a recess for flat head screws. The body diameter of your countersink should be equal to or larger than your screw's head diameter and its included angle should match your screw's head angle.

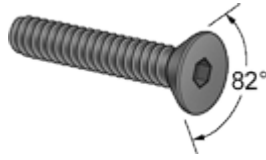
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4-40 Flat Head Screws

Friday, May 10, 2013 5:18 PM



Black Oxide Alloy Steel Flat Head



Fully Threaded

Designed with a beveled neck and a flat head, these screws sit flush within countersunk holes. They meet ASTM F835 and have a Class 3A thread fit. Screw sizes through 1/2" have a minimum Rockwell hardness of C39 and minimum tensile strength of 144,000 psi. Sizes larger than 1/2" have a minimum Rockwell hardness of C37 and minimum tensile strength of 135,000 psi. Screw length is measured from the top of the head. Note: Flat head screws are not recommended for high strength applications. Black-oxide alloy steel offers mild rust resistance and has some lubrication qualities.

Lg.	Pkg. Qty.		Per Pkg.
1/8"	25	91253A102 •	\$13.13
3/16"	50	91253A104 •	9.09
1/4"	100	91253A106 •	7.74
5/16"	100	91253A107 •	8.36
3/8"	100	91253A108 •	8.69
7/16"	50	91253A109 •	6.21
1/2"	100	91253A110 •	8.88
5/8"	100	91253A112 •	9.00
3/4"	100	91253A113 •	9.11
7/8"	25	91253A114 •	8.57
1"	50	91253A115 •	17.79
1 1/4"	25	91253A117 •	10.27

•Fully threaded.

*Head is undercut to 70% of standard height to allow more threading.

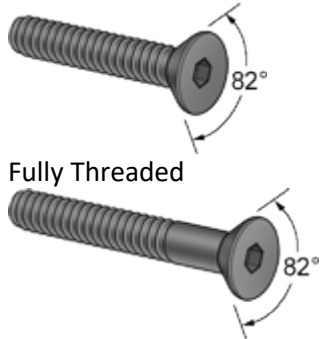
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6-32 Flat Head Screws

Friday, May 10, 2013 5:00 PM



Black Oxide Alloy Steel Flat Head



Partially Threaded

Designed with a beveled neck and a flat head, these screws sit flush within countersunk holes. They meet ASTM F835 and have a Class 3A thread fit. Screw sizes through 1/2" have a minimum Rockwell hardness of C39 and minimum tensile strength of 144,000 psi. Sizes larger than 1/2" have a minimum Rockwell hardness of C37 and minimum tensile strength of 135,000 psi. Screw length is measured from the top of the head. Note: Flat head screws are not recommended for high strength applications. Black-oxide alloy steel offers mild rust resistance and has some lubrication qualities.

Lg.	Pkg. Qty.		Per Pkg.
1/4"	100	91253A144 *	\$8.66
5/16"	50	91253A145 *	4.42
3/8"	100	91253A146 *	8.88
7/16"	50	91253A147 *	6.25
1/2"	100	91253A148 *	9.57
5/8"	100	91253A150 *	9.76
3/4"	100	91253A151 *	9.98
7/8"	25	91253A152 *	9.38
1"	25	91253A153 *	10.81
1 1/4"	25	91253A155	8.48
1 1/2"	25	91253A157	10.18
1 3/4"	25	91253A158	11.25
2"	25	91253A159	13.17

*Fully threaded.

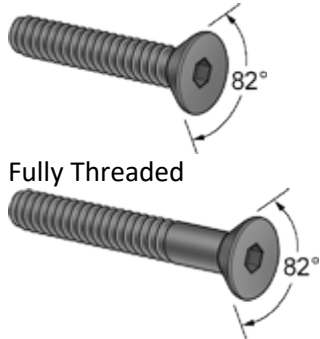
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8-32 Flat Head Screws

Friday, May 10, 2013 5:39 PM



Black Oxide Alloy Steel Flat Head



Partially Threaded

Designed with a beveled neck and a flat head, these screws sit flush within countersunk holes. They meet ASTM F835 and have a Class 3A thread fit. Screw sizes through 1/2" have a minimum Rockwell hardness of C39 and minimum tensile strength of 144,000 psi. Sizes larger than 1/2" have a minimum Rockwell hardness of C37 and minimum tensile strength of 135,000 psi. Screw length is measured from the top of the head. Note: Flat head screws are not recommended for high strength applications. Black-oxide alloy steel offers mild rust resistance and has some lubrication qualities.

Lg.	Pkg. Qty.		Per Pkg.
1/4"	50	91253A189 *	\$14.23
5/16"	25	91253A190 *	13.16
3/8"	100	91253A192 *	8.84
7/16"	100	91253A193 *	10.39
1/2"	100	91253A194 *	11.67
5/8"	100	91253A196 *	12.29
3/4"	100	91253A197 *	12.84
7/8"	25	91253A198 *	6.47
1"	100	91253A199 *	14.08
1 1/4"	25	91253A201	13.87
1 1/2"	25	91253A204	15.13
1 3/4"	10	91253A206	5.05
2"	10	91253A209	7.84
2 1/4"	10	91253A211	8.52
2 1/2"	10	91253A213	10.00
3"	10	91253A217	10.54

*Fully threaded.

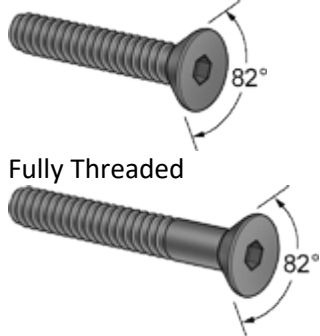
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10-24 Flat Head Screws

Friday, May 10, 2013 5:41 PM



Black Oxide Alloy Steel Flat Head



Partially Threaded

Designed with a beveled neck and a flat head, these screws sit flush within countersunk holes. They meet ASTM F835 and have a Class 3A thread fit. Screw sizes through 1/2" have a minimum Rockwell hardness of C39 and minimum tensile strength of 144,000 psi. Sizes larger than 1/2" have a minimum Rockwell hardness of C37 and minimum tensile strength of 135,000 psi. Screw length is measured from the top of the head. Note: Flat head screws are not recommended for high strength applications. Black-oxide alloy steel offers mild rust resistance and has some lubrication qualities.

Lg.	Pkg. Qty.		Per Pkg.
1/4"	25	91253A238 *	\$4.85
5/16"	25	91253A239 *	5.56
3/8"	100	91253A240 *	8.75
7/16"	25	91253A241 *	5.69
1/2"	100	91253A242 *	12.53
5/8"	100	91253A244 *	13.31
3/4"	100	91253A245 *	14.07
7/8"	50	91253A246 *	16.58
1"	50	91253A247 *	10.48
1 1/4"	50	91253A249 *	11.67
1 1/2"	25	91253A251	10.36
1 3/4"	25	91253A253	8.33
2"	10	91253A255	7.60
2 1/4"	25	91253A256	9.45
2 1/2"	5	91253A257	4.17
3"	5	91253A260	5.30

*Fully threaded.

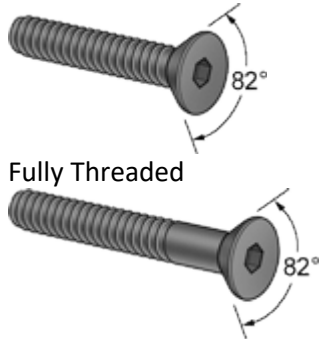
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10-32 Flat Head Screws

Friday, May 10, 2013 5:43 PM



Black Oxide Alloy Steel Flat Head



Partially Threaded

Designed with a beveled neck and a flat head, these screws sit flush within countersunk holes. They meet ASTM F835 and have a Class 3A thread fit. Screw sizes through 1/2" have a minimum Rockwell hardness of C39 and minimum tensile strength of 144,000 psi. Sizes larger than 1/2" have a minimum Rockwell hardness of C37 and minimum tensile strength of 135,000 psi. Screw length is measured from the top of the head. Note: Flat head screws are not recommended for high strength applications. Black-oxide alloy steel offers mild rust resistance and has some lubrication qualities.

Lg.	Pkg. Qty.		Per Pkg.
1/4"	50	91253A002 *	\$9.75
5/16"	25	91253A025 *	6.21
3/8"	100	91253A001 *	14.74
1/2"	100	91253A003 *	10.49
5/8"	100	91253A006 *	10.66
3/4"	100	91253A008 *	11.05
7/8"	50	91253A009 *	10.11
1"	50	91253A010 *	7.07
1 1/4"	25	91253A012 *	4.55
1 1/2"	25	91253A014	4.81
1 3/4"	25	91253A016	12.58
2"	25	91253A018	10.98
2 1/4"	10	91253A020	5.36
2 1/2"	5	91253A022 *	4.41
3"	5	91253A024 *	8.59

*Fully threaded.

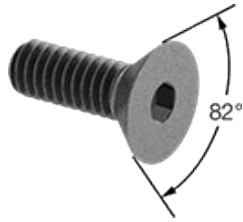
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1/4-20 Flat Head Screws

Friday, May 10, 2013 5:54 PM



Alloy Steel Hex Drive Flat Head Screws



Black Oxide Stainless Steel

Made from alloy steel, these screws are nearly twice as strong as stainless steel flat head screws. They're angled under the head to sit flush within countersunk holes. Length is measured from the top of the head.

Screws with an undercut profile have a shallow head for use in thin materials. Black-oxide alloy steel screws have mild corrosion resistance in dry environments.

Zinc-plated alloy steel screws resist corrosion in wet environments.

Lg.	Threading	Min. Thread Lg.	Flat Head Profile	Head Dia.	Head Ht.	Drive Size	Tensile Strength, psi	Pkg. Qty.	Pkg.
1/4"	Full	—	Undercut	0.531"	0.107"	5/32"	120,000	10	91253A533 \$10.61
3/8"	Full	—	Standard	0.531"	0.161"	5/32"	120,000	50	91253A535 10.76
7/16"	Full	—	Standard	0.531"	0.161"	5/32"	120,000	25	91253A288 11.04
1/2"	Full	—	Standard	0.531"	0.161"	5/32"	120,000	50	91253A537 10.87
9/16"	Full	—	Standard	0.531"	0.161"	5/32"	120,000	10	91253A289 8.25
5/8"	Full	—	Standard	0.531"	0.161"	5/32"	120,000	50	91253A539 11.17
3/4"	Full	—	Standard	0.531"	0.161"	5/32"	120,000	50	91253A540 7.86
7/8"	Full	—	Standard	0.531"	0.161"	5/32"	120,000	25	91253A536 11.25
1"	Full	—	Standard	0.531"	0.161"	5/32"	120,000	50	91253A542 8.42
1 1/8"	Full	—	Standard	0.531"	0.161"	5/32"	120,000	25	91253A291 12.52
1 1/4"	Full	—	Standard	0.531"	0.161"	5/32"	120,000	50	91253A544 8.33
1 3/8"	Full	—	Standard	0.531"	0.161"	5/32"	120,000	10	91253A545 11.72
1 1/2"	Full	—	Standard	0.531"	0.161"	5/32"	120,000	25	91253A546 5.49
1 5/8"	Partial	1 1/4"	Standard	0.531"	0.161"	5/32"	120,000	5	91253A292 8.83
1 3/4"	Partial	7/8"	Standard	0.531"	0.161"	5/32"	120,000	25	91253A548 6.56
2"	Partial	1 1/8"	Standard	0.531"	0.161"	5/32"	120,000	25	91253A550 6.84
2 1/4"	Partial	1"	Standard	0.531"	0.161"	5/32"	120,000	10	91253A554 13.54
2 1/2"	Partial	1"	Standard	0.531"	0.161"	5/32"	120,000	10	91253A556 15.54
2 3/4"	Partial	1"	Standard	0.531"	0.161"	5/32"	120,000	10	91253A558 9.50
3"	Partial	1"	Standard	0.531"	0.161"	5/32"	120,000	5	91253A560 10.11
3 1/4"	Partial	1"	Standard	0.531"	0.161"	5/32"	120,000	5	91253A562 5.30
3 1/2"	Partial	1"	Standard	0.531"	0.161"	5/32"	120,000	5	91253A564 3.50
4"	Partial	1"	Standard	0.531"	0.161"	5/32"	120,000	1	91253A566 1.19
5"	Partial	1"	Standard	0.531"	0.161"	5/32"	120,000	10	91253A477 11.97
6"	Partial	1"	Standard	0.531"	0.161"	5/32"	120,000	10	91253A480 11.92

From <<https://www.mcmaster.com/#flat-head-socket-cap-screws/=1att1f9>>

Button Head Screws

Friday, May 10, 2013 5:49 PM

TITAN ROBOTICS CLUB
TEAM 492



Socket Head Cap Screw Dimensions



Fully threaded sizes are indicated with a footnote. For all other sizes, manufacturing standards allow threads to fall between standard minimum and maximum lengths. For head dimensions and thread length information, download [general information](#) for all socket head cap screws or click on a part number to view a technical drawing.

Flat Head Socket Cap Screws—Use a [countersink](#) to create a recess for flat head screws. The body diameter of your countersink should be equal to or larger than your screw's head diameter and its included angle should match your screw's head angle.

Pasted from <<http://www.mcmaster.com/#socket-head-cap-screws/=mp1vqd>>

4-40 Button Head Screws

Friday, May 10, 2013 5:53 PM

TITAN ROBOTICS CLUB
TEAM 492



Black Oxide Alloy Steel Button Head



Fully Threaded



Partially Threaded

Screws provide a wide bearing surface, low head, and a finished appearance. Screws are made from an alloy steel that exceeds Grade 5 and conform to ASTM F835. Minimum Rockwell hardness is C39 for sizes up to and including 1/2" diameter. Minimum tensile strength is 144,000 psi for sizes up to and including 1/2" diameter. Class 3A thread fit. Screw length is measured from under the head. Note: Button head screws are not recommended for high strength applications.

Black oxide offers mild rust resistance and some lubricity.

Lg.	Pkg. Qty.		Per Pkg.
1/8"	50	91255A103 *	\$10.94
3/16"	100	91255A105 *	10.68
1/4"	100	91255A106 *	10.83
5/16"	100	91255A107 *	12.49
3/8"	100	91255A108 *	11.51
1/2"	100	91255A110 *	11.82
5/8"	50	91255A112 *	9.54
3/4"	50	91255A113 *	9.59
7/8"	50	91255A115	9.59
1"	50	91255A116	10.21
1 1/4"	25	91255A117 *	10.75

*Fully threaded.

Pasted from <<http://www.mcmaster.com/#socket-head-cap-screws/=mp20kw>>

6-32 Button Head Screws

Thursday, May 09, 2013 9:12 PM



Alloy Steel Button Head



Fully Threaded



Partially Threaded

Black-Oxide Alloy Steel

Screws provide a wide bearing surface, low head, and a finished appearance. Screws are made from an alloy steel that exceeds Grade 5 and conform to ASTM F835. Minimum Rockwell hardness is C39 for sizes up to and including 1/2" diameter. Minimum tensile strength is 144,000 psi for sizes up to and including 1/2" diameter. Class 3A thread fit. Screw length is measured from under the head. Note: Button head screws are not recommended for high strength applications. Black oxide offers mild rust resistance and some lubricity.

Lg.	Pkg. Qty.		Per Pkg.
1/8"	50	91255A140 *	\$11.43
3/16"	50	91255A142 *	10.39
1/4"	100	91255A144 *	10.86
5/16"	50	91255A145 *	9.36
3/8"	100	91255A146 *	10.97
1/2"	100	91255A148 *	11.83
5/8"	100	91255A150 *	12.93
3/4"	50	91255A151 *	9.56
7/8"	50	91255A152	9.96
1"	50	91255A153	10.22
1 1/4"	25	91255A155	7.33
1 1/2"	25	91255A157	9.07

*Fully threaded.

Pasted from <<http://www.mcmaster.com/#socket-head-cap-screws/=molydq>>

8-32 Button Head Screws

Friday, May 10, 2013 5:53 PM



Black Oxide Alloy Steel Button Head



Fully Threaded



Partially Threaded

Screws provide a wide bearing surface, low head, and a finished appearance. Screws are made from an alloy steel that exceeds Grade 5 and conform to ASTM F835. Minimum Rockwell hardness is C39 for sizes up to and including 1/2" diameter. Minimum tensile strength is 144,000 psi for sizes up to and including 1/2" diameter. Class 3A thread fit. Screw length is measured from under the head. Note: Button head screws are not recommended for high strength applications.

Black oxide offers mild rust resistance and some lubricity.

Lg.	Pkg. Qty.		Per Pkg.
3/16"	50	91255A189 *	\$8.81
1/4"	100	91255A190 *	11.90
5/16"	50	91255A191 *	6.58
3/8"	100	91255A192 *	12.40
1/2"	100	91255A194 *	12.48
5/8"	50	91255A196 *	7.50
3/4"	50	91255A197 *	7.74
1"	50	91255A199	10.27
1 1/4"	10	91255A201	10.11
1 1/2"	10	91255A203	10.76
2"	5	91255A205 *	6.12
2 1/4"	5	91255A206 *	9.38

*Fully threaded.

Pasted from <<http://www.mcmaster.com/#socket-head-cap-screws/=mp21v0>>

10-24 Button Head Screws

Friday, May 10, 2013 5:53 PM

TITAN ROBOTICS CLUB
TEAM 492



Black Oxide Alloy Steel Button Head



Fully Threaded



Partially Threaded

Screws provide a wide bearing surface, low head, and a finished appearance. Screws are made from an alloy steel that exceeds Grade 5 and conform to ASTM F835. Minimum Rockwell hardness is C39 for sizes up to and including 1/2" diameter. Minimum tensile strength is 144,000 psi for sizes up to and including 1/2" diameter. Class 3A thread fit. Screw length is measured from under the head. Note: Button head screws are not recommended for high strength applications.

Black oxide offers mild rust resistance and some lubricity.

Lg.	Pkg. Qty.		Per Pkg.
1/4"	100	91255A238 *	\$13.11
3/8"	100	91255A240 *	13.06
1/2"	50	91255A242 *	7.16
5/8"	50	91255A244 *	7.48
3/4"	50	91255A245 *	7.96
7/8"	50	91255A246 *	9.08
1"	50	91255A247 *	8.46
1 1/4"	25	91255A248	10.65
1 1/2"	25	91255A250	10.94
2"	10	91255A252	5.95

*Fully threaded.

Pasted from <<http://www.mcmaster.com/#socket-head-cap-screws/=mp229g>>

10-32 Button Head Screws

Friday, May 10, 2013 5:51 PM

TITAN ROBOTICS CLUB
TEAM 492



Black Oxide Alloy Steel Button Head



Fully Threaded



Partially Threaded

Screws provide a wide bearing surface, low head, and a finished appearance. Screws are made from an alloy steel that exceeds Grade 5 and conform to ASTM F835. Minimum Rockwell hardness is C39 for sizes up to and including 1/2" diameter. Minimum tensile strength is 144,000 psi for sizes up to and including 1/2" diameter. Class 3A thread fit. Screw length is measured from under the head. Note: Button head screws are not recommended for high strength applications.

Black oxide offers mild rust resistance and some lubricity.

Lg.	Pkg. Qty.		Per Pkg.
1/4"	100	91255A261 *	\$13.11
5/16"	25	91255A262 *	7.05
3/8"	100	91255A263 *	13.06
1/2"	50	91255A265 *	7.16
5/8"	50	91255A267 *	7.74
3/4"	50	91255A269 *	10.81
7/8"	50	91255A271 *	10.84
1"	50	91255A273 *	10.93
1 1/4"	10	91255A274	9.60
1 1/2"	10	91255A275	7.57
1 3/4"	10	91255A276	5.77
2"	10	91255A278	5.95

*Fully threaded.

Pasted from <<http://www.mcmaster.com/#socket-head-cap-screws/=mp1vqd>>

1/4-20 Button Head Screws

Friday, May 10, 2013 5:54 PM

TITAN ROBOTICS CLUB
TEAM 492



Black Oxide Alloy Steel Button Head



Fully Threaded



Partially Threaded

Screws provide a wide bearing surface, low head, and a finished appearance. Screws are made from an alloy steel that exceeds Grade 5 and conform to ASTM F835. Minimum Rockwell hardness is C39 for sizes up to and including 1/2" diameter. Minimum tensile strength is 144,000 psi for sizes up to and including 1/2" diameter. Class 3A thread fit. Screw length is measured from under the head. Note: Button head screws are not recommended for high strength applications.

Black oxide offers mild rust resistance and some lubricity.

Lg.	Pkg. Qty.		Per Pkg.
1/4"	25	91255A533 *	\$7.35
3/8"	50	91255A535 *	7.56
1/2"	50	91255A537 *	7.53
5/8"	50	91255A539 *	8.04
3/4"	50	91255A540 *	8.57
7/8"	50	91255A541 *	8.24
1"	50	91255A542 *	9.23
1 1/4"	25	91255A544	10.85
1 1/2"	10	91255A546 *	8.32
1 3/4"	10	91255A548	8.40
2"	10	91255A545	7.00
2 1/2"	10	91255A547	7.35
3"	10	91255A549	9.80

*Fully threaded.

Pasted from <<http://www.mcmaster.com/#socket-head-cap-screws/=mp22rt>>

Socket Head Cap Screws

Friday, May 10, 2013 5:50 PM

TITAN ROBOTICS CLUB
TEAM 492



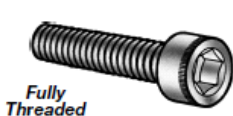
Socket Head Cap Screw Dimensions



Fully threaded sizes are indicated with a footnote. For all other sizes, manufacturing standards allow threads to fall between standard minimum and maximum lengths. For head dimensions and thread length information, download [general information](#) for all socket head cap screws or click on a part number to view a technical drawing.

Pasted from <<http://www.mcmaster.com/#socket-head-cap-screws/=mp1sde>>

Socket Head Cap Screw Dimensions



Hex Sizes and Head Dimensions

Inch Sizes

Screw Size	No. 0	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 8	No. 10	No. 12	1/4"
Decimal Approx.	0.060"	0.073"	0.086"	0.099"	0.112"	0.125"	0.138"	0.164"	0.190"	0.216"	0.250"
Hex Size	0.050"	1/16"	5/64"	5/64"	3/32"	3/32"	7/64"	9/64"	5/32"	5/32"	3/16"
Head Height	0.060"	0.073"	0.086"	0.099"	0.112"	0.125"	0.138"	0.164"	0.190"	0.216"	1/4"
Head Dia.	0.096"	0.118"	0.140"	0.161"	0.183"	0.205"	0.226"	0.270"	0.312"	0.324"	3/8"

Screw Size	5/16"	3/8"	7/16"	1/2"	9/16"	5/8"	3/4"	7/8"	1"	1 1/8"	1 1/4"	1 3/8"	1 1/2"	1 3/4"	2"	2 1/4"	2 1/2"	3"
Hex Size	1/4"	5/16"	3/8"	3/8"	7/16"	1/2"	5/8"	3/4"	3/4"	7/8"	7/8"	1"	1"	1 1/4"	1 1/2"	1 3/4"	1 3/4"	2 1/4"
Head Height	5/16"	3/8"	7/16"	1/2"	9/16"	5/8"	3/4"	7/8"	1"	1 1/8"	1 1/4"	1 3/8"	1 1/2"	1 3/4"	2"	2 1/4"	2 1/2"	3"
Head Dia.	15/32"	9/16"	21/32"	3/4"	27/32"	15/16"	1 1/8"	1 1/16"	1 1/2"	1 11/16"	1 7/8"	2 1/16"	2 1/4"	2 5/8"	3"	3 3/8"	3 3/4"	4 1/2"

Metric Sizes

Screw Size	M1.6	M2	M2.5	M2.6	M3	M4	M5	M6	M8	M10	M12	M14	M16	M18	M20	M22	M24	M30	M36
Hex Size, mm	1.5	1.5	2	2	2.5	3	4	5	6	8	10	12	14	14	17	17	19	22	27
Pitch, mm	0.35	0.4	0.45	0.45	0.5	0.7	0.8	1	1.25	1.5	1.75	2	2	2.5	2.5	2.5	3	3.5	4
Head Height, mm	1.6	2	2.5	2.6	3	4	5	6	8	10	12	14	16	18	20	22	24	30	36
Head Dia., mm	3	3.8	4.5	5	5.5	7	8.5	10	13	16	18	21	24	27	30	33	36	45	54

Thread Lengths

Screws may be fully or partially threaded. For partially threaded screws, manufacturing standards allow thread lengths to vary between the minimums and maximums listed in the tables below.

Alloy Steel—Inch Sizes

Screw Size	No. 0	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 8	No. 10	No. 12	1/4"	5/16"	3/8"	7/16"
Minimum	1/2"	5/8"	5/8"	5/8"	3/4"	3/4"	3/4"	7/8"	7/8"	7/8"	1"	1 1/8"	1 1/4"	1 3/8"
Maximum	5/8"	7/8"	7/8"	7/8"	1 3/16"	1 3/16"	1 3/16"	1 5/16"	1 3/8"	1 3/8"	1 1/2"	1 23/32"	1 15/16"	2 1/64"

Screw Size	1/2"	9/16"	5/8"	3/4"	7/8"	1"	1 1/8"	1 1/4"	1 3/8"	1 1/2"	1 3/4"	2"	2 1/4"	2 1/2"	3"
Minimum	1 1/2"	1 5/8"	1 3/4"	2"	2 1/4"	2 1/2"	2 13/16"	3 1/8"	3 3/16"	3 3/4"	4 3/8"	5"	5 5/8"	6 1/4"	7 1/2"
Maximum	2 7/16"	3"	2 15/16"	3 1/4"	3 11/16"	4 1/8"	4 11/16"	5 1/8"	5 21/32"	6 1/8"	7 1/8"	8 1/8"	9"	10"	11 3/4"

Stainless Steel—Inch Sizes

Screw Size	No. 0	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 8	No. 10	No. 12	1/4"	5/16"	3/8"	7/16"	1/2"	5/8"	3/4"	7/8"	1"	1 1/4"
Minimum	1/2"	Full	5/8"	5/8"	3/4"	3/4"	3/4"	3/4"	7/8"	7/8"	1"	1 1/8"	1 1/4"	1 3/8"	1 1/2"	1 3/4"	2"	2 1/4"	2 1/2"	2 1/2"
Maximum	1"	Full	1"	1"	1 1/2"	1 1/2"	1 1/2"	2"	2"	1 1/2"	3"	3"	3"	3"	4 1/2"	4"	3 1/2"	4"	4 1/2"	6"

Metric Sizes

Screw Size	M1.6	M2	M2.5	M2.6	M3	M4	M5	M6	M8	M10	M12	M14	M16	M18	M20	M22	M24	M30	M36
Minimum, mm	Fully	Fully	Fully	Fully	18	20	22	24	28	32	36	40	44	48	52	56	60	72	84
Maximum, mm	Fully	Fully	Fully	Fully	20.5	23.5	26	29	34.3	39.5	44.8	50	54	60.5	64.5	68.5	75	89.5	104

4-40 Socket Head Cap Screws

Friday, May 10, 2013 5:19 PM

TITAN ROBOTICS CLUB
TEAM 492



Black-Oxide Alloy Steel



Fully Threaded



Partially Threaded

The standard among high-strength fasteners, these screws are made from an alloy steel that's comparable to Grade 8 steel and conforms to ASTM A574. They have a black-oxide finish that provides lubricity and mild rust resistance.

Screw sizes through 1" have a Class 3A thread fit. Screw sizes through 1/2" have a minimum Rockwell hardness of C39 and minimum tensile strength of 180,000 psi. Screw length is measured from under the head.

Lg.	Pkg. Qty.		Per Pkg.
1/8"	50	91251A135 *	\$10.60
3/16"	100	91251A105 *	7.99
1/4"	100	91251A106 *	8.08
5/16"	100	91251A107 *	8.12
3/8"	100	91251A108 *	7.95
7/16"	100	91251A831 *	10.32
1/2"	100	91251A110 *	8.34
9/16"	25	91251A208 *	10.30
5/8"	100	91251A112 *	8.12
3/4"	100	91251A113 *	8.29
7/8"	100	91251A114 *	10.15
1"	50	91251A115	5.31
1 1/8"	25	91251A209	12.00
1 1/4"	50	91251A078	5.17
1 3/8"	25	91251A210	14.50
1 1/2"	50	91251A149	11.48
1 3/4"	10	91251A160	6.86
2"	10	91251A162	5.36

*Fully threaded.

Pasted from <<http://www.mcmaster.com/#socket-head-cap-screws/=mp2430>>

6-32 Socket Head Cap Screws

Thursday, May 09, 2013 8:27 PM

TITAN ROBOTICS CLUB
TEAM 492



Black-Oxide Alloy Steel



Fully Threaded



Partially Threaded

The standard among high-strength fasteners, these screws are made from an alloy steel that's comparable to Grade 8 steel and conforms to ASTM A574. They have a black-oxide finish that provides lubricity and mild rust resistance.

Screw sizes through 1" have a Class 3A thread fit. Screw sizes through 1/2" have a minimum Rockwell hardness of C39 and minimum tensile strength of 180,000 psi. Screw length is measured from under the head.

Lg.	Pkg. Qty.		Per Pkg.
1/8"	50	91251A864 *	\$11.20
3/16"	50	91251A866 *	7.50
1/4"	100	91251A144 *	8.33
5/16"	100	91251A145 *	10.00
3/8"	100	91251A146 *	8.29
7/16"	50	91251A178 *	7.00
1/2"	100	91251A148 *	8.12
9/16"	50	91251A867 *	12.50
5/8"	100	91251A150 *	8.33
3/4"	100	91251A151 *	8.50
7/8"	100	91251A152 *	8.76
1"	100	91251A153 *	8.93
1 1/8"	25	91251A870 *	12.25
1 1/4"	50	91251A155	9.46
1 3/8"	25	91251A874	15.50
1 1/2"	50	91251A157	9.79
1 5/8"	10	91251A875	10.80
1 3/4"	50	91251A158	6.99
2"	50	91251A159	7.21

*Fully threaded.

Pasted from <<http://www.mcmaster.com/#socket-head-cap-screws/=mold2m>>

8-32 Socket Head Cap Screws

Friday, May 10, 2013 5:53 PM

TITAN ROBOTICS CLUB
TEAM 492



Black-Oxide Alloy Steel



Fully Threaded



Partially Threaded

The standard among high-strength fasteners, these screws are made from an alloy steel that's comparable to Grade 8 steel and conforms to ASTM A574. They have a black-oxide finish that provides lubricity and mild rust resistance.

Screw sizes through 1" have a Class 3A thread fit. Screw sizes through 1/2" have a minimum Rockwell hardness of C39 and minimum tensile strength of 180,000 psi. Screw length is measured from under the head.

Lg.	Pkg. Qty.		Per Pkg.
1/8"	25	91251A179 *	\$5.48
3/16"	50	91251A180 *	8.88
1/4"	100	91251A190 *	8.89
5/16"	100	91251A191 *	8.84
3/8"	100	91251A192 *	8.93
7/16"	50	91251A182 *	10.00
1/2"	100	91251A194 *	10.08
5/8"	100	91251A196 *	10.37
3/4"	100	91251A197 *	12.70
7/8"	100	91251A198 *	11.05
1"	50	91251A199 *	7.51
1 1/8"	25	91251A183 *	12.60
1 1/4"	50	91251A201	7.36
1 3/8"	25	91251A185	14.00
1 1/2"	50	91251A203	8.04
1 5/8"	10	91251A187	7.14
1 3/4"	25	91251A082	7.75
1 7/8"	10	91251A188	8.40
2"	25	91251A205	5.11

*Fully threaded.

Pasted from <<http://www.mcmaster.com/#socket-head-cap-screws/=mp24pm>>

10-24 Socket Head Cap Screws

Friday, May 10, 2013 5:53 PM

TITAN ROBOTICS CLUB
TEAM 492



Black-Oxide Alloy Steel



Fully Threaded



Partially Threaded

The standard among high-strength fasteners, these screws are made from an alloy steel that's comparable to Grade 8 steel and conforms to ASTM A574. They have a black-oxide finish that provides lubricity and mild rust resistance.

Screw sizes through 1" have a Class 3A thread fit. Screw sizes through 1/2" have a minimum Rockwell hardness of C39 and minimum tensile strength of 180,000 psi. Screw length is measured from under the head.

Lg.	Pkg. Qty.		Per Pkg.
1/4"	50	91251A083 *	\$5.53
5/16"	50	91251A238 *	10.59
3/8"	100	91251A240 *	9.74
7/16"	100	91251A974 *	14.26
1/2"	100	91251A242 *	9.93
9/16"	50	91251A975 *	8.33
5/8"	100	91251A244 *	10.26
3/4"	100	91251A245 *	10.67
7/8"	100	91251A246 *	11.11
1"	100	91251A247 *	12.37
1 1/8"	25	91251A248	10.09
1 1/4"	50	91251A249	10.35
1 3/8"	25	91251A250	11.34
1 1/2"	50	91251A251	10.81
1 5/8"	25	91251A977	13.43
1 3/4"	50	91251A252	11.06
1 7/8"	25	91251A978	14.81
2"	50	91251A253	11.81
2 1/4"	25	91251A254	9.40
2 1/2"	25	91251A255	10.19

*Fully threaded.

Pasted from <<http://www.mcmaster.com/#socket-head-cap-screws/=mp250m>>

10-32 Socket Head Cap Screws

Friday, May 10, 2013 5:51 PM

TITAN ROBOTICS CLUB
TEAM 492



Black-Oxide Alloy Steel



Fully Threaded



Partially Threaded

The standard among high-strength fasteners, these screws are made from an alloy steel that's comparable to Grade 8 steel and conforms to ASTM A574. They have a black-oxide finish that provides lubricity and mild rust resistance.

Screw sizes through 1" have a Class 3A thread fit. Screw sizes through 1/2" have a minimum Rockwell hardness of C39 and minimum tensile strength of 180,000 psi. Screw length is measured from under the head.

Lg.	Pkg. Qty.		Per Pkg.
3/16"	10	91251A901 *	\$3.74
1/4"	50	91251A338 *	13.74
5/16"	50	91251A337 *	12.96
3/8"	100	91251A340 *	9.10
7/16"	50	91251A350 *	6.90
1/2"	100	91251A342 *	8.93
9/16"	50	91251A356 *	7.66
5/8"	100	91251A344 *	9.55
3/4"	100	91251A345 *	9.93
7/8"	50	91251A346 *	5.89
1"	50	91251A347 *	7.82
1 1/8"	5	91251A348	6.28
1 1/4"	50	91251A349	10.94
1 1/2"	50	91251A351	9.61
1 3/4"	25	91251A352	5.72
2"	25	91251A353	6.15
2 1/4"	25	91251A354	9.56
2 1/2"	25	91251A355	10.41

*Fully threaded.

Pasted from <http://www.mcmaster.com/#socket-head-cap-screws/=mp25d5>>

1/4-20 Socket Head Cap Screws

Friday, May 10, 2013 5:54 PM

TITAN ROBOTICS CLUB
TEAM 492



Black-Oxide Alloy Steel



Fully Threaded



Partially Threaded

The standard among high-strength fasteners, these screws are made from an alloy steel that's comparable to Grade 8 steel and conforms to ASTM A574. They have a black-oxide finish that provides lubricity and mild rust resistance.

Screw sizes through 1" have a Class 3A thread fit. Screw sizes through 1/2" have a minimum Rockwell hardness of C39 and minimum tensile strength of 180,000 psi. Screw length is measured from under the head.

Lg.	Pkg. Qty.		Per Pkg.
1/4"	100	91251A533 *	\$17.90
5/16"	50	91251A534 *	8.75
3/8"	100	91251A535 *	18.40
7/16"	50	91251A536 *	13.91
1/2"	100	91251A537 *	10.09
9/16"	25	91251A538 *	7.42
5/8"	50	91251A539 *	7.19
3/4"	50	91251A540 *	6.96
7/8"	50	91251A541 *	7.82
1"	50	91251A542 *	7.58
1 1/8"	25	91251A560 *	9.30
1 1/4"	50	91251A544 *	11.03
1 3/8"	10	91251A543 *	5.83
1 1/2"	50	91251A546	10.42
1 3/4"	25	91251A548	5.54
2"	25	91251A550	6.10
2 1/4"	25	91251A551	7.83
2 1/2"	25	91251A552	8.49

*Fully threaded.

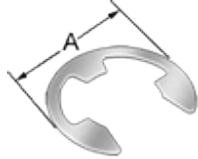
Pasted from <<http://www.mcmaster.com/#socket-head-cap-screws/=mp23cp>>

External Retaining Rings (E-Style)

Friday, May 10, 2013 6:18 PM



Side-Mount External Retaining Rings (E-Style)



Snap rings into the groove from the side of the shaft. Their three prongs make contact with the shaft and provide a wider shoulder than other external retaining rings for a larger bearing surface. They are magnetic.

Black-finish and zinc and yellow chromate-plated steel rings have a minimum Rockwell hardness of C47. Stainless steel rings are made of Type 15-7 or 17-7 PH stainless steel. Minimum Rockwell hardness is C44.



For technical drawings and 3-D models, click on a part number.

	Fits Groove		Ring Size		Black-Finish Steel		Stainless Steel		
For Shaft Dia.	Dia.	Width	(A)	Thick.	Pkg. Qty.		Pkg. Qty.		Per Pkg.
1/16"	0.052"	0.012"	0.14"	0.01"	100	97431A210	\$4.14	50	98408A112 \$8.91
3/32"	0.074"	0.02"	0.187"	0.015"	100	97431A220	3.99	50	98408A114 9.31
7/64"	0.079"	0.02"	0.375"	0.015"	100	97431A230	4.00	50	98408A123 10.61
1/8"	0.095"	0.02"	0.23"	0.015"	100	97431A240	3.99	50	98408A116 9.39
9/64"	0.102"	0.02"	0.203"	0.015"	100	97431A250	4.00	50	98408A117 8.49
5/32"	0.116"	0.029"	0.282"	0.025"	100	97431A260	3.99	25	98408A124 5.20
11/64"	0.127"	0.029"	0.312"	0.025"	100	97431A270	4.34	25	98408A125 5.30
3/16"	0.147"	0.029"	0.335"	0.025"	100	97431A280	3.99	25	98408A126 5.26
7/32"	0.188"	0.029"	0.437"	0.025"	100	97431A290	5.07	25	98408A122 5.75
1/4"	0.21"	0.029"	0.527"	0.025"	100	97431A300	5.55	25	98408A120 6.60
5/16"	0.25"	0.029"	0.5"	0.025"	100	97431A310	5.34	25	98408A132 5.55
3/8"	0.303"	0.039"	0.66"	0.035"	100	97431A320	7.82	10	98408A134 4.45
7/16"	0.343"	0.039"	0.687"	0.035"	100	97431A330	9.24	10	98408A136 4.95
1/2"	0.396"	0.046"	0.8"	0.042"	100	97431A340	9.78	10	98408A138 6.44

Pasted from <<http://www.mcmaster.com/#e-style-retaining-rings/=mp2dou>>

External Retaining Ring

Friday, May 10, 2013 6:26 PM

TITAN ROBOTICS CLUB
TEAM 492



External Retaining Rings



1/8" to 15/64"



1/4" to 10"

Pull rings open to pass over the end of a shaft and release to spring into a groove. They meet ASME B18.27.1 and are magnetic.

Black-finish and zinc and yellow chromate-plated steel rings have a minimum Rockwell hardness of C40. Stainless steel rings are made of Type 15-7 or 17-7 PH stainless steel. Minimum Rockwell hardness is C43.

To install, see [retaining ring pliers and tools](#).



For technical drawings and 3-D models, click on a part number.

	Fits Groove	Ring Size	Black-Finish Steel	Stainless Steel						
For Shaft Dia.	Dia.	Width	(A)	Thick.	Pkg. Qty.		Per Pkg.	Pkg. Qty.		Per Pkg.
1/8"	0.117"	0.012"	0.112"	0.01"	100	97633A110	\$6.30	—	—	—
5/32"	0.146"	0.012"	0.142"	0.01"	100	97633A115	7.04	—	—	—
3/16"	0.175"	0.018"	0.168"	0.015"	100	97633A120	7.82	—	—	—
7/32"	0.205"	0.018"	0.196"	0.015"	100	97633A125	10.00	—	—	—
15/64"	0.222"	0.018"	0.215"	0.015"	100	97633A127	12.08	—	—	—
1/4"	0.23"	0.029"	0.225"	0.025"	100	97633A130	7.82	10	91590A113	\$8.50
9/32"	0.261"	0.029"	0.256"	0.025"	100	97633A140	8.84	10	91590A112	8.55
5/16"	0.29"	0.029"	0.281"	0.025"	100	97633A150	8.84	10	91590A115	8.59
11/32"	0.321"	0.029"	0.309"	0.025"	100	97633A160	8.84	10	91590A116	8.63
3/8"	0.352"	0.029"	0.338"	0.025"	100	97633A170	8.74	10	91590A117	8.36
13/32"	0.382"	0.029"	0.366"	0.025"	100	97633A180	9.24	10	91590A118	8.88
7/16"	0.412"	0.029"	0.395"	0.025"	100	97633A190	9.68	10	91590A119	8.46
15/32"	0.443"	0.029"	0.428"	0.025"	50	97633A195	7.14	10	91590A121	10.58
1/2"	0.468"	0.039"	0.461"	0.035"	100	97633A200	10.13	10	91590A122	9.37

Pasted from <<http://www.mcmaster.com/#retaining-rings/=mp28vg>>

Nylock Nuts

Friday, May 10, 2013 6:46 PM



Nylon-Insert Hex Locknuts



The nylon insert provides vibration resistance and prevents loosening—without damaging mating threads. Nuts are reusable. Each has a Class 2B thread fit and is reliable at temperatures up to 250° F (unless noted).



For technical drawings and 3-D models, click on a part number.

Thread Size	Width	Height	Pkg. Qty.	Per Pkg.		
18-8 Stainless Steel						
2-56		1/4"	9/64"	50	91831A002	7.01
3-48		1/4"	9/64"	25	91831A004	1.95
4-40		1/4"	9/64"	100	91831A005	3.93
5-40		1/4"	9/64"	100	91831A006	4.52
6-32		5/16"	11/64"	100	91831A007	4.59
8-32		11/32"	15/64"	100	91831A009	5.92
10-24		3/8"	15/64"	100	91831A011	6.54
10-32		3/8"	15/64"	100	91831A411	6.54
12-24		7/16"	5/16"	50	91831A025	5.92
1/4"-20		7/16"	5/16"	50	91831A029	5.01
1/4"-28		7/16"	5/16"	50	91831A120	5.54

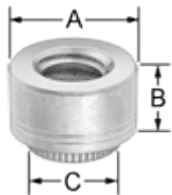
Pasted from <<http://www.mcmaster.com/#nylock-nuts/=mp2mc7>>

Pasted from <<http://www.mcmaster.com/#nylock-nuts/=mp2lnd>>

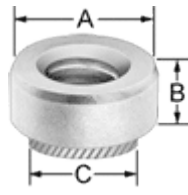
PEM Nuts (18-8 SS)

Friday, May 10, 2013 6:49 PM

TITAN ROBOTICS CLUB
TEAM 492



Round Head Broach Style



Round Head Clinch Style

Captive Nuts

Also known as insert nuts, these fasteners are well-suited for use in lightweight materials. To install, simply press the knurled end into a hole using an arbor press or similar pressure tool. The knurls cut into the panel to hold the nut in place. Inch sizes have a Class 2B thread fit (except nylon-insert locknuts which have a Class 3B thread fit); metric have a Class 6H thread fit. Nuts are not rated for hardness (unless noted).

Use broach style nuts in soft aluminum, polycarbonates, glass, epoxy, and resin laminates. Use clinch style nuts in sheet metal. Easy-align round head clinch style two-piece nuts (also called floating nuts) can freely move up to 0.030" —making alignment with mating holes and/or male threaded fasteners easier. Round head clinch style nylon-insert locknuts come with a nylon 6/6 insert that keeps screws from coming loose. Inserts are reliable up to 250° F.

Tin-plated steel nuts are good for soldering. 18-8 stainless steel nuts provide excellent corrosion resistance and may be mildly magnetic. Zinc-plated steel nuts provide good corrosion resistance (metric sizes are case hardened to a minimum surface hardness of C52).



For technical drawings and 3-D models, click on a part number.

Round Head Broach Style

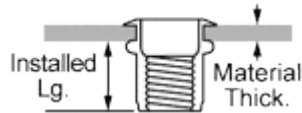
Thread Size	For Min. Panel Thick.	Mounting Hole Dia.	(A)	(B)	(C)	PEM Part No.	Pkg. Qty.		Per Pkg.
2-56	0.06"	0.147"	0.22"	0.07"	0.17"	KFS2-256	25	94648A310	10.22
4-40	0.06"	0.166"	0.22"	0.07"	0.19"	KFS2-440	25	94648A320	9.82
6-32	0.06"	0.213"	0.29"	0.07"	0.24"	KFS2-632	25	94648A330	11.49
8-32	0.06"	0.25"	0.35"	0.10"	0.27"	KFS2-832	25	94648A340	13.49
10-24	0.06"	0.272"	0.38"	0.13"	0.29"	KFS2-024	10	94648A350	6.65
10-32	0.06"	0.272"	0.38"	0.13"	0.29"	KFS2-032	25	94648A360	14.95
1/4"-20	0.06"	0.328"	0.44"	0.24"	0.35"	KFS2-420	10	94648A370	10.31

Pasted from <<http://www.mcmaster.com/#pem-style-nuts/=mp2mq3>>

Heavy Duty Rivet Nuts

Saturday, May 25, 2013 8:16 AM

TITAN ROBOTICS CLUB
TEAM 492



With knurls that increase resistance to spin, these rivet nuts can handle more torque than smooth nuts. Install in a drilled hole using a [tool](#). The tool collapses the nut, creating a back flange that holds the nut to the material. Thread class is 2B for inch sizes and 6H for metric sizes.

Aluminum nuts are one-third the weight of steel and offer mild corrosion resistance.

Zinc yellow-chromate plated steel nuts have good rust resistance.

18-8 stainless steel nuts have excellent corrosion resistance.

Open End—Nuts are open at bottom, so you can use a long screw or bolt.

Closed End—The thread area is enclosed, which prevents leakage past the threads from either side of your application.

Self-Sealing—Nuts have PVC foam bonded under the flange to seal out liquids and gas.



For technical drawings and 3-D models, click on a part number.

Open End

Thread	Drill Size	Material Thick.	Body		Flange			Max. Installed Lg.	Pkg. Qty	Aluminum	
			Dia.	Lg.	Dia.	Thick.	Pkg.			Pkg.	
6-32	17/64"	0.020"-0.080"	0.265"	0.420"	0.390"	0.030"	0.305"	25	94020A311	\$7.74	
6-32	17/64"	0.080"-0.130"	0.265"	0.470"	0.390"	0.030"	0.305"	25	94020A315	8.02	
8-32	17/64"	0.020"-0.080"	0.265"	0.420"	0.390"	0.030"	0.305"	25	94020A319	8.06	
8-32	17/64"	0.080"-0.130"	0.265"	0.470"	0.390"	0.030"	0.305"	25	94020A323	8.78	
10-24	19/64"	0.020"-0.130"	0.296"	0.475"	0.415"	0.030"	0.315"	25	94020A327	9.29	
10-24	19/64"	0.130"-0.225"	0.296"	0.585"	0.415"	0.030"	0.315"	25	94020A331	11.83	
10-32	19/64"	0.020"-0.130"	0.296"	0.475"	0.415"	0.030"	0.315"	25	94020A335	9.10	
10-32	19/64"	0.130"-0.225"	0.296"	0.585"	0.415"	0.030"	0.315"	25	94020A339	13.13	
1/4"-20	25/64"	0.027"-0.165"	0.390"	0.580"	0.500"	0.030"	0.380"	25	94020A343	12.80	
1/4"-20	25/64"	0.165"-0.260"	0.390"	0.680"	0.500"	0.030"	0.380"	10	94020A347	6.50	

Pasted from <<http://www.mcmaster.com/#standard-rivet-nuts/=mwkapy>>

Helicoil Inserts

Sunday, December 24, 2017 10:58 AM



18-8 Stainless Steel Helical Inserts



Also known as Heli-Coil inserts, use these to repair threads in metals. They have smooth, round coils so screws can be easily installed and removed. The coils expand once installed to securely anchor the insert. A prong grips the tool during installation and must be properly engaged in the tool's driving contour. Remove the prong to allow full passage of a screw. Installation requires a drill bit, a helical insert tap, an installation tool, and a prong break-off tool.

From <<https://www.mcmaster.com/#helical-inserts/=1atr4j3>>

Thread Size	Installed Lg.	Drill Size	For Max Hole Dia	Pkg Qty	P/N	Pkg Price	Instl Tool	Instl Tool Price	Prong Break-off Tool	Break-off Tool Price
6-32	0.138"	No. 25	0.1495"	10	91732A355	\$ 4.99	90261A152	\$ 95.53	92955A105	\$ 70.84
6-32	0.207"	No. 25	0.1495"	10	91732A286	\$ 4.17	90261A152	\$ 95.53	92955A105	\$ 70.84
6-32	0.276"	No. 25	0.1495"	10	91732A707	\$ 6.03	90261A152	\$ 95.53	92955A105	\$ 70.84
6-32	0.345"	No. 25	0.1495"	10	91732A708	\$ 5.63	90261A152	\$ 95.53	92955A105	\$ 70.84
6-32	0.414"	No. 25	0.1495"	5	91732A425	\$ 2.69	90261A152	\$ 95.53	92955A105	\$ 70.84
8-32	0.164"	No. 16	0.177"	10	91732A359	\$ 4.99	90261A153	\$ 96.63	92955A107	\$ 70.84
8-32	0.246"	No. 16	0.177"	10	91732A287	\$ 4.17	90261A153	\$ 96.63	92955A107	\$ 70.84
8-32	0.328"	No. 16	0.177"	10	91732A713	\$ 6.15	90261A153	\$ 96.63	92955A107	\$ 70.84
8-32	0.410"	No. 16	0.177"	10	91732A714	\$ 4.93	90261A153	\$ 96.63	92955A107	\$ 70.84
10-24	0.190"	No. 5	0.2055"	10	91732A364	\$ 4.44	90261A154	\$ 91.01	92955A109	\$ 70.84
10-24	0.285"	No. 5	0.2055"	10	91732A211	\$ 4.17	90261A154	\$ 91.01	92955A109	\$ 70.84
10-32	0.190"	13/64"	0.2031"	10	91732A511	\$ 4.07	90261A161	\$ 91.01	92955A109	\$ 70.84
10-32	0.285"	13/64"	0.2031"	10	91732A231	\$ 4.27	90261A161	\$ 91.01	92955A109	\$ 70.84
1/4"-20	0.250"	H	0.2656"	10	91732A368	\$ 4.44	90261A155	\$ 91.01	92955A111	\$ 70.84
1/4"-20	0.375"	H	0.2656"	10	91732A212	\$ 4.17	90261A155	\$ 91.01	92955A111	\$ 70.84

Key-Locking Inserts

Sunday, December 24, 2017 10:53 AM



18-8 Stainless Steel Key-Locking Inserts for Soft Metals



Installation Tool

These are more corrosion resistant than black-phosphate steel inserts. Drive the keys into the surrounding material for a more secure hold than thread-locking inserts. Use them to repair or convert threads in soft metals such as aluminum. Inserts may be mildly magnetic. They're comparable to Keensert inserts. Installation requires a drill bit, a tap, an installation tool, and a hammer.



For technical drawings and 3-D models, click on a part number.

Inch

Inserts

Thread Size	Tap Size	Installed Lg.	Drill Bit Size	For Maximum Hole Diameter	No. of Locking Keys	Each		Installation Tools		
						1-9	10-Up		Each	
8-32	5/16"-18	0.313"	I	0.272"	2	91731A047	\$2.82	\$2.25	92100A708	\$14.67
10-24	3/8"-16	0.313"	Q	0.332"	2	91731A051	3.31	2.66	92100A709	14.33
10-24	5/16"-18	0.313"	I	0.272"	2	93340A405	2.93	2.48	93875A001	14.85
10-32	3/8"-16	0.313"	Q	0.332"	2	91731A049	3.22	2.56	92100A709	14.33
10-32	5/16"-18	0.313"	I	0.272"	2	93340A305	2.93	2.48	93875A001	14.85
1/4"-20	3/8"-16	0.375"	Q	0.332"	2	93340A410	3.16	2.66	93875A010	14.85
1/4"-20	7/16"-14	0.375"	X	0.397"	2	91731A052	3.18	2.70	92100A711	12.78
1/4"-28	3/8"-16	0.375"	Q	0.332"	2	93340A310	3.16	2.66	93875A010	14.85
1/4"-28	7/16"-14	0.375"	X	0.397"	2	91731A064	3.17	2.70	92100A711	12.78
5/16"-18	1/2"-13	0.438"	29/64"	0.4531"	4	91731A053	4.71	4.00	92100A715	12.78
5/16"-18	7/16"-14	0.438"	X	0.397"	4	93340A415	5.24	4.41	93875A015	14.85
5/16"-24	1/2"-13	0.438"	29/64"	0.4531"	4	91731A071	4.70	4.00	92100A715	12.78
5/16"-24	7/16"-14	0.438"	X	0.397"	4	93340A315	5.17	4.39	93875A015	14.85

From <<https://www.mcmaster.com/#key-locking-threaded-inserts/=1atr32n>>

Bearings, Bushings & Slides

Friday, December 22, 2017 8:26 AM

TITAN ROBOTICS CLUB
TEAM 492



BEARINGS, BUSHINGS & SLIDES

- A. STEEL BALL BEARING**
 - A. FLANGED MINIATURE**
 - B. FLANGED OPEN**
 - C. FLANGED DOUBLE SEAL**
- B. THRUST BEARINGS**
- C. BUSHINGS**
- D. IGUS DELRIN BEARINGS**
- E. LAZY SUSAN/TURNTABLE**
- F. LINEAR SLIDES**

Bushing vs. Bearing

Friday, December 22, 2017 8:52 AM



A bushing and bearing perform the same task to different levels of complexity. Both reduce friction around a shaft, so that the 2 parts can move independently of each other.

This is a **bushing**;



The bushing is, at its simplest, a simple tube in between the 2 parts, whereas a bearing might use a race of balls or rollers (not the only bearings, but the most common). They can be plastic (usually nylon) or a soft metal like bronze. Simple how they work, put something with low friction between two moving parts. A bushing, as a sleeve will be one half of a rotating journal bearing assembly with shaft surface itself being the "journal" part that rotates and the bushing the stationary "sleeve" part that supports it. These are typically used in slower speed applications.



A **bearing** is a machine element that constrains relative motion to only the desired motion, and reduces friction between moving parts. It uses moving balls or rollers to reduce friction. However not all bearings are equal.

Pictured to the left is a ball bearing. They are very good at high speed rotational motion. They aren't designed to take high radial load so can/will deform and seize up.



What you ideally want for that application are needle bearings. These are capable of suffering huge radial loads. However they are comparatively very expensive for a good needle bearing.

From <<https://www.quora.com/What-is-difference-between-a-bushing-and-a-bearing-Where-is-the-disaster-bushing-located-on-the-pump>>

Steel Ball Bearings

Saturday, May 25, 2013 9:15 AM

TITAN ROBOTICS CLUB
TEAM 492



Open



Flanged Open



Double Shielded



Double Sealed



Flanged Double Sealed

Count on solid performance from these steel ball bearings. Temperature range is -20° to $+250^{\circ}$ F. Maximum speed is 1200 rpm for open bearings; 2500 rpm for all others (unless noted). These bearings are not ABEC rated.

Open bearings run cool and are easy to lubricate.

Double-shielded bearings have steel shields that block out dirt. They come greased.

Double-sealed bearings have Buna-N seals (unless noted) that block out dirt, preserve lubricants, and reduce noise. They come greased.

Flanged bearings are easy to install; the flange provides a stop for quick positioning.



For technical drawings and 3-D models, click on a part number.

Pasted from <<http://www.mcmaster.com/#standard-ball-and-roller-bearings/=mwkz9k>>

Flanged Miniature Bearings

Saturday, May 25, 2013 9:02 AM

TITAN ROBOTICS CLUB
TEAM 492



Flanged Open—Inch

For Shaft Dia.	OD	Flange OD	Dynamic Load Cap., lbs.	Max. rpm	Wd.	Flange Thick.		Each
1/8"	1/4"	0.296"	64	80,000	3/32"	0.02"	57155K205	5.71
1/8"	5/16"	0.359"	124	71,000	0.109"	0.02"	57155K206	5.27
1/8"	3/8"	0.44"	144	67,000	5/32"	0.03"	57155K207	6.33
5/32"	5/16"	0.359"	81	63,000	0.109"	0.02"	57155K208	7.41
3/16"	5/16"	0.359"	81	63,000	0.109"	0.02"	57155K209	5.98
3/16"	3/8"	0.422"	160	60,000	1/8"	0.02"	57155K301	6.97
3/16"	1/2"	0.565"	293	50,000	5/32"	0.04"	57155K302	5.00
1/4"	3/8"	0.422"	84	56,000	1/8"	0.02"	57155K303	6.38
1/4"	1/2"	0.547"	243	50,000	1/8"	0.02"	57155K304	5.62
1/4"	5/8"	0.69"	335	45,000	0.196"	0.04"	57155K305	4.96
5/16"	1/2"	0.547"	122	48,000	5/32"	0.03"	57155K306	6.88

Pasted from <<http://www.mcmaster.com/#standard-ball-and-roller-bearings/=mwku57>>

Flanged Double Shielded—Inch



For Shaft Dia.	OD	Flange OD	Dynamic Load Cap., lbs.	Max. rpm	Wd.	Flange Thick.		Each
1/8"	1/4"	0.296"	64	80,000	0.109"	0.03"	57155K313	5.67
1/8"	5/16"	0.359"	124	71,000	9/64"	0.03"	57155K314	6.28
1/8"	3/8"	0.422"	144	63,000	9/64"	0.03"	57155K315	7.08
1/8"	3/8"	0.44"	144	67,000	5/32"	0.03"	57155K316	5.21
5/32"	5/16"	0.359"	81	63,000	1/8"	0.04"	57155K317	7.65
3/16"	5/16"	0.359"	81	63,000	1/8"	0.04"	57155K318	6.35
3/16"	3/8"	0.422"	160	60,000	1/8"	0.03"	57155K319	4.78
3/16"	1/2"	0.565"	293	50,000	0.196"	0.04"	57155K321	6.38
1/4"	3/8"	0.422"	84	56,000	1/8"	0.04"	57155K322	7.60
1/4"	1/2"	0.547"	243	50,000	3/16"	0.05"	57155K323	5.70
1/4"	5/8"	0.69"	335	45,000	0.196"	0.04"	57155K324	5.85
5/16"	1/2"	0.547"	122	48,000	5/32"	0.03"	57155K325	6.88

Pasted from <<http://www.mcmaster.com/#standard-ball-and-roller-bearings/=mwku57>>

Flanged Open Bearings

Saturday, May 25, 2013 9:11 AM



Flanged Open



Flanged Open

For Shaft Dia.	OD	Wd.	Flange OD	Flange Thick.	Dynamic Load Cap., lbs.		Each
1/4"	11/16"	5/16"	13/16"	3/64"	287	6383K213	\$3.17
1/4"	7/8"	5/16"	1"	3/64"	356	6383K214	4.44
5/16"	7/8"	5/16"	1"	3/64"	341	6383K215	4.44
3/8"	1 1/16"	7/16"	1 3/16"	1/16"	509	6383K227	5.34
3/8"	1 1/8"	1/2"	1 1/4"	1/16"	533	6383K232	5.47
7/16"	1 1/16"	7/16"	1 3/16"	1/16"	509	6383K224	5.35
1/2"	1 1/8"	7/16"	1 1/4"	1/16"	310	6383K234 *	7.61
1/2"	1 3/8"	1/2"	1 1/2"	1/16"	450	6383K241 *	10.11
1/2"	1 1/2"	11/16"	1 5/8"	1/16"	769	6383K245	8.20
1/2"	1 3/4"	5/8"	1 7/8"	1/16"	1,187	6383K253	10.59
5/8"	1 3/8"	1/2"	1 1/2"	1/16"	450	6383K244 *	10.11
5/8"	1 1/2"	31/64"	1 5/8"	1/16"	769	6383K247	8.22
3/4"	1 3/4"	5/8"	1 7/8"	1/16"	1,187	6383K251	9.91
1"	2"	9/16"	2 1/8"	1/16"	820	6383K257 *	15.08

*Maximum speed is 1000 rpm, load capacity listed @ 100 rpm.

Pasted from <<http://www.mcmaster.com/#standard-ball-and-roller-bearings/=mwkz9k>>

Flanged Double Sealed Bearings

Saturday, May 25, 2013 9:13 AM

TITAN ROBOTICS CLUB
TEAM 492



Flanged Double Sealed



Flanged Double Sealed

For Shaft Dia.	OD	Wd.	Flange OD	Flange Thick.	Dynamic Load Cap., lbs.		Each
1/4"	11/16"	3/8"	13/16"	1/16"	255	6384K342 ‡•	\$6.30
5/16"	7/8"	13/32"	1"	1/16"	325	6384K343 ‡	6.81
3/8"	7/8"	13/32"	1"	1/16"	325	6384K344 ‡	6.81
3/8"	29/32"	13/32"	1"	1/16"	350	6384K346 ‡	7.31
3/8"	1 1/8"	7/16"	1 1/4"	1/16"	600	6384K348 ‡	8.01
1/2"	1 1/8"	7/16"	1 1/4"	1/16"	310	6384K361 *	9.85
1/2"	1 3/8"	1/2"	1 1/2"	1/16"	450	6384K363 *	11.15
5/8"	1 3/8"	1/2"	1 1/2"	1/16"	450	6384K365 *	11.15
3/4"	1 5/8"	9/16"	1 3/4"	1/16"	1,300	6384K367 ‡	10.78
3/4"	1 3/4"	9/16"	1 7/8"	1/16"	1,300	6384K369 ‡	10.76
3/4"	2"	5/8"	2 1/8"	1/16"	1,480	6384K374 ‡	14.85
1"	2"	9/16"	2 1/8"	1/16"	820	6384K373 *	19.17

*Maximum speed is 1000 rpm, load capacity listed @ 100 rpm.

•Seal is plastic with metal backing.

‡Maximum speed is 3000 rpm.

Pasted from <<http://www.mcmaster.com/#standard-ball-and-roller-bearings/=mwkz9k>>

Thrust Bearings

Friday, December 22, 2017 8:31 AM



Oil-Embedded Thrust Bearings



CAD

Startup friction causes these porous bronze bearings to release a thin layer of oil on the bearing's surface. They are also known as Oilite® bearings.

Note: Dynamic load capacity is the maximum load a bearing can withstand at a given shaft speed. If your application's load and speed requirements are below the values listed, the bearing will work.

For technical drawings and 3-D models, click on a part number.

SAE 841 Bronze Bearings

OD	Thick.	Dynamic Thrust Load Capacity	Lubrication	Lubricant	Temperature Range, °F	Each
For 1/4" Shaft Dia.						
7/16"	1/16"	200 lbs. @ 120 rpm	Lubricated	SAE 30 Oil	-35° to 300°	5906K561 \$0.42
1/2"	1/16"	290 lbs. @ 120 rpm	Lubricated	SAE 30 Oil	-35° to 300°	5906K562 .48
5/8"	1/16"	510 lbs. @ 120 rpm	Lubricated	SAE 30 Oil	-35° to 300°	5906K531 .96
For 5/16" Shaft Dia.						
5/8"	1/16"	460 lbs. @ 120 rpm	Lubricated	SAE 30 Oil	-35° to 300°	5906K563 .54
3/4"	1/16"	730 lbs. @ 120 rpm	Lubricated	SAE 30 Oil	-35° to 300°	5906K564 .76
For 3/8" Shaft Dia.						
5/8"	1/16"	390 lbs. @ 120 rpm	Lubricated	SAE 30 Oil	-35° to 300°	5906K565 .55
3/4"	1/16"	660 lbs. @ 120 rpm	Lubricated	SAE 30 Oil	-35° to 300°	5906K511 .90
3/4"	1/8"	660 lbs. @ 120 rpm	Lubricated	SAE 30 Oil	-35° to 300°	5906K533 1.06
For 7/16" Shaft Dia.						
3/4"	1/16"	580 lbs. @ 120 rpm	Lubricated	SAE 30 Oil	-35° to 300°	5906K566 .65
For 1/2" Shaft Dia.						
3/4"	1/16"	490 lbs. @ 120 rpm	Lubricated	SAE 30 Oil	-35° to 300°	5906K512 .93
7/8"	3/16"	730 lbs. @ 120 rpm	Lubricated	SAE 30 Oil	-35° to 300°	5906K411 1.04
1"	1/16"	930 lbs. @ 120 rpm	Lubricated	SAE 30 Oil	-35° to 300°	5906K513 1.24
1"	3/32"	930 lbs. @ 120 rpm	Lubricated	SAE 30 Oil	-35° to 300°	5906K535 1.24
1"	1/8"	930 lbs. @ 120 rpm	Lubricated	SAE 30 Oil	-35° to 300°	5906K514 1.26

From <<https://www.mcmaster.com/#=1asp766>>

Bushings

Friday, December 22, 2017 8:28 AM



Startup friction causes these porous bronze bearings to release a thin layer of oil on the bearing's surface. They are also known as Oilite® bearings.

Note: Dynamic load capacity is the maximum load a bearing can withstand at a given shaft speed. If your application's load and speed requirements are below the values listed, the bearing will work.

For technical drawings and 3-D models, click on a part number.



For Housing ID	Lg.	Flange OD	Flange Thick.	Dynamic Radial Load Capacity	Dynamic Thrust Load Capacity	Lubrication	Each
For 3/16" Shaft Dia.							
5/16"	1/4"	7/16"	1/16"	90 lbs. @ 120 rpm	245 lbs. @ 120 rpm	Lubricated	6338K563 .44
5/16"	3/8"	7/16"	1/16"	140 lbs. @ 120 rpm	245 lbs. @ 120 rpm	Lubricated	6338K564 .58
5/16"	1/2"	7/16"	1/16"	185 lbs. @ 120 rpm	245 lbs. @ 120 rpm	Lubricated	6338K311 .87
3/8"	3/8"	7/16"	1/16"	140 lbs. @ 120 rpm	245 lbs. @ 120 rpm	Lubricated	6338K565 1.02
For 1/4" Shaft Dia.							
3/8"	1/4"	1/2"	1/16"	125 lbs. @ 120 rpm	290 lbs. @ 120 rpm	Lubricated	6338K411 .77
3/8"	3/8"	1/2"	1/16"	185 lbs. @ 120 rpm	290 lbs. @ 120 rpm	Lubricated	6338K412 .79
3/8"	1/2"	1/2"	1/16"	250 lbs. @ 120 rpm	290 lbs. @ 120 rpm	Lubricated	6338K413 1.09
3/8"	3/4"	1/2"	1/16"	370 lbs. @ 120 rpm	290 lbs. @ 120 rpm	Lubricated	6338K451 1.95
7/16"	1/2"	1/2"	1/16"	250 lbs. @ 120 rpm	290 lbs. @ 120 rpm	Lubricated	6338K566 2.18
1/2"	5/8"	5/8"	1/16"	310 lbs. @ 120 rpm	510 lbs. @ 120 rpm	Lubricated	6338K567 1.52
1/2"	3/4"	5/8"	1/16"	370 lbs. @ 120 rpm	510 lbs. @ 120 rpm	Lubricated	6338K568 1.95
For 5/16" Shaft Dia.							
7/16"	3/8"	9/16"	1/16"	230 lbs. @ 120 rpm	340 lbs. @ 120 rpm	Lubricated	6338K453 1.01
7/16"	1/2"	9/16"	1/16"	310 lbs. @ 120 rpm	340 lbs. @ 120 rpm	Lubricated	6338K452 1.13
7/16"	3/4"	9/16"	1/16"	460 lbs. @ 120 rpm	340 lbs. @ 120 rpm	Lubricated	6338K454 1.23
9/16"	1/2"	11/16"	1/16"	310 lbs. @ 120 rpm	580 lbs. @ 120 rpm	Lubricated	6338K455 5.91
9/16"	3/4"	11/16"	1/16"	460 lbs. @ 120 rpm	580 lbs. @ 120 rpm	Lubricated	6338K456 6.14
5/8"	3/4"	7/8"	1/8"	460 lbs. @ 120 rpm	950 lbs. @ 120 rpm	Lubricated	6338K457 5.24

From <<https://www.mcmaster.com/#=1asp94v>>

Bushings (Cont)

Friday, December 22, 2017 8:28 AM

TITAN ROBOTICS CLUB TEAM 492



For Housing ID	Lg.	Flange OD	Flange Thick.	Dynamic Radial Load Capacity	Dynamic Thrust Load Capacity	Lubrication	Each
For 3/8" Shaft Dia.							
1/2"	1/4"	11/16"	1/16"	185 lbs. @ 120 rpm	520 lbs. @ 120 rpm	Lubricated	6338K414 .74
1/2"	1/2"	5/8"	1/16"	370 lbs. @ 120 rpm	390 lbs. @ 120 rpm	Lubricated	6338K312 .93
1/2"	1/2"	11/16"	1/16"	370 lbs. @ 120 rpm	520 lbs. @ 120 rpm	Lubricated	6338K415 .85
1/2"	3/4"	11/16"	1/16"	560 lbs. @ 120 rpm	520 lbs. @ 120 rpm	Lubricated	6338K416 1.13
9/16"	1/2"	11/16"	1/16"	370 lbs. @ 120 rpm	520 lbs. @ 120 rpm	Lubricated	6338K569 1.22
9/16"	3/4"	11/16"	1/16"	560 lbs. @ 120 rpm	520 lbs. @ 120 rpm	Lubricated	6338K571 2.62
5/8"	1/2"	7/8"	1/16"	370 lbs. @ 120 rpm	890 lbs. @ 120 rpm	Lubricated	6338K461 1.18
5/8"	3/4"	7/8"	1/16"	560 lbs. @ 120 rpm	890 lbs. @ 120 rpm	Lubricated	6338K463 1.60
5/8"	1"	7/8"	1/16"	750 lbs. @ 120 rpm	890 lbs. @ 120 rpm	Lubricated	6338K465 2.03
For 7/16" Shaft Dia.							
9/16"	1/2"	11/16"	1/16"	430 lbs. @ 120 rpm	440 lbs. @ 120 rpm	Lubricated	6338K462 1.30
9/16"	3/4"	11/16"	1/16"	650 lbs. @ 120 rpm	440 lbs. @ 120 rpm	Lubricated	6338K464 1.63
5/8"	3/4"	7/8"	1/8"	650 lbs. @ 120 rpm	820 lbs. @ 120 rpm	Lubricated	6338K466 1.82
For 1/2" Shaft Dia.							
5/8"	3/8"	7/8"	1/8"	370 lbs. @ 120 rpm	730 lbs. @ 120 rpm	Lubricated	6338K417 1.12
5/8"	1/2"	7/8"	1/16"	500 lbs. @ 120 rpm	730 lbs. @ 120 rpm	Lubricated	6338K572 .99
5/8"	1/2"	7/8"	1/8"	500 lbs. @ 120 rpm	730 lbs. @ 120 rpm	Lubricated	6338K418 1.15
5/8"	3/4"	7/8"	1/8"	750 lbs. @ 120 rpm	730 lbs. @ 120 rpm	Lubricated	6338K419 1.08
5/8"	1"	7/8"	1/8"	1,000 lbs. @ 120 rpm	730 lbs. @ 120 rpm	Lubricated	6338K421 1.44
11/16"	1/2"	7/8"	1/8"	500 lbs. @ 120 rpm	730 lbs. @ 120 rpm	Lubricated	6338K573 1.70
11/16"	3/4"	7/8"	1/8"	750 lbs. @ 120 rpm	730 lbs. @ 120 rpm	Lubricated	6338K574 1.95
3/4"	1/2"	1"	1/8"	500 lbs. @ 120 rpm	930 lbs. @ 120 rpm	Lubricated	6338K422 1.60
3/4"	3/4"	1"	1/8"	750 lbs. @ 120 rpm	930 lbs. @ 120 rpm	Lubricated	6338K423 1.22
3/4"	1"	1"	1/8"	1,000 lbs. @ 120 rpm	930 lbs. @ 120 rpm	Lubricated	6338K424 2.28

From <<https://www.mcmaster.com/#=1asp94v>>



iglide® J, sleeve bearing with flange, mm

- The versatile endurance runner, highly resistant to wear on (nearly) all shafts with very low coefficients of friction
- Low wear against different shaft materials
- Low coefficients of friction in dry operation
- Vibration-dampening



iglide® J, sleeve bearing, mm

- The versatile endurance runner, highly resistant to wear on (nearly) all shafts with very low coefficients of friction
- Low wear against different shaft materials
- Low coefficients of friction in dry operation
- Vibration-dampening



iglide® L280, thrust washer, mm

The classic endurance runner, very wear resistant on (virtually) all shafts

- For especially long service life
- Low coefficient of friction
- Extremely high wear resistance



igubal® pillow block bearings

igubal® pillow block bearings consist of a housing with a bearing insert. They are especially easy to install, compensate for misalignment, and prevent edge loads.



igubal® flange bearing

Like all igubal® products, these flange bearings consist of a housing made from igumid G and a spherical ball made from either iglide® L280 or iglide® R for standard parts, or with any iglide material as a special. igubal® flange bearings correspond to dimensional series E and are offered with two or four mounting holes.



Turntable

Friday, December 22, 2017 8:29 AM

TITAN ROBOTICS CLUB
TEAM 492



Silver Table Bearing, Heavy Duty Aluminum Alloy Hardware Rotating Turntable Bearing Swivel Plate for Dining-Table

Details

- MATERIAL: Come with good quality and high performance, Adopting heavy duty aluminium alloy material, solid, durable and corrosion resistant.
- APPLICATION: Ideal for cake decorations, TV monitor stand, electronic repair, sculpture base, catering services, food display, serving.
- FUNCTION: These bearings can be screwed or fixed as they have through holes and pre-drilled holes. Single-row bearing for supporting radial loads.
- CLEAN AND INSTALLATION: This lazy susan with the Smooth surface and beautiful, easy to clean. Easy to set up, no installation is required.
- PACKAGE INCLUDED: 1 x Table Bearing

From <https://www.amazon.com/Aluminium-Hardware-Rotating-Turntable-Dining-Table/dp/B0757G3X9H/ref=sr_1_1?s=industrial&ie=UTF8&qid=1514840232&sr=8-1&keywords=estink+table+bearing>

Linear Slides

Monday, January 1, 2018 12:36 PM

**TITAN ROBOTICS CLUB
TEAM 492**



LINEAR SLIDES

- A. IGUS LINEAR SLIDES**
- B. 80/20 LINEAR SLIDES**
- C. SERVOCITY LINEAR SLIDES**
- D. REV LINEAR SLIDES**



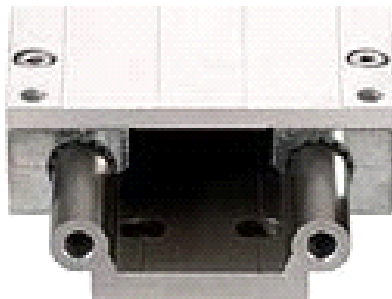
DryLin® N low profile guide systems

DryLin® N low profile guide systems offer you low profiles in various widths. Like in all DryLin® products, the carriage runs without lubrication in anodized aluminum profiles. The material used and the unique design make DryLin® N a cost-efficient and flexible guide system.

- 1 Rail made of anodized aluminum
- 2 Gliding elements made of iglide® J or J200
- 3 Carriage made of chromated zinc or plastic
- 4 Carriage with threaded hole or through hole

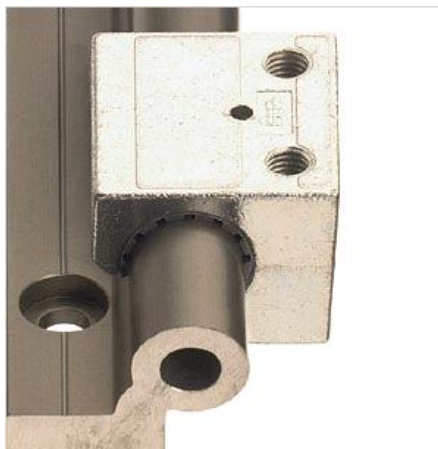


From <https://www.igus.com/wpck/17357/drylin_n>



drylin® W - profile guides

The drylin® W profile guides constitutes a cost-efficient pre-assembled system. The design allows extremely high flexibility in design and a simple installation by the application of individual or double rails. Hard-anodized aluminum is used as rail material and provides for the best friction and wear results by profile guides. The exclusion of lubrication also makes the system extremely insensitive to dirt and because of the cleanness it is well-suited for applications in clean and hygienic environments too.



From <https://www.igus.com/wpck/17373/drylin_w>

80/20 Linear Slides

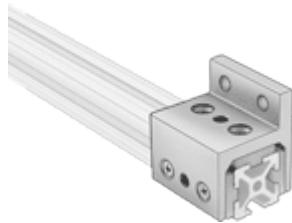
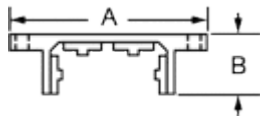
Monday, January 1, 2018 12:36 PM



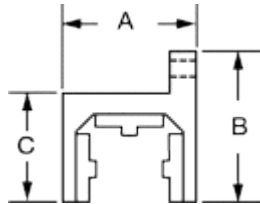
Sleeve Bearing Carriages for Single Rails



Horizontal Mount



Side Mount



Carriages have through holes to allow fastening from the top of your load into the carriage as well as from the bottom of the carriage into your load. Sleeve-bearing carriages can handle dirt, water, impact, and vibration.

Optional hand brakes mount to sleeve-bearing and high-strength sleeve-bearing carriages to hold them in place on the rail. The carriages have a mounting hole for the brakes.

From <https://www.mcmaster.com/#>

For Rail Ht.	Lg.	(A)	(B)	(C)	Dia.	Dp.		Each
Horizontal Mount								
1"	1 7/8"	2 15/16"	1 1/4"	—	1/4"	5/16"	47065T959	\$ 46.16
1"	4"	2 15/16"	1 1/4"	—	1/4"	5/16"	47065T961	\$ 59.41
1 1/2"	2 13/16"	4"	1 7/8"	—	5/16"	3/8"	47065T962	\$ 58.00
1 1/2"	6"	4"	1 7/8"	—	5/16"	3/8"	47065T963	\$ 75.02
Side Mount								
1"	1 7/8"	1 5/8"	2"	1 5/16"	1/4"	5/16"	47065T953	\$ 43.51
1"	4"	1 5/8"	2"	1 5/16"	1/4"	5/16"	47065T954	\$ 55.86
1 1/2"	2 13/16"	2 1/2"	2 3/4"	2"	5/16"	1/2"	47065T955	\$ 55.35
1 1/2"	6"	2 1/2"	2 3/4"	2"	5/16"	1/2"	47065T956	\$ 71.47

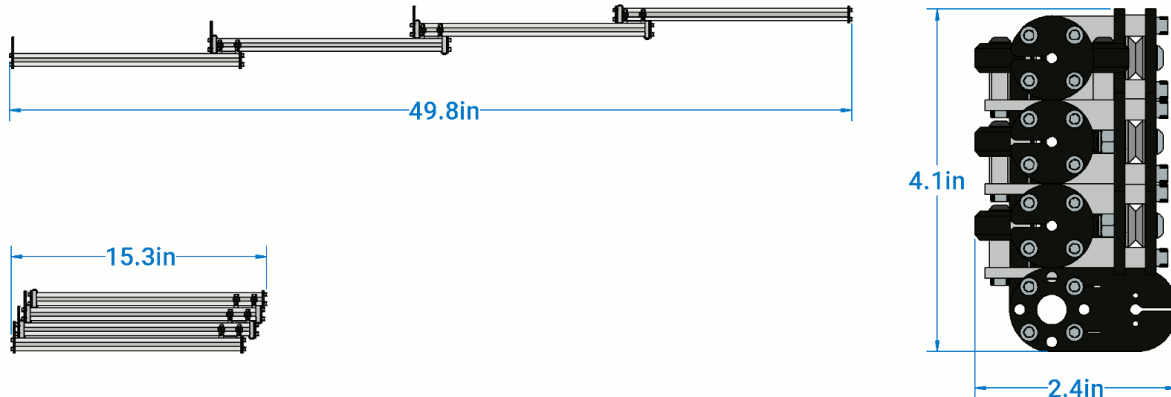
From <https://www.mcmaster.com/#>



Cascading X-Rail Slide Kit



From <<https://www.servocity.com/cascading-x-rail-slide-kit>>



The Cascading X-Rail Slide Kit provides all the mechanical pieces necessary to build a winch-driven extendable arm. Fasten a motor or HS-785HB servo to the first stage of the slide kit and spool up the provided synthetic cable to get up to 34.5" of arm extension! This kit uses bearings throughout - each stage is supported by Standard V-Wheels that lock into the chamfered guides of the X-Rail. The synthetic cable is routed over ultra smooth v-bearings so the torque provided by the servo or motor can be transformed into linear thrust rather than lost due to friction. The arm, at full extension is rated for a 2lb load; perfect for adding a gripper or grapple hook.

From <<https://www.servocity.com/cascading-x-rail-slide-kit>>

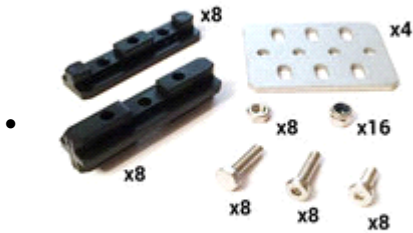
REV Linear Slides

Monday, January 1, 2018 12:44 PM

**TITAN ROBOTICS CLUB
TEAM 492**



[REV-41-1098 - 15mm Linear Motion Kit](#)



This linear motion kit is used with the REV 15mm Extrusion System. This kit can be configured in many different ways, but the most common allows for teams to build simple elevators and lifts for their robots. When building light duty lifts, the kit has enough parts for 4 single extrusion stages. When building heavy duty lifts (dual post) the kit has enough parts for 1 complete stage.

From <<http://www.revrobotics.com/15mm-linear-motion-kit/>>

[REV-21-1202 - 1" Extrusion Endcap Slide - 4 Pack](#)



The REV 1" Extrusion Endcap Slide allows teams to create compact and robust multistage lifts when combined with the 1" Linear Motion Kit ([REV-15-1189](#)) and the REV 1" Extrusion ([REV-21-1000](#)). The slide tab is offset allowing stages to fully nest when collapsed maximizing extension on multi-stage applications.

From <<http://www.revrobotics.com/rev-21-1202/>>

Power Transmission

Saturday, December 9, 2017 9:37 AM

TITAN ROBOTICS CLUB
TEAM 492



POWER TRANSMISSION

- A. CHAIN**
- B. CONVEYOR O-RING**
- C. GEARS**
- D. TIMING BELTS**
- E. DIRECT DRIVE COUPLING**

Chain

Saturday, May 17, 2014 8:08 AM



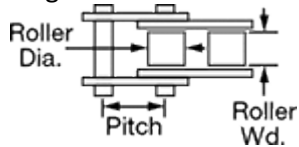
ANSI Roller Chain and Links

Connecting links are also known as master links. They're used to join the ends of a chain length. The side plate is easy to remove for attaching to a chain. Adding links are also known as roller links. They require two connecting links to join chain. Adding-and-connecting links are also known as half links and offset links. A combination of connecting and adding links, they can join chain that requires an odd number of links. The side plate is easy to remove for attaching to chain.



For technical drawings and 3-D models, click on a part number.

Single Strand



Chain

Roller Chain Trade No.	Pitch	Roller Dia.	Roller Wd.	Working Load, lbs.	Lengths, ft.	Per Ft.
Steel						
25	1/4"	0.130"	1/8"	85	1-20, 50, 100	6261K171 \$5.14
35	3/8"	0.200"	3/16"	190	1-20, 50, 100	6261K172 3.90



Connecting Links

Each

[6261K108](#)

\$1.00

[6261K191](#)

.82



Adding Links

Each

[6261K106](#)

\$0.62

[6261K241](#)

.70



Adding-and-Connecting Links

Each

[6261K105](#)

\$2.00

[6261K261](#)

1.78

From <<https://www.mcmaster.com/#roller-chain/=1asphtml>>

AndyMark #25 Sprocket Reference

Friday, March 15, 2013 11:26 AM

TITAN ROBOTICS CLUB
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Part #	Teeth	Bore (Inches)	Pitch Dia. (Inches)	Weight (Pounds)
am-0233	32	1.125	2.563	0.05
am-0116	34	0.875	2.717	0.06
am-0509	34	1.125	2.717	0.06
am-0099	36	0.875	2.868	0.07
am-0234	36	1.125	2.868	0.07
am-0162	38	0.875	3.03	0.08
am-0661	38	1.125	3.03	0.08
am-0163	40	0.875	3.19	0.09
am-0662	40	1.125	3.19	0.09
am-0235	42	1.125	3.341	0.09
am-0101	48	0.875	3.822	0.12
am-0236	48	1.125	3.822	0.12
am-0102	54	0.875	4.311	0.16
am-0663	54	1.125	4.311	0.16
am-0103	60	0.875	4.772	0.2
am-0237	60	1.125	4.772	0.2
am-0115	66	0.875	5.267	0.25
am-0238	66	1.125	5.267	0.25

AndyMark #35 Sprocket Reference

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**TITAN ROBOTICS CLUB
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Part #	Teeth	Bore (Inches)	Pitch Dia. (Inches)	Weight (Pounds)
am-0245	22	1.123	2.683	0.07
am-0118	22	0.875	2.683	0.07
am-0216	22	1.125	2.683	0.07
am-0119	24	0.875	2.878	0.08
am-0217	24	1.125	2.878	0.08
am-0142	26	0.875	3.118	0.10
am-0218	26	1.125	3.118	0.10
am-0737	26	1.625	3.118	0.08
am-0219	28	1.125	3.335	0.12
am-0146	30	0.875	3.687	0.14
am-0220	30	1.125	3.687	0.14
am-0052	32	0.875	3.815	0.16
am-0221	32	1.125	3.815	0.16
am-0053	36	0.875	4.307	0.20
am-0222	36	1.125	4.307	0.20
am-0054	42	0.875	5.028	0.28
am-0223	42	1.125	5.028	0.28
am-0055	48	0.875	5.945	0.43
am-0224	48	1.125	5.945	0.34
am-0056	54	0.875	6.48	0.54
am-0225	54	1.125	6.48	0.54
am-0057	60	0.875	7.20	0.68
am-0226	60	1.125	7.20	0.68

Conveyor O-Rings

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TITAN ROBOTICS CLUB
TEAM 492



Conveyor O-Ring Lookup Table

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**TITAN ROBOTICS CLUB
TEAM 492**



O-Ring Length
(Roller Diameter in inches)

O-Ring Diameter
(Roller Diameter in inches)





















Distance between Rollers	1.5	1.9	2	2.375	2.5		1.5	1.9	2	2.375	2.5
10	24.712	25.969	26.283	27.461	27.854		7.8662	8.2662	8.3662	8.7412	8.8662
10.5	25.712	26.969	27.283	28.461	28.854		8.1845	8.5845	8.6845	9.0595	9.1845
11	26.712	27.969	28.283	29.461	29.854		8.5028	8.9028	9.0028	9.3778	9.5028
11.5	27.712	28.969	29.283	30.461	30.854		8.8211	9.2211	9.3211	9.6961	9.8211
12	28.712	29.969	30.283	31.461	31.854		9.1394	9.5394	9.6394	10.014	10.139
12.5	29.712	30.969	31.283	32.461	32.854		9.4577	9.8577	9.9577	10.333	10.458
13	30.712	31.969	32.283	33.461	33.854		9.7761	10.176	10.276	10.651	10.776
13.5	31.712	32.969	33.283	34.461	34.854		10.094	10.494	10.594	10.969	11.094
14	32.712	33.969	34.283	35.461	35.854		10.413	10.813	10.913	11.288	11.413
14.5	33.712	34.969	35.283	36.461	36.854		10.731	11.131	11.231	11.606	11.731
15	34.712	35.969	36.283	37.461	37.854		11.049	11.449	11.549	11.924	12.049
15.5	35.712	36.969	37.283	38.461	38.854		11.368	11.768	11.868	12.243	12.368
16	36.712	37.969	38.283	39.461	39.854		11.686	12.086	12.186	12.561	12.686
16.5	37.712	38.969	39.283	40.461	40.854		12.004	12.404	12.504	12.879	13.004
17	38.712	39.969	40.283	41.461	41.854		12.323	12.723	12.823	13.198	13.323
17.5	39.712	40.969	41.283	42.461	42.854		12.641	13.041	13.141	13.516	13.641
18	40.712	41.969	42.283	43.461	43.854		12.959	13.359	13.459	13.834	13.959
18.5	41.712	42.969	43.283	44.461	44.854		13.277	13.677	13.777	14.152	14.277
19	42.712	43.969	44.283	45.461	45.854		13.596	13.996	14.096	14.471	14.596
19.5	43.712	44.969	45.283	46.461	46.854		13.914	14.314	14.414	14.789	14.914
20	44.712	45.969	46.283	47.461	47.854		14.232	14.632	14.732	15.107	15.232
20.5	45.712	46.969	47.283	48.461	48.854		14.551	14.951	15.051	15.426	15.551
21	46.712	47.969	48.283	49.461	49.854		14.869	15.269	15.369	15.744	15.869
21.5	47.712	48.969	49.283	50.461	50.854		15.187	15.587	15.687	16.062	16.187
22	48.712	49.969	50.283	51.461	51.854		15.506	15.906	16.006	16.381	16.506
22.5	49.712	50.969	51.283	52.461	52.854		15.824	16.224	16.324	16.699	16.824
23	50.712	51.969	52.283	53.461	53.854		16.142	16.542	16.642	17.017	17.142
23.5	51.712	52.969	53.283	54.461	54.854		16.461	16.861	16.961	17.336	17.461
24	52.712	53.969	54.283	55.461	55.854		16.779	17.179	17.279	17.654	17.779
24.5	53.712	54.969	55.283	56.461	56.854		17.097	17.497	17.597	17.972	18.097
25	54.712	55.969	56.283	57.461	57.854		17.415	17.815	17.915	18.29	18.415

O-Ring Part Number Table

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**TITAN ROBOTICS CLUB
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SDP-SI O-Ring Part Number						
 A 6R11-08262	1/4"	8.500"	Neoprene	70	\$	2.98
 A 6R11-08280	1/4"	9.000"	Neoprene	70	\$	3.07
 A 6R11-08300	1/4"	9.500"	Neoprene	70	\$	3.11
 A 6R11-08314	1/4"	10.000"	Neoprene	70	\$	3.13
 A 6R11-08324	1/4"	10.500"	Neoprene	70	\$	5.32
 A 6R11-08346	1/4"	11.000"	Neoprene	70	\$	6.05
 A 6R11-08350	1/4"	11.500"	Neoprene	70	\$	6.41
 A 6R11-08380	1/4"	12.000"	Neoprene	70	\$	6.64
 A 6R11-08393	1/4"	12.500"	Neoprene	70	\$	6.78
 A 6R11-08408	1/4"	13.000"	Neoprene	70	\$	6.81
 A 6R11-08420	1/4"	13.500"	Neoprene	70	\$	6.85
 A 6R11-08440	1/4"	14.000"	Neoprene	70	\$	6.87
 A 6R11-08456	1/4"	14.500"	Neoprene	70	\$	6.89
 A 6R11-08470	1/4"	15.000"	Neoprene	70	\$	6.91
 A 6R11-08487	1/4"	15.500"	Neoprene	70	\$	7.16
 A 6R11-08503	1/4"	16.000"	Neoprene	70	\$	8.16
 A 6R11-08518	1/4"	16.500"	Neoprene	70	\$	8.23
 A 6R11-08524	1/4"	17.000"	Neoprene	70	\$	8.41
 A 6R11-08550	1/4"	17.500"	Neoprene	70	\$	8.55
 A 6R11-08565	1/4"	18.000"	Neoprene	70	\$	8.81

Gears

Friday, December 22, 2017 10:08 AM

**TITAN ROBOTICS CLUB
TEAM 492**



Gears Types (1 of 3)




Saturday, May 17, 2014 8:08 AM



There are many different types of gears. For the purposes of this section we will focus on different gear geometry and not different quality, materials, etc...

No matter how long I spend working with gears, I seem to always run into some new ones that I have never heard of before. I am focusing on the most common types of gears and if I miss any, or you know of some not listed in this section, please feel free to email us and we will gladly add them to our list. info@gearsandstuff.com





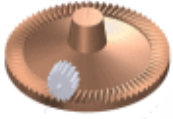

Each type of gear has its own purpose as well as unique advantages and disadvantages. We will try to address as much information on each type of gear as possible.

Types Of Gears		
Gear Type	Description	Photo
Spur Gears	<p>Spur gears are by far the most common type of gear and with the exceptions of the "cog" the type of gear that has been around the longest.</p> <p>Spur gears have teeth that run perpendicular to the face of the gear.</p>	 <p>Click Image To Enlarge</p>
Helical Gears	<p>Helical gears are very similar to spur gears except the teeth are not perpendicular to the face. The teeth are at an angle to the face giving helical gears more tooth contact in the same area.</p> <p>Helical gears can also be used on non-parallel shafts to transmit motion.</p> <p>Helical gears tend to run quieter and smoother than spur gears due to the increased number of teeth in constant contact at any one period of time.</p>	 <p>Click Image To Enlarge</p>
Herringbone Gears	<p>Herringbone gears resemble two helical gears that have been placed side by side. They are often referred to as "double helicals".</p> <p>One benefit of herringbone gears is that it helps to avoid issues related to side thrust created with the use of helical gears.</p>	 <p>Click Image To Enlarge</p>

Gears Types (2 of 3)

Saturday, May 17, 2014 8:08 AM





<p>Bevel / Miter Gears</p>	<p>Bevel gears are used mostly in situations that require power to be transmitted at right angles (or applications that are not parallel). Bevel gears can have different angles of application but tend to be 90°.</p>	 <p>Click Image To Enlarge</p>
<p>Worm Gears</p>	<p>Worm gears are used to transmit power at 90° and where high reductions are required. The worm resembles a thread that rides in concaved or helical teeth.</p>	 <p>Click Image To Enlarge</p>
<p>Internal Gears</p>	<p>Internal gears typically resemble inverted spur gears but are occasionally cut as helical gears.</p>	 <p>Click To Enlarge</p>
<p>Racks</p>	<p>A rack is basically a straight gear used to transmit power and motion in a linear movement.</p>	 <p>Click On Image To Enlarge</p>
<p>Face Gears</p>	<p>Face gears transmit power at (usually) right angles in a circular motion. Face gears are not very common in industrial application.</p>	 <p>Click Image To Enlarge</p>
<p>Involute Splines</p>	<p>Splined shafts and hubs are usually used as connectors in many different types of applications. One of the most common applications is to connect motors to gear reducers. They may also be used in transmissions. Involute splines resemble spur gears, but tend to have different pressure angles.</p>	 <p>Click Image To Enlarge</p>

Gears Types (3 of 3)

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TITAN ROBOTICS CLUB
TEAM 492



Straight Sided Splines	Straight sided splines often serve the same function as involute splines but have "straight sided" teeth instead of involute teeth.	 Click On Image To Enlarge
Sprockets	Sprockets are used to run chains or belts. They are typically used in conveyor systems.	 Click Image To Enlarge

Pasted from <http://www.gearsandstuff.com/types_of_gears.htm>

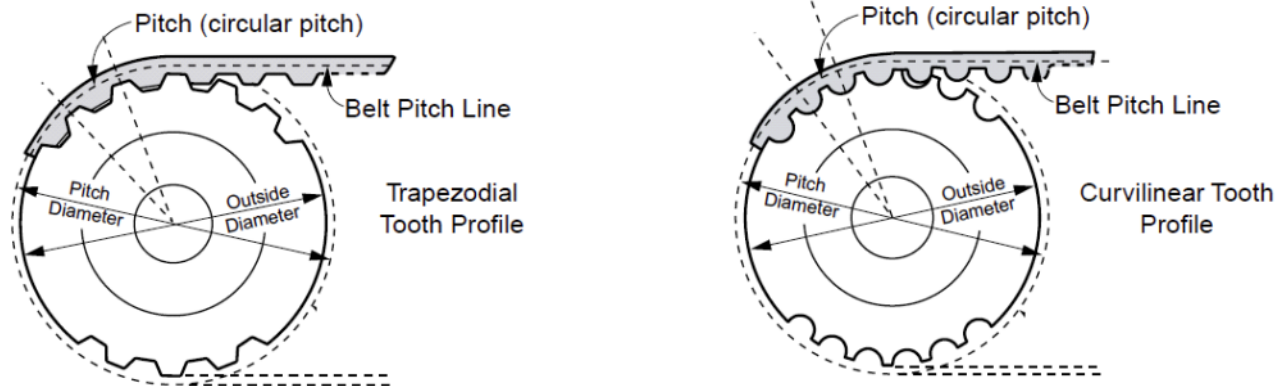
Gear Information:

<http://www.gearsandstuff.com/>

Timing Belts

Saturday, May 17, 2014 8:08 AM

TITAN ROBOTICS CLUB
TEAM 492



Welcome from Gates Corporation

Gates Corporation is excited to be an Official Sponsor of the FIRST Robotics Competition!

Belt Benefits

Gates 5M PowerGrip® HTD® belts are ideally sized for drives and functional applications on a FIRST Robotics Competition robot.

- Lightweight – much lighter than chain and gearing systems for comparable loads
- Useful – PowerGrip HTD rubber belt drive systems are ideal not only for drives, but also for linear motion, lifts, game object conveying, positioning, and even for precisely flinging objects
- Easy to Work With – aluminum sprockets are easy to machine and belting can be wrapped, cemented, or riveted to the structure
- Oil-Free – these drives remain clean because oil is not needed and present a complete image of current technology
- Quiet – reduced noise as compared with other drive technologies such as chain and gears

Additional Information

If you require more assistance please go online to www.gates.com/FIRST to watch helpful videos, use online calculators, and download additional resources.

Part Information

Your belt drive chassis kit includes:

- Five Gates PowerGrip HTD belts

Where to Get More

For details on getting additional or different Gates parts, please reference the FIRST Robotics Competition “Where to Get More” document or visit: www.gates.com/first.

Timing Belts: Belt Drive Application Tips

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TITAN ROBOTICS CLUB
TEAM 492



Best advice – One test is worth 1,000 calculations.

Handling the Belts – Do not bend belts smaller than the diameter of the 15 groove sprocket. A single tight bend or crimp will break the belt's fiberglass tensile member and cause loss of strength and potential premature failure of the belt.



Do not pry belts onto or off sprockets. To correctly install or remove belts, create slack by adjusting center distance or moving belt tensioner. Do not roll belts onto or off sprockets either.



Sprocket Flanges – Provide flanges on either both sides of one sprocket or one side on the driver and the opposite side on the driven sprocket. All belts naturally migrate to one side of the sprocket. You must use flanges as described.



Belt Tensioning – Tension the belt so that when the drive is under full anticipated load (including shock loads) the belt does not get slack on one side, or the belt teeth try to climb out of the sprocket grooves. Make sure the mounting structure does not deflect when either tensioning the belt or under operating conditions.



If you lose tension, the belt will jump teeth. Keep belt shafts parallel and sprockets in line with each other. Apply as much tension to the belt as possible without damaging any equipment.

Timing Belts: Belt Drive Application Tips



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Belt Alignment – Sprockets must be aligned and shafts parallel in both planes. Alignment can easily be checked using a straight edge.

Belt Wrap – Keep a minimum of 6 belt teeth fully in mesh on the circumference of each sprocket. This will allow a properly tensioned belt to perform at 100% of its load rating. A backside idler can be useful for both tensioning the drive and increasing the belt wrap around the sprocket. The idler is used on the slack side of a belt drive and must be 1.25" in diameter for 5mm pitch PowerGrip HTD belts.

Guarding & Debris Protection – A piece of flat plastic supported in between the belt spans is a simple way to eliminate pinch points and keep debris out of the drive.

Product Ratings – Load capacity of the belts is proportional to their width. Gates belt ratings are set to guarantee long life on industrial applications. For FIRST Robotics Competition applications, your load capability is going to be determined by the shaft-to sprocket connections, belt wrap, and the ability to pretension the drive so that the belt does not jump teeth. With adequate belt wrap and proper installation tension, you will be surprised by the durability of this product!

Splicing Belts – Belts or belting should not be field connected or spliced together by any means other than connecting the belts with clamp plates. You need to use the correct pitch length belt.



Timing Belts: Component Specifications

Saturday, May 17, 2014 11:27 PM



Components are categorized by “pitch”, which is the distance from the center of one tooth to the center of the next tooth on a belt.

Gates belts are identified by length, pitch, and width. Example: the 520-5M-15 is a belt with a 520 mm length, 5 mm pitch, and 15 mm width.

Gates sprockets are identified by tooth count, pitch, width, and material. Example: P16-5M-15AL is a 16 tooth sprocket, 5 mm pitch, 15 mm width and made of aluminum.

NOTE: 25mm wide sprockets are not available as a stock part through Gates.

Belt & Sprocket Compatibility

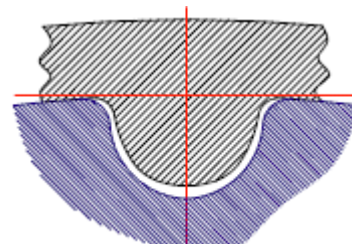
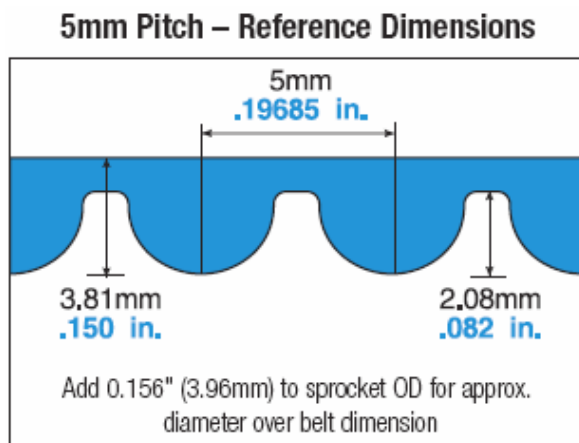
It’s possible that some teams have received Gates PowerGrip® GT®2 belts and sprockets in the past, which should not be confused with PowerGrip HTD components (GT2 and HTD describe two different tooth profiles or shapes).

Gates recommends only using belt types with their corresponding sprocket types. PowerGrip GT2 belts can be used in PowerGrip HTD sprockets, but it’s not recommended.

DO NOT USE POWERGRIP HTD BELTS IN POWERGRIP GT2 SPROCKETS.

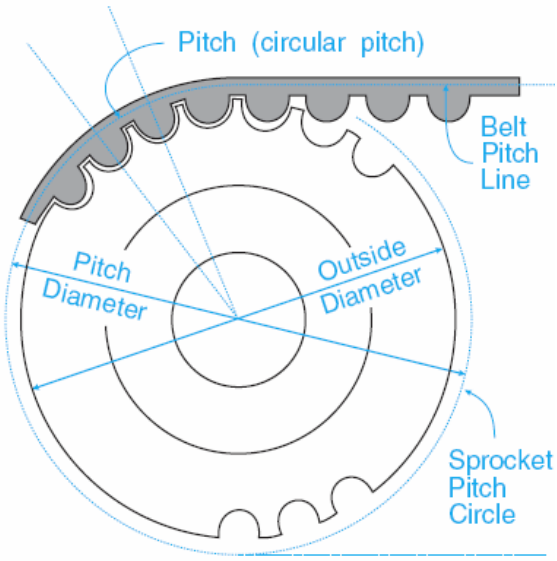
The figures below illustrate the tooth meshing characteristics of the two belt/sprocket combinations.

5M PowerGrip GT2 Belt in PowerGrip HTD Sprocket

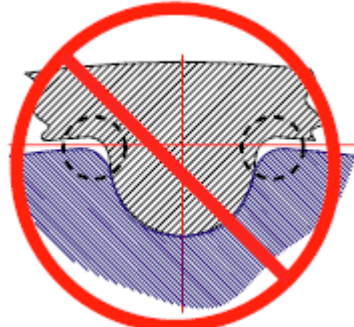


Not Recommended

- Reduced performance
- The sprocket/bushing capacity may be too low for new designs



5M PowerGrip HTD Belt in PowerGrip GT2 Sprocket



No Compatibility

- The belt tooth is too large to fully seat in the sprocket groove

Timing Belts: Selecting Your Drive Components

Saturday, May 17, 2014 11:35 PM

TITAN ROBOTICS CLUB
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1. Determine your speed ratio. (Do your shaft's rpms need to stay the same, speed up, or slow down?) Find the closest speed ratio value on the center distance table in Appendix D.
2. For that speed ratio, check to see which size of sprockets is most desirable for the drive package size on your robot. (Note that using larger sprockets will give a higher torque rating for the belt drive)
3. See which belt length (based on your center distance) is the best choice.
4. If you know your loading requirements then you can use the power ratings tables in Appendix E to check your drive's torque rating against your peak loads.

Example:

Your robot has a motor on it that has an output of 600 rpm, which you want to connect to another shaft that's roughly 16" away, which you want to rotate at 200 rpm. You want to transfer 1000 oz-in at 600rpm.

1. To calculate your desired speed ratio, divide your driveR speed by your desired driveN speed. ($600/200 = 3.0$).
2. Using the chart, you only have one sprocket combination that can give you a 3.0 speed ratio (using a 20 and 60 tooth sprockets)
3. Going across the chart, you see that the closest center distance available is 15.70" using a 1000-5M-15 belt.
4. Checking the belt drive torque rating
 - Looking at the Power Rating Table, you need to find the rating of the smaller pulley at its respective rpm.
 - For this example you're looking for the 20 tooth pulley running at 600 rpm. Looking at the table there is no
 - listing for 600 rpm so you will need to interpolate this value using the torque ratings from 500 rpm and 800
 - rpm. After interpolating you should get a torque rating of 683 oz-in @ 600 rpm.
 - Now you must apply the length correction factor to the torque rating. Referencing the length correction
 - factor chart below the torque rating chart, you will see the correction factor for a 1000-5M-15 belt is 1.1. The final torque rating for the belt drive is then: $683 \text{ oz-in} \times 1.1 = 751 \text{ oz-in}$
5. So your design order should consist of:
 - 1000-5M-15 Belt
 - P20-5M-15AL Sprocket
 - P60-5M-15AL Sprocket

Timing Belts: Center Distance Table

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Sprocket #1		Sprocket #2		Speed Ratio	Belt Lengths						
Teeth	Pitch Ø (in)	Teeth	Pitch Ø (in)		300-5M-15	400-5M-15	500-5M-15	600-5M-15	800-5M-15	1000-5M-15	1270-5M-15
15	0.94	15	0.94	1.00	4.43	6.40	8.37	10.34	14.27	18.21	23.52
18	1.128	18	1.128	1.00	4.13	6.10	8.07	10.04	13.98	17.91	23.23
20	1.253	20	1.253	1.00	3.94	5.91	7.88	9.84	13.78	17.72	23.03
25	1.567	25	1.567	1.00	3.45	5.41	7.38	9.35	13.29	17.22	22.54
30	1.88	30	1.88	1.00	2.95	4.92	6.89	8.86	12.80	16.73	22.05
40	2.506	40	2.506	1.00		3.94	5.91	7.88	11.81	15.75	21.07
60	3.76	60	3.76	1.00				5.91	9.84	13.78	19.10
18	1.128	20	1.253	1.11	4.04	6.00	7.97	9.94	13.88	17.82	23.13
15	0.94	18	1.128	1.20	4.28	6.25	8.22	10.19	14.12	18.06	23.38
25	1.567	30	1.88	1.20	3.20	5.17	7.13	9.10	13.04	16.98	22.29
20	1.253	25	1.567	1.25	3.69	5.66	7.63	9.60	13.53	17.47	22.79
15	0.94	20	1.253	1.33	4.18	6.15	8.12	10.09	14.03	17.96	23.28
30	1.88	40	2.506	1.33	2.44	4.42	6.39	8.36	12.30	16.24	21.55
18	1.128	25	1.567	1.39	3.78	5.75	7.72	9.69	13.63	17.57	22.88
20	1.253	30	1.88	1.50	3.43	5.41	7.38	9.35	13.28	17.22	22.54
40	2.506	60	3.76	1.50			4.88	6.86	10.81	14.75	20.07
25	1.567	40	2.506	1.60	2.67	4.65	6.63	8.60	12.54	16.48	21.80
15	0.94	25	1.567	1.67	3.92	5.90	7.87	9.84	13.78	17.71	23.03
18	1.128	30	1.88	1.67	3.52	5.50	7.47	9.44	13.38	17.32	22.64
15	0.94	30	1.88	2.00	3.66	5.64	7.61	9.59	13.53	17.47	22.78
20	1.253	40	2.506	2.00	2.89	4.88	6.86	8.84	12.78	16.72	22.04
30	1.88	60	3.76	2.00		3.31	5.33	7.32	11.28	15.23	20.55
18	1.128	40	2.506	2.22	2.97	4.97	6.96	8.93	12.88	16.82	22.14
25	1.567	60	3.76	2.40		3.52	5.55	7.55	11.51	15.46	20.79
15	0.94	40	2.506	2.67	3.10	5.11	7.09	9.07	13.02	16.96	22.28
20	1.253	60	3.76	3.00		3.73	5.77	7.77	11.75	15.70	21.03
18	1.128	60	3.76	3.33		3.81	5.86	7.86	11.84	15.79	21.12
15	0.94	60	3.76	4.00		3.93	5.99	8.00	11.98	15.93	21.26

Timing Belts: Power Rating Tables

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Rated Torque (Oz-in) For Small Sprocket							
Speed	Small Sprocket Tooth Count						
rpm	15	18	20	25	30	40	60
0 (stall)	624	777	886	1176	1495	2208	3671
300	624	705	801	1061	1344	1972	3254
500	511	623	708	933	1176	1709	2793
800	449	556	632	827	1039	1500	2425
1000	426	526	599	782	980	1406	2266
1600	383	472	532	692	865	1231	1955
2000	363	445	502	655	812	1152	1816
2500	343	420	475	612	765	1077	1674
3000	328	402	454	587	725	1013	1559

*The rating for a belt drive is calculated at the smallest sprocket traveling at the fastest rotational speed.

Length Correction Factor							
For Belt #	300-5M	400-5M	500-5M	600-5M	800-5M	1000-5M	1270-5M
Factor	0.8	0.8	0.9	1.0	1.0	1.1	1.2

Timing Belts: Frequently Asked Questions (FAQ)

Saturday, December 9, 2017 8:26 AM

TITAN ROBOTICS CLUB
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Q: How do I figure out what belt/sprocket combination I need?

A: First, determine what your desired speed ratio is, and the distance between the two shafts (also known as the center distance) is. Once you have this determined, use the center distance tables to determine the appropriate belt / sprocket combination, along with belt length. Then use the power rating tables to determine the capacity of the drive you have selected.

Q: How will my sprocket size selection affect my shaft rotational speeds?

A: If you have a belt connecting two different shafts, the change in speed is proportional to the ratio of the sprocket diameters. This change in speed is called the "speed ratio". For example, if one shaft has a 2" pulley and the other shaft has a 6" pulley, the shaft with the 2" pulley will rotate three times to every one rotation of the 6" pulley, or the drive has a speed ratio of 3.0 down. This means the driven shaft is being slowed down by a factor of 3 compared to the input (driver) shaft.

$$\text{Speed Ratio} = \frac{\text{rpm (faster)}}{\text{rpm (slower)}} = \frac{\text{PD}}{\text{pd}} = \frac{N}{n}$$

Where: rpm = Revolutions per minute

PD = Larger pitch diameter

pd = Smaller pitch diameter

N = Larger sprocket grooves

n = Smaller sprocket grooves

Q: I have a performance curve for the motor that I wanted to use with my belt drive. What values should I use to size my belt drive?

A: There are a few things that should be considered when sizing a belt drive. When looking at a performance curve, it's tempting to size the drive for the stall torque or for the max power available, but that might not be correct.

For example, you should keep in mind if you are limited in the electrical power of your system, i.e. are you required to use a fuse / circuit breaker? If so, then the loads you should design around should be on the performance curve below the maximum Amp output.

Q: How do I determine the correct belt length?

A: Use the Center Distance table provided, calculators at www.gates.com/first, design software (available at www.gates.com/drivedesign), or use belt length equation shown.

The exact belt pitch length, in inches, can be found as follows:

$$\text{Pitch Length} = 2(\text{CD})(\text{Cos } \phi) + \frac{(\text{PD} + \text{pd})}{2} + \frac{\phi (\text{PD} - \text{pd})}{180}$$

$$\phi = \text{Sin}^{-1} \left(\frac{\text{PD} - \text{pd}}{2\text{CD}} \right)$$

Where: CD = Drive center distance, in.
PD = Large pitch diameter, in.
pd = Small pitch diameter, in.

The approximate center distance in inches can be found as follows:

$$\text{Center Distance} = \frac{K + \sqrt{K^2 - 32(\text{PD} - \text{pd})^2}}{16}$$

$$K = 4\text{PL} - 6.28 (\text{PD} + \text{pd})$$

Where: PD = Large pitch diameter, in.
pd = Small pitch diameter, in.
PL = Belt pitch length, in.

Timing Belts: Frequently Asked Questions (FAQ)

TITAN ROBOTICS CLUB
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Saturday, May 17, 2014 11:42 PM

Q: I am unable to adjust my center distance to tension my belt drive: does Gates have an idler that they suggest I use?

A: Gates does not offer a one-piece idler for the 5mm PowerGrip HTD belts. If you do not have enough adjustment to put adequate tension on the belt, it is recommended to use a flat pulley pushing on the backside of the belt. Also known as a backside idler, this is the easiest way to apply tension to the belt. Unfortunately Gates does not have a backside idler available through the product line; however an idler pulley is easy to fabricate if a machinist is available. You may also purchase an idler from the following:

- B&B Manufacturing: 1-888-889-1896
 - o Part No: 22-5M15SP25
 - o P22-5M-15 Pulley with pressed bearings.
 - o \$18.50 each
 - o Sprockets, belts, and idlers available from B&B

- Fenner Drives: www.fennerdrives.com
 - o PowerMax Idler
 - o Part No: FA2010
 - o 2.0" OD flat idler with pressed bearings (17mm ID)
 - o Must use with 17mm mounting adapters (sold separately).
 - Available in a variety of mounting bores. Example Part No: CB0001
 - o Available at Motion Industries (www.motionindustries.com), Applied Industrial Technology (www.applied.com), and other power transmission distributors.

Q: Do I need to have flanges on my belt drive?

A: Yes, at least 2 on one sprocket, or one flange on both sprockets. Belt drives will track to one side, so you need flanges to make sure the belt doesn't come off of the pulley.

Q: How do I convert torque in units of ounce-inches (oz-in) to horsepower (hp)?

A: Convert the units of oz-in to units of pound-inches (lb-in). There are 16 ounces in 1 pound, so simply divide your torque in oz-in by 16. Now that you have units of lb-in, you can use the following equation.

$$\text{Horsepower} = \frac{(Q) (\text{rpm})}{63025}$$

Where: Q = Torque, lb-in

rpm = Revolutions per minute

Be sure to use torque and rpm values at the same shaft; do not mix torque and rpm values from different shafts.

Q: Are there any guidelines for boring out minimum plain bore (MPB) sprockets?

A: See Appendix G.

Timing Belts:

Minimum Plain Bore Sprockets

Saturday, May 17, 2014 11:42 PM

TITAN ROBOTICS CLUB
TEAM 492



When using MPB PowerGrip®GT®2 sprockets in power transmission systems, important guidelines should be followed for proper product finishing and application. Due to the high load carrying capacity and high operating tensions often found in PowerGrip® belt drive systems, it is imperative to use and adhere to industry standard practices. When finishing MPB sprockets for high performance belt drive systems, care should be taken to ensure proper functionality and performance. General re-bore instructions and specifications are as follows:

1. Materials used in PowerGrip® HTD sprockets are 6061 – T6 aluminum grade.
2. The maximum bore diameter specified by the manufacturer for each sprocket size should NOT be exceeded, or a keyway used which reduces the hub thickness to less than its minimum allowable value. See the Sprocket Specification Tables for a listing of recommended bore ranges by sprocket size. Bores exceeding the maximum recommended value for a particular sprocket size can adversely affect the structural integrity, thereby reducing their load-carrying capability. The minimum metal thickness between the keyway and hub O.D. should be no less than the set screw diameter specified for the corresponding sprocket size. See Figure 1 below.

- A listing of minimum set screw diameters is included below.
 - P18-5M: 8-32
 - P19-5M thru P22-5M: 10-32
 - P23-5M thru P32-5M: 1/4
 - P34-5M thru P38-5M: 5/16
 - P40-5M thru P50-5M: 3/8

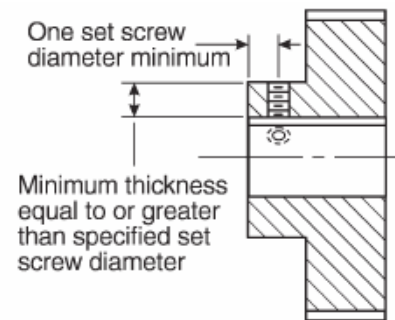


Figure 1 — Minimum Hub Thickness And Set Screw Placement Guidelines

3. The fit between a finished sprocket bore and its mating shaft in a power transmission system must not allow relative movement between the bore and the shaft when the drive is subjected to belt tension and torque loads. This is accomplished, in the case of plain bore sprockets, with the use of set screws and keys and by controlling the fit or clearance between the sprocket bore and its mating shaft. Cyclical, pulsating, or reversing loads may wear the sprocket bore and/or keyway due to the relative movement between the contacting surfaces of the shaft and the bore. The resulting wear may increase the clearance further, if an interference fit is not used. In order to maximize the performance of high capacity belt drives using plain bore style sprockets, the following for recommendations presented in Table 2 (below) should be followed: Class 1 Clearance Fits should be used when the transmitted load is smooth in nature. Interference Fits should be used for PowerGrip HTD curvilinear drives transmitting cyclical, pulsating, or reversing loads.

4. DO NOT chuck or center the sprocket on guide flanges. Soft jaws should be used when chucking on the sprocket teeth. Center (indicate) the sprocket using the sprocket tooth O.D. If chucked on the Rim I.D. or Hub O.D., the sprocket should be centered with respect to the sprocket tooth O.D. Guide flanges are permanently mounted and should not be re-moved. If original flanges must be removed, they should be replaced with NEW flanges. New guide flanges should be attached securely with care using mechanical fasteners such as screws. Note: Improper guide flange reassembly may cause serious personal injury and/or mechanical damage.

Timing Belts: Minimum Plain Bore Sprockets



Saturday, May 17, 2014 11:56 PM

Table 2 - Recommended Shaft / Bore Fits (Inches)

Nominal Bore Range Over - To (Incl.)	Shaft Tol. (minus)	Clearance Fits		Interference Fits			
		Class 1- Smooth Load		Cyclical, Pulsating, Reversing Load			
		Bore Tol. (Plus)	Fit Tol. (Plus)	Bore Tolerance Range (Minus)		Fit Tolerance Range (Minus)	
0.4375 - 0.5626	0.0005	0.0010	0.0015	0.0005	0.0010	0.0000	0.0010
0.5625 - 0.8750	0.0005	0.0010	0.0015	0.0005	0.0010	0.0000	0.0010
0.8750 - 1.2500	0.0005	0.0010	0.0015	0.0005	0.0010	0.0000	0.0010
1.2500 - 1.3750	0.0005	0.0010	0.0015	0.0005	0.0010	0.0000	0.0010
1.3750 - 1.500	0.0005	0.0010	0.0015	0.0005	0.0010	0.0000	0.0010
1.5000 - 1.7500	0.0010	0.0010	0.0020	0.0010	0.0020	0.0000	0.0020

Table 2 was extracted in part from AGMA Standard for Bores and Keyways for Flexible Couplings (Inch Series) AGMA 9002-A86 Table.

5. Set screw holes in the sprocket hub must be placed properly for maximum holding strength. For both standard and shallow key seats, two (2) set screws should be used as illustrated in Figure 2. The total holding strength of the set screws is dependent upon their placement and design. Generally, one screw should be placed directly over the keyway, and the other screw at ninety degrees (90°) from the keyway, or at sixty-five degrees (65°) from the keyway—a more recent practice that improves holding power. Sometimes four set screws (or two pair) are used for increased holding strength.

- Each set screw should be placed axially—a minimum of one set screw diameter from the end of the sprocket hub extension. See Figure 1. For recommended set screw tightening torque values see Table

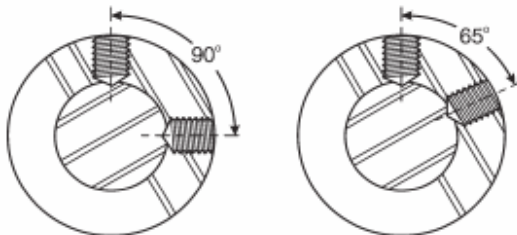


Figure 2 - Set Screw Angles

Table 3—Recommended Tightening Torque Values For Set Screws

Set Screw Size	Hex Key Size (in)	Approximate Installation Torque Values (lb-in)
8-32	5/64	20
10-32	3/32	35
1/4	1/8	80
5/16	5/32	160
3/8	3/16	275
7/16	7/32	430
1/2	1/4	615
5/8	5/16	1315

6. Standard square or rectangular keys should be used. See below for standard key dimensions.

Standard Keyseat Dimensions

Shaft Diam. (In)	Keyseat (in)		Key (in)	
	Width	Depth	Width	Depth
0.313-0.438	3/32	3/64	3/32	3/32
0.500-0.563	1/8	1/16	1/8	1/8
0.625-0.875	3/16	3/32	3/16	3/16
0.938-1.250	1/4	1/8	1/4	1/4
1.313-1.375	5/16	5/32	5/16	5/16
1.438-1.750	3/8	3/16	3/8	3/8
1.813-2.250	1/2	1/4	1/2	1/2

Direct Drive Couplings

Friday, December 22, 2017 4:50 PM

**TITAN ROBOTICS CLUB
TEAM 492**



Couplings connect two shafts and transfer motion from one to the other. There are two types of couplings: rigid and flexible. Rigid couplings connect two shafts that are aligned. They are also good for handling high-torque applications. Flexible couplings connect two shafts that are misaligned. Make Sure the Couplings You Have Selected Can Handle Your Torque and RPM Requirements
Couplings are rated by maximum torque and maximum rpm. Use this formula to determine the maximum torque you need:

$$\text{Max. Torque (in.-lbs.)} = \frac{\text{hp} \times 63,000}{\text{rpm}}$$

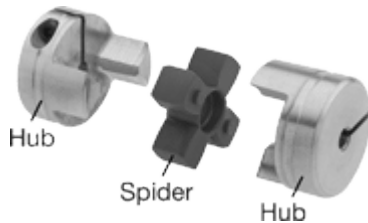
From <<https://www.mcmaster.com/#standard-shaft-couplings/=1at0nss>>

Clamping Flexible Shaft Couplings

Saturday, May 17, 2014 8:09 AM



Components of a Coupling Shown Assembled



(Each Component Sold Separately)

Designed to grip evenly around your shaft, these couplings provide more holding power than set screw couplings without marring the shaft. Tighten the clamping screw to secure. Also known as Lovejoy couplings, they have a spider-shaped cushion between two hubs to reduce shock and handle minor shaft misalignment.

A complete coupling consists of two hubs and one spider (each component sold separately). Hubs are aluminum for light weight and good corrosion resistance.

Hytrel spiders provide fair vibration damping and excellent chemical resistance. Polyurethane spiders provide fair vibration damping and good chemical resistance.



For technical drawings and 3-D models, click on a part number.
6026 Aluminum Hubs and Hytrel Rubber Spiders

From <<https://www.mcmaster.com/#standard-shaft-couplings/=1asuez9>>

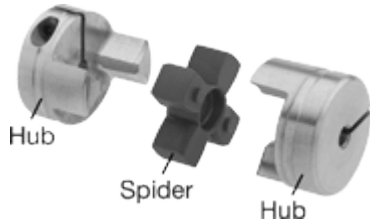
6026 Aluminum Hubs						Hytrel Rubber Spiders					
O'all Lg.	OD	For Motion Type	For Shaft Dia.	McMaster P/N	Each	Max. Speed, rpm	Max. Torque, in.-lbs.	Misalignment Capability		McMaster P/N	Each
								Parallel	Angular		
7/8"	9/16"	Fwd / Rev Start / Stop	1/8", 3/16", 1/4"	2401K12	\$ 35.70	27,000	42	0.002"	0.8°	2401K82	\$ 9.65
1 3/16"	51/64"	Fwd / Rev Start / Stop	3/16", 1/4", 5/16", 3/8"	2401K13	\$ 29.70	19,000	105	0.002"	0.8°	2401K84	\$ 12.40
1 11/32"	63/64"	Fwd / Rev Start / Stop	3/16", 1/4", 5/16", 3/8", 7/16"	2401K14	\$ 46.33	15,200	210	0.002"	0.8°	2401K86	\$ 21.72
1 25/64"	1 3/16"	Fwd / Rev Start / Stop	3/16", 1/4", 3/8", 1/2", 5/8"	2401K15	\$ 32.40	12,700	280	0.002"	0.8°	2401K88	\$ 13.19

Clamping Flexible Shaft Couplings

Saturday, May 17, 2014 8:09 AM



Components of a Coupling
Shown Assembled



(Each Component Sold Separately)

Designed to grip evenly around your shaft, these couplings provide more holding power than set screw couplings without marring the shaft. Tighten the clamping screw to secure. Also known as Lovejoy couplings, they have a spider-shaped cushion between two hubs to reduce shock and handle minor shaft misalignment.

A complete coupling consists of two hubs and one spider (each component sold separately). Hubs are aluminum for light weight and good corrosion resistance.

Hytrel spiders provide fair vibration damping and excellent chemical resistance. Polyurethane spiders provide fair vibration damping and good chemical resistance.



For technical drawings and 3-D models, click on a part number.
6026 Aluminum Hubs and Hytrel Rubber Spiders

From <<https://www.mcmaster.com/#standard-shaft-couplings/=1asuez9>>

6026 Aluminum Hubs						Polyurethane Spiders					
O'all Lg.	OD	For Motion Type	For Shaft Dia.	McMaster P/N	Each	Max. Speed, rpm	Max. Torque, in.-lbs.	Misalignment Capability		McMaster P/N	Each
								Parallel	Angular		
7/8"	9/16"	Fwd / Rev Start / Stop	1/8", 3/16", 1/4", 3/16"	2401K12	\$ 35.70	27,000	21	0.004"	1°	2401K81	\$ 4.23
1 3/16"	51/64"	Fwd / Rev Start / Stop	1/4", 5/16", 3/8", 3/16"	2401K13	\$ 29.70	19,000	53	0.004"	1°	2401K83	\$ 5.07
1 11/32"	63/64"	Fwd / Rev Start / Stop	1/4", 5/16", 3/8", 7/16"	2401K14	\$ 46.33	15,200	89	0.004"	1°	2401K85	\$ 22.14
1 25/64"	1 3/16"	Fwd / Rev Start / Stop	3/16", 1/4", 3/8", 1/2", 5/8"	2401K15	\$ 32.40	12,700	130	0.004"	1°	2401K87	\$ 8.26

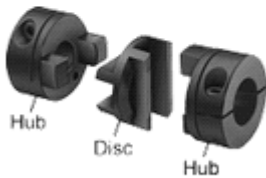
Clamping High-Parallel-Misalignment Flexible Shaft Couplings



Saturday, December 23, 2017 12:41 AM



Components of a Coupling Shown Assembled



(Each Component Sold Separately)

Designed to grip evenly around your shaft, these couplings provide more holding power than set screw couplings without marring the shaft. Tighten the clamping screws to secure. Also known as Oldham couplings, they have a slotted disc that allows hubs to slide independently—good for applications with parallel shaft misalignment. They also allow zero backlash (no play) and never need lubrication.

A complete coupling consists of two hubs and one disc (each component sold separately). Hubs are aluminum for light weight and good corrosion resistance.

Acetal discs stand up to high twisting forces. Nylon discs have excellent vibration and shock absorption.



For technical drawings and 3-D models, click on a part number.

From <https://www.mcmaster.com/#standard-shaft-couplings/=1at6fte>

2024 Aluminum Hubs						Acetal Plastic Discs						
O'all Lg.	OD	For Motion Type	For Shaft Dia.	McMaster P/N	Each	Max. Speed, rpm	Max. Torque, in.-lbs.	Misalignment Capability			McMaster P/N	Each
								Parallel	Angular	Axial		
1"	3/4"	Fwd / Rev, Start/Stop	3/16", 1/4", 5/16", 3/8", (plus Metric)	9889T1	\$14.46	4,500	93	0.008"	0.5°	0.004"	59985K62	\$2.81
1 1/4"	1"	Fwd / Rev, Start/Stop	3/8", 1/2", (plus Metric)	9889T2	19.86	4,500	165	0.008"	0.5°	0.004"	59985K63	5.24
1 7/8"	1 5/16"	Fwd / Rev, Start/Stop	1/2", 5/8", (plus Metric)	9889T3	29.32	4,500	350	0.008"	0.5°	0.006"	59985K64	7.57
2"	1 5/8"	Fwd / Rev, Start/Stop	3/8", 1/2", 5/8", 3/4", (plus Metric)	9889T4	32	4,500	480	0.01"	0.5°	0.006"	59985K65	9.62

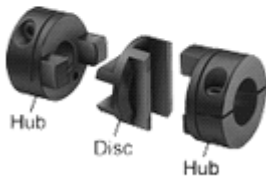
Clamping High-Parallel-Misalignment Flexible Shaft Couplings



Saturday, December 23, 2017 12:41 AM



Components of a Coupling Shown Assembled



(Each Component Sold Separately)

Designed to grip evenly around your shaft, these couplings provide more holding power than set screw couplings without marring the shaft. Tighten the clamping screws to secure. Also known as Oldham couplings, they have a slotted disc that allows hubs to slide independently—good for applications with parallel shaft misalignment. They also allow zero backlash (no play) and never need lubrication.

A complete coupling consists of two hubs and one disc (each component sold separately). Hubs are aluminum for light weight and good corrosion resistance.

Acetal discs stand up to high twisting forces. Nylon discs have excellent vibration and shock absorption.



For technical drawings and 3-D models, click on a part number.

From <https://www.mcmaster.com/#standard-shaft-couplings/=1at6fte>

2024 Aluminum Hubs						Nylon Plastic Discs						
O'all Lg.	OD	For Motion Type	For Shaft Dia.	McMaster P/N	Each	Max. Speed, rpm	Max. Torque, in.-lbs.	Misalignment Capability			McMaster P/N	Each
								Parallel	Angular	Axial		
1"	3/4"	Fwd / Rev, Start/Stop	3/16", 1/4", 5/16", 3/8", (plus Metric)	9889T1	\$ 14.46	4,500	85	0.008"	0.5°	0.004"	59985K92	\$ 4.41
1 1/4"	1"	Fwd / Rev, Start/Stop	1/4", 5/16", 3/8", 1/2", (plus Metric)	9889T2	\$ 19.86	4,500	140	0.008"	0.5°	0.004"	59985K93	\$ 6.38
1 7/8"	1 5/16"	Fwd / Rev, Start/Stop	5/16", 3/8", 1/2", 5/8", (plus Metric)	9889T3	\$ 29.32	4,500	300	0.008"	0.5°	0.006"	59985K94	\$ 9.30
2"	1 5/8"	Fwd / Rev, Start/Stop	3/8", 1/2", 5/8", 3/4", (plus Metric)	9889T4	\$ 32.00	4,500	400	0.01"	0.5°	0.006"	59985K95	\$ 12.89

Clamping Precision Flexible Shaft Couplings



Saturday, December 23, 2017 12:41 AM



Designed to grip evenly around your shaft, these couplings provide more holding power than set screw couplings without marring the shaft. Tighten the clamping screws to secure. Cuts in the coupling body allow flexibility to handle parallel, axial, and angular misalignment. Often used for light duty encoder and stepper drive applications, they allow zero backlash (no play) and never need lubrication. Also known as helical beam couplings. Acetal couplings are lightweight and corrosion resistant.



Aluminum couplings are lightweight with good corrosion resistance. For technical drawings and 3-D models, click on a part number.

For Shaft Dia.	O'all Lg.	OD	For Motion Type	Max. Speed, rpm	Max. Torque, in.-lbs.	Misalignment Capability			McMaste r P/N	Each
						Parallel	Angular	Axial		
3/16" x 3/16"	3/4"	1/2"	Fwd / Rev, Start/Stop	10,000	5	0.005"	2"	0.005"	6208K369	\$ 40.34
3/16" x 3/16"	3/4"	3/4"	Fwd / Rev, Start/Stop	10,000	20	0.006"	3"	0.006"	6208K425	\$ 41.50
3/16" x 3/16"	7/8"	5/8"	Fwd / Rev, Start/Stop	10,000	12	0.01"	3"	0.008"	6208K385	\$ 41.06
3/16" x 3/16"	1"	3/4"	Fwd / Rev, Start/Stop	10,000	25	0.01"	3"	0.008"	6208K453	\$ 39.47
3/16" x 1/4"	3/4"	3/4"	Fwd / Rev, Start/Stop	10,000	20	0.006"	3"	0.006"	6208K432	\$ 41.50
3/16" x 1/4"	7/8"	5/8"	Fwd / Rev, Start/Stop	10,000	12	0.01"	3"	0.008"	6208K388	\$ 41.06
1/4" x 3/16"	1"	3/4"	Fwd / Rev, Start/Stop	10,000	25	0.01"	3"	0.008"	6208K456	\$ 39.47
1/4" x 3/16"	1"	1"	Fwd / Rev, Start/Stop	10,000	42	0.006"	3"	0.006"	6208K483	\$ 42.28
1/4" x 3/16"	1 1/4"	1 1/4"	Fwd / Rev, Start/Stop	10,000	84	0.006"	3"	0.006"	6208K551	\$ 56.31
1/4" x 3/16"	1 1/2"	1"	Fwd / Rev, Start/Stop	10,000	63	0.015"	5"	0.01"	6208K523	\$ 44.28
1/4" x 1/4"	3/4"	3/4"	Fwd / Rev, Start/Stop	10,000	20	0.006"	3"	0.006"	6208K433	\$ 41.50
1/4" x 1/4"	7/8"	5/8"	Fwd / Rev, Start/Stop	10,000	12	0.01"	3"	0.008"	6208K389	\$ 41.06
1/4" x 1/4"	1"	3/4"	Fwd / Rev, Start/Stop	10,000	25	0.01"	3"	0.008"	6208K457	\$ 39.47
1/4" x 1/4"	1"	1"	Fwd / Rev, Start/Stop	10,000	42	0.006"	3"	0.006"	6208K484	\$ 42.28
1/4" x 1/4"	1 1/4"	1 1/4"	Fwd / Rev, Start/Stop	10,000	84	0.006"	3"	0.006"	6208K552	\$ 56.31
1/4" x 1/4"	1 1/2"	1"	Fwd / Rev, Start/Stop	10,000	63	0.015"	5"	0.01"	6208K524	\$ 44.28
1/4" x 3/8"	1"	1"	Fwd / Rev, Start/Stop	10,000	42	0.006"	3"	0.006"	6208K494	\$ 42.28
1/4" x 3/8"	1 1/4"	1 1/4"	Fwd / Rev, Start/Stop	10,000	84	0.006"	3"	0.006"	6208K555	\$ 56.31
1/4" x 3/8"	1 1/2"	1"	Fwd / Rev, Start/Stop	10,000	63	0.015"	5"	0.01"	6208K534	\$ 44.28
1/4" x 1/2"	1 1/4"	1 1/4"	Fwd / Rev, Start/Stop	10,000	84	0.006"	3"	0.006"	6208K565	\$ 56.31
3/8" x 3/16"	1"	1"	Fwd / Rev, Start/Stop	10,000	42	0.006"	3"	0.006"	6208K493	\$ 42.28
3/8" x 3/16"	1 1/4"	1 1/4"	Fwd / Rev, Start/Stop	10,000	84	0.006"	3"	0.006"	6208K554	\$ 56.31
3/8" x 3/16"	1 1/2"	1"	Fwd / Rev, Start/Stop	10,000	63	0.015"	5"	0.01"	6208K533	\$ 44.28
3/8" x 3/16"	2"	1 1/4"	Fwd / Rev, Start/Stop	10,000	115	0.015"	5"	0.01"	6208K584	\$ 58.25
3/8" x 1/4"	2"	1 1/4"	Fwd / Rev, Start/Stop	10,000	115	0.015"	5"	0.01"	6208K585	\$ 58.25
3/8" x 1/4"	2 3/8"	1 1/2"	Fwd / Rev, Start/Stop	10,000	155	0.015"	5"	0.01"	6208K621	\$ 72.19
3/8" x 3/8"	1"	1"	Fwd / Rev, Start/Stop	10,000	42	0.006"	3"	0.006"	6208K496	\$ 42.28
3/8" x 3/8"	1 1/4"	1 1/4"	Fwd / Rev, Start/Stop	10,000	84	0.006"	3"	0.006"	6208K557	\$ 56.31
3/8" x 3/8"	1 1/2"	1"	Fwd / Rev, Start/Stop	10,000	63	0.015"	5"	0.01"	6208K536	\$ 44.28
3/8" x 3/8"	2"	1 1/4"	Fwd / Rev, Start/Stop	10,000	115	0.015"	5"	0.01"	6208K587	\$ 58.25
3/8" x 3/8"	2 3/8"	1 1/2"	Fwd / Rev, Start/Stop	10,000	155	0.015"	5"	0.01"	6208K623	\$ 72.19
3/8" x 1/2"	1 1/4"	1 1/4"	Fwd / Rev, Start/Stop	10,000	84	0.006"	3"	0.006"	6208K567	\$ 56.31
1/2" x 3/16"	1 1/4"	1 1/4"	Fwd / Rev, Start/Stop	10,000	84	0.006"	3"	0.006"	6208K564	\$ 56.31
1/2" x 3/16"	2"	1 1/4"	Fwd / Rev, Start/Stop	10,000	115	0.015"	5"	0.01"	6208K594	\$ 58.25
1/2" x 1/4"	2"	1 1/4"	Fwd / Rev, Start/Stop	10,000	115	0.015"	5"	0.01"	6208K595	\$ 58.25
1/2" x 1/4"	2 3/8"	1 1/2"	Fwd / Rev, Start/Stop	10,000	155	0.015"	5"	0.01"	6208K628	\$ 72.19
1/2" x 3/8"	2"	1 1/4"	Fwd / Rev, Start/Stop	10,000	115	0.015"	5"	0.01"	6208K597	\$ 58.25
1/2" x 3/8"	2 3/8"	1 1/2"	Fwd / Rev, Start/Stop	10,000	155	0.015"	5"	0.01"	6208K631	\$ 72.19
1/2" x 3/8"	2 1/2"	1 5/8"	Fwd / Rev, Start/Stop	10,000	215	0.015"	5"	0.01"	6208K655	\$ 91.81
1/2" x 3/8"	2 3/4"	1 3/4"	Fwd / Rev, Start/Stop	10,000	250	0.015"	5"	0.01"	6208K681	\$ 90.91
1/2" x 1/2"	1 1/4"	1 1/4"	Fwd / Rev, Start/Stop	10,000	84	0.006"	3"	0.006"	6208K569	\$ 56.31
1/2" x 1/2"	2"	1 1/4"	Fwd / Rev, Start/Stop	10,000	115	0.015"	5"	0.01"	6208K598	\$ 58.25
1/2" x 1/2"	2 3/8"	1 1/2"	Fwd / Rev, Start/Stop	10,000	155	0.015"	5"	0.01"	6208K633	\$ 72.19
1/2" x 1/2"	2 1/2"	1 5/8"	Fwd / Rev, Start/Stop	10,000	215	0.015"	5"	0.01"	6208K657	\$ 91.81
1/2" x 1/2"	2 3/4"	1 3/4"	Fwd / Rev, Start/Stop	10,000	250	0.015"	5"	0.01"	6208K683	\$ 90.91

Clamping Shaft Couplings

Saturday, December 23, 2017 12:41 AM



For Keyed Shafts

Designed to grip evenly around your shaft, clamping couplings provide more holding power than set screw couplings without marring the shaft. Slide onto the end of your shaft and tighten the clamping screws to secure. Good for high-torque applications, rigid couplings connect two shafts that are aligned, allowing for no relative movement between the shafts.



For Round Shafts

Stainless steel couplings have excellent corrosion resistance.



For technical drawings and 3-D models, click on a part number.

From <https://www.mcmaster.com/#standard-shaft-couplings/=1at6yix>

Steel - For Keyed Shafts							
For Shaft Dia.	O'all Lg.	OD	For Motion Type	Max. Speed, rpm	Max. Torque, in.-lbs.	McMaster P/N	Each
3/8" x 3/8"	1 3/8"	7/8"	Fwd / Rev, Start/Stop	4,000	450	61005K111	\$ 37.92
1/2" x 1/2"	1 3/4"	1 1/8"	Fwd / Rev, Start/Stop	4,000	950	61005K122	\$ 41.73

Steel - For Round Shafts							
For Shaft Dia.	O'all Lg.	OD	For Motion Type	Max. Speed, rpm	Max. Torque, in.-lbs.	McMaster P/N	Each
3/16" x 3/16"	7/8"	9/16"	Fwd / Rev, Start/Stop	4,000	200	61005K1	\$ 25.95
1/4" x 3/16"	1"	5/8"	Fwd / Rev, Start/Stop	4,000	200	61005K2	\$ 27.49
1/4" x 1/4"	1"	5/8"	Fwd / Rev, Start/Stop	4,000	200	61005K311	\$ 25.76
3/8" x 1/4"	1 3/8"	7/8"	Fwd / Rev, Start/Stop	4,000	450	61005K511	\$ 38.22
3/8" x 3/8"	1 3/8"	7/8"	Fwd / Rev, Start/Stop	4,000	450	61005K322	\$ 31.24
1/2" x 3/8"	1 3/4"	1 1/8"	Fwd / Rev, Start/Stop	4,000	950	61005K522	\$ 40.54
1/2" x 1/2"	1 3/4"	1 1/8"	Fwd / Rev, Start/Stop	4,000	950	61005K331	\$ 33.41



PNEUMATICS

- A. PNEUMATICS ASSEMBLY INSTRUCTIONS**
- B. PARKER PNEUMATICS FITTINGS**
- C. PUSH TO CONNECT FLOW CONTROL**
- D. PNEUMATICS TUBE RACK**
- E. TUBE T-CLIP**
- F. PNEUMATIC SINGLE ACTING CYLINDER**
- G. PNEUMATIC DOUBLE ACTING CYLINDER**

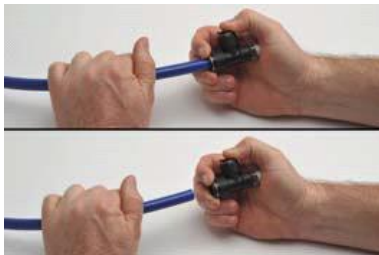
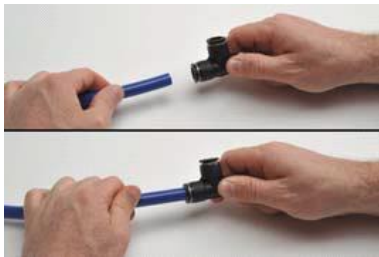
FIRST Robotics Competition Pneumatics Manual can be found at:

<https://firstfrc.blob.core.windows.net/frc2017/pneumatics-manual.pdf>

Pneumatics Assembly Instructions

Sunday, May 18, 2014 8:24 AM

TITAN ROBOTICS CLUB
TEAM 492



Pneumatic Fitting Instructions and Caution Information

Prepare the NITRA™ tubing for cutting and make sure to have the proper tubing cutters like the NITRA TC-12 or TC-20. (If cutting bonded tubing, carefully split the tubes with a knife and then pull apart as needed.)



Cut the NITRA tubing at a right angle with the axis using a standard tube cutter. After cutting the tubing, make sure to check the cut end for an even cut with no debris.

Insertion of the NITRA tubing into fittings

- Make sure the tube is inserted fully into the fitting.
- Pull the tube gently to make sure it does not release.
- If the tube end is damaged or deformed, leakage or unexpected tube release may occur. Make sure to check tubing end thoroughly.

Removing the NITRA tubing from fittings

- Make sure the pressure in the tube is zero before releasing the tube from the fittings.
- To release the tubing, press the release ring at the end of the fitting and pull the tube with one hand.
- Inspect the released tube end and make a clean cut if it is damaged or deformed.

Common Precautions for Tubing and Fitting Products

Warnings:

- Do not use fittings with media other than air.
- Avoid installing with tubing under tension or with excessive bends.
- Do not use the product where weld spatters occur as fire may occur.
- Product damage or air leakage may occur at places where there is excessive rotation or vibration of the fittings.
- Use caution in water as the product may be damaged by surge pressure.
- Do not use the product where it is directly exposed to fluids such as cutting oil, lubricating oil, and coolant oil.

Cautions:

- Assemble the tubing only after cleaning away impurities such as dust and excess debris.
- Fitting products are recommended for air systems only. Avoid using for other purposes.

Parker Pneumatic Fittings

Friday, March 15, 2013 2:25 PM

TITAN ROBOTICS CLUB
TEAM 492



[Union Straight](#)
NITRA™ Pneumatic
Fittings
from **\$5.50** (5
pack)
(USxxx)



[Union Reducer](#)
NITRA™ Pneumatic
Fittings
from **\$7.00** (5 pack)
(URxxx)



[Union Tee](#)
NITRA™ Pneumatic
Fittings
from **\$7.75** (5 pack)
(UTxxx)



[Union Tee Reducer](#)
NITRA™ Pneumatic
Fittings
from **\$8.25** (5 pack)
(UTRxxx)



[Union Elbow](#)
NITRA™ Pneumatic
Fittings
from **\$5.00** (5
pack)
(ULxxx)



[Union Y](#)
NITRA™ Pneumatic
Fittings
from **\$8.50** (5
pack)
(UYxxx)



[Union Y Reducer](#)
NITRA™ Pneumatic
Fittings
from **\$11.00** (5
pack)
(URYxxx)



[Union Cross](#)
NITRA™ Pneumatic
Fittings
from **\$13.00** (5
pack)
(UXxxx)



[Union Triple
Branch](#)
NITRA™ Pneumatic
Fittings
from **\$18.00** (5
pack)
(UTRxxx)



[Bulkhead Union](#)
NITRA™ Pneumatic
Fittings
from **\$11.50** (5
pack)
(UBxxx)



[Plug](#)
NITRA™ Pneumatic
Fittings
from **\$2.50** (5
pack)
(PLUGxxx)



[Plug-in Reducer](#)
NITRA™ Pneumatic
Fittings
from **\$4.50** (5
pack)
(PRxxx)



[Male Straight
\(Hex Body\)](#)
NITRA™ Pneumatic
Fittings
from **\$4.25** (5
pack)
(MSxxx)



[Male Straight
\(Round Body\)](#)
NITRA™ Pneumatic
Fittings
from **\$4.25** (5
pack)
(MSRxxx)



[Female Straight](#)
NITRA™ Pneumatic
Fittings
from **\$7.75** (5
pack)
(FSxxx)

Parker Pneumatic Fittings (Pg 2)

Friday, March 15, 2013 2:27 PM

TITAN ROBOTICS CLUB
TEAM 492



Male Elbow
NITRA™ Pneumatic Fittings
from **\$5.75** (5 pack)
(MExxx)



Long Male Elbow
NITRA™ Pneumatic Fittings
from **\$10.50** (5 pack)
(MELxxx)



Female Elbow
NITRA™ Pneumatic Fittings
from **\$11.50** (5 pack)
(FExxx)



Male Branch Tee
NITRA™ Pneumatic Fittings
from **\$9.50** (5 pack)
(MBTxxx)



Male Run Tee
NITRA™ Pneumatic Fittings
from **\$10.50** (5 pack)
(MRTxxx)



Male Y
NITRA™ Pneumatic Fittings
from **\$10.50** (5 pack)
(MYxxx)



Bulkhead Female
NITRA™ Pneumatic Fittings
from **\$13.50** (5 pack)
(FBxxx)



Manual Hand Valve
NITRA™ Pneumatic Fittings
from **\$13.00** (2 pack)
(HVVxxx)



Check Valve
NITRA™ Pneumatic Fittings
from **\$29.00** (5 pack)
(CVUxxx)



Stop Valve
NITRA™ Pneumatic Fittings
from **\$27.00** (5 pack)
(SVUxxx)

Pasted from <[<http://www.automationdirect.com/adc/Overview/Catalog/Pneumatic_Components/Pneumatic_Fittings - a- Air Couplings/Push-to-Connect Pneumatic Fittings \(Thermoplastic\)>](http://www.automationdirect.com/adc/Overview/Catalog/Pneumatic_Components/Pneumatic_Fittings_-_a-Air_Couplings/Push-to-Connect_Pneumatic_Fittings_(Thermoplastic))>

Push-to-Connect Flow Control

Sunday, May 18, 2014 8:49 AM

TITAN ROBOTICS CLUB
TEAM 492



ELBOW METER-IN
NITRA™ Flow
Control Valve
from <--->
(2 pack) (FVRxxx)



ELBOW METER-OUT
NITRA™ Flow Control Valve
from <--->
(2 pack) (FVSxxx)



IN-LINE (STRAIGHT)
NITRA™ Flow Control Valve
from <--->
(2 pack) (FVUxxx)

NITRA Pneumatic Push-to-Connect Flow Control (Speed Controller) Valves provide accurate airflow regulation for precise motion control of pneumatic cylinders. NITRA flow control valve bodies are made of strong thermoplastic (PBT) and have stainless steel tube gripping claws. Threaded components are nickel-plated brass and have pre-applied Teflon thread sealant. Flow control valve bodies can be rotated after installation to allow for variations in piping direction.

- Meter-in , meter-out and in-line configurations
- Inch and metric sizes available
- NPT and BSPT (R) threads available
- Tough thermoplastic bodies, stainless steel tube gripping claws, nickel-plated threads with pre-applied Teflon sealant
- Bodies can be rotated after installation
- Release rings are color coded to differentiate between meter-in and meter-out

2-Way & 3-Way Shutoff Valve

Monday, January 1, 2018 11:48 AM

TITAN ROBOTICS CLUB
TEAM 492



Inline Manual Shutoff Valves - 2-Way/ 3-Way Locking/Non-Locking



Non-Locking Valve

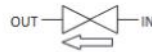
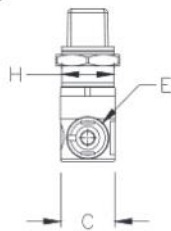
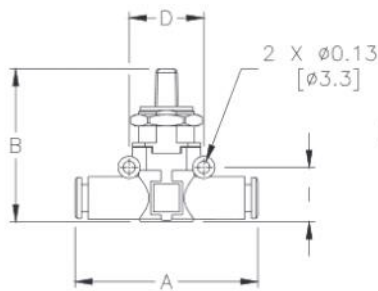
Locking Valve



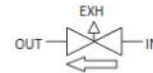
NITRA pneumatic push-to-connect in-line hand valves have a technopolymer body and nickel-plated brass valve insert, with a range of 0 to 150 psi. Both 2-way and 3-way valves are available with or without locking capability. 3-way valves relieve pressure downstream when in the closed position.

Features

- Works with flexible pneumatic tubing
- Easily added to existing circuits
- 2-way and 3-way valves available
- Lockable valves keep valve in closed position during maintenance (Note: Valve can only be locked in closed position)
- Two-year warranty



2-Way Valve



3-Way Valve

Specialty Control & Indicators

Sunday, April 29, 2018 4:27 PM

TITAN ROBOTICS CLUB
TEAM 492



PRU14

Compare

NITRA pneumatic push-to-connect inline pressure regulator, technopolymer body, 1/4in tube inlet(s), 1/4in tube outlet(s), 15-120 psi adjustable range.

[Specifications](#) | [More info...](#)

\$21.00

✓ In Stock

Qty. In Cart:

Update Cart



PGU14

Compare

NITRA pneumatic push-to-connect inline pressure gauge, technopolymer body, 1/4in tube inlet(s), 1/4in tube outlet(s), 0-170 psi range.

[Specifications](#) | [More info...](#)

\$18.00

✓ In Stock

Qty. In Cart:

Update Cart



PMU14A

Compare

NITRA pneumatic push-to-connect inline pressure indicator, technopolymer body, 1/4in tube inlet(s), 1/4in tube outlet(s), 29-145 psi range, orange indication.

[Specifications](#) | [More info...](#)

\$12.00

✓ In Stock

Qty. In Cart:

Update Cart



PMU14G

Compare

NITRA pneumatic push-to-connect inline pressure indicator, technopolymer body, 1/4in tube inlet(s), 1/4in tube outlet(s), 29-145 psi range, green indication.

[Specifications](#) | [More info...](#)

\$12.00

✓ In Stock

Qty. In Cart:

Update Cart

Mounts and Formed Connector Tube



Sunday, April 29, 2018 4:39 PM



FBKT

Compare

NITRA pneumatic mounting bracket, plated steel. For use with push-to-connect fittings.

[Specifications](#) | [More info...](#)

\$2.25

✓ In Stock

Qty. In Cart:

0

Update Cart



TU14

Compare

NITRA pneumatic U-tube, polyamide, 1/4in. For use with push-to-connect fittings.

[Specifications](#) | [More info...](#)

\$3.00

✓ In Stock

Qty. In Cart:

0

Update Cart



2PU532C10

Compare

NITRA pneumatic bonded coiled tubing, ether-based polyurethane, black and clear blue, double 5/32in outside diameter, 0.093in inside diameter, 10 coils, 2.0ft (0.61m) working length.

[Specifications](#) | [More info...](#)

\$6.00

✓ In Stock

Qty. In Cart:

0

Update Cart



2PU14-50

Compare

NITRA pneumatic bonded tubing, ether-based polyurethane, black and clear blue, double 1/4in outside diameter, 0.156in inside diameter, 50ft package.

[Specifications](#) | [More info...](#)

\$34.00

✓ In Stock

Qty. In Cart:

0

Update Cart



3PU14-50

Compare

NITRA pneumatic bonded tubing, ether-based polyurethane, black, clear blue and blue, triple 1/4in outside diameter, 0.156in inside diameter, 50ft package.

[Specifications](#) | [More info...](#)

\$51.00

✓ In Stock

Qty. In Cart:

0

Update Cart

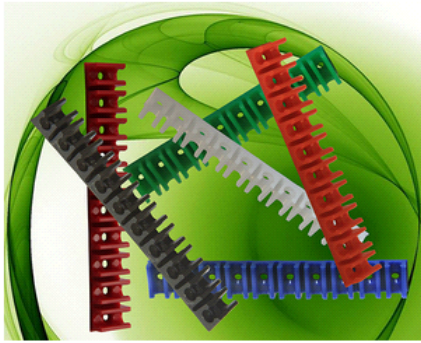
Pneumatic Tube Rack

Sunday, December 10, 2017 10:45 AM

TITAN ROBOTICS CLUB
TEAM 492



Tube Racks



Click to Enlarge
Tube Racks

Polyconn's tube racks will keep your pneumatic hoses and tubes neat and in order. These sturdy plastic racks have 5, 7, or 10 tubing channels (depending on diameter) to clip hoses and tubes in place. The channels are easily separated into smaller sections if necessary. Standard color is black, but other colors are available. Tube racks from Polyconn will help avoid tangles and kinks in your pneumatic hoses, and will keep your multiple lines from turning into a jumbled mess.

Our [Tubing Accessories Catalog and Price List](#) are available on-line. Request a quote for the Tube Rack you need on-line today, or [contact Polyconn](#) for further information.

If the Qty shows "In Stock" please note that the availability is subject to change dependent upon quantity ordered.

Products



Tube Racks 1/4 OD
(16 Products)

[View Details](#)



Tube Racks 5/32 OD
(3 Products)

[View Details](#)



Tube Racks 3/16 OD
(4 Products)

[View Details](#)



Tube Racks Non-Separable
(3 Products)

<http://www.polyconn.com/tube-racks#2>

Tube T-Clips

Sunday, December 10, 2017 10:52 AM



Tube T-Clips



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Tube T-Clips

Our Tubing Accessories Catalog and Price List are available on-line. Request a quote for the Tube Clips you need on-line today, or [contact Polyconn](#) for further information.

If the Qty shows "In Stock" please note that the availability is subject to change dependent upon quantity ordered.

*Please select the quantity for each item you wish to order and click the 'Add To Cart' button below.

PCT-4-2

Price \$21.93 (0.44/ea.)

Quantity In Stock

Add # of Pkgs:

Specifications

Tube Size: 5/32"

A: 0.61"

B: 0.40"

C: 0.70"

D: 0.24"

E: 0.27"

F: 0.12"

G: 0.22"

H: 0.37"

Pkg: 50

PCT-6-2

Price \$27.34 (0.55/ea.)

Quantity **Call for Avail.**

Add # of Pkgs:

Specifications

Tube Size: 1/4"

A: 0.811"

B: 0.506"

C: 0.808"

D: 0.324"

E: 0.334"

F: 0.122"

G: 0.262"

H: 0.364"

Pkg: 50

PCT-8-2

Price \$28.95 (0.58/ea.)

Quantity In Stock

Add # of Pkgs:

Specifications

Tube Size: 5/16"

A: 1.00"

B: 0.626"

C: 0.970"

D: 0.404"

E: 0.414"

F: 0.162"

G: 0.322"

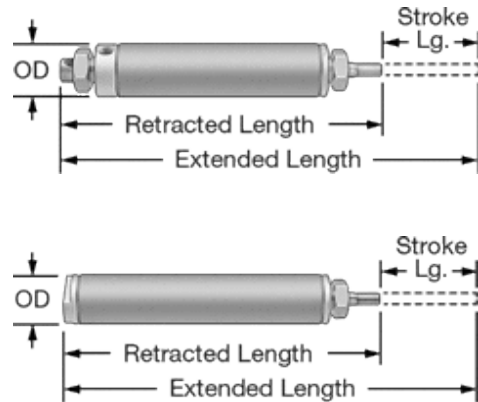
H: 0.484"

Pkg: 50

<http://www.polyconn.com/tube-t-clips>

Pneumatic Single Acting Cylinders (Universal Mount)

Monday, January 1, 2018 11:14 AM



More basic and cost effective than double-acting cylinders, these single-acting cylinders exert force in one direction and have a spring to return the rod to its original position.

Air-extend cylinders, also known as push style, use air to extend the rod. Air-retract cylinders, also known as pull style, use air to retract the rod.

Universal-mount cylinders have threads on both ends to mount in a fixed position or you can use the hole on the back end to pivot mount.

Nose-mount cylinders have threads on the rod end and mount in a fixed position.

From <<https://www.mcmaster.com/#pneumatic-cylinders/=1axvfbu>>

Stroke Length	Force @ 100 psi, lbs.	Air Inlet Thread Size	Thread Type	Gender	Air Extend, Spring Retract Length			Air Retract, Spring Extend Length		
					Retracted	Extended	Each	Retracted	Extended	Each

5/8" Bore Size (0.69" OD)

1/2"	31	10-32	UNF	Female	3.57"	4.07"	6498K266	50.09	4.13"	4.63"	6498K845	68.08
1"	31	10-32	UNF	Female	4.51"	5.51"	6498K267	52.29	5.13"	6.13"	6498K874	71.26
1 1/2"	31	10-32	UNF	Female	5.89"	7.39"	6498K837	54.72	6.01"	7.51"	6498K875	75.04
2"	31	10-32	UNF	Female	6.39"	8.39"	6498K269	57.66	7.01"	9.01"	6498K876	78.84
2 1/2"	31	10-32	UNF	Female	7.77"	10.27"	6498K838	60.14	8.89"	11.39"	6498K877	82.62
3"	31	10-32	UNF	Female	8.27"	11.27"	6498K271	62.95	8.89"	11.89"	6498K878	86.40
4"	31	10-32	UNF	Female	10.15"	14.15"	6498K272	68.44	10.77"	14.77"	6498K879	94.12
5"	31	10-32	UNF	Female	12.03"	17.03"	6498K839	71.12	12.65"	17.65"	6498K912	97.98
6"	31	10-32	UNF	Female	13.91"	19.91"	6498K843	73.88	14.53"	20.53"	6498K913	101.84
8"	31	10-32	UNF	Female	17.67"	25.67"	6498K844	76.62	18.29"	26.29"	6498K914	105.70

Pneumatic Single Acting Cylinders (Universal Mount) - (Cont)

Monday, January 1, 2018 11:14 AM



3/4" Bore Size (0.86" OD)

Stroke Length	Force @ 100 psi, lbs.	Air Inlet			Air Extend, Spring Retract			Air Retract, Spring Extend				
		Thread Size	Thread Type	Gender	Retracted Length	Extended Length	Each	Retracted Length	Extended Length	Each		
1/2"	40	1/8	NPT	Female	4.25"	4.75"	6498K521	26.30	4.41"	4.91"	6498K036	34.51
1"	40	1/8	NPT	Female	4.75"	5.75"	6498K522	27.66	4.91"	5.91"	6498K037	36.39
1 1/2"	40	1/8	NPT	Female	5.94"	7.44"	6498K523	29.06	6.1"	7.6"	6498K038	38.32
2"	40	1/8	NPT	Female	6.44"	8.44"	6498K524	30.40	6.6"	8.6"	6498K039	40.19
2 1/2"	40	1/8	NPT	Female	7.63"	10.13"	6498K035	31.81	7.79"	10.29"	6498K041	42.08
3"	40	1/8	NPT	Female	8.13"	11.13"	6498K525	33.18	8.29"	11.29"	6498K042	43.98
4"	40	1/8	NPT	Female	9.82"	13.82"	6498K526	35.94	9.98"	13.98"	6498K043	47.78
5"	40	1/8	NPT	Female	11.51"	16.51"	6498K527	38.68	11.67"	16.67"	6498K044	51.60
6"	40	1/8	NPT	Female	13.2"	19.2"	6498K528	41.44	13.36"	19.36"	6498K045	55.40
8"	40	1/8	NPT	Female	16.58"	24.58"	6498K762	46.90	16.74"	24.74"	6498K046	62.94

From <<https://www.mcmaster.com/#pneumatic-cylinders/=1axvfbu>>

Pneumatic Single Acting Cylinders (Universal Mount) - (Cont)



Monday, January 1, 2018 11:14 AM

1 1/16" Bore Size (1.12" OD)

Stroke Length	Force @ 100 psi, lbs.	Air Inlet			Air Extend, Spring Retract			Air Retract, Spring Extend				
		Thread Size	Thread Type	Gender	Retracted Length	Extended Length	Each	Retracted Length	Extended Length	Each		
1/2"	90	1/8	NPT	Female	4.5"	5"	6498K062	28.45	4.85"	5.35"	6498K064	37.75
1"	90	1/8	NPT	Female	5"	6"	6498K532	30.20	5.35"	6.35"	6498K065	40.11
1 1/2"	90	1/8	NPT	Female	6.06"	7.56"	6498K533	31.69	6.66"	8.16"	6498K066	42.54
2"	90	1/8	NPT	Female	6.56"	8.56"	6498K534	33.66	7.16"	9.16"	6498K067	44.94
2 1/2"	90	1/8	NPT	Female	7.62"	10.12"	6498K063	35.40	8.47"	10.97"	6498K068	47.36
3"	90	1/8	NPT	Female	8.12"	11.12"	6498K535	37.16	8.97"	11.97"	6498K069	49.82
4"	90	1/8	NPT	Female	9.68"	13.68"	6498K536	40.64	10.78"	14.78"	6498K071	54.64
5"	90	1/8	NPT	Female	11.24"	16.24"	6498K537	44.27	12.59"	17.59"	6498K072	59.46
6"	90	1/8	NPT	Female	12.8"	18.8"	6498K538	47.62	14.4"	20.4"	6498K073	64.34
8"	90	1/8	NPT	Female	15.92"	23.92"	6498K772	54.58	18.02"	26.02"	6498K074	74.04

From <<https://www.mcmaster.com/#pneumatic-cylinders/=1axvfbu>>

Pneumatic Single Acting Cylinders (Universal Mount) - (Cont)

Monday, January 1, 2018 11:14 AM



1 1/4" Bore Size (1.34" OD)

Stroke Length	Force @ 100 psi, lbs.	Air Inlet			Air Extend, Spring Retract				Air Retract, Spring Extend			
		Thread Size	Thread Type	Gender	Retracted Length	Extended Length	Each	Retracted Length	Extended Length	Each		
1/2"	120	1/8	NPT	Female	5.85"	6.35"	6498K089	41.28	6.22"	6.72"	6498K095	46.50
1"	120	1/8	NPT	Female	6.35"	7.35"	6498K965	43.48	6.72"	7.72"	6498K096	49.02
1 1/2"	120	1/8	NPT	Female	7.66"	9.16"	6498K091	45.68	8.03"	9.53"	6498K097	51.52
2"	120	1/8	NPT	Female	8.16"	10.16"	6498K966	47.86	8.53"	10.53"	6498K098	54.00
2 1/2"	120	1/8	NPT	Female	9.47"	11.97"	6498K092	50.06	9.84"	12.34"	6498K099	56.52
3"	120	1/8	NPT	Female	9.97"	12.97"	6498K967	52.24	10.34"	13.34"	6498K101	59.00
4"	120	1/8	NPT	Female	11.78"	15.78"	6498K968	56.62	12.15"	16.15"	6498K102	64.00
5"	120	1/8	NPT	Female	13.59"	18.59"	6498K093	61.00	13.96"	18.96"	6498K103	69.00
6"	120	1/8	NPT	Female	15.4"	21.4"	6498K969	65.38	15.77"	21.77"	6498K104	73.98
8"	120	1/8	NPT	Female	19.02"	27.02"	6498K094	74.14	19.39"	27.39"	6498K105	83.98

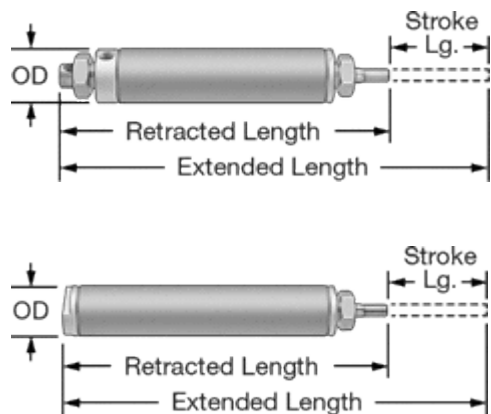
From <<https://www.mcmaster.com/#pneumatic-cylinders/=1axvfbu>>



Pneumatic Single Acting Cylinders (Nose Mount)

TITAN ROBOTICS CLUB
TEAM 492

Monday, January 1, 2018 11:14 AM



More basic and cost effective than double-acting cylinders, these single-acting cylinders exert force in one direction and have a spring to return the rod to its original position.

Air-extend cylinders, also known as push style, use air to extend the rod. Air-retract cylinders, also known as pull style, use air to retract the rod.

Universal-mount cylinders have threads on both ends to mount in a fixed position or you can use the hole on the back end to pivot mount.

Nose-mount cylinders have threads on the rod end and mount in a fixed position.

From <<https://www.mcmaster.com/#pneumatic-cylinders/=1axvfbu>>

Stroke Length	Force @ 100 psi, lbs.	Air Inlet			Air Extend, Spring Retract			Air Retract, Spring Extend		
		Thread Size	Thread Type	Gender	Retracted Length	Extended Length	Each	Retracted Length	Extended Length	Each

5/8" Bore Size (0.69" OD)

1/2"	31	10-32	UNF	Female	2.88"	3.38"	6498K132	38.18	3.45"	3.95"	6498K823	53.46
1"	31	10-32	UNF	Female	3.82"	4.82"	6498K135	40.34	4.45"	5.45"	6498K824	56.48
1 1/2"	31	10-32	UNF	Female	5.2"	6.7"	6498K814	43.04	5.33"	6.83"	6498K825	60.26
2"	31	10-32	UNF	Female	5.7"	7.7"	6498K137	45.74	6.33"	8.33"	6498K826	64.06
2 1/2"	31	10-32	UNF	Female	7.08"	9.58"	6498K815	48.50	7.21"	9.71"	6498K827	67.92
3"	31	10-32	UNF	Female	7.58"	10.58"	6498K138	51.28	8.21"	11.21"	6498K828	71.78
4"	31	10-32	UNF	Female	9.46"	13.46"	6498K139	56.68	10.09"	14.09"	6498K829	79.34
5"	31	10-32	UNF	Female	11.34"	16.34"	6498K816	59.44	11.97"	16.97"	6498K833	83.22
6"	31	10-32	UNF	Female	13.22"	19.22"	6498K817	62.20	13.85"	19.85"	6498K834	87.06
8"	31	10-32	UNF	Female	16.98"	24.98"	6498K818	62.20	17.61"	25.61"	6498K835	90.92

Pneumatic Single Acting Cylinders (Nose Mount) - (Cont)

Monday, January 1, 2018 11:14 AM

TITAN ROBOTICS CLUB
TEAM 492



3/4" Bore Size (0.86" OD)

Stroke Length	Force @ 100 psi, lbs.	Air Inlet			Air Extend, Spring Retract				Air Retract, Spring Extend			
		Thread Size	Thread Type	Gender	Retracted	Extended		Each	Retracted	Extended		Each
1/2"	40	1/8	NPT	Female	3.19"	3.69"	6498K195	17.24	4"	4.5"	6498K049	25.36
1"	40	1/8	NPT	Female	3.69"	4.69"	6498K141	18.50	4.5"	5.5"	6498K051	27.21
1 1/2"	40	1/8	NPT	Female	4.88"	6.38"	6498K1	19.90	5.69"	7.19"	6498K052	29.26
2"	40	1/8	NPT	Female	5.38"	7.38"	6498K142	21.26	6.19"	8.19"	6498K053	31.27
2 1/2"	40	1/8	NPT	Female	6.57"	9.07"	6498K048	22.64	7.38"	9.88"	6498K054	33.28
3"	40	1/8	NPT	Female	7.07"	10.07"	6498K143	24.00	7.88"	10.88"	6498K055	35.31
4"	40	1/8	NPT	Female	8.76"	12.76"	6498K144	26.70	9.57"	13.57"	6498K056	39.28
5"	40	1/8	NPT	Female	10.45"	15.45"	6498K145	29.48	11.26"	16.26"	6498K057	43.32
6"	40	1/8	NPT	Female	12.14"	18.14"	6498K146	32.24	12.95"	18.95"	6498K058	47.38
8"	40	1/8	NPT	Female	15.52"	23.52"	6498K147	37.76	16.33"	24.33"	6498K059	55.48

Pneumatic Single Acting Cylinders (Nose Mount) - (Cont)



Monday, January 1, 2018 11:14 AM

1 1/16" Bore Size (1.12" OD)

Stroke Length	Force @ 100 psi, lbs.	Air Inlet			Air Extend, Spring Retract				Air Retract, Spring Extend			
		Thread Size	Thread Type	Gender	Retracted Length	Extended Length	Each	Retracted Length	Extended Length	Each		
1/2"	90	1/8	NPT	Female	3.62"	4.12"	6498K176	19.40	4.43"	4.93"	6498K077	28.16
1"	90	1/8	NPT	Female	4.12"	5.12"	6498K171	21.20	4.93"	5.93"	6498K078	30.75
1 1/2"	90	1/8	NPT	Female	5.18"	6.68"	6498K177	22.98	6.24"	7.74"	6498K079	33.24
2"	90	1/8	NPT	Female	5.68"	7.68"	6498K172	24.66	6.74"	8.74"	6498K081	35.76
2 1/2"	90	1/8	NPT	Female	6.74"	9.24"	6498K076	26.41	8.05"	10.55"	6498K082	38.29
3"	90	1/8	NPT	Female	7.24"	10.24"	6498K173	28.12	8.55"	11.55"	6498K083	40.78
4"	90	1/8	NPT	Female	8.8"	12.8"	6498K174	31.64	10.36"	14.36"	6498K084	45.88
5"	90	1/8	NPT	Female	10.36"	15.36"	6498K179	35.27	12.17"	17.17"	6498K085	50.88
6"	90	1/8	NPT	Female	11.92"	17.92"	6498K175	38.60	13.98"	19.98"	6498K086	56.00
8"	90	1/8	NPT	Female	15.04"	23.04"	6498K732	45.60	17.6"	25.6"	6498K087	66.10

Pneumatic Single Acting Cylinders (Nose Mount) - (Cont)

Monday, January 1, 2018 11:14 AM

TITAN ROBOTICS CLUB
TEAM 492



1 1/4" Bore Size (1.34" OD)

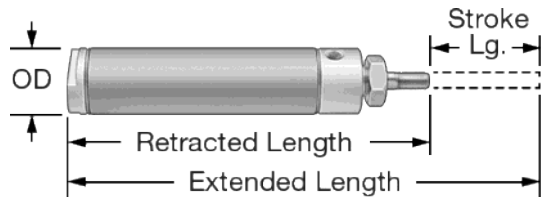
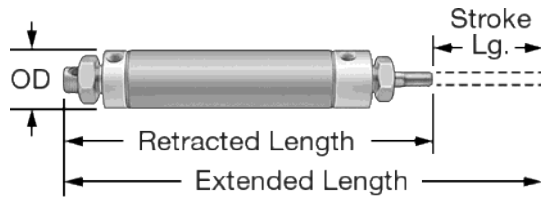
Stroke Length	Force @ 100 psi, lbs.	Air Inlet			Air Extend, Spring Retract				Air Retract, Spring Extend			
		Thread Size	Thread Type	Gender	Retracted	Extended	Each	Retracted	Extended	Each		
1/2"	120	1/8	NPT	Female	4.72"	5.22"	6498K107	30.67	5.53"	6.03"	6498K168	39.91
1"	120	1/8	NPT	Female	5.22"	6.22"	6498K951	32.87	6.03"	7.03"	6498K197	42.74
1 1/2"	120	1/8	NPT	Female	6.53"	8.03"	6498K108	35.10	7.34"	8.84"	6498K198	45.64
2"	120	1/8	NPT	Female	7.03"	9.03"	6498K952	37.26	7.84"	9.84"	6498K199	48.44
2 1/2"	120	1/8	NPT	Female	8.34"	10.84"	6498K109	39.48	9.15"	11.65"	6498K201	51.32
3"	120	1/8	NPT	Female	8.84"	11.84"	6498K953	41.64	9.65"	12.65"	6498K202	54.14
4"	120	1/8	NPT	Female	10.65"	14.65"	6498K954	46.04	11.46"	15.46"	6498K203	59.84
5"	120	1/8	NPT	Female	12.46"	17.46"	6498K136	50.40	13.27"	18.27"	6498K204	65.52
6"	120	1/8	NPT	Female	14.27"	20.27"	6498K165	54.78	15.08"	21.08"	6498K205	71.22
8"	120	1/8	NPT	Female	17.89"	25.89"	6498K166	63.54	18.7"	26.7"	6498K206	82.62

From <https://www.mcmaster.com/#pneumatic-cylinders/=1axvfbu>

Pneumatic Double Acting Cylinders (Universal Mount)

Friday, December 22, 2017 3:04 PM

**TITAN ROBOTICS CLUB
TEAM 492**



Create linear motion with the most popular of our air cylinders. Universal-mount cylinders have threads on both ends to mount in a fixed position or you can use the hole on the back end to pivot mount. Nose-mount cylinders have threads on the rod end and mount in a fixed position.



For technical drawings and 3-D models, click on a part number.

Check online for additional sizes

From <<https://www.mcmaster.com/#pneumatic-cylinders/=1axv4a2>>

Universal Mount (Stainless Steel)

Length				Force @ 100 psi, lbs.	Air Inlet			Each
Stroke	Retracted	Extended	Thread Size		Thread Type	Gender		
9/16" Bore Size (0.62" OD)								
1/2"	3.75"	4.25"	25	10-32	UNF	Female	6498K854	29.38
1"	4.25"	5.25"	25	10-32	UNF	Female	6498K855	30.38
1 1/2"	4.75"	6.25"	25	10-32	UNF	Female	6498K364	31.47
2"	5.25"	7.25"	25	10-32	UNF	Female	6498K856	32.46
2 1/2"	5.75"	8.25"	25	10-32	UNF	Female	6498K365	33.52
3"	6.25"	9.25"	25	10-32	UNF	Female	6498K857	34.54
4"	7.25"	11.25"	25	10-32	UNF	Female	6498K858	36.62
5"	8.25"	13.25"	25	10-32	UNF	Female	6498K859	38.72
6"	9.25"	15.25"	25	10-32	UNF	Female	6498K864	40.84
8"	11.25"	19.25"	25	10-32	UNF	Female	6498K865	45.00
10"	13.25"	23.25"	25	10-32	UNF	Female	6498K866	51.38

From <<https://www.mcmaster.com/#pneumatic-cylinders/=1axv4a2>>

Pneumatic Double Acting Cylinders (Universal Mount) - (cont)



Friday, December 22, 2017 3:04 PM

Universal Mount (Stainless Steel)

Length				Air Inlet			Each
Stroke	Retracted	Extended	Force @ 100 psi, lbs.	Thread Size	Thread Type	Gender	
5/8" Bore Size (0.69" OD)							
1/2"	3.94"	4.44"	31	10-32	UNF	Female	6498K428 44.02
1"	4.44"	5.44"	31	10-32	UNF	Female	6498K429 45.32
1 1/2"	4.94"	6.44"	31	10-32	UNF	Female	6498K792 46.56
2"	5.44"	7.44"	31	10-32	UNF	Female	6498K432 47.80
2 1/2"	5.94"	8.44"	31	10-32	UNF	Female	6498K793 49.04
3"	6.44"	9.44"	31	10-32	UNF	Female	6498K433 50.30
4"	7.44"	11.44"	31	10-32	UNF	Female	6498K434 52.72
5"	8.44"	13.44"	31	10-32	UNF	Female	6498K435 54.72
6"	9.44"	15.44"	31	10-32	UNF	Female	6498K436 57.31
8"	11.44"	19.44"	31	10-32	UNF	Female	6498K438 62.74
10"	13.44"	23.44"	31	10-32	UNF	Female	6498K441 67.70
3/4" Bore Size (0.86" OD)							
1/2"	5.03"	5.53"	40	1/8	NPT	Female	6498K631 30.37
1"	5.53"	6.53"	40	1/8	NPT	Female	6498K632 31.16
1 1/2"	6.03"	7.53"	40	1/8	NPT	Female	6498K633 32.30
2"	6.53"	8.53"	40	1/8	NPT	Female	6498K634 33.28
2 1/2"	7.03"	9.53"	40	1/8	NPT	Female	6498K443 34.36
3"	7.53"	10.53"	40	1/8	NPT	Female	6498K635 35.34
4"	8.53"	12.53"	40	1/8	NPT	Female	6498K636 37.44
5"	9.53"	14.53"	40	1/8	NPT	Female	6498K637 39.50
6"	10.53"	16.53"	40	1/8	NPT	Female	6498K638 41.62
7"	11.53"	18.53"	40	1/8	NPT	Female	6498K861 43.66
8"	12.53"	20.53"	40	1/8	NPT	Female	6498K639 46.13
9"	13.53"	22.53"	40	1/8	NPT	Female	6498K403 47.88
10"	14.53"	24.53"	40	1/8	NPT	Female	6498K641 49.94

Pneumatic Double Acting Cylinders (Universal Mount) - (cont)



Friday, December 22, 2017 3:04 PM

Universal Mount (Stainless Steel)

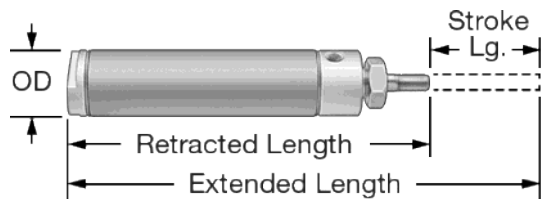
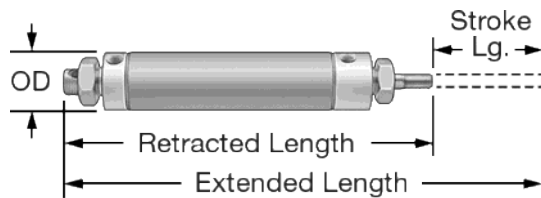
Length				Force @ 100 psi, lbs.	Air Inlet			Each
Stroke	Retracted	Extended	Thread Size		Thread Type	Gender		
1 1/16" Bore Size (1.12" OD)								
1/2"	5.12"	5.62"	90	1/8	NPT	Female	6498K651	34.10
1"	5.62"	6.62"	90	1/8	NPT	Female	6498K652	35.12
1 1/2"	6.12"	7.62"	90	1/8	NPT	Female	6498K653	35.86
2"	6.62"	8.62"	90	1/8	NPT	Female	6498K654	37.24
2 1/2"	7.12"	9.62"	90	1/8	NPT	Female	6498K407	38.32
3"	7.62"	10.62"	90	1/8	NPT	Female	6498K655	39.28
4"	8.62"	12.62"	90	1/8	NPT	Female	6498K656	41.40
5"	9.62"	14.62"	90	1/8	NPT	Female	6498K657	43.46
6"	10.62"	16.62"	90	1/8	NPT	Female	6498K658	45.50
7"	11.62"	18.62"	90	1/8	NPT	Female	6498K871	47.62
8"	12.62"	20.62"	90	1/8	NPT	Female	6498K659	49.68
9"	13.62"	22.62"	90	1/8	NPT	Female	6498K872	51.78
10"	14.62"	24.62"	90	1/8	NPT	Female	6498K661	53.84
1 1/4" Bore Size (1.34" OD)								
1/2"	6.38"	6.88"	120	1/8	NPT	Female	6498K437	48.46
1"	6.88"	7.88"	120	1/8	NPT	Female	6498K972	49.80
1 1/2"	7.38"	8.88"	120	1/8	NPT	Female	6498K973	51.16
2"	7.88"	9.88"	120	1/8	NPT	Female	6498K974	52.46
2 1/2"	8.38"	10.88"	120	1/8	NPT	Female	6498K451	53.80
3"	8.88"	11.88"	120	1/8	NPT	Female	6498K975	55.10
4"	9.88"	13.88"	120	1/8	NPT	Female	6498K976	57.76
5"	10.88"	15.88"	120	1/8	NPT	Female	6498K977	60.40
6"	11.88"	17.88"	120	1/8	NPT	Female	6498K978	63.00
7"	12.88"	19.88"	120	1/8	NPT	Female	6498K459	65.66
8"	13.88"	21.88"	120	1/8	NPT	Female	6498K979	68.30
9"	14.88"	23.88"	120	1/8	NPT	Female	6498K462	70.94
10"	15.88"	25.88"	120	1/8	NPT	Female	6498K981	73.60

From <<https://www.mcmaster.com/#pneumatic-cylinders/=1axv4a2>>

Pneumatic Double Acting Cylinders (Nose Mount)



Friday, December 22, 2017 3:04 PM



Create linear motion with the most popular of our air cylinders. Universal-mount cylinders have threads on both ends to mount in a fixed position or you can use the hole on the back end to pivot mount. Nose-mount cylinders have threads on the rod end and mount in a fixed position.

For technical drawings and 3-D models, click on a part number.

Check online for additional sizes

From <<https://www.mcmaster.com/#pneumatic-cylinders/=1axv4a2>>

Length	Stroke	Retracted	Extended	Force @ 100 psi, lbs.
--------	--------	-----------	----------	-----------------------

Air Inlet	Thread Size	Thread Type	Gender	Each
-----------	-------------	-------------	--------	------

9/16" Bore Size (0.62" OD)

Length	Stroke	Retracted	Extended	Force @ 100 psi, lbs.	Thread Size	Thread Type	Gender	Part Number	Each
1/2"	3.28"	3.78"	25	10-32	UNF	Female	6498K366	21.00	
1"	3.78"	4.78"	25	10-32	UNF	Female	6498K367	21.86	
1 1/2"	4.28"	5.78"	25	10-32	UNF	Female	6498K369	22.74	
2"	4.78"	6.78"	25	10-32	UNF	Female	6498K376	23.54	
2 1/2"	5.28"	7.78"	25	10-32	UNF	Female	6498K383	24.42	
3"	5.78"	8.78"	25	10-32	UNF	Female	6498K385	25.25	
4"	6.78"	10.78"	25	10-32	UNF	Female	6498K388	26.97	
5"	7.78"	12.78"	25	10-32	UNF	Female	6498K389	28.68	
6"	8.78"	14.78"	25	10-32	UNF	Female	6498K393	30.39	
8"	10.78"	18.78"	25	10-32	UNF	Female	6498K394	33.84	
10"	12.78"	22.78"	25	10-32	UNF	Female	6498K401	39.05	

From <<https://www.mcmaster.com/#pneumatic-cylinders/=1axvchd>>

Pneumatic Double Acting Cylinders (Nose Mount) - (cont)

TITAN ROBOTICS CLUB
TEAM 492



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Length			Force @ 100 psi, lbs.	Air Inlet			Each
Stroke	Retracted	Extended		Thread Size	Thread Type	Gender	
5/8" Bore Size (0.69" OD)							
1/2"	3.25"	3.75"	31	10-32	UNF	Female	6498K328 46.18
1"	3.75"	4.75"	31	10-32	UNF	Female	6498K329 47.38
1 1/2"	4.25"	5.75"	31	10-32	UNF	Female	6498K778 48.62
2"	4.75"	6.75"	31	10-32	UNF	Female	6498K358 49.86
2 1/2"	5.25"	7.75"	31	10-32	UNF	Female	6498K779 51.10
3"	5.75"	8.75"	31	10-32	UNF	Female	6498K359 52.36
4"	6.75"	10.75"	31	10-32	UNF	Female	6498K361 54.84
5"	7.75"	12.75"	31	10-32	UNF	Female	6498K787 57.32
6"	8.75"	14.75"	31	10-32	UNF	Female	6498K363 57.51
8"	10.75"	18.75"	31	10-32	UNF	Female	6498K788 64.80
10"	12.75"	22.75"	31	10-32	UNF	Female	6498K789 69.76
3/4" Bore Size (0.86" OD)							
1/2"	3.97"	4.47"	40	1/8	NPT	Female	6498K164 21.64
1"	4.47"	5.47"	40	1/8	NPT	Female	6498K151 22.34
1 1/2"	4.97"	6.47"	40	1/8	NPT	Female	6498K163 23.61
2"	5.47"	7.47"	40	1/8	NPT	Female	6498K152 24.44
2 1/2"	5.97"	8.47"	40	1/8	NPT	Female	6498K368 25.62
3"	6.47"	9.47"	40	1/8	NPT	Female	6498K153 26.50
4"	7.47"	11.47"	40	1/8	NPT	Female	6498K154 28.60
5"	8.47"	13.47"	40	1/8	NPT	Female	6498K155 30.66
6"	9.47"	15.47"	40	1/8	NPT	Female	6498K156 32.78
7"	10.47"	17.47"	40	1/8	NPT	Female	6498K157 34.82
8"	11.47"	19.47"	40	1/8	NPT	Female	6498K162 36.94
9"	12.47"	21.47"	40	1/8	NPT	Female	6498K821 39.00
10"	13.47"	23.47"	40	1/8	NPT	Female	6498K159 41.10

From <<https://www.mcmaster.com/#pneumatic-cylinders/=1axvchd>>

Pneumatic Double Acting Cylinders (Nose Mount) - (cont)

TITAN ROBOTICS CLUB
TEAM 492



Friday, December 22, 2017 3:04 PM

Length			Force @ 100 psi, lbs.	Air Inlet			Each
Stroke	Retracted	Extended		Thread Size	Thread Type	Gender	
1 1/16" Bore Size (1.12" OD)							
1/2"	4.24"	4.74"	90	1/8	NPT	Female	6498K194 24.72
1"	4.74"	5.74"	90	1/8	NPT	Female	6498K181 25.76
1 1/2"	5.24"	6.74"	90	1/8	NPT	Female	6498K193 26.92
2"	5.74"	7.74"	90	1/8	NPT	Female	6498K182 27.78
3"	6.74"	9.74"	90	1/8	NPT	Female	6498K183 29.92
4"	7.74"	11.74"	90	1/8	NPT	Female	6498K184 31.96
5"	8.74"	13.74"	90	1/8	NPT	Female	6498K185 34.08
6"	9.74"	15.74"	90	1/8	NPT	Female	6498K186 36.12
7"	10.74"	17.74"	90	1/8	NPT	Female	6498K831 38.24
8"	11.74"	19.74"	90	1/8	NPT	Female	6498K187 40.28
9"	12.74"	21.74"	90	1/8	NPT	Female	6498K189 42.40
10"	13.74"	23.74"	90	1/8	NPT	Female	6498K191 44.44
1 1/4" Bore Size (1.34" OD)							
1/2"	5.25"	5.75"	120	1/8	NPT	Female	6498K487 37.58
1"	5.75"	6.75"	120	1/8	NPT	Female	6498K955 38.94
1 1/2"	6.25"	7.75"	120	1/8	NPT	Female	6498K494 40.28
2"	6.75"	8.75"	120	1/8	NPT	Female	6498K956 41.58
2 1/2"	7.25"	9.75"	120	1/8	NPT	Female	6498K495 42.94
3"	7.75"	10.75"	120	1/8	NPT	Female	6498K957 44.24
4"	8.75"	12.75"	120	1/8	NPT	Female	6498K958 46.88
5"	9.75"	14.75"	120	1/8	NPT	Female	6498K959 49.54
6"	10.75"	16.75"	120	1/8	NPT	Female	6498K961 52.18
7"	11.75"	18.75"	120	1/8	NPT	Female	6498K496 54.84
8"	12.75"	20.75"	120	1/8	NPT	Female	6498K962 57.42
9"	13.75"	22.75"	120	1/8	NPT	Female	6498K497 60.14
10"	14.75"	24.75"	120	1/8	NPT	Female	6498K963 62.74

From <https://www.mcmaster.com/#pneumatic-cylinders/=1axvchd>

Cylinder Mounts

Monday, January 1, 2018 11:45 AM

**TITAN ROBOTICS CLUB
TEAM 492**



CYLINDER MOUNTS

- A. CYLINDER FOOT / BRACKET**
- B. T-SLOTTED FRAMING BRACKET**
- C. CYLINDER ROD ENDS**

Cylinder Foot / Brackets

Monday, January 1, 2018 10:04 AM

TITAN ROBOTICS CLUB
TEAM 492



Foot Brackets



For Bore Size	Material		Each
7/16"	Zinc-Plated Steel	4952K126	\$3.78
5/8"	Zinc-Plated Steel	4952K126	3.78
3/4"	Zinc-Plated Steel	6498K33	4.16
1 1/16"	Zinc-Plated Steel	6498K33	4.16
1 1/4"	Zinc-Plated Steel	6498K34	6.42
1 1/2"	Zinc-Plated Steel	6498K34	6.42
2"	Zinc-Plated Steel	6498K575	14.06

Pivot Brackets with Pin



For Bore Size	Material	Includes	Each
7/16"	Zinc-Plated Steel	___	6498K71 \$3.88
5/8"	Zinc-Plated Steel	Pin, Retaining Rings	4952K114 4.66
3/4"	Zinc-Plated Steel	Pin, Retaining Rings	6498K72 4.60
1 1/16"	Zinc-Plated Steel	Pin, Retaining Rings	6498K72 4.60
1 1/4"	Zinc-Plated Steel	Pin, Retaining Rings	6498K563 8.32
1 1/2"	Zinc-Plated Steel	___	6498K73 8.22
2"	Zinc-Plated Steel	Pin, Retaining Rings	6498K564 15.96

From <<https://www.mcmaster.com/#pneumatic-cylinders/=1axvfbu>>

T-Slotted Framing Bracket

Monday, January 1, 2018 11:13 AM



T-Slotted Framing Bracket



For Bore Size	For Extrusion Size	Material	Includes	Each
7/16"	1"	Aluminum	Screws 6498K991	\$39.22
5/8"	1"	Aluminum	Screws 6498K991	39.22
3/4"	1"	Aluminum	Screws 6498K992	39.22
1 1/16"	1"	Aluminum	Screws 6498K992	39.22
1 1/4"	1"	Aluminum	Screws 6498K991	39.22
1 1/2"	1"	Aluminum	Screws 6498K991	39.22
2"	1"	Aluminum	Screws 6498K992	39.22

Cylinder Rod Ends

Monday, January 1, 2018 11:13 AM



Rod Clevis with Pin



For Bore Size	Material	Includes	Each
7/16"	Zinc-Plated Steel	Nut, Pin, Retaining Rings 4952K101	\$4.22
5/8"	Zinc-Plated Steel	Nut, Pin, Retaining Rings 4952K101	4.22
3/4"	Zinc-Plated Steel	Nut, Pin, Retaining Rings 6498K42	4.60
1 1/16"	Zinc-Plated Steel	Nut, Pin, Retaining Rings 6498K43	4.60
1 1/4"	Zinc-Plated Steel	Nut, Pin, Retaining Rings 6498K44	7.30
1 1/2"	Zinc-Plated Steel	Nut, Pin, Retaining Rings 6498K44	7.30
2"	Zinc-Plated Steel	Nut, Pin, Retaining Rings 6498K554	7.30

Rod Ends



For Bore Size	OD	ID	Shank Thread Size	Thread Length	Thread Direction	Each
7/16"	5/8"	3/16"	10-32	1/2"	Right Hand 60645K311	\$3.32
5/8"	5/8"	3/16"	10-32	1/2"	Right Hand 60645K311	3.32
3/4"	3/4"	1/4"	1/4"-28	11/16"	Right Hand 60645K321	3.11
1 1/16"	7/8"	5/16"	5/16"-24	11/16"	Right Hand 60645K331	3.67
1 1/4"	1 1/8"	7/16"	7/16"-20	15/16"	Right Hand 60645K351	5.80
1 1/2"	1 1/8"	7/16"	7/16"-20	15/16"	Right Hand 60645K351	5.80
2"	1 5/16"	1/2"	1/2"-20	1 1/16"	Right Hand 60645K361	6.58

Solenoid Control Valves

Sunday, April 29, 2018 4:59 PM

TITAN ROBOTICS CLUB
TEAM 492



Solenoids





Sunday, April 29, 2018 4:55 PM



- 12V solenoid valve includes connectors and wires
- 4 different manifold sizes available
- Base mounts include input fittings

In stock

Product Name	Availability	Price
SMC SY3140-6LZ Single Solenoid Valve (use with Base Mount) 217-3233	Out of Stock	\$49.99
SMC SY3240-6LZ Double Solenoid Valve (use with Base Mount) 217-2948	Out of Stock	\$69.99

Part#	Valve Function	Fitting Size	Voltage	CFM	Price
 am-2343	Double	M5	12VDC	0.3	\$89.00
 am-2344	Single	M5	12VCD	0.3	\$72.00
 am-3323	Single	1/8" NPT	12VDC	0.78	\$39.00
 am-3324	Double	1/8" NPT Female	12VDC	0.78	\$52.00

Solenoid Mounting

Sunday, April 29, 2018 4:49 PM

TITAN ROBOTICS CLUB
TEAM 492



Solenoid Mounting

SINGLE ACTING SOLENOID
(217-3233)

[57.50]
2.264
OVERALL HEIGHT

DOUBLE ACTING SOLENOID
(217-2948)

[26.50]
1.043

([108.60])
4.276

[28.40]
1.118

	Description SS5Y3-41-03-N7	
	Dwg No 217 Pneumatic Base Mounts	
	Project VEXpro	Sheet 1 of 1
	Release 1/4/2016	ALL DIMENSIONS ARE IN INCHES (MM).

WWW.VEXPRO.COM

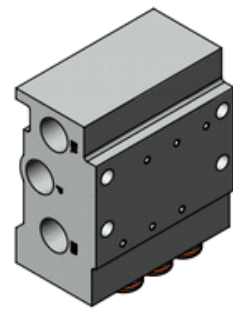
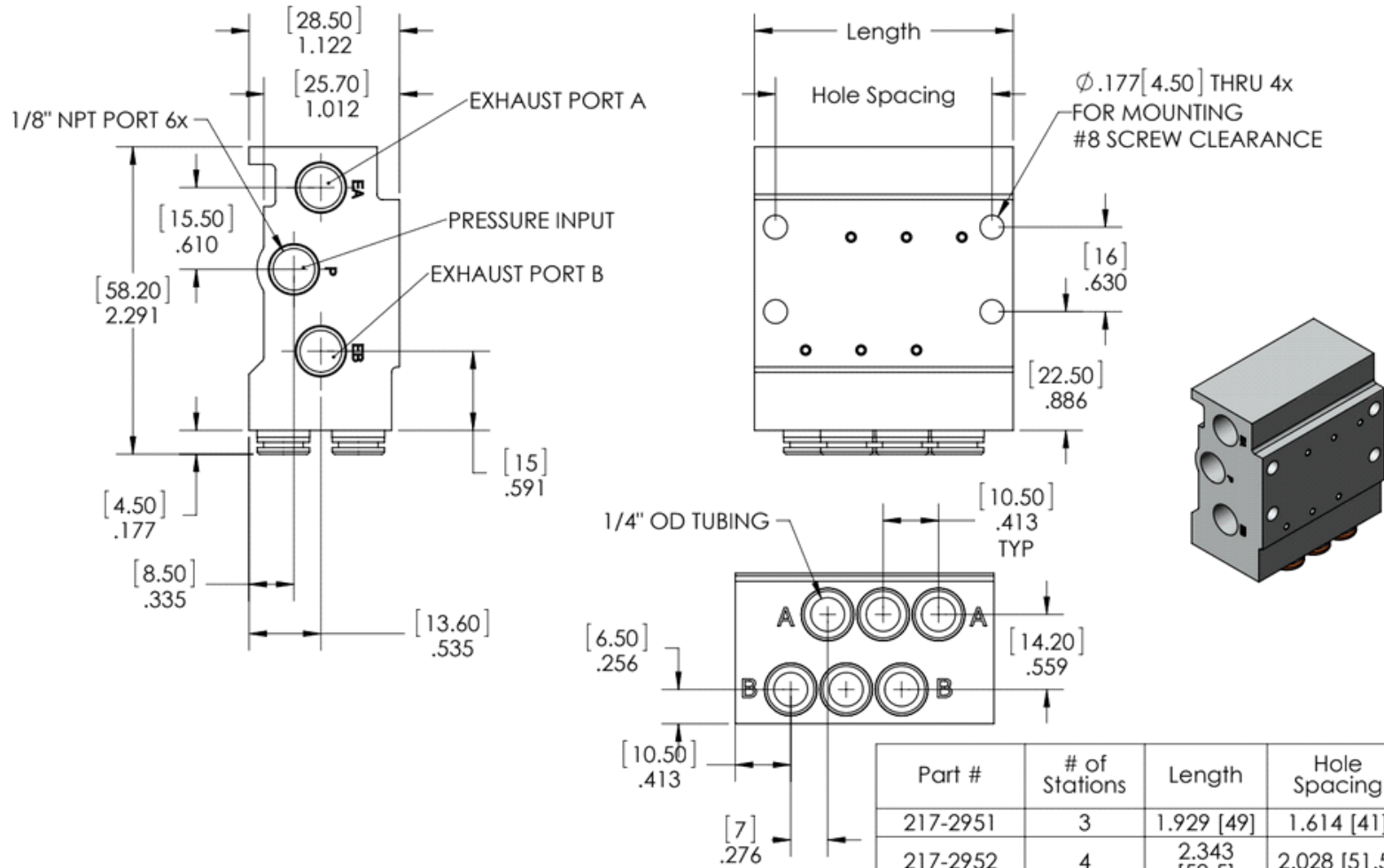
Solenoid Base Mount

Sunday, April 29, 2018 4:46 PM

TITAN ROBOTICS CLUB
TEAM 492



SMC Solenoid Base Mounts



Part #	# of Stations	Length	Hole Spacing
217-2951	3	1.929 [49]	1.614 [41]
217-2952	4	2.343 [59.5]	2.028 [51.5]
217-2953	5	2.756 [70]	2.441 [62]
217-2954	6	3.169 [80.5]	2.854 [72.5]



Description		SMC Base Mount	
Dwg No		217 Pneumatic Base Mounts	
Project	VEXpro	Sheet 1 of 2	
Release	1/4/2016	ALL DIMENSIONS ARE IN INCHES (MM).	

WWW.VEXPRO.COM

Reference Information

Saturday, December 9, 2017 9:37 AM

**TITAN ROBOTICS CLUB
TEAM 492**



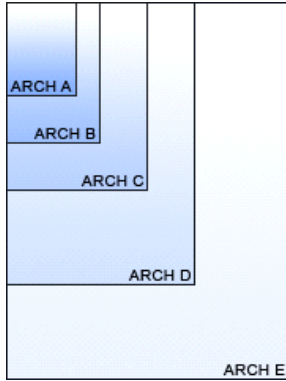
REFERENCE INFORMATION

A. STANDARD DRAWING SHEET SIZES

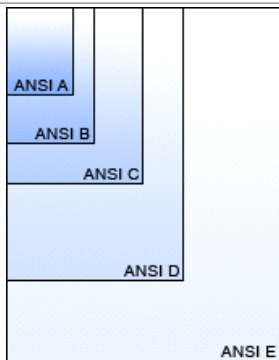


Architectural and Engineering Drawing Sizes

These architectural and engineering drawing size reference charts are provided for your convenience and reference.



Standard US Architectural Drawing Sizes		
Drawing Size	Dimensions (millimeters)	Dimensions (inches)
ARCH A	228.6 x 304.8	9 x 12
ARCH B	304.8 x 457.2	12 x 18
ARCH C	457.2 x 609.6	18 x 24
ARCH D	609.6 x 914.4	24 x 36
ARCH E	914.4 x 1219.2	36 x 48



Standard US Engineering Drawing Sizes		
Drawing Size	Dimensions (millimeters)	Dimensions (inches)
ANSI A	215.9 x 279.4	8.5 x 11
ANSI B	279.4 x 431.8	11 x 17
ANSI C	431.8 x 558.8	17 x 22
ANSI D	558.8 x 863.6	22 x 34
ANSI E	863.6 x 1117.6	34 x 44

Pasted from <<http://www.engineersupply.com/Drawing-Size-Reference-Table.aspx>>



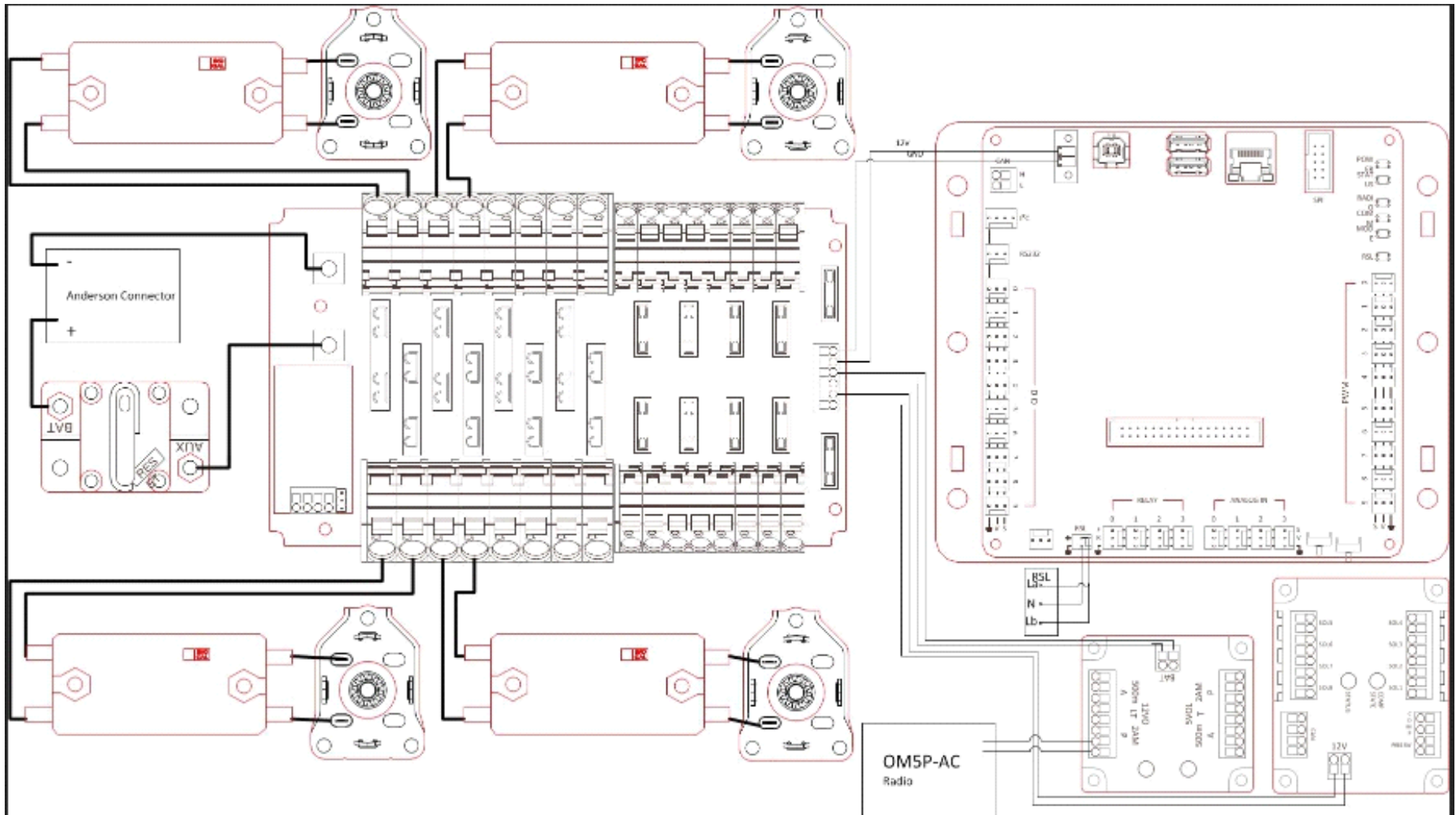
ELECTRICAL

- A. FRC CONTROL SYSTEM**
- B. MOTOR COLOR CODING STANDARD**
- C. LEGAL WIRE SIZE**
- D. BRANCH CIRCUIT PROTECTION REQUIREMENTS**
- E. PNEUMATIC PINOUT STANDARD**
- F. CAN BUS PINOUT (DRIVE MOTORS)**
- G. CAN BUS PINOUT (AUX MOTORS)**
- H. ROBORIO LAYOUT**

FRC Control System

Thursday, December 21, 2017 9:43 PM

TITAN ROBOTICS CLUB
TEAM 492



Motor Color Coding Standard

Saturday, December 9, 2017 9:37 AM

TITAN ROBOTICS CLUB
TEAM 492



All power connections are through Anderson Connectors. We keep an inventory of many colors of connectors, as well as matching electrical tape. To keep things organized and easier to manage, we color-coded all our wires and ports using electrical tape to match the color coding on all of the connectors; it's a form of "Visual Cues". We don't want to accidentally plug something into the wrong port and make our robot go haywire (pun intended).

Motor	Color	Channel
Left Front Drive Wheel	Orange	CANTalon3
Right Front Drive Wheel	Yellow	CANTalon4
Left Rear Drive Wheel	Green	CANTalon5
Right Rear Drive Wheel	Blue	CANTalon6
TBD1	Purple	CANTalon7
TBD2	Gray	CANTalon8
TBD3	White	CANTalon??
TBD4	Red	CANTalon??

Servo	Color	Channel
Servo1	Orange	??
Servo2	Yellow	??
Servo3	Green	??
Servo4	Blue	??
Servo5	Purple	??
Servo6	Gray	??
Servo7	White	??
Servo8	Red	??

Legal Wire Size

Thursday, December 21, 2017 9:14 PM



Application	Minimum Wire Size
40A protected Circuit	12 AWG
30A protected Circuit	14 AWG
20A protected Circuit	18 AWG
Between the PDP dedicated terminals and the VRM or PCM	18 AWG
Compressor outputs from the PCM	18 AWG
<= 5A protected Circuit	22 AWG
VRM 2 A Circuits	24 AWG
RoboRIO PWM port outputs	26 AWG
SIGNAL LEVEL circuits (i.e. circuits which draw $\leq 1A$ continuous and have a source incapable of delivering $>1A$, including but not limited to roboRIO non-PWM outputs, CAN signals, PCMSolenoid outputs, VRM500mA outputs and Arduino outputs)	28 AWG
From < https://firstfrc.blob.core.windows.net/frc2017/Manual/2017FRCGameSeasonManual.pdf >	

All non-SIGNAL LEVEL wiring with a constant polarity (i.e., except for outputs of relay modules, motor controllers, or sensors) shall be color-coded along their entire length from the manufacturer as follows:

- A. Red, yellow, white, brown, or black-with-stripe on the positive (e.g. +24VDC, +12VDC, +5VDC, etc.) connections
- B. Black or blue for the common or negative side (-) of the connections.

Wires that are originally attached to legal devices are considered part of the device and by default legal. Such wires are exempt from R59.

From <<https://firstfrc.blob.core.windows.net/frc2017/Manual/2017FRCGameSeasonManual.pdf>>

- What fuse/breaker size should I use for each type of motors: CIM, mini CIM, micro CIM, Window motors, 775 Pro ... etc?

Branch circuit protection reqts

Thursday, December 21, 2017 9:32 PM

**TITAN ROBOTICS CLUB
TEAM 492**



Branch Circuit	Circuit Breaker Value	Quantity Allowed Per Breaker
From < https://firstfrc.blob.core.windows.net/frc2017/Manual/2017FRCGameSeasonManual.pdf >		
Motor Controller	Up to 40A	1
Custom Circuit	Up to 40A	1
Fans permitted per rules, and not already part of COTS computing devices	Up to 20A	No Limit
Relay Module	Up to 20A	1
PCM - Compressor	20A	1
Additional VRM (non-radio)/Additional PCM (non-Compressor)	20A	3 total

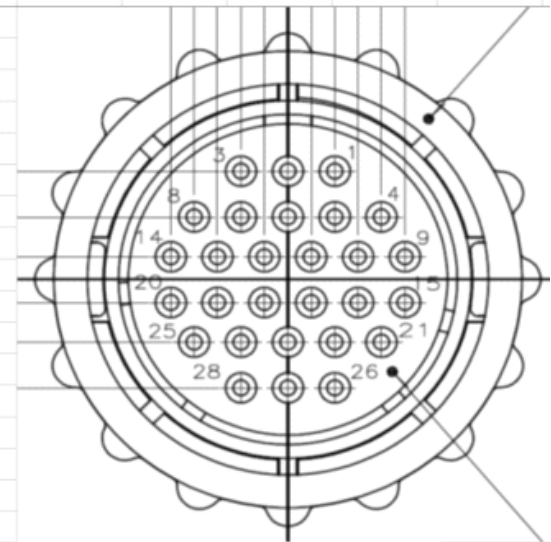
Pneumatic Pinout Standard

Saturday, December 23, 2017 9:40 AM

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TEAM 492



Pneumatic Control (Round 28-pin connector)	Color	Controller	Channel	Round 28-p	Wire Color	test box color
Reserved 1 +	Red	PCM1	0	1	Orange/White	Brown/yellow
Reserved 1 -	Red	PCM1	0	5	Orange	
Reserved 2 +	Orange	PCM1	1	2	Green/White	White/green/orange
Reserved 2 -	Orange	PCM1	1	6	Green	
Reserved 3 +	Yellow	PCM1	2	3	Blue/White	white/black
Reserved 3 -	Yellow	PCM1	2	7	Blue	
Reserved 4 +	Green	PCM1	3	9	Brown/White	white/blue/violet
Reserved 4 -	Green	PCM1	3	15	Brown	
Reserved 5 +	Blue	PCM1	4	10	Orange/White	white/green/violet
Reserved 5 -	Blue	PCM1	4	16	Orange	
Reserved 6 +	Purple	PCM1	5	11	Green/White	white/blue
Reserved 6 -	Purple	PCM1	5	17	Green	
Reserved 6 +	Gray	PCM1	6	12	Blue/White	
Reserved 6 -	Gray	PCM1	6	18	Blue	
Reserved 7 +	White	PCM1	7	13	Brown/White	
Reserved 7 -	White	PCM1	7	19	Brown	
Reserved 8 +	Red	PCM2	0	14	Orange/White	
Reserved 8 -	Red	PCM2	0	20	Orange	
Reserved 9 +	Orange	PCM2	1	22	Green/White	
Reserved 9 -	Orange	PCM2	1	26	Green	
Reserved 10 +	Yellow	PCM2	2	23	Blue/White	
Reserved 10 -	Yellow	PCM2	2	27	Blue	
Reserved 11 +	Green	PCM2	3	24	Brown/White	
Reserved 11 -	Green	PCM2	3	28	Brown	
PCM1 pressure SW +	Orange	PCM1	n/a	4	Orange/White	
PCM1 pressure SW -	Orange	PCM1	n/a	21	Orange	
PCM2 pressure SW +	Green	PCM2	n/a	8	Green/White	
PCM2 pressure SW -	Green	PCM2	n/a	25	Green	



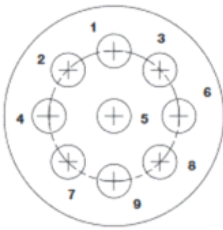
TE TE Connectivity

PLUG ASSEMBLY, STD SEX,
SERIES 2, 17-28, CPC

CODE DRAWING NO
79 C-205839

CAN Bus Pinout (Drive Motors)

Saturday, December 23, 2017 4:17 PM

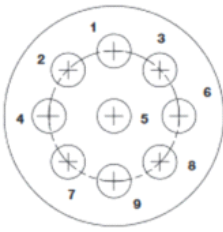


Arrangement 11-9
Max. Wire Ins. Dia. = .068 (1.73)

Motor Controller (SPC2 11-9 female)	Color	Channel	Connector Pin	Wire Color	Header Pin
LeftFrontMotor Encoder A	Orange	CANTalon 3	1	Orange/White	3
LeftFrontMotor 5V	Orange	CANTalon 3	6	Orange	1
LeftFrontMotor Encoder B	Orange	CANTalon 3	2	Green/White	7
LeftFrontMotor GND	Orange	CANTalon 3	7	Green	5
LeftFrontMotor FWD	Orange	CANTalon 3	3	Blue/White	4
LeftFrontMotor REV	Orange	CANTalon 3	8	Blue	6
LeftFrontMotor Analog	Orange	CANTalon 3	4	Brown/White	8
LeftFrontMotor 3V	Orange	CANTalon 3	9	Brown	2
RightFrontMotor Encoder A	Yellow	CANTalon 4	1	Orange/White	3
RightFrontMotor 5V	Yellow	CANTalon 4	6	Orange	1
RightFrontMotor Encoder B	Yellow	CANTalon 4	2	Green/White	7
RightFrontMotor GND	Yellow	CANTalon 4	7	Green	5
RightFrontMotor FWD	Yellow	CANTalon 4	3	Blue/White	4
RightFrontMotor REV	Yellow	CANTalon 4	8	Blue	6
RightFrontMotor Analog	Yellow	CANTalon 4	4	Brown/White	8
RightFrontMotor 3V	Yellow	CANTalon 4	9	Brown	2
LeftRearMotor Encoder A	Green	CANTalon 5	1	Orange/White	3
LeftRearMotor 5V	Green	CANTalon 5	6	Orange	1
LeftRearMotor Encoder B	Green	CANTalon 5	2	Green/White	7
LeftRearMotor GND	Green	CANTalon 5	7	Green	5
LeftRearMotor FWD	Green	CANTalon 5	3	Blue/White	4
LeftRearMotor REV	Green	CANTalon 5	8	Blue	6
LeftRearMotor Analog	Green	CANTalon 5	4	Brown/White	8
LeftRearMotor 3V	Green	CANTalon 5	9	Brown	2
RightRearMotor Encoder A	Blue	CANTalon 6	1	Orange/White	3
RightRearMotor 5V	Blue	CANTalon 6	6	Orange	1
RightRearMotor Encoder B	Blue	CANTalon 6	2	Green/White	7
RightRearMotor GND	Blue	CANTalon 6	7	Green	5
RightRearMotor FWD	Blue	CANTalon 6	3	Blue/White	4
RightRearMotor REV	Blue	CANTalon 6	8	Blue	6
RightRearMotor Analog	Blue	CANTalon 6	4	Brown/White	8
RightRearMotor 3V	Blue	CANTalon 6	9	Brown	2

CAN Bus Pinout (Aux Motors)

Saturday, December 23, 2017 4:17 PM



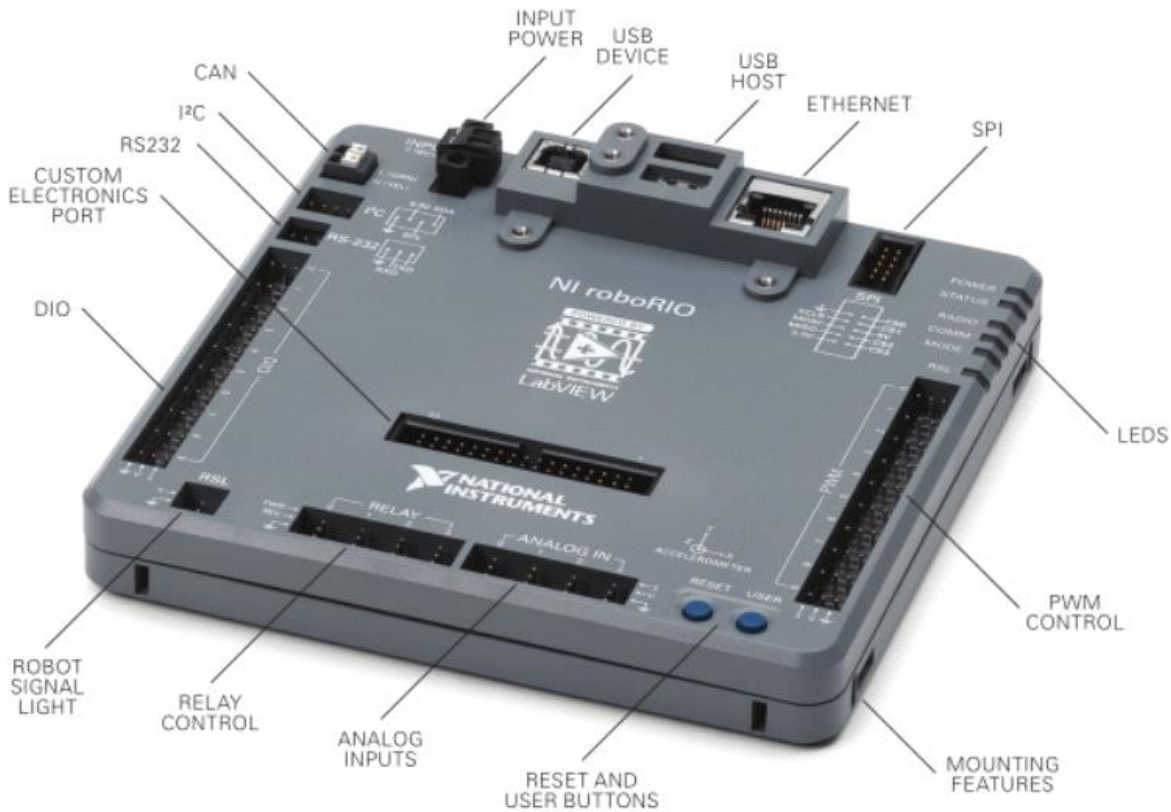
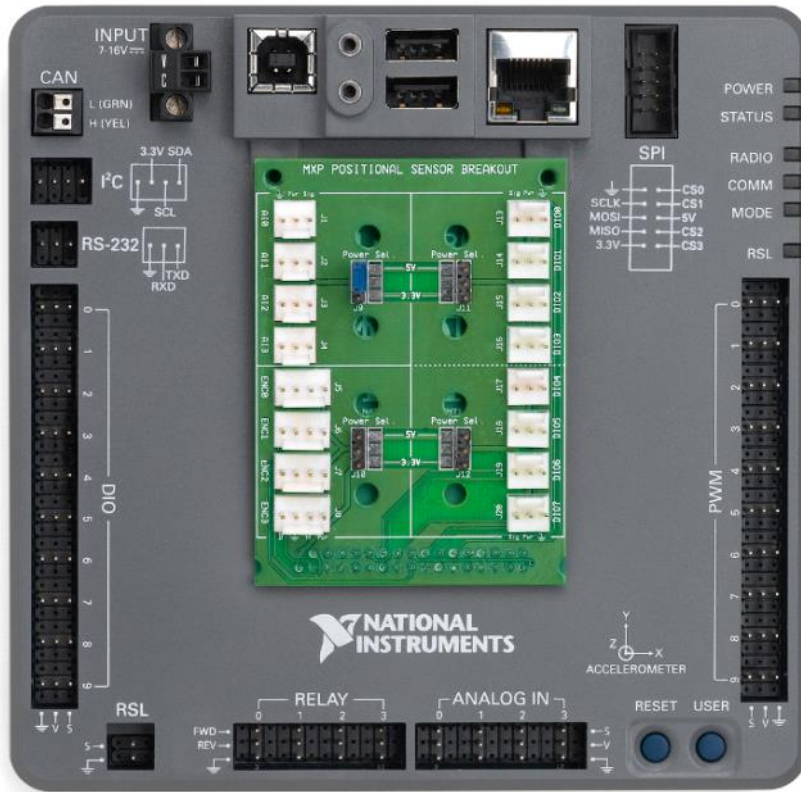
Arrangement 11-9
Max. Wire Ins. Dia. = .068 (1.73)

Motor Controller (SPC2 11-9 female)	Color	Channel	Connector Pin	Wire Color	Header Pin
Aux1Motor Encoder A	Purple	CANTalon 7	1	Orange/White	3
Aux1Motor 5V	Purple	CANTalon 7	6	Orange	1
Aux1Motor Encoder B	Purple	CANTalon 7	2	Green/White	7
Aux1Motor GND	Purple	CANTalon 7	7	Green	5
Aux1Motor FWD	Purple	CANTalon 7	3	Blue/White	4
Aux1Motor REV	Purple	CANTalon 7	8	Blue	6
Aux1Motor Analog	Purple	CANTalon 7	4	Brown/White	8
Aux1Motor 3V	Purple	CANTalon 7	9	Brown	2
Aux2Motor Encoder A	Gray	CANTalon 8	1	Orange/White	3
Aux2Motor 5V	Gray	CANTalon 8	6	Orange	1
Aux2Motor Encoder B	Gray	CANTalon 8	2	Green/White	7
Aux2Motor GND	Gray	CANTalon 8	7	Green	5
Aux2Motor FWD	Gray	CANTalon 8	3	Blue/White	4
Aux2Motor REV	Gray	CANTalon 8	8	Blue	6
Aux2Motor Analog	Gray	CANTalon 8	4	Brown/White	8
Aux2Motor 3V	Gray	CANTalon 8	9	Brown	2
Aux3Motor Encoder A	White	CANTalon ??	1	Orange/White	3
Aux3Motor 5V	White	CANTalon ??	6	Orange	1
Aux3Motor Encoder B	White	CANTalon ??	2	Green/White	7
Aux3Motor GND	White	CANTalon ??	7	Green	5
Aux3Motor FWD	White	CANTalon ??	3	Blue/White	4
Aux3Motor REV	White	CANTalon ??	8	Blue	6
Aux3Motor Analog	White	CANTalon ??	4	Brown/White	8
Aux3Motor 3V	White	CANTalon ??	9	Brown	2
Aux4Motor Encoder A	Red	CANTalon ??	1	Orange/White	3
Aux4Motor 5V	Red	CANTalon ??	6	Orange	1
Aux4Motor Encoder B	Red	CANTalon ??	2	Green/White	7
Aux4Motor GND	Red	CANTalon ??	7	Green	5
Aux4Motor FWD	Red	CANTalon ??	3	Blue/White	4
Aux4Motor REV	Red	CANTalon ??	8	Blue	6
Aux4Motor Analog	Red	CANTalon ??	4	Brown/White	8
Aux4Motor 3V	Red	CANTalon ??	9	Brown	2

RoboRIO Layout

Saturday, December 23, 2017 4:34 PM

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TEAM 492



Monday, January 1, 2018 10:04 AM

**TITAN ROBOTICS CLUB
TEAM 492**



Connectors

Saturday, December 23, 2017 12:47 AM

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CONNECTORS

- A. ANDERSON POWERPOLE CONNECTORS**
- B. MOLEX CONNECTORS**
- C. CPC CIRCULAR CONNECTORS**
- D. SUBMINIATURE D CONNECTORS**
- E. FERRULES AND CRIMPERS**
- F. INSULATED RING CONNECTORS**
- G. FULLY INSULATED QUICK DISCONNECT TERMINALS**

Anderson Powerpole Connectors

Saturday, December 9, 2017 9:46 AM

TITAN ROBOTICS CLUB
TEAM 492



Home > DC Power Products > Anderson Powerpole Connectors



PP15/30/45 Loose Piece Powerpole Colored Housing


These housings are used with the 15, 30 and 45 amp Powerpole contacts. Available in colors Red, Black, Blue, Green, White, Orange, Yellow, Gray, Brown, Violet and Pink. [Read Full Description](#)

Select Options



[Read All Reviews \(5\)](#) | [Add your review](#)

	Red	1327	In Stock	\$0.37	Volume Pricing Available ?	<input type="checkbox"/>	0	▼
	Black	1327G6	In Stock	\$0.37	Volume Pricing Available ?	<input type="checkbox"/>	0	▼
	Blue	1327G8	In Stock	\$0.39	Volume Pricing Available ?	<input type="checkbox"/>	0	▼
	Green	1327G5	In Stock	\$0.39	Volume Pricing Available ?	<input type="checkbox"/>	0	▼
	Orange	1327G17	In Stock	\$0.39	Volume Pricing Available ?	<input type="checkbox"/>	0	▼
	Violet	1327G23	In Stock	\$0.39	Volume Pricing Available ?	<input type="checkbox"/>	0	▼
	Yellow	1327G16	In Stock	\$0.39	Volume Pricing Available ?	<input type="checkbox"/>	0	▼
	White	1327G7	In Stock	\$0.39	Volume Pricing Available ?	<input type="checkbox"/>	0	▼
	Gray	1327G18	In Stock	\$0.39	Volume Pricing Available ?	<input type="checkbox"/>	0	▼
	Brown	1327G21	In Stock	\$0.39	Volume Pricing Available ?	<input type="checkbox"/>	0	▼
	Pink	1327G22	In Stock	\$0.39	Volume Pricing Available ?	<input type="checkbox"/>	0	▼



PP15 Loose Piece 15 Amp Powerpole Contact 1332

★★★★★ 3

As Low As \$0.15 each

SKU: 1332




PP30 Loose Piece 30 Amp Powerpole Contact 1331

★★★★★

As Low As \$0.15 each

SKU: 1331



PP45 Loose Piece 45 Amp Powerpole Contact 261G2

★★★★★

As Low As \$0.36 each

SKU: 261G2-LPBK

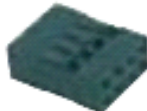


.100" (2.54mm) Non-Polarized Connector Housings & Crimp Pins

JAMECO ValuePro



103191



103254



100766



145358

- Mates with 0.025" square post on pattern of 0.100" centers (male headers, pg 54)
- Housing material: plastic
- Pin material: brass/tin plated
- Temp. rating: -55°C to +105°C
- Use crimper P/N 159266, pg 120
- Current rating: 1A
- 26-22 AWG

*** Web Code: YAL**

Single Row

* Order in multiples of 10

Part No.	Cross Ref. No.	Contacts	1	10	100
<u>100812</u>	SCH2	2	* \$0.22	\$0.19	
<u>157383</u>	SCH3	3	.39	.35	.29
<u>100803</u>	SCH4	4	.39	.35	.29
<u>163686</u>	SCH5	5	.35	.29	.25
<u>103212</u>	SCH6	6	.49	.45	.39
<u>2259753</u>	CH328-07-R	7	.45	.39	.35
<u>103203</u>	SCH8	8	.45	.39	.35
<u>2259761</u>	CH328-09-R	9	.49	.45	.39
<u>103191</u>	SCH10	10	.59	.55	.49
<u>103182</u>	SCH20	20	.65	.59	.55
<u>103158</u>	SCH36	36	.69	.59	.55

Double Row

*** Web Code: ZBQ**

<u>103254</u>	DCH8	8	\$0.39	\$0.35	\$0.29
<u>157421</u>	DCH10	10	.45	.39	.35

Crimp Pins for Single/Double Row Housings

* Order in multiples of 10

*** Web Code: XAL**

Part No.	Cross Ref. No.	Description	10	100	500
<u>100766</u>	FCH1	Female pin	\$0.19	\$0.15	\$0.12
<u>145358</u>	MCH1	Male pin	.19	.15	.12

<https://www.jameco.com/Jameco/catalogs/c171/P57.pdf>



Circular Plastic Connectors (CPC)

CPC comes in six different series to allow you to choose the product best suited to your design requirements

- **Series 1** – Standard Density:
Signals up to 13 A
(also available in Sealed)
- **Series 2** – High Density:
Signals up to 7.5 A
- **Series 3** – Power Density:
Power up to 25 A
- **Series 4** – Power and Signal Combination:
Signals up to 13 A,
Power up to 25 A
- **Series 5** – Power (Sealable):
Power up to 45 A
- **Series 6** – Power and Signal Combination (Sealable):
Signals up to 13 A,
Power up to 45 A

Series 1 (Sealed), 5 and 6 now available in F1 rated material



Circular Plastic Connectors (CPC) enable engineers to design rugged products quickly and affordably by offering a versatile range of power and signal connectivity solutions

Meet rugged and space-saving requirements

- UL94V-0 stabilized heat resistant plastic housings and variants.
- Design for either IP65 or IP67 sealing when needed.
- Eliminate rectangular connector waste when space saving is critical.

Speed up go-to-market and reduce installation time

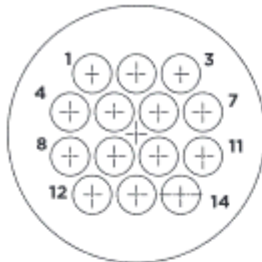
- Select from a broad portfolio to move from idea to design to production faster.
- Quickly pair power and signal for a variety of input and output requirements when a hybrid approach is needed.
- Select the best contact termination based on application – not the connector. (Hand, semi-automated or automatic termination tooling)

Design with cost-effective, high-performance materials and configuration

- Leverage the lightweight, all-plastic shell as a lower cost alternative to metal.
- Eliminate the cost of hand tools for mating with the connect-disconnect polarized housings.
- Make repair easy with less downtime with removable crimp contacts and replaceable coupling rings.



Connector Series and Types

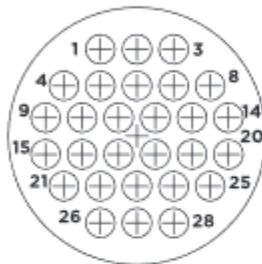


Series 1 – Size 16 Contacts

Series 1 connectors permit the use of multiple combinations of signal and coaxial circuits in the same housing by accepting durable Multimate contacts. These pin and socket contacts include Type III+ and

subminiature coaxial contacts, interchangeable in the same Multimate contact cavity. Type III+ contacts (.062 [1.57] pin diameter) are capable of carrying a maximum of 13 amperes when crimped in wire.

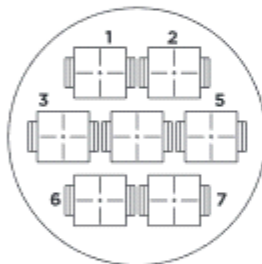
Type III solder contacts and posted contacts for pc board applications are also available. Many connector arrangements offer both standard and reverse sex contact loading – **from 4 thru 37 positions.**



Series 2 – Size 20 Contacts

Series 2 connectors accept Size 20 DF (precision formed) and Size 20 DM (screw-machined) pin and socket contacts with a .040 [1.02] pin diameter. Size 20 DF contacts are available in crimp and solder versions, as well as a posted version for wrap-type and

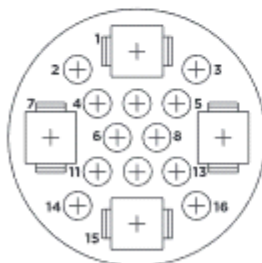
pc board applications. Maximum current carrying capability is 7.5 amperes. Many connector arrangements offer both standard and reverse sex contact loading – **from 8 thru 63 positions.**



Series 3 – Power Contacts

Series 3 connectors accept Type XII power contacts which can carry up to 25 amps per contact. These contacts will accommodate a wire size range of 16 to 10 AWG [1.4 to 5 mm²].

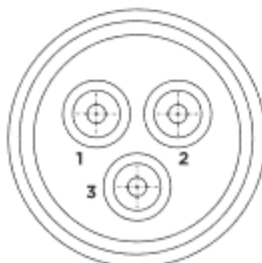
Two connector sizes are available in both standard and reverse sex connector arrangements **3 and 7 positions.**



Series 4 – Combination, Size 16 and Power Contacts

Series 4 connectors accept Size 16 Multimate and Type XII power contacts, combining the signal and coaxial circuit capabilities of Series 1 connectors with the power circuit capabilities of Series 3 connectors.

Available in three connector sizes offering power mixing combinations totaling **13, 16 and 22 positions.**



Series 5 – Power Contacts .125 POWERBAND

Series 5 connectors combine the revolutionary performance of the new AMP POWERBAND Contact, high current contact in configurations similar to the Series 3 connectors. AMP POWERBAND contacts offer the electrical performance of

the best Mil Spec Size 8 screw-machined contacts with the economy and productivity of strip-fed, precision formed contacts. Series 5 connectors are environmentally sealable to meet IEC IP 65 and IP 67 specifications.

Rated at 250 VAC or VDC, 50 amperes maximum in a single contact, the connectors are available in free-hanging and panelmount applications – **one connector configuration containing three .125 POWERBAND contacts.**

CPC Contact Arrangement

Thursday, December 14, 2017 5:35 PM

**TITAN ROBOTICS CLUB
TEAM 492**



CPC Plastic					
Shell Size	Series 1 7-17 A/600 V, Signal	Series 2 1.4-8.3 A/250 V, Signal	Series 3 33-47 A/600V, Power		
11	 11-4	 11-8	 11-19		
13	 13-8				
17	 17-14	 17-16	 17-28	 17-3	
23	 23-24	 23-37	 23-57	 23-63	 23-7

Metal CPC					
Shell Size	Series 1 7-17 A/600 V, Signal	Series 2 1.4-8.3 A/250 V, Signal	Series 3 33-47 A/600V, Power		
14	 14-5	 14-7			
22	 22-14	 22-16	 22-28	 22-3	
28	 28-24	 28-37	 28-57	 28-63	 28-7

CPC Series 2 Contact Arrangement

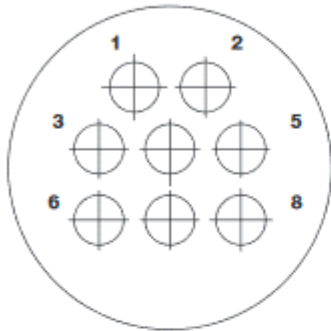
Thursday, December 14, 2017 5:42 PM

**TITAN ROBOTICS CLUB
TEAM 492**



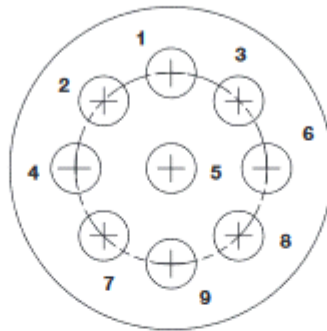
Note: Contact arrangements shown are of pin mating face (plug or receptacle). Socket mating face is mirror image.

Shell Size 11

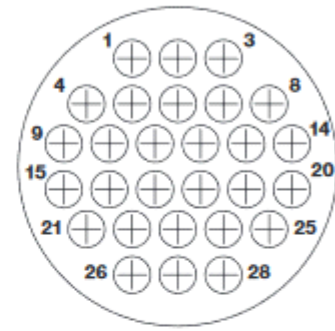


Arrangement 11-8
Max. Wire Ins. Dia. = .068 [1.73]

Shell Size 17

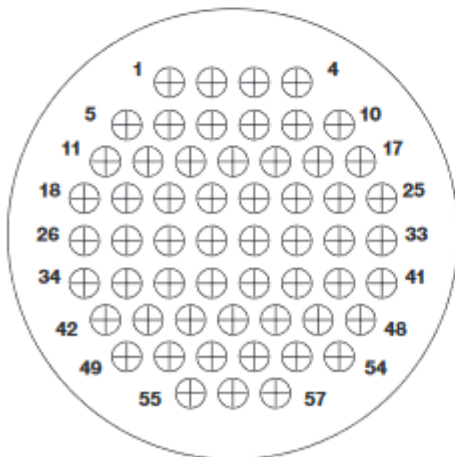


Arrangement 11-9
Max. Wire Ins. Dia. = .068 [1.73]

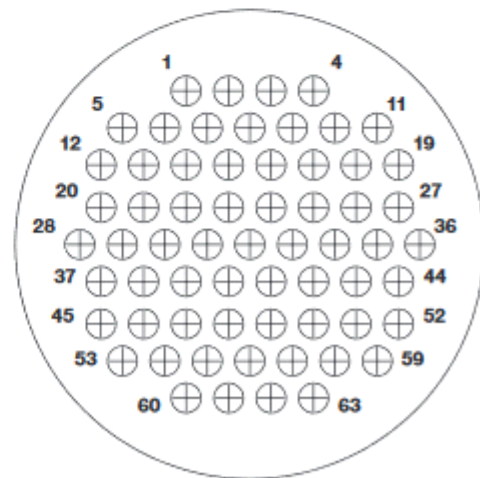


Arrangement 17-28
Max. Wire Ins. Dia. = .068 [1.73]

Shell Size 23



Arrangement 23-57
Max. Wire Ins. Dia. = .068 [1.73]



Arrangement 23-63
Max. Wire Ins. Dia. = .068 [1.73]



Cable or Panel Mount

(Accepts Size 20 DM or DF Crimp, Snap-In Contacts)



Square Flange Receptacle

Standard Sex Connectors

(Receptacles accept Size 20 DM or DF pin contacts, Plugs accept Size 20 DM or DF socket contacts)

Arrangement		Square Flange Receptacle		Free-Hanging Receptacle	Plug
Shell Size	No. of Positions	With Mounting Holes	With Threaded Inserts ¹		
11-8		—	205841-3	—	205838-1
11-9		206486-1	206852-8	206486-2	206485-1
17-28		205840-3	205840-4	206152-1	—
23-63		205843-1	—	205843-2	—

¹ Four 4-40 threaded inserts per receptacle.

Reverso Sex Connectors

(Receptacles accept Size 20 DM or DF socket contacts, Plugs accept Size 20 DM or DF pin contacts)

Arrangement		Square Flange Receptacle		Free-Hanging Receptacle	Plug
Shell Size	No. of Positions	With Mounting Holes	With Threaded Inserts ¹		
11-8		206433-1	206433-3	206433-2	206434-1
17-28		206038-1	206038-4	206038-2	206039-1
23-57		206438-1	—	206438-2	206437-1

¹ Four 4-40 threaded inserts per receptacle.

Note: For Standard and Reverse Sex Connectors the maximum wire insulation diameter is .068 [1.73].



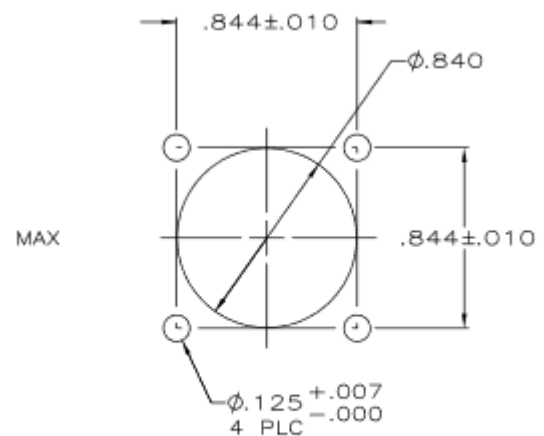
Free-Hanging Receptacle



Plug

Replacement Coupling Rings

Shell Size	Part No.
11	213811-1
17	213810-1
23	213812-1



RECOMMENDED PANEL CUTOUT
SCALE 2:1

CPC Cable Clamps

Thursday, December 14, 2017 5:44 PM

TITAN ROBOTICS CLUB TEAM 492



Cable clamps provide strain relief and can be used on all series receptacles and plugs.



Standard Size

Material

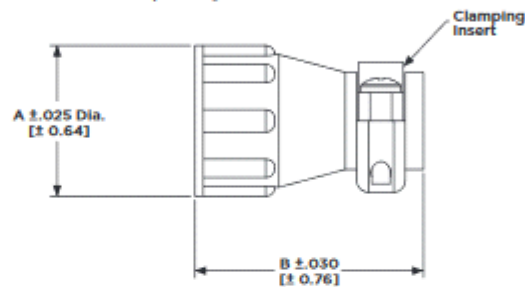
Black thermoplastic heat-stabilized, fire-resistant, self-extinguishing, UL 94V-0 rated

Shell Size	Dimensions		Cable O.D. (Max.)	Thread Size	Part No.	
	A	B			Individually Packaged	Bulk Packaged*
11	.825 [20.96]	1.250 [31.75]	.329 [8.36]	5/8-24 UNEF-2B	1-206062-4	1-206062-7** (400)
13	.950 [24.13]	1.400 [35.56]	.453 [11.51]	3/4-20 UNEF-2B	206966-7	206966-9** (200)
17	1.125 [28.58]	1.400 [35.56]	.453 [11.51]	15/16-20 UNEF-2B	206070-8	1-206070-0** (200)
23	1.600 [40.64]	1.555 [39.5]	.703 [17.86]	1-3/8-18 UNEF-2B	206138-8	1-206138-0** (100)

* Numbers in parentheses specify, in multiples, the minimum quantity of parts that can be ordered.
 ** Packaging includes two screws: shell sizes 11-17, screw length .500 [12.7]; shell size 23, screw length .625 [15.88].

Notes:

1. Clamping areas adjustable by inverting or changing clamping inserts. The quantity of inserts supplied with each assembly is as follows: for size 11 cable clamps, one insert; for all other cable clamps, two inserts.
2. Components for all cable clamps are packaged unassembled. This includes the cable clamp, two screws and the clamping inserts.
3. Cable clamps can be threaded directly onto plugs or receptacles, or onto back-shell extenders (page 40).
4. Replacement screws are available in the following sizes: 3/8 in. [9.52] - **5019024-1**, 1/2 in. [12.7] - **5019024-2**, 5/8 in. [15.88] - **5019024-3**, 1 in. [25.4] - **5019024-4**, 3/4 in. [19.05] - **5019024-5**.
5. Cable clamp inserts not sold separately.



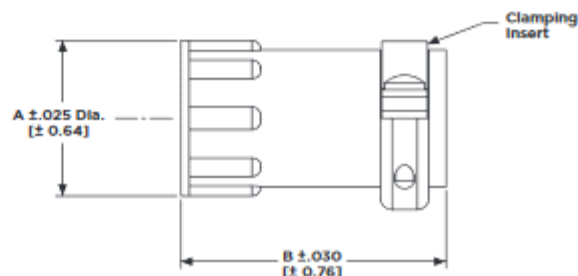
Large Size

Shell Size	Dimensions		Cable O.D. (Max.)	Thread Size	Part No.	
	A	B			Individually Packaged	Bulk Packaged*
11	.850 [21.59]	1.450 [36.83]	.453 [11.51]	5/8-24 UNEF-2B	206358-5	206358-6** (200)
13	1.131 [28.73]	1.655 [42.04]	.703 [17.86]	3/4-20 UNEF-2B	—	207008-6** (100)
17	1.131 [28.73]	1.655 [42.04]	.703 [17.86]	15/16-20 UNEF-2B	206322-9	1-206322-0** (100)
23	1.600 [40.64]	1.655 [42.04]	1.125 [28.58]	1-3/8-18 UNEF-2B	206512-5	206512-6** (75)

* Numbers in parentheses specify, in multiples, the minimum quantity of parts that can be ordered.
 ** Packaging includes two screws: shell size 11, screw length .500 [12.7]; shell sizes 13-23, screw length .625 [15.88].

Notes:

1. Clamping areas adjustable by inverting or changing clamping inserts. The quantity of inserts supplied with each assembly is as follows: for size 23 cable clamps, four inserts; for all other cable clamps, two inserts.
2. Components for all cable clamps are packaged unassembled. This includes the cable clamp, two screws and the clamping inserts.
3. Cable clamps can be threaded directly onto plugs or receptacles, or onto back-shell extenders (page 40).
4. Replacement screws are available in the following sizes: 3/8 in. [9.52] - **5019024-1**, 1/2 in. [12.7] - **5019024-2**, 5/8 in. [15.88] - **5019024-3**, 1 in. [25.4] - **5019024-4**, 3/4 in. [19.05] - **5019024-5**.
5. Cable clamp inserts not sold separately.



Sub-miniature D Connectors

Saturday, December 9, 2017 9:55 AM

TITAN ROBOTICS CLUB
TEAM 492



Connectors

JAMECO ValuePro

* Web Code: EAB

223010



Metal Solder-Cup

Part No.	Manufacturer	Product No.	Contacts	Gender	1	10	100
<u>15748</u>	ValuePro	1001-9P-R	9	M	\$.89	\$.79	\$.69
<u>15771</u>	Steren	500-109	9	F .....	.85	.69	.55
<u>223052</u>	AMP	747905-2	9	F	2.49	2.25	1.95
<u>15035</u>	ValuePro	1001-15P-R	15	M	1.05	.95	.85
<u>15078</u>	ValuePro	1002-15P-R*	15	M	1.16	.89	.85
<u>15052</u>	ValuePro	1001-15S-R	15	F	1.05	.95	.85
<u>164823</u>	ValuePro	1002-15S-R*	15	F	1.09	.89	.75
<u>15115</u>	ValuePro	1001-25P-R	25	M	1.35	1.09	.99
<u>223010</u>	AMP	747912-2	25	M	3.95	3.59	3.25
<u>15157</u>	Steren	500-125	25	F	1.35	1.09	.99
<u>15473</u>	ValuePro	1001-37P-R	37	M	1.45	1.19	1.09
<u>15500</u>	ValuePro	1001-37S	37	F	1.35	1.09	.99
<u>2185758</u>	Amphenol-RF	17-20370-11	37	M	1.75	1.49	1.25
<u>482732</u>	Amphenol	EDD50P	50	M	1.95	1.75	1.59
<u>482741</u>	Amphenol	EDD50S	50	F	2.95	2.59	2.25

Crimp-Type

* Web Code: UBR



73189



38771

Part No.	Manufacturer	Product No.	Contacts	Gender	1	10	100
<u>73189</u>	Steren	500-010	9	M	\$.69	\$.59	\$.49
<u>73197</u>	Steren	500-110	9	F .....	.69	.59	.49
<u>222842</u>	AMP	205203-3 (Tin)	9	F .....	.89	.79	.69
<u>222691</u>	AMP	205203-1 (Zinc)	9	F .....	.99	.89	.79
<u>38789</u>	ValuePro	500-027	25	M .....	.89	.75	.65
<u>38771</u>	Steren	500-1N27	25	F .....	.89	.75	.65

<https://www.jameco.com/Jameco/catalogs/c171/P50.pdf>

Ferrules & Crimpers

Monday, January 1, 2018 10:05 AM

TITAN ROBOTICS CLUB
TEAM 492



Info

Product Overview:

This crimp tool is used in non welding, standard electrical connections, for tubular bare terminals and tubular pre-insulated terminals. This tool can be used with ferrules like these: [20 AWG Ferrule](#), [18 AWG Ferrule](#), [16 AWG Ferrule](#) and [12 AWG Ferrule](#).

Specifications:

Application: Bushing Type Terminal
Crimping capability: 0.25 - 10 mm²
American Standard AWG: 23-7

From <<http://www.andymark.com/product-p/am-3739.htm>>



[12 AWG Grey Ferrule Crimps - Bulk Qty \(am-3738 12\)](#)
Price: \$0.05



[16 AWG Red Ferrule Crimps - Bulk Qty \(am-3738 16\)](#)
Price: \$0.05



[18 AWG Yellow Ferrule Crimps - Bulk Qty \(am-3738 18\)](#)
Price: \$0.05



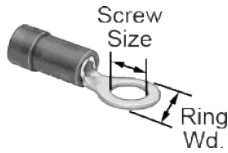
[20 AWG White Ferrule Crimps - Bulk Qty \(am-3738 20\)](#)
Price: \$0.05

From <<http://www.andymark.com/Electrical-s/41.htm>>

Insulated Ring Connectors

Monday, January 1, 2018 10:15 AM

TITAN ROBOTICS CLUB
TEAM 492



A plastic cover on the barrel provides electrical insulation rated to 600 volts. Mount these terminals on a threaded screw or stud for a more secure connection than spade and hook terminals. Use a crimper (not included) to install wire.

Nylon-insulated terminals have an internal metal sleeve that provides an extra-tight crimp in high-vibration applications.

From <<https://www.mcmaster.com/#electrical-connectors/=1axur33>>

For Wire Gauge	For Screw Size	For Screw Size	Ring Wd.	Insulation Color	Pkg. Qty.		Pkg.	Pkg. Qty.	Pkg.	
26-22	No. 2	0.09"	0.19"	Yellow	—	—	—	25	7113K263	\$12.47
26-22	No. 4	0.11"	0.19"	Yellow	—	—	—	25	7113K264	10.36
26-22	No. 6	0.14"	0.24"	Yellow	—	—	—	25	7113K265	10.36
26-22	No. 8	0.16"	0.25"	Yellow	—	—	—	25	7113K266	10.36
26-22	No. 10	0.19"	0.31"	Yellow	—	—	—	25	7113K267	12.48
22-18	No. 6	0.14"	0.31"	Red	100	7113K35	\$15.44	50	7113K451	12.57
22-18	No. 8	0.16"	0.33"	Red	100	7113K611	15.42	50	7113K731	13.79
22-18	No. 10	0.19"	0.33"	Red	100	7113K98	15.44	50	7113K452	12.61
22-18	1/4"	0.25"	0.47"	Red	50	7113K612	9.84	50	7113K732	14.83
22-18	5/16"	0.31"	0.47"	Red	50	7113K613	10.46	25	7113K733	8.30
22-18	3/8"	0.38"	0.56"	Red	50	7113K614	12.69	25	7113K734	9.40
16-14	No. 6	0.14"	0.25"	Blue	50	7113K23	8.30	50	7113K453	13.36
16-14	No. 8	0.16"	0.33"	Blue	50	7113K49	7.90	50	7113K454	12.52
16-14	No. 10	0.19"	0.33"	Blue	50	7113K24	7.90	50	7113K455	12.53
16-14	1/4"	0.25"	0.47"	Blue	50	7113K25	9.25	50	7113K456	15.38
16-14	5/16"	0.31"	0.47"	Blue	50	7113K92	9.25	50	7113K457	15.55
16-14	3/8"	0.38"	0.56"	Blue	50	7113K95	12.46	25	7113K458	9.63
12-10	No. 8	0.16"	0.38"	Yellow	50	7113K48	11.27	25	7113K459	10.24
12-10	No. 10	0.19"	0.38"	Yellow	50	7113K29	11.28	25	7113K461	9.95
12-10	1/4"	0.25"	0.53"	Yellow	50	7113K31	13.29	25	7113K462	10.69
12-10	3/8"	0.38"	0.59"	Yellow	25	7113K32	7.62	25	7113K464	11.19

From <<https://www.mcmaster.com/#electrical-connectors/=1axur33>>

Fully Insulated Quick Disconnect

Monday, January 1, 2018 10:21 AM

TITAN ROBOTICS CLUB
TEAM 492



Single-Crimp Female



Single-Crimp Male



Double-Crimp Female



Double-Crimp Male

The connection tab on these terminals is completely covered with insulation, leaving no metal exposed when mated. They slide together and pull apart with ease, so they are convenient for applications that require frequent connections. Use a crimper (not included) to install wire.

Double-crimp terminals have a barrel that can be crimped twice for an extra-tight grip in high-vibration applications.

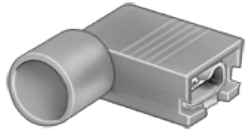
From <<https://www.mcmaster.com/#electrical-connectors/=1axusv>>

For Wire Gauge	Wd.	Thick.	Insulation Color	Insulation Material	Pkg. Qty.	Pkg.
Single Crimp Female						
26-24	0.187"	0.020"	Yellow	Nylon Plastic	25	7243K46 \$9.57
26-22	0.260"	0.150"	Blue	Nylon Plastic	10	4916K81 5.47
22-18	0.250"	0.032"	Red	Nylon Plastic	50	7243K11 13.73
16-14	0.250"	0.032"	Blue	Nylon Plastic	50	7243K21 13.71
12-10	0.250"	0.032"	Yellow	Nylon Plastic	25	7243K31 9.57
Male						
22-18	0.250"	0.032"	Red	Nylon Plastic	50	7243K12 13.55
16-14	0.250"	0.032"	Blue	Nylon Plastic	50	7243K22 14.37
12-10	0.250"	0.032"	Yellow	Nylon Plastic	25	7243K32 8.69
Double Crimp Female						
22-18	0.110"	0.020"	Red	Nylon Plastic	25	7243K111 14.50
22-18	0.187"	0.020"	Red	Nylon Plastic	25	7243K112 11.59
22-18	0.250"	0.032"	Red	Nylon Plastic	25	7243K114 11.55
16-14	0.110"	0.020"	Blue	Nylon Plastic	25	7243K115 14.50
16-14	0.187"	0.020"	Blue	Nylon Plastic	25	7243K116 11.67
16-14	0.250"	0.032"	Blue	Nylon Plastic	25	7243K117 11.56
12-10	0.250"	0.032"	Yellow	Nylon Plastic	25	7243K69 14.13
Male						
22-18	0.187"	0.020"	Red	Nylon Plastic	25	7243K118 12.46
22-18	0.250"	0.032"	Red	Nylon Plastic	25	7243K119 12.52
16-14	0.187"	0.020"	Blue	Nylon Plastic	25	7243K121 12.60
16-14	0.250"	0.032"	Blue	Nylon Plastic	25	7243K122 12.34
12-10	0.250"	0.032"	Yellow	Nylon Plastic	25	7243K33 12.33

Fully Insulated 90° Flag Quick-Disconnect Terminals



Monday, January 1, 2018 10:26 AM



The connection tab on these terminals is completely covered with insulation, leaving no metal exposed when mated. Connect wire to a screw or stud at a right angle to fit connections into tight spaces. These terminals slide together and pull apart with ease, so they are convenient for applications that require frequent connections. Use a crimper (not included) to install wire. Double-crimp terminals have a barrel that can be crimped twice for an extra-tight grip in high-vibration applications.



From <<https://www.mcmaster.com/#electrical-connectors/=1axuwgm>>

For Wire Gauge	Wd.	Thick.	Insulation Color	Insulation Material	Pkg. Qty.	Pkg.
Female						
Single Crimp						
22-18	0.187"	0.020"	Red	Nylon Plastic	25	7820K11 \$8.14
22-18	0.250"	0.032"	Red	Nylon Plastic	25	7820K12 8.14
16-14	0.187"	0.020"	Blue	Nylon Plastic	25	7820K13 7.70
16-14	0.250"	0.032"	Blue	Nylon Plastic	25	7820K14 7.76
12-10	0.250"	0.032"	Yellow	Nylon Plastic	10	7820K84 7.56
Double Crimp						
22-18	0.187"	0.020"	Red	Nylon Plastic	25	7820K41 12.14
22-18	0.250"	0.032"	Red	Nylon Plastic	25	7820K42 12.27
16-14	0.187"	0.020"	Blue	Nylon Plastic	25	7820K43 13.33
16-14	0.250"	0.032"	Blue	Nylon Plastic	25	7820K44 13.29
12-10	0.250"	0.032"	Yellow	Nylon Plastic	10	7820K94 8.23

From <<https://www.mcmaster.com/#electrical-connectors/=1axuwgm>>

Motors

Saturday, December 23, 2017 12:49 AM

TITAN ROBOTICS CLUB
TEAM 492



MOTORS

- A. MOTOR SPECIFICATIONS**
- B. THE FOUR KEY CHARACTERISTICS OF DC MOTORS**
- C. USING A MOTOR CURVE**
- D. MOTOR CURVES**
- E. OTHER CONSIDERATIONS**
- F. DENSO MOTOR SPECIFICATION**

Motor Specs (from VEX)

Sunday, December 10, 2017 10:41 AM



		Free Speed (RPM)	Free Current (A)	Maximum Power (W)	Stall Torque (N · m)	Stall Current (A)
CIM Motor		5330	2.7	337	2.41	131
Mini CIM Motor		5840	3	215	1.41	89
BAG Motor		13180	1.8	149	0.43	53
775pro		18730	0.7	347	0.71	134
AndyMark 9015		14270	3.7	134	0.36	71
AndyMark NeverRest		5480	0.4	25	0.17	10
AndyMark RS775-125		5800	1.6	43	0.28	18
BaneBots RS-775 18V		13050	2.7	246	0.72	97
BaneBots RS-550		19000	0.4	190	0.38	84



Motion is an integral part of mobile robotics. Whether robots are lifting an object, spinning a wheel, or performing some other action, they almost always include some form of actuator. The most common way to achieve such motion is through the use of a motor, and the most common type of motor used in hobbyist or competition robotics is the direct current (“DC”) motor.

DC motors, at their core, operate under a straightforward principle: the conversion of electrical energy (an input **voltage** and drawn **current**) into mechanical energy (an output shaft spinning at some **speed**, with some amount of **torque**).

The amount of mechanical output produced by a motor is dependent upon the amount of load placed upon it. This concept is key to understanding DC motor performance. As load (or mechanical resistance) increases, motors will draw more current and output more torque to overcome this load. However, as that torque increases, speed decreases proportionally. Additionally, as current draw increases, battery life decreases and wear on the motor increases.

To learn more about the relationships between speed, torque, and power, visit [Unit F.4 of the VEX IQ Curriculum](#) or [Unit 7.2 of the VEX EDR Curriculum](#).

For a more in-depth look at DC motors and their use in robotics, visit [Unit 7.3 of the VEX EDR Curriculum](#).

Jump To Topic

- [The 4 Key Characteristics of DC Motors](#)
- [The "Down-Up" Dyno Test](#)
- [Using a Motor Curve](#)
- [Other Considerations](#)



From <http://motors.vex.com/introduction>

The Four Key Characteristics of DC Motors



Thursday, December 21, 2017 8:12 PM

These tradeoffs must all be considered when designing a mechanism that uses a motor in a particular application. To help understand a specific motor's capabilities in such an application, four key characteristics are used to define a motor's performance:

- **Free Speed (RPM)** – The maximum speed at which a motor will rotate when under no load
- **Free Current (A)** – The minimum current a motor will draw when under no load
- **Stall Torque (N · m)** – The amount of load placed on a motor that will cause it to stall (stop moving)
- **Stall Current (A)** – The amount of current drawn by a motor when it is stalled

These characteristics represent the theoretical minimum and maximum conditions for a motor. Under no load, a motor spins at its Free Speed and draws a Free Current. Conversely, Stall Torque and Stall Current represent a motor being worked to its maximum, to the point at which it can no longer move. In good mechanism design, motors rarely operate at one of these four edge conditions. Holding something at stall torque (with max input voltage) is a great way to quickly destroy a motor, and spinning at free speed ensures that very little actual work can be done (since max speed corresponds to zero torque). Instead, engineers use motor curves to optimize motor usage somewhere in the middle.

The "Down-Up" Dyno Test [\(top\)](#)

VEX Robotics motor curves were developed experimentally using a "down-up" dynamometer test.

1. A motor is spun at free speed
2. A brake is slowly applied (linearly increasing in torque over time), bringing the motor down to a predetermined RPM
3. The brake is slowly released and the motor is allowed to return to its free speed

A variety of data, such as output speed, output torque, current draw, and power input/output, is taken throughout this test. The "down" (brake applied) side is then averaged with the "up" (brake released) side.

Why "Down-Up"?

The mechanics of a dyno test are crucial to developing and publishing accurate motor specifications. When a motor is spinning at free speed while attached to a dyno drum, the system contains a high amount of rotational inertia. This inertia complements the motor's own output, creating a false reading for peak output power that can be higher than the motor's actual performance. However, manufacturers do not always adjust for inertia cancellation when measuring their motor's performance, and spec sheets rarely detail the circumstances under which their information was derived.

By testing and averaging both the "down" (inertia helping the motor) and "up" (inertia resisting the motor) sides, this method is the best way to represent a motor's true capacity.

From <<http://motors.vex.com/introduction>>

Using a Motor Curve

Thursday, December 21, 2017 8:12 PM

TITAN ROBOTICS CLUB
TEAM 492



Motor curves are primarily used in two scenarios: Determining what motor (and gear reduction) to use in a particular application, and learning more about the state of a motor currently operating in a system.

1 - Determining which motor (and gear reduction) to use in a particular application

"Which motor should I use to lift this object?"

In competition robotics, the task to be performed will need to be defined and modeled by the designer. As a simplified example, consider a game piece that weighs 40.0 N, being lifted by an arm that is 0.5 m long, running through a 100:1 gearbox:

$$\text{Torque @ Arm} = \text{Force} \times \text{Distance}$$

$$\text{Torque @ Arm} = 40.0 \text{ N} \times 0.5 \text{ m}$$

$$\text{Torque @ Arm} = 20 \text{ N} \cdot \text{m}$$

$$\text{Torque @ Motor} = (\text{Torque @ Arm}) \div (\text{Gear Reduction})$$

$$\text{Torque @ Motor} = \frac{20 \text{ N} \cdot \text{m}}{100}$$

$$\text{Torque @ Motor} = 0.2 \text{ N} \cdot \text{m}$$

Thus, the motor that drives this arm will need to output **0.2 N · m** of torque.

Note: To learn more about how gear ratio can affect speed and torque, visit [Unit G.3 of the VEX IQ Curriculum](#) or [Unit 8.4 of the VEX EDR Curriculum](#).

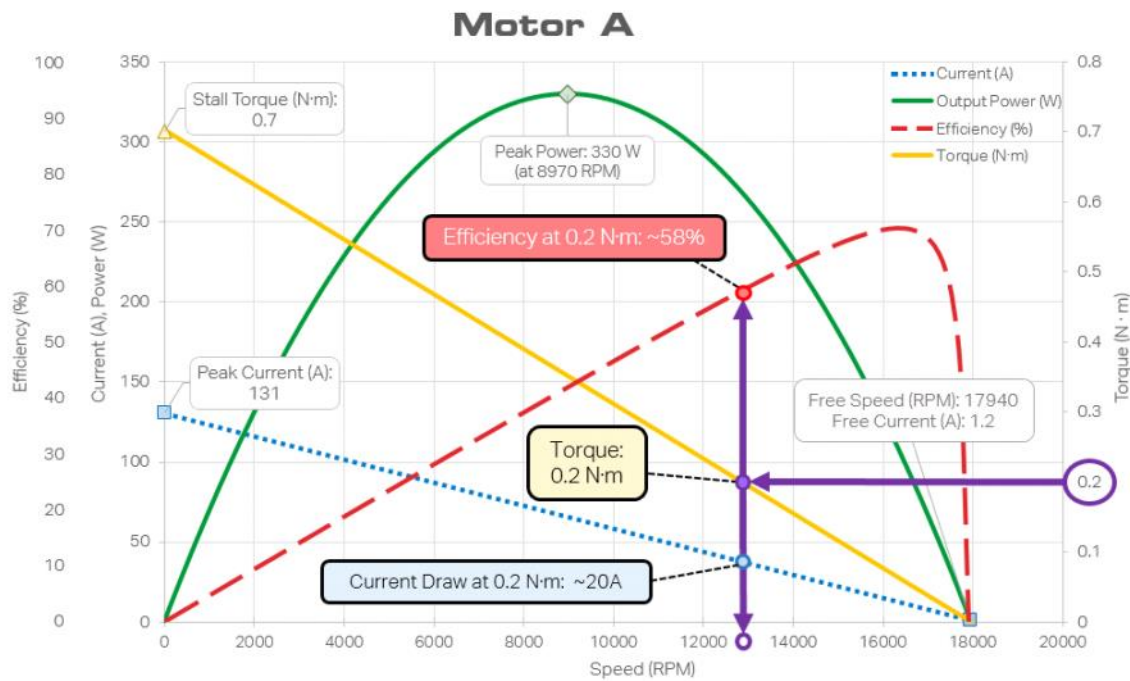
This output torque requirement can then be compared against published Motor Curves to learn more about the state of the motor during this action. Consider the following two curves [click to enlarge]:

From <<http://motors.vex.com/introduction>>

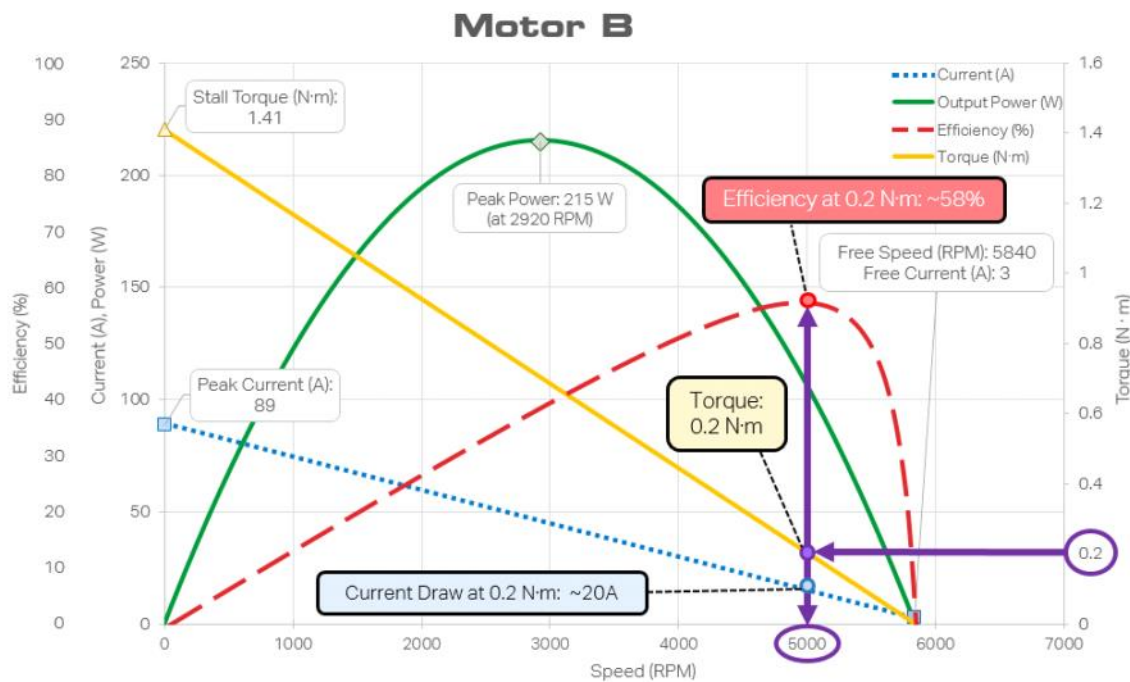
Motor Curves

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Motor A achieves 0.2 N · m of torque at roughly 13000 RPM, drawing roughly 40 A. With a 100:1 gearbox, this equates to an arm speed of 130 RPM. At this torque, the motor is operating just under 60% efficiency, below its peak.



Motor B can achieve 0.2 N · m of torque at roughly 5000 RPM, drawing roughly 20 A. With a 100:1 gearbox, this equates to an arm speed of 50 RPM. At this torque, the motor is operating at around 60% efficiency, very near its peak.

From <<http://motors.vex.com/introduction>>

Using a Motor Curve (cont)

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TEAM 492



Using these types of calculations, an engineer can combine this information with other details of the system to determine the best motor for their application. Is 50 RPM too slow? Is 40 A too high of a current draw? Is a higher efficiency needed for thermal or battery reasons?

As should quickly become evident, there are a number of variables involved in making this determination. Gear ratio, arm length, even game piece weight. Many times, designers will develop spreadsheet calculators to modify these values and seek out a condition that satisfies their needs.

Note: Current Draw at Peak Power

For an even quicker "back of the napkin" calculation, designers will sometimes simply calculate the amount of work being performed (Work = Mass × Gravity × Height) over a set amount of time (Power = Work ÷ Time) and select a motor matching that power requirement. For example, if a robot had to lift a 20.0 kg object 1.0 m in the air over 1.0 second:

$$\text{Power} = \frac{\text{Work}}{\text{Time}}$$

$$\text{Power} = \frac{\text{Mass} \times \text{Gravity} \times \text{Height}}{\text{Time}}$$

$$\text{Power} = \frac{20 \text{ kg} \times 9.8 \text{ m/s}^2 \times 1.0 \text{ m}}{1.0 \text{ s}}$$

$$\text{Power} = 196 \text{ W}$$

In the above example, Motor B would be the closest match for a power requirement of 196 W. However, what happens when there are two motors matching that peak power need? It is generally best to choose the motor with the lowest current draw, as this will extend your battery life and reduce strain on the electrical system. This becomes especially important under a sustained load, when current limiters or circuit breakers must be taken into account. This is covered in more detail below.

2 – Learning more about the state of a motor currently operating in a system

"Why does this motor burn up after lifting the object?"

If a motor has already been installed and an engineer wants to know more about the state of the system, the same theory as above can be reversed. At a known voltage, it takes one measured value (such as current draw) to determine the rest of the motor's attributes at that moment.

For example, again consider Motor A. If an ammeter is used to measure a current draw of 25 A, then it is now known that the motor is exerting around 0.11 N · m of torque and is operating around its peak efficiency of just under 70%. However, if the ammeter is reading 140 A, then the motor is currently operating under an extreme stall condition.

Note: VEX Robotics motor curves were made at 12 V. The four key characteristics (free speed / current, stall torque / current) approximately scale proportionally with system voltage. If Motor A was running at 6 V, its stall current would drop from 130 A to 65 A, and its stall torque would drop from 0.7 N · m to 0.35 N · m. If an ammeter reading showed a current draw of 25 A:

From <http://motors.vex.com/introduction>

$$\frac{\text{Stall Current}}{\text{Measured Current}} = \frac{65 \text{ A}}{25 \text{ A}} = 2.6$$

$$\text{Output Torque} = \frac{\text{Stall Torque}}{2.6} = \frac{0.35 \text{ N} \cdot \text{m}}{2.6}$$

$$\text{Output Torque} = 0.13 \text{ N} \cdot \text{m}$$

Other Considerations

Thursday, December 21, 2017 8:20 PM



While motor curves are an immensely useful tool to use during mechanism design, there are a few other characteristics of a motor or a system to keep in mind.

Thermal Mass

Most motors, if pushed to their stall torque or peak power, will burn themselves out if left there for too long. However, that acceptable time varies from motor to motor. Some motors may have a very high peak power, but can only be run under that full power in short bursts. Other motors have no problem sitting at their peak power, but may have other drawbacks (higher current draw, lower peak power, etc).

Because this property is so inherently dependent on the system and application, it is not typically published by manufacturers. However, thermal mass can be approximated by dividing a motor's peak power by its weight. For example:

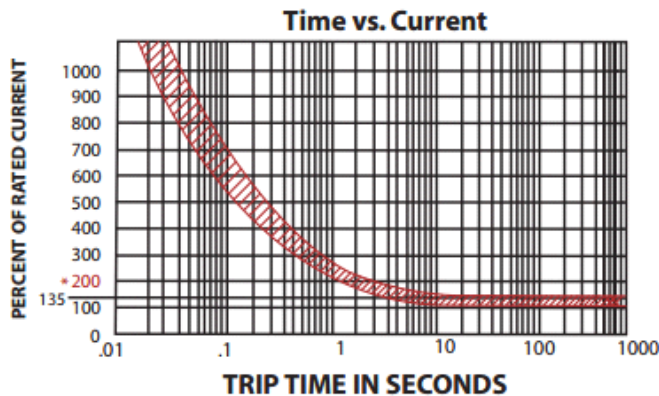
	Peak Power	Motor Weight	Thermal Mass
Motor A	330 W	0.75 lb	440 W/lb
Motor B	215 W	2.16 lb	99.5 W/lb

In this scenario, Motor A would be more useful for shorter bursts of high power, while Motor B could sustain its power for much longer. However, this comparison should only be used as a relative approximation, not as a firmly defined property.

Current Limits

Most competitive robots involve some sort of safety cutoff, such as a thermal cutoff inside the motor or a current limiting circuit breaker. These limits must be taken into account when determining an acceptable current draw for a given application.

Circuit breakers can usually hold a current draw past their rating for a set amount of time. Manufacturers typically provide a spec sheet that includes a graph such as the following, taken from the 20A / 30A Snap Action VB3 circuit breakers [sold by VEXpro](#):



From <http://motors.vex.com/introduction>

If Motor A from the above example (drawing 40 A) were wired through a 20A breaker, it would be pulling 200% of the breaker's rated current. Referencing this chart, the system could sustain this draw for roughly 1 – 4 seconds before tripping the breaker and cutting power to the motor.

Mathematical Assumptions

Though the motor curves are experimentally built, the calculations they are being used for ignore many real-world system characteristics such as friction, shock loading, or the effects of gravity (such as when moving an arm up vs moving it down). In some cases, these assumptions lend themselves to a more conservative calculation; in some cases, the opposite is true.

It is important to remember that the engineering design process consists of much more than calculations based off of spec sheets and charts – once a direction has been set, it's time to build a prototype, test, and iterate as required!

Denso Motor Specifications

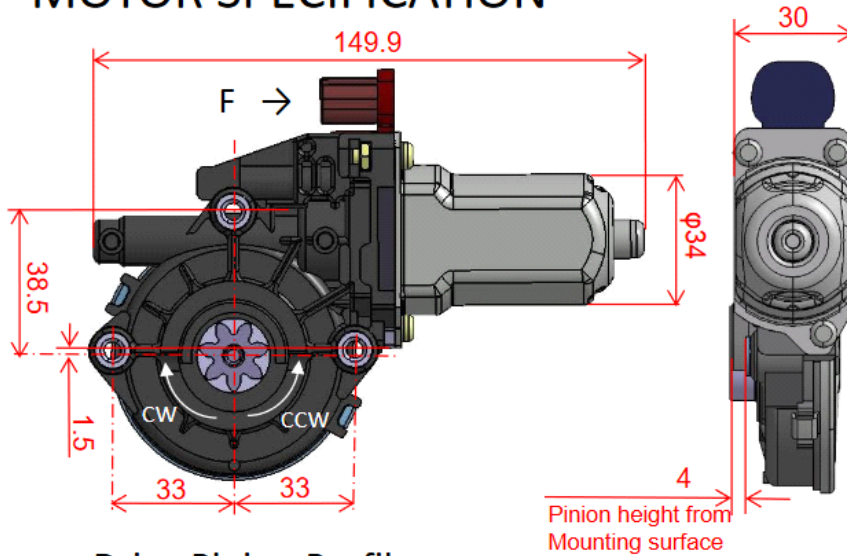
Thursday, December 21, 2017 8:49 PM

TITAN ROBOTICS CLUB
TEAM 492

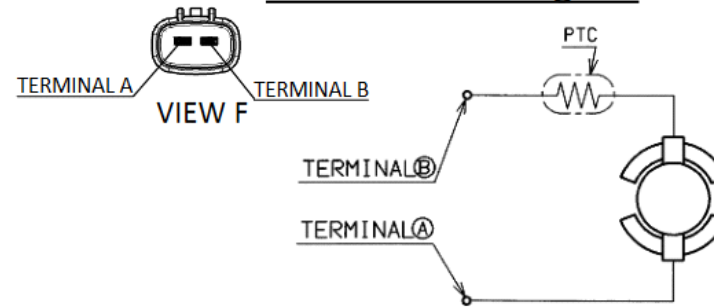


Feb. 3, 2014

MOTOR SPECIFICATION



Motor Circuit Diagram



Rotation Direction

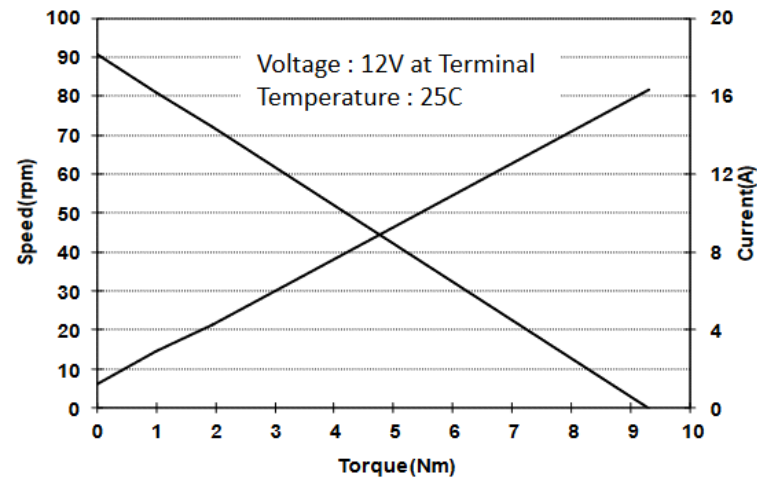
(View from Drive Pinion)

	Terminal A	Terminal B
CW	-	+
CCW	+	-

Drive Pinion Profile

Gear Tooth Profile	Profile Shifted Spur Gear Full Depth Tooth
Module	2
Pressure Angle	20 degree
Number of Teeth	7
Pitch Diameter	$\phi 14$
Addendum Modification	+0.5
Circular Pitch	6.283
Over Pin Diameter	$\Phi 25.287(0/-0.1)$ Pin Dia. $\phi 5.86$
Base Tangent Length	$9.736(0/-0.1)$ 2 Teeth
Outer Diameter	$\Phi 19.6 \pm 0.05$
Base Circle Diameter	$\Phi 13.156$

Motor performance



Monday, January 1, 2018 10:31 AM

**TITAN ROBOTICS CLUB
TEAM 492**



Sensors

Friday, December 22, 2017 8:24 AM

TITAN ROBOTICS CLUB
TEAM 492



SENSOR

- A. ENCODERS**
- B. COLOR SENSOR**
- C. LIGHT SENSOR**
- D. RANGE SENSOR**
- E. TOUCH SENSOR**
- F. POSITION SENSOR**
- G. GYRO SENSOR**
- H. POTENTIOMETER**
 - I. PRESSURE SENSOR**
 - J. INTERFACE BOARDS**

Sensors

Sunday, October 23, 2016 7:18 PM

**TITAN ROBOTICS CLUB
TEAM 492**



The following is a list of sensors that we are using on our robot this year, categorized by their primary functions:

- For general autonomous driving
 - o Gyro sensor (to determine the heading of the robot)
 - o Motor encoders on each of the four wheels and the particle accelerator (to determine how far the robot has travelled or how many times the accelerator has shot)
- To push the beacon button
 - o Color sensor (to determine color of the beacon)
 - o Ultrasonic sensor (to determine distance from the field wall)
 - o Light sensor (to detect the white line on the floor in front of the beacon)
 - o Touch sensor (to tell us the absolute position of our particle accelerator so we know when it has completed the firing sequence)

Encoders

Thursday, December 28, 2017 8:39 PM



Absolute Encoder with Cable (am-2899)
Price: \$45.00
In Stock
★★★★★ (6)

The MA3 is a miniature rotary absolute shaft encoder that reports the shaft position over 360 with no stops or gaps. This is the Analog output version (10-bit analog, 2.6 kHz sampling rate). Half-Turn(180*) = 2.5 V.

Specifications For Encoder:

- US Digital encoder part number: MA3-A10-250-N
- Body Diameter: 0.48"
- Overall Length: 1.26"
- Shaft Diameter: 0.2498"



Hall Effect Two Channel Encoder (am-2816a)
Price: \$25.00
In Stock
★★★★☆ (7)

This encoder is featured on the PG series gearmotors. All current PG gearmotors include this pre-attached, however older versions may not include it. This encoder is not compatible with am-0914, am-0915, or am-2193. Note: Because the encoder is connected to the back of the motor shaft, the rotation is backwards from normal front mounted encoders so you will need compensate for this in software or simply connect Ch. A output to your Ch. B input and Ch. B output to your Ch. A input.



E4T OEM Miniature Optical Encoder Kit (am-3132)
Price: \$42.00
In Stock
★★★★★ (11)

The E4T miniature optical encoder provides digital quadrature encoder feedback for high volume, limited space applications. The E4T is designed to be a drop in replacement for the E4P that offers higher maximum speed and increased output drive.

Specifications:

- Cycles per Revolution: 360
- Pulses per Revolution: 1440
- Max RPM: ~16,666
- Input Voltage: 5VDC
- For Shaft Size: 1/4"



CIMcoder (am-3314a)
Price: \$42.00
In Stock
★★★★★ (3)

This encoder mounts to the nose of a CIM Motor and senses the rotations of the CIM Motor output shaft. A housing, mounted to the CIM Motor, protects the encoder circuitry while a collet spins with the motor output shaft. The CIMCoder decreases the over CIM shaft length by 0.31".



SRX Magnetic Encoder (am-3445)
Price: \$40.00
In Stock

The SRX Mag Encoder is a rotary sensor that can be used to measure rotational position and velocity. The device senses the magnetic field of a diametrically polarized magnet to determine rotational position with 12 bit precision. The device provides both a Quadrature interface that may be used for relative position measurement and a Pulse Width Modulated output for absolute position measurement. The device connects directly to the Talon SRX data port and is directly supported in the Talon SRX firmware.

Color Sensor

Tuesday, November 22, 2016 8:12 PM

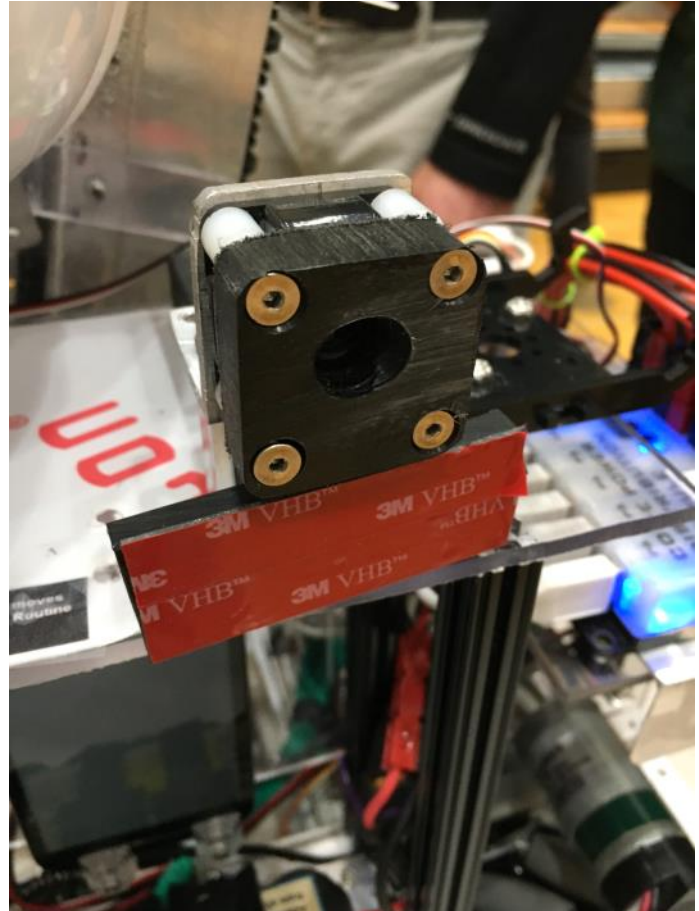


When the robot reaches the beacon, the color sensor will detect whether the color of the beacon is red or blue, so that our robot will be able to push the beacon button corresponding to our alliance color, earning points for our alliance.

This sensor is located on the left side of our button presser mechanism, so that it can only detect the color on the left side of the beacon. If that side of the beacon is the correct color, then the left side linear actuator will deploy. If that side of the beacon is the wrong color, then the other side must be by default the correct color, and so the right side linear actuator will deploy.

Light Shield:

Through testing, we found that the color sensor could not differentiate the beacon color under bright fluorescent light. This is because the white light essentially "washes out" the color LEDs of the beacon. Our solution to this problem was to attach a black light shield to the color sensor that blocks most of the fluorescent light from entering its lens.



Light Sensor

Friday, November 25, 2016 8:27 PM

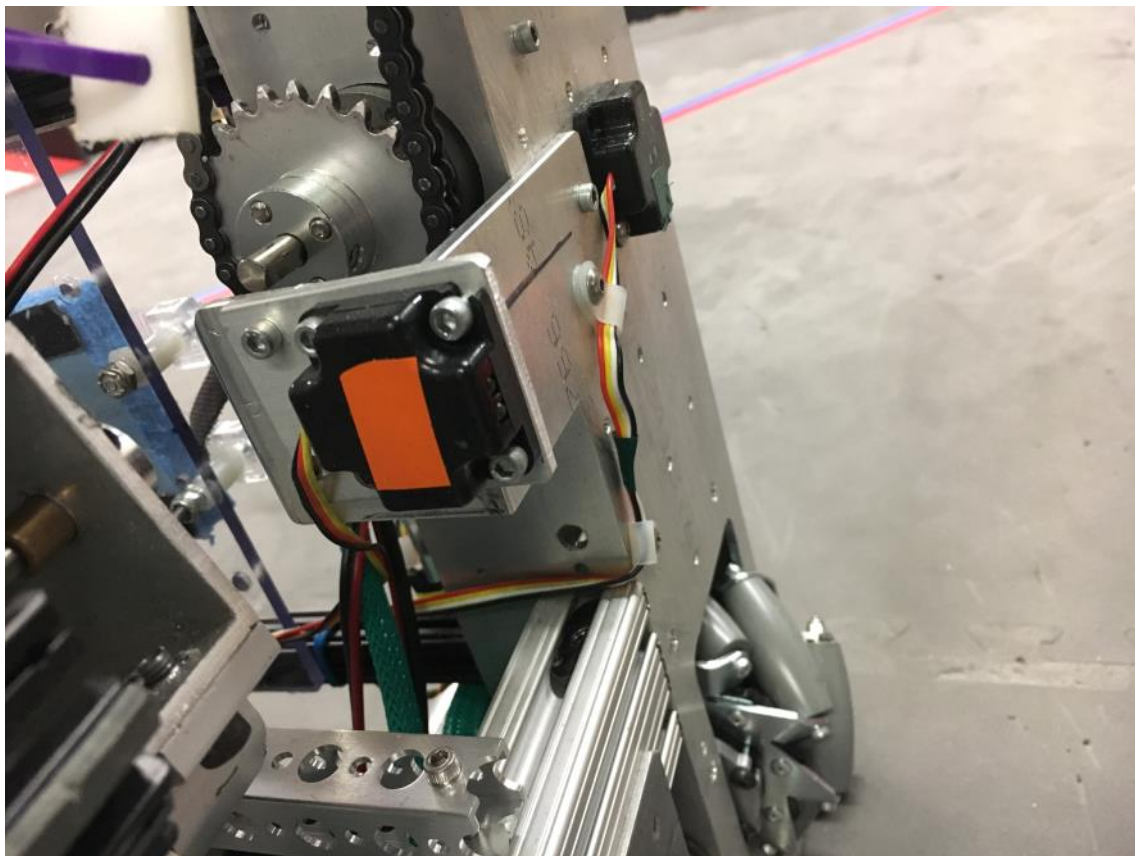
**TITAN ROBOTICS CLUB
TEAM 492**



The light sensor (also called the Optical Distance Sensor) is mounted under our robot facing down, so that it can read the brightness of the area of the field that the robot is on. The sensor works by shining light on the target area and detecting how much light reflects back. Bright colors reflect more light than dark colors. In our code, we designated a threshold value of brightness which, if crossed, would indicate that our robot had found a white line.

We use our light sensor during autonomous to detect the white tape that leads to the beacons.

Both the Optical Distance Sensor and the Color Sensor are mounted on the bottom of the robot. We initially started with the Color Sensor for line detection, but due to the i2C timing issue, we changed to the ODS. The ODS is an analog sensor, allowing us to not impact the update rate on the I2C bus.



Range Sensor

Sunday, November 27, 2016 3:59 PM



The ultrasonic sensor is used to detect how far an obstacle is from the robot, working in a way similar to echolocation.

The Range Sensor combines ultrasonic and optical measuring elements to obtain a reading between 1cm and 255cm. The ultrasonic accurately measures the distance to a target up to 255cm away, but it loses accuracy if the object is closer than 5cm. This is where the optical sensor comes into play as it can measure from 1cm out to about 7cm. This sensor is I2C.

Specifications

Power	5 volts DC. 20 mA max.
Standard 4 pin connector	For connection to 4 pin I2C port
Logic voltage levels	Logic 0 – 0 volts, Logic 1 – 5 volts

From <<http://www.modernroboticsinc.com/range-sensor>>



NEW! LIDAR Lite 3 (am-3829)
Price: \$150.00
In Stock



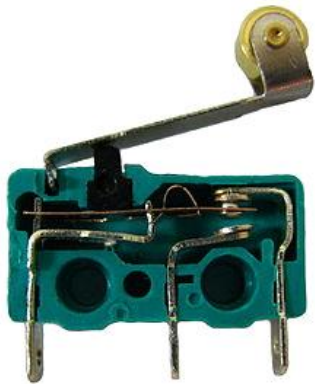
Ultrasonic proximity sensor, EZ0, MB1200, MaxBotix (am-2435)
Price: \$45.00
In Stock
★★★★★ (3)



Ultrasonic proximity sensor, EZ, MB1013, MaxBotix (am-2434)
Price: \$35.00
In Stock
★★★★★ (3)

Touch Sensor

Tuesday, November 29, 2016 7:56 PM



The internals of a micro switch. Contacts, from left to right, are common, normally open, and normally closed.

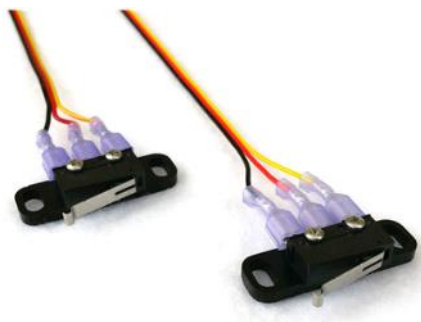
A **miniature snap-action switch**, also trademarked and frequently known as a **micro switch**, is an electric [switch](#) that is actuated by very little physical force, through the use of a [tipping-point mechanism](#), sometimes called an "over-center" mechanism. The defining feature of micro switches is that a relatively small movement at the actuator button produces a relatively large movement at the electrical contacts, which occurs at high speed (regardless of the speed of actuation).

From <https://en.wikipedia.org/wiki/Miniature_snap-action_switch>



Microswitches are available in "normally Closed" or "normally Open" configurations.

Push Switch (am-3372)
Price: \$1.50
In Stock



Two Snap Action Switches with wires connected and mounting plates included. Great for limiting travel and detecting objects using a forgiving angle and small force. Plug-and-play.

From <<http://www.modernroboticsinc.com/limit-switch-kit>>

Position Sensor

Thursday, December 28, 2017 9:11 PM

TITAN ROBOTICS CLUB
TEAM 492



This small board is the quickest way to measure speed or position on almost any rotating or sliding mechanism. Simply mount the PCB facing the object to be measured, and apply a contrasting mark to the object – Electrical Tape or black permanent marker work well on metallic surfaces. Silver marker or white paint work well on dull ones. Most targets can be measured accurately between 0.5 and 1.5in. When connected to a 5V supply, the TLEN sensor will output a pulse (High-Bright/Reflective. Low-Dark) for each mark on the object being measured.

Touchless Encoder (am-3507)

Price: \$22.50



The CTRE Talon Tach is a multipurpose reflective sensor with limit switch and tachometer capabilities. The device powers an infrared emitter and senses how much of the light is reflected to a detector. Small solder pad selectors allow for easy selection of the forward limit, reverse limit, and tachometer features. Dual 10-pin Talon headers permit daisy chaining of Talon Tachs with other devices.

Talon Tach (am-3778)

Price: \$14.00

In Stock

- Senses reflective surfaces 1-5mm away
- Single LED for showing sensor state
- Square-wave output with low jitter
- Connects directly to Talon SRX without the need for custom cables
- 3-pin header holes for non-Talon use
- Supported by Talon SRX firmware

Gyro Sensor

Friday, December 30, 2016 8:38 PM



The gyro sensor is essential during autonomous because it determines the heading of the robot.

One thing that makes our autonomous program sophisticated is its use of absolute heading rather than relative heading. With relative heading, the robot uses its previous position as a reference point when turning. There is usually a small amount of error associated with each turn, and all of these errors will eventually add up to impact our robot's performance. With absolute heading however, the robot establishes a zero degree reference point upon initialization and bases all its turning on that point. This prevents cumulative error when turning.

Also, as you can see in the picture below, the analog gyro board is mounted on four rubber grommets so they can isolate and absorb any vibration while the robot is moving. This greatly reduces the signal noise and minimizes gyro drifting.



6 Degrees of Freedom IMU Digital Combo Board (am-2314)

Price: \$40.00

In Stock

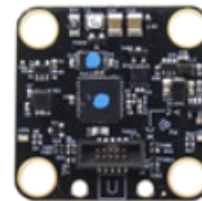
★★★★☆ (1)



navX MXP Robotics Navigation Sensor (am-3060b)

Price: \$99.00

In Stock



Analog Devices, Gyro Board (am-3555)

Price: \$35.00

In Stock

★★★★★ (2)

Gadgeteer Pigeon IMU (am-3556)

Price: \$60.00

In Stock



NavX Micro Navigation Sensor (am-3554)

Price: \$79.00

In Stock

★★★★★ (1)

Potentiometer

Sunday, December 10, 2017 10:41 AM

TITAN ROBOTICS CLUB
TEAM 492



String Potentiometer Kit (no housing) (am-2618)

Price: \$17.00



Precision Potentiometer, 10turn 5Kohms (am-2619)

Price: \$14.00

In Stock

Pressure Sensor

Thursday, December 28, 2017 5:54 PM

TITAN ROBOTICS CLUB
TEAM 492



Analog Pressure Sensor (am-3219)

Price: \$30.00

In Stock



The REV Robotics Analog Pressure Sensor is a 5V sensor that can measure pressures up to 200 PSI. It outputs an analog voltage that is proportional to the measured pressure and can plug directly into the roboRIO or the [MXP breakout Moreboard](#). This [Female Fitting, 1/8" NPT, 1/4" tube \(am-2033\)](#) mates perfectly with this sensor and allows the sensor to be integrated with your standard tubing setup of a robot.

Applications

- Real-time pressure feedback
 - View on smart dashboard
 - View on robot with devices such as the REV Digit MXP or [RIOduino + touch screen](#)
- Measuring actuation pressure
- Pressure-based decisions
 - Is there enough pressure left for a specific action?
- Estimating current air volume
- Determining leak rates
- Prototyping
 - How much pressure does a specific action take?
 - Verification of calculations at the cylinder

From <http://www.andymark.com/product-p/am-3219.htm>

Interface Boards

Thursday, December 28, 2017 5:57 PM

TITAN ROBOTICS CLUB
TEAM 492



Talon SRX Universal Breakout Board (am-3281)

Price: \$15.00

In Stock

★★★★★ (2)



Sentinel Interface Board for the Talon SRX (am-3495)

Price: \$18.00

In Stock

★★★★★ (1)



Bosch Seat Motor DIO Kit (am-3812)

Price: \$5.00

In Stock

Amana HSS Single/Double Flute Bits

Friday, June 29, 2018 9:29 AM

TITAN ROBOTICS CLUB
TEAM 492



D	B	d	L	Rotation	Flute	Brand	Tool No.	📷	Our Price
1/8	3/8	1/4	2-5/8	Upcut	1	Amana Tool	HSS1620	📷	\$13.50 \$10.13
1/8	3/8	1/4	2-5/8	Upcut	2	Amana Tool	HSS1630	📷	\$9.50 \$7.13
3/16	5/8	1/4	2-7/8	Upcut	1	Amana Tool	HSS1621	📷	\$11.50 \$8.63
1/4	5/8	1/4	2-3/4	Upcut	1	Amana Tool	HSS1622	📷	\$9.95 \$7.46
1/4	3/4	1/2	3-1/4	Upcut	1	Amana Tool	HSS1623	📷	\$18.55 \$13.91
1/4	5/8	1/4	2-3/4	Upcut	2	Amana Tool	HSS1633	📷	\$8.95 \$6.71
1/4	3/4	1/4	2-3/4	Upcut	2	Amana Tool	HSS1634	📷	\$8.95 \$6.71
1/4	3/4	1/2	3-1/4	Upcut	2	Amana Tool	HSS1635	📷	\$19.50 \$14.63
1/4	1	1/4	3	Upcut	2	Amana Tool	HSS1636	📷	\$9.50 \$7.13
5/16	3/4	1/2	3-1/4	Upcut	2	Amana Tool	HSS1637	📷	\$17.90 \$13.43
3/8	1	3/8	3	Upcut	2	Amana Tool	HSS1641	📷	\$15.50 \$11.63
1/2	1-1/4	1/2	3-1/4	Upcut	2	Amana Tool	HSS1644	📷	\$20.95 \$15.71
1/2	1-1/2	1/2	3-1/2	Upcut	2	Amana Tool	HSS1645	📷	\$23.50 \$17.63



High Speed Steel (HSS) Single & Double Flute Aluminum Cutting Router Bits

Tool No.	Max RPM	Flutes	Chip Load Per Tooth (1D Cutting Length)		
			Soft Wood	Hard Wood	Aluminum
HSS1620	18,000	1	0.008" - 0.010"	0.006" - 0.008"	0.004" - 0.006"
HSS1621	18,000	1	0.008" - 0.010"	0.006" - 0.008"	0.004" - 0.006"
HSS1622	18,000	1	0.008" - 0.010"	0.006" - 0.008"	0.004" - 0.006"
HSS1623	18,000	1	0.008" - 0.010"	0.006" - 0.008"	0.004" - 0.006"
HSS1628	18,000	1	0.008" - 0.010"	0.006" - 0.008"	0.004" - 0.006"
HSS1629	18,000	1	0.008" - 0.010"	0.006" - 0.008"	0.004" - 0.006"
HSS1630	18,000	2	0.006" - 0.008"	0.005" - 0.007"	0.002" - 0.004"
HSS1633	18,000	2	0.006" - 0.008"	0.005" - 0.007"	0.002" - 0.004"
HSS1634	18,000	2	0.006" - 0.008"	0.005" - 0.007"	0.002" - 0.004"
HSS1635	16,000	2	0.006" - 0.008"	0.005" - 0.007"	0.002" - 0.004"
HSS1636	18,000	2	0.006" - 0.008"	0.005" - 0.007"	0.002" - 0.004"
HSS1637	16,000	2	0.006" - 0.008"	0.005" - 0.007"	0.002" - 0.004"
HSS1641	18,000	2	0.007" - 0.009"	0.006" - 0.008"	0.003" - 0.005"
HSS1644	18,000	2	0.008" - 0.010"	0.007" - 0.009"	0.004" - 0.008"
HSS1645	18,000	2	0.008" - 0.010"	0.007" - 0.009"	0.004" - 0.008"
HSS1650	18,000	2	0.006" - 0.008"	0.005" - 0.007"	0.002" - 0.004"
HSS1653	18,000	2	0.006" - 0.008"	0.005" - 0.007"	0.002" - 0.004"
HSS1654	16,000	2	0.006" - 0.008"	0.005" - 0.007"	0.002" - 0.004"
HSS1659	16,000	2	0.006" - 0.008"	0.005" - 0.007"	0.002" - 0.004"
HSS1656	18,000	2	0.006" - 0.008"	0.005" - 0.007"	0.002" - 0.004"
HSS1661	18,000	2	0.008" - 0.010"	0.007" - 0.009"	0.004" - 0.008"

Simple Machining Calculations:

To find **RPM**: SFM x 3.82 / diameter of tool

To find **SFM**: 0.262 x diameter of tool x RPM

To find **Feed Rate IPM**: RPM x # of flutes x chip load

To find **Chip Load**: Feed Rate IPM / (RPM x # of Flutes)

Depth of Cut: 1 x D Use recommended chip load

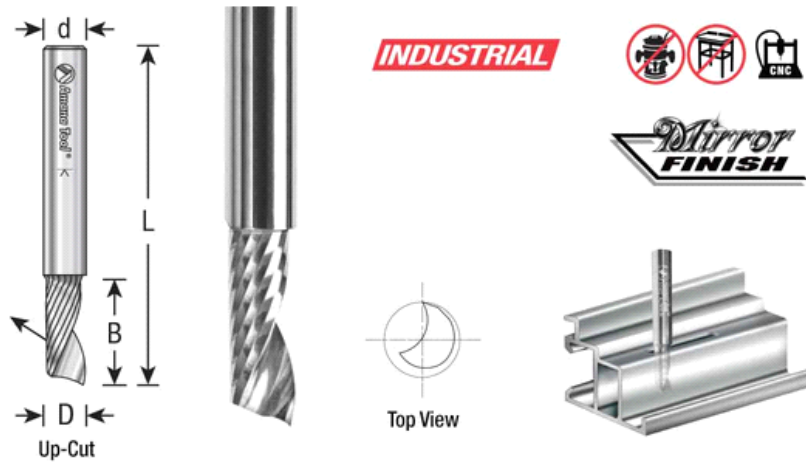
2 x D Reduce chip load by 25%

3 x D Reduce chip load by 50%

Amana HSS Single "O" flute Bits

Friday, June 29, 2018 9:32 AM

TITAN ROBOTICS CLUB
TEAM 492



D	B	d	L	Rotation	Flute	Brand	Tool No.	📷	Our Price
1/16	1/4	1/8	1-1/2	Upcut	1	Amana Tool	51470	📷	\$35.35 \$26.51
3/32	1/4	1/8	2	Upcut	1	Amana Tool	51472	📷	\$35.35 \$26.51
1/8	5/16	1/4	1-1/2	Upcut	1	Amana Tool	51373	📷	\$39.85 \$29.89
1/8	5/16	1/8	1-1/2	Upcut	1	Amana Tool	51406	📷	\$38.50 \$28.88
1/8	1/2	1/4	2	Upcut	1	Amana Tool	51454	📷	\$51.20 \$38.40
1/8	1/2	1/8	2	Upcut	1	Amana Tool	51459	📷	\$39.95 \$29.96
1/8	1/4	1/8	1-1/2	Upcut	1	Amana Tool	51471	📷	\$34.30 \$25.73
1/8	1/4	1/4	2	Upcut	1	Amana Tool	51474	📷	\$39.85 \$29.89
1/8	5/8	1/4	2-1/2	Upcut	1	Amana Tool	51482	📷	\$41.55 \$31.16
1/8	3/4	1/4	2-1/2	Upcut	1	Amana Tool	51486	📷	\$44.70 \$33.53
5/32	5/16	3/16	2	Upcut	1	Amana Tool	51473	📷	\$36.95 \$27.71
3/16	1/2	3/16	2	Upcut	1	Amana Tool	51374	📷	\$38.95 \$29.21
3/16	5/8	3/16	2	Upcut	1	Amana Tool	51375	📷	\$39.60 \$29.70

Amana HSS Single "O" flute Bits

Friday, June 29, 2018 9:36 AM

TITAN ROBOTICS CLUB
TEAM 492

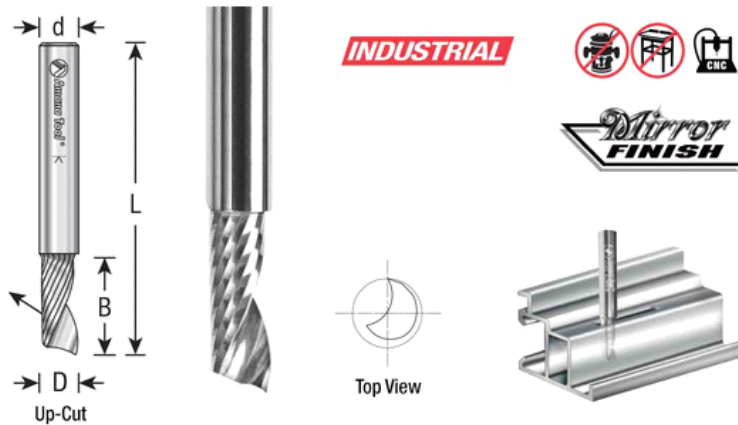


D	B	d	L	Rotation	Flute	Brand	Tool No.	📷	Our Price
3/16	1/2	1/4	2	Upcut	1	Amana Tool	51408	📷	\$45.75 \$34.31
3/16	7/8	1/4	2-1/2	Upcut	1	Amana Tool	51456	📷	\$55.95 \$41.96
3/16	3/8	3/16	1-1/2	Upcut	1	Amana Tool	51475	📷	\$36.35 \$27.26
3/16	3/8	1/4	2	Upcut	1	Amana Tool	51477	📷	\$43.65 \$32.74
3/16	5/8	1/4	2	Upcut	1	Amana Tool	51478	📷	\$46.75 \$35.06
1/4	3/4	1/4	2	Upcut	1	Amana Tool	51377	📷	\$44.30 \$33.23
1/4	5/8	1/4	2-1/2	Upcut	1	Amana Tool	51401	📷	\$46.50 \$34.88
1/4	5/8	1/4	2	Upcut	1	Amana Tool	51402	📷	\$45.75 \$34.31
1/4	7/8	1/4	2-1/2	Upcut	1	Amana Tool	51458	📷	\$58.25 \$43.69
1/4	1-1/2	1/4	3	Upcut	1	Amana Tool	51476	📷	\$59.95 \$44.96
1/4	3/8	1/4	2	Upcut	1	Amana Tool	51479	📷	\$42.60 \$31.95
1/4	3/4	1/4	2-1/2	Upcut	1	Amana Tool	51480	📷	\$46.75 \$35.06
1/4	1-1/4	1/4	3	Upcut	1	Amana Tool	51481	📷	\$62.35 \$46.76

Amana HSS Single "O" flute Bits

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D	B	d	L	Rotation	Flute	Brand	Tool No.	📷	Our Price
1/4	1-1/4	1/4	3	Upcut	1	Amana Tool	51481	📷	\$62.35 \$46.76
9/32	5/8	1/4	2	Upcut	1	Amana Tool	51451	📷	\$59.95 \$44.96
5/16	3/4	1/2	3	Upcut	1	Amana Tool	51483	📷	\$99.95 \$74.96
5/16	9/16	5/16	2-1/2	Upcut	1	Amana Tool	51642	📷	\$59.95 \$44.96
21/64	3/4	1/2	3	Upcut	1	Amana Tool	51455	📷	\$99.95 \$74.96
11/32	9/16	3/8	2-1/2	Upcut	1	Amana Tool	51457	📷	\$59.95 \$44.96
3/8	1	3/8	3	Upcut	1	Amana Tool	51378	📷	\$81.00 \$60.75
3/8	3/4	3/8	3	Upcut	1	Amana Tool	51484	📷	\$72.95 \$54.71
3/8	1-1/8	3/8	3	Upcut	1	Amana Tool	51485	📷	\$83.15 \$62.36
3/8	1-3/8	3/8	3-1/2	Upcut	1	Amana Tool	51643	📷	\$99.95 \$74.96
1/2	1-1/8	1/2	2-1/2	Upcut	1	Amana Tool	51379	📷	\$109.95 \$81.79
1/2	1-1/8	1/2	3-1/2	Upcut	1	Amana Tool	51487	📷	\$119.95 \$89.96
1/2	1-5/8	1/2	3-1/2	Upcut	1	Amana Tool	51489	📷	\$129.95 \$97.46
1/2	1-3/8	1/2	3-1/2	Upcut	1	Amana Tool	51644	📷	\$119.95 \$89.96

Amana HSS Single "O" flute Bits

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Solid Carbide Aluminum Cutting Spiral Single 'O' Flute Router Bits

Diameter	IPM at 18,000 RPM (Inches Per Minute)	Spindle Speed SFM (Surface Feet Per Minute)	Chip Load Per Tooth
1/16" (0.0625)	35 - 70	600 - 1,000	0.002" - 0.004"
2mm	35 - 70	600 - 1,000	0.002" - 0.004"
3/32" (0.0938)	35 - 70	600 - 1,000	0.002" - 0.004"
3mm	35 - 70	600 - 1,000	0.002" - 0.004"
1/8" (0.125)	35 - 70	600 - 1,000	0.002" - 0.004"
5/32" (0.1563)	35 - 70	600 - 1,000	0.002" - 0.004"
4mm	35 - 70	600 - 1,000	0.002" - 0.004"
3/16" (0.1875)	55 - 110	600 - 1,000	0.003" - 0.006"
5mm	55 - 110	600 - 1,000	0.003" - 0.006"
6mm	55 - 110	600 - 1,000	0.003" - 0.006"
1/4" (0.250)	55 - 110	600 - 1,000	0.003" - 0.006"
9/32" (0.2813)	55 - 110	600 - 1,000	0.003" - 0.006"
5/16" (0.3125)	55 - 110	600 - 1,000	0.003" - 0.006"
8mm	70 - 145	600 - 1,000	0.004" - 0.008"
21/64" (0.3281)	70 - 145	600 - 1,000	0.004" - 0.008"
11/32" (0.3438)	70 - 145	600 - 1,000	0.004" - 0.008"
9mm	70 - 145	600 - 1,000	0.004" - 0.008"
3/8" (0.375)	70 - 145	600 - 1,000	0.004" - 0.008"
10mm	70 - 145	600 - 1,000	0.004" - 0.008"
12mm	110 - 180	600 - 1,000	0.006" - 0.010"
1/2" (0.500)	145 - 215	600 - 1,000	0.008" - 0.012"

Tool Reference #'s		
Up-Cut	Down-Cut	Dia.
51370	—	1.5mm
51371	—	3mm
51373	—	1/8"
51374	—	3/16"
51375	—	3/16"
51377	—	1/4"
51378	—	3/8"
51379	—	1/2"
51401	—	1/4"
51402	51502	1/4"
51406	51506	1/8"
51408	51508	3/16"
51409	—	1/4"
51451	—	9/32"
51454	51503	1/8"
51455	—	21/64"
51456	—	3/16"
51457	—	11/32"
51458	—	1/4"
51459	51501	1/8"
51470	—	1/16"
51471	51771	1/8"
—	51772	1/8"
51472	—	3/32"
51473	—	5/32"
51474	—	1/8"
51475	—	3/16"
51476	—	1/4"
51477	51773	3/16"
51478	—	3/16"
51479	—	1/4"
51480	51775	1/4"
51481	—	1/4"
51482	—	1/8"
51483	—	5/16"
51484	—	3/8"
51485	—	3/8"
51486	—	1/8"
51487	—	1/2"
51489	—	1/2"
51490	—	3mm
51492	—	4mm
51494	—	5mm
51496	—	6mm
51498	—	8mm
51642	—	5/16"
51643	—	3/8"
51644	—	1/2"
57300	—	2mm
57301	—	2.5mm
57302	—	3mm
57303	—	4mm
57304	—	6mm
57306	—	10mm
—	57307	3mm
—	57308	6mm

Simple Machining Calculations:

To find **RPM**: (SFM x 3.82) / diameter of tool

To find **SFM**: 0.262 x diameter of tool x RPM

To find **Feed Rate**: RPM x # of flutes x chip load

To find **Chip Load**: IPM / (RPM x # of Flutes)

Depth of Cut: 1 x D Use recommended chip load

2 x D Reduce chip load by 25%

3 x D Reduce chip load by 50%



ZrN Coated Radius and Chamfer Edge Aluminum Cutting CNC End Mill Feed / Speed Rates & Chipload

INDUSTRIAL

Tool No.	Feed rate Inch/Min	Chip load Inch/Rev
Aluminum	9" - 36"	0.0005" - 0.002"
Brass	9" - 36"	0.0005" - 0.002"
Copper	9" - 36"	0.0005" - 0.002"
Plastic	36" - 90"	0.002" - 0.005"

Chip-Load at 18,000 RPM Maximum

Simple Machining Calculations:
 To find **RPM**: SFM x 3.282 / diameter of tool
 To find **SFM**: 0.262 x diameter of tool x RPMs
 To find **Feed Rate**: RPM x # of flutes x chip load

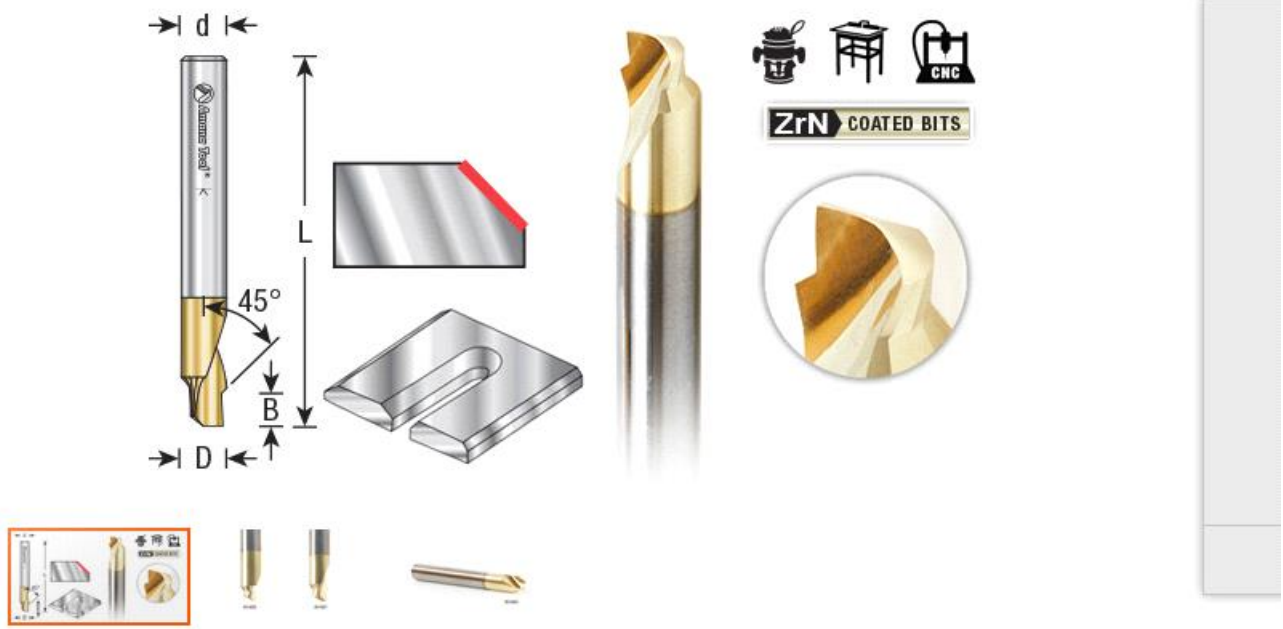


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Chamfer Edge ZrN Coated End Mill

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*Sort the Table by clicking on the Column Heading

D	B	d	L	Flute	a°	Brand	Tool No.	📷	Our Price
3/16	3/32	1/4	2	1	45°	Amana Tool	51625	📷	\$53.95 \$40.46
3/16	1/8	1/4	2	1	45°	Amana Tool	51627	📷	\$57.45 \$43.09

Radius Edge ZrN Coated End Mill

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*Sort the Table by clicking on the Column Heading

D	B	d	L	R	Flute	Brand	Tool No.	Our Price
3/16	3/32	1/4	2	3/64	1	Amana Tool	51620	\$56.15 \$42.11
3/16	1/8	1/4	2	3/64	1	Amana Tool	51622	\$55.20 \$41.40