



Machinists Handbook

Workshop Reference
Charts and Calculations

Marc Cronin

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Conversion Charts

Conversion Calculations

Length

Kilometers (km)	x	0.62	=	Miles (mi)
Miles (mi)	x	1.61	=	Kilometers (km)
Kilometers (km)	x	3280.8	=	Feet (ft)
Feet (ft)	x	0.0003048	=	Kilometers (km)
Meters (m)	x	3.28	=	Feet (ft)
Feet (ft)	x	0.3	=	Meters (m)
Centimeters (cm)	x	0.39	=	Inches (in)
Inches (in)	x	2.54	=	Centimeters (cm)
Millimeters (mm)	x	0.039	=	Inches (in)
Inches (in)	x	25.4	=	Millimeters (mm)
Meters (m)	x	39.37	=	Inches (in)
Inches (in)	x	0.0254	=	Meters (m)
Meters (m)	x	1.09361	=	Yards (yd)
Yards (yd)	x	0.91	=	Meters (m)
Kilometers (km)	x	1093.61	=	Yards (yd)
Yards (yd)	x	0.00091	=	Kilometers (km)

Volume

Liters (l)	x	1.057	=	Quarts (qt)
Quarts (qt)	x	0.95	=	Liters (l)
Liters (l)	x	0.264	=	Gallons (gal)
Gallons (gal)	x	3.785	=	Liters (l)
Milliliters (ml)	x	0.0042	=	Cups (c)
Cups (c)	x	236.6	=	Milliliters (ml)
Milliliters (ml)	x	0.0338	=	Ounces (oz)
Ounces (oz)	x	29.57	=	Milliliters (ml)

Mass

Kilogram (kg)	x	0.0011	=	Tons (ton)
Tons (ton)	x	907.18	=	Kilograms (kg)
Kilogram (kg)	x	2.2046	=	Pounds (lb)
Pounds (lb)	x	0.454	=	Kilograms (kg)
Grams (g)	x	0.035	=	Ounces (oz)
Ounces (oz)	x	28.35	=	Grams (g)
Grams (g)	x	0.002205	=	Pounds (lb)
Pounds (lb)	x	453.592	=	Grams (g)
Milligrams (mg)	x	0.000035	=	Ounces (oz)
Ounces (oz)	x	28350	=	Milligrams (mg)

Temperature

Fahrenheit (F)	$(\text{Temperature (F)} - 32) * 5/9$	Celsius (C)
Celsius (C)	$(\text{Temperature (C)} * 9/5) + 32$	Fahrenheit (F)

Measurement Conversion Charts

Fraction	Decimal	mm	Fraction	Decimal	mm	Fraction	Decimal	mm
.	0.0039	0.1	15/64	0.2344	5.9531	5/8	0.625	15.875
.	0.0079	0.2	.	0.2362	6	.	0.6299	16
.	0.0118	0.3	1/4	0.25	6.35	41/64	0.6406	16.2719
1/64	0.0156	0.3969	.	0.2559	6.5	.	0.6496	16.5
.	0.0157	0.4	17/64	0.2656	6.7469	21/32	0.6563	16.6688
.	0.0197	0.5	.	0.2756	7	.	0.6693	17
.	0.0236	0.6	9/32	0.2813	7.1438	43/64	0.6719	17.0656
.	0.0276	0.7	.	0.2953	7.5	11/16	0.6875	17.4625
1/32	0.0313	0.7938	19/64	0.2969	7.5406	.	0.689	17.5
.	0.0315	0.8	5/16	0.3125	7.9375	45/64	0.7031	17.8594
.	0.0354	0.9	.	0.315	8	.	0.7087	18
.	0.0394	1	21/64	0.3281	8.3344	23/32	0.7188	18.2563
.	0.0433	1.1	.	0.3346	8.5	.	0.7283	18.5
3/64	0.0469	1.1906	11/32	0.3438	8.7313	47/64	0.7344	18.6531
.	0.0472	1.2	.	0.3543	9	.	0.748	19
.	0.0512	1.3	23/64	0.3594	9.1281	3/4	0.75	19.05
.	0.0551	1.4	.	0.374	9.5	49/64	0.7656	19.4469
.	0.0591	1.5	3/8	0.375	9.525	.	0.7677	19.5
1/16	0.0625	1.5875	25/64	0.3906	9.9219	25/32	0.7813	19.8438
.	0.063	1.6	.	0.3937	10	.	0.7874	20
.	0.0669	1.7	13/32	0.4063	10.3188	51/64	0.7969	20.2406
.	0.0709	1.8	.	0.4134	10.5	.	0.8071	20.5
.	0.0748	1.9	27/64	0.4219	10.7156	13/16	0.8125	20.6375
5/64	0.0781	1.9844	.	0.4331	11	.	0.8268	21
.	0.0787	2	7/16	0.4375	11.1125	53/64	0.8281	21.0344
.	0.0827	2.1	.	0.4528	11.5	27/32	0.8438	21.4313
.	0.0866	2.2	29/64	0.4531	11.5094	.	0.8465	21.5
.	0.0906	2.3	15/32	0.4688	11.9063	55/64	0.8594	21.8281
3/32	0.0938	2.3813	.	0.4724	12	.	0.8661	22
.	0.0945	2.4	31/64	0.4844	12.3031	7/8	0.875	22.225
.	0.0984	2.5	.	0.4921	12.5	.	0.8858	22.5
7/64	0.1094	2.7781	1/2	0.5	12.7	57/64	0.8906	22.6219
.	0.1181	3	.	0.5118	13	.	0.9055	23
1/8	0.125	3.175	33/64	0.5156	13.0969	29/32	0.9063	23.0188
.	0.1378	3.5	17/32	0.5313	13.4938	59/64	0.9219	23.4156
9/64	0.1406	3.5719	.	0.5315	13.5	.	0.9252	23.5
5/32	0.1563	3.9688	35/64	0.5469	13.8906	15/16	0.9375	23.8125
.	0.1575	4	.	0.5512	14	.	0.9449	24
11/64	0.1719	4.3656	9/16	0.5625	14.2875	61/64	0.9531	24.2094
.	0.1772	4.5	.	0.5709	14.5	.	0.9646	24.5
3/16	0.1875	4.7625	37/64	0.5781	14.6844	31/32	0.9688	24.6063
.	0.1969	5	.	0.5906	15	.	0.9843	25
13/64	0.2031	5.1594	19/32	0.5938	15.0813	63/64	0.9844	25.0031
.	0.2165	5.5	39/64	0.6094	15.4781	1	1	25.4
7/32	0.2188	5.5563	.	0.6102	15.5			

Measurement Conversion Charts

Fraction	Decimal	mm
1 1/64	1.0156	25.7969
1 1/32	1.0313	26.1938
1 3/64	1.0469	26.5906
1 1/16	1.0625	26.9875
1 5/64	1.0781	27.3844
1 3/32	1.0938	27.7813
1 7/64	1.1094	28.1781
1 1/8	1.125	28.575
1 9/64	1.1406	28.9719
1 5/32	1.1563	29.3688
1 11/64	1.1719	29.7656
1 3/16	1.1875	30.1625
1 13/64	1.2031	30.5594
1 7/32	1.2188	30.9563
1 15/64	1.2344	31.3531
1 1/4	1.25	31.75
1 17/64	1.2656	32.1469
1 9/32	1.2813	32.5438
1 19/64	1.2969	32.9406
1 5/16	1.3125	33.3375
1 21/64	1.3281	33.7344
1 11/32	1.3438	34.1313
1 23/64	1.3594	34.5281
1 3/8	1.375	34.925
1 25/64	1.3906	35.3219
1 13/32	1.4063	35.7188
1 27/64	1.4219	36.1156
1 7/16	1.4375	36.5125
1 29/64	1.4531	36.9094
1 15/32	1.4688	37.3063
1 31/64	1.4844	37.7031
1 1/2	1.5	38.1
1 33/64	1.5156	38.4969
1 17/32	1.5313	38.8938
1 35/64	1.5469	39.2906
1 9/16	1.5625	39.6875

Fraction	Decimal	mm
1 37/64	1.5781	40.0844
1 19/32	1.5938	40.4813
1 39/64	1.6094	40.8781
1 5/8	1.625	41.275
1 41/64	1.6406	41.6719
1 21/32	1.6563	42.0688
1 43/64	1.6719	42.4656
1 11/16	1.6875	42.8625
1 45/64	1.7031	43.2594
1 23/32	1.7188	43.6563
1 47/64	1.7344	44.0531
1 3/4	1.75	44.45
1 49/64	1.7656	44.8469
1 25/32	1.7813	45.2438
1 51/64	1.7969	45.6406
1 13/16	1.8125	46.0375
1 53/64	1.8281	46.4344
1 27/32	1.8438	46.8313
1 55/64	1.8594	47.2281
1 7/8	1.875	47.625
1 57/64	1.8906	48.0219
1 29/32	1.9063	48.4188
1 59/64	1.9219	48.8156
1 15/16	1.9375	49.2125
1 61/64	1.9531	49.6094
1 31/32	1.9688	50.0063
1 63/64	1.9844	50.4031
2	2	50.8

Measurement Conversion Charts

Fraction	Decimal	mm
2 1/64	2.0156	51.1969
2 1/32	2.0313	51.5938
2 3/64	2.0469	51.9906
2 1/16	2.0625	52.3875
2 5/64	2.0781	52.7844
2 3/32	2.0938	53.1813
2 7/64	2.1094	53.5781
2 1/8	2.125	53.975
2 9/64	2.1406	54.3719
2 5/32	2.1563	54.7688
2 11/64	2.1719	55.1656
2 3/16	2.1875	55.5625
2 13/64	2.2031	55.9594
2 7/32	2.2188	56.3563
2 15/64	2.2344	56.7531
2 1/4	2.25	57.15
2 17/64	2.2656	57.5469
2 9/32	2.2813	57.9438
2 19/64	2.2969	58.3406
2 5/16	2.3125	58.7375
2 21/64	2.3281	59.1344
2 11/32	2.3438	59.5313
2 23/64	2.3594	59.9281
2 3/8	2.375	60.325
2 25/64	2.3906	60.7219
2 13/32	2.4063	61.1188
2 27/64	2.4219	61.5156
2 7/16	2.4375	61.9125
2 29/64	2.4531	62.3094
2 15/32	2.4688	62.7063
2 31/64	2.4844	63.1031
2 1/2	2.5	63.5
2 33/64	2.5156	63.8969
2 17/32	2.5313	64.2938
2 35/64	2.5469	64.6906
2 9/16	2.5625	65.0875

Fraction	Decimal	mm
2 37/64	2.5781	65.4844
2 19/32	2.5938	65.8813
2 39/64	2.6094	66.2781
2 5/8	2.625	66.675
2 41/64	2.6406	67.0719
2 21/32	2.6563	67.4688
2 43/64	2.6719	67.8656
2 11/16	2.6875	68.2625
2 45/64	2.7031	68.6594
2 23/32	2.7188	69.0563
2 47/64	2.7344	69.4531
2 3/4	2.75	69.85
2 49/64	2.7656	70.2469
2 25/32	2.7813	70.6438
2 51/64	2.7969	71.0406
2 13/16	2.8125	71.4375
2 53/64	2.8281	71.8344
2 27/32	2.8438	72.2313
2 55/64	2.8594	72.6281
2 7/8	2.875	73.025
2 57/64	2.8906	73.4219
2 29/32	2.9063	73.8188
2 59/64	2.9219	74.2156
2 15/16	2.9375	74.6125
2 61/64	2.9531	75.0094
2 31/32	2.9688	75.4063
2 63/64	2.9844	75.8031
3	3	76.2

Screw Thread Charts

Metric Coarse Thread Chart

Nominal Size ISO	Minor Diameter	Major Diameter	Thread Height	Pitch	Pitch Diameter	Tap Drill Diameter
1	0.693	1	0.153	0.25	0.838	0.75
1.1	0.793	1.1	0.153	0.25	0.938	0.85
1.2	0.893	1.2	0.153	0.25	1.038	0.95
1.4	1.032	1.4	0.184	0.3	1.205	1.1
1.6	1.171	1.6	0.215	0.35	1.373	1.25
1.8	1.371	1.8	0.215	0.35	1.573	1.45
2	1.509	2	0.245	0.4	1.74	1.6
2.2	1.648	2.2	0.276	0.45	1.908	1.75
2.5	1.948	2.5	0.276	0.45	2.208	2.05
3	2.387	3	0.307	0.5	2.675	2.5
3.5	2.764	3.5	0.368	0.6	3.11	2.9
4	3.141	4	0.429	0.7	3.545	3.3
4.5	3.58	4.5	0.46	0.75	4.013	3.8
5	4.019	5	0.491	0.8	4.48	4.2
6	4.773	6	0.613	1	5.35	5
7	5.773	7	0.613	1	6.35	6
8	6.466	8	0.767	1.25	7.188	6.8
9	7.466	9	0.767	1.25	8.188	7.8
10	8.16	10	0.92	1.5	9.026	8.5
11	9.16	11	0.92	1.5	10.026	9.5
12	9.853	12	1.074	1.75	10.863	10.2
14	11.546	14	1.227	2	12.701	12
16	13.546	16	1.227	2	14.701	14
18	14.933	18	1.534	2.5	16.376	15.5
20	16.933	20	1.534	2.5	18.376	17.5
22	18.933	22	1.534	2.5	20.376	19.5
24	20.319	24	1.84	3	22.051	21
27	23.319	27	1.84	3	25.051	24
30	25.706	30	2.147	3.5	27.727	26.5
33	28.706	33	2.147	3.5	30.727	29.5
36	31.093	36	2.454	4	33.402	32
39	34.093	39	2.454	4	36.402	35
42	36.479	42	2.76	4.5	39.077	37.5
45	39.479	45	2.76	4.5	42.077	40.5
48	41.866	48	3.067	5	44.752	43
52	45.866	52	3.067	5	48.752	47
56	49.252	56	3.374	5.5	52.428	50.5
60	53.252	60	3.374	5.5	56.428	54.5
64	56.639	64	3.681	6	60.103	58
68	60.639	68	3.681	6	64.103	62

Dimensions in mm unless otherwise stated

Metric Fine Thread Chart

Nominal Size ISO	Minor Diameter	Major Diameter	Thread Height	Pitch	Pitch Diameter	Tap Drill Diameter
22	20.773	22	0.613	1	21.35	21
22	20.16	22	0.92	1.5	21.026	20.5
22	19.546	22	1.227	2	20.701	20
24	22.773	24	0.613	1	23.35	23
24	22.16	24	0.92	1.5	23.026	22.5
24	21.546	24	1.227	2	22.701	22
25	23.773	25	0.613	1	24.35	24
25	23.16	25	0.92	1.5	24.026	23.5
25	22.546	25	1.227	2	23.701	23
27	25.773	27	0.613	1	26.35	26
27	25.16	27	0.92	1.5	26.026	25.5
27	24.546	27	1.227	2	25.701	25
28	26.773	28	0.613	1	27.35	27
28	26.16	28	0.92	1.5	27.026	26.5
28	25.546	28	1.227	2	26.701	26

Dimensions in mm unless otherwise stated

BSW British Standard Whitworth Thread Chart

Fraction Size	Minor Diameter	Major Diameter	Thread Height	Pitch	Threads per inch (TPI)	Tap Drill Diameter
1/16"	1.05	1.587	0.27	0.423	60	1.15
3/32"	1.703	2.381	0.338	0.529	48	1.9
1/8"	2.362	3.175	0.406	0.635	40	2.5
5/32"	2.952	3.969	0.507	0.793	32	3.2
3/16"	3.407	4.762	0.677	1.058	24	3.7
7/32"	4.201	5.556	0.677	1.058	24	4.5
1/4"	4.724	6.35	0.813	1.27	20	5.1
5/16"	6.131	7.938	0.904	1.411	18	6.5
3/8"	7.492	9.525	1.017	1.588	16	7.9
7/16"	8.789	11.113	1.162	1.814	14	9.2
1/2"	9.99	12.7	1.355	2.117	12	10.4
9/16"	11.58	14.29	1.355	2.117	12	11.89
5/8"	12.918	15.876	1.479	2.309	11	13.4
3/4"	15.798	19.051	1.627	2.54	10	16.25
7/8"	18.611	22.226	1.807	2.822	9	19.25
1"	21.335	25.4	2.033	3.175	8	22
1 1/8"	23.929	28.576	2.324	3.629	7	24.5
1 1/4"	27.104	31.751	2.324	3.629	7	27.25
1 3/8"	29.505	34.926	2.711	4.233	6	30.25
1 1/2"	32.68	38.1	2.711	4.233	6	33.5
1 5/8"	34.771	41.277	3.253	5.08	5	35.5
1 3/4"	37.946	44.452	3.253	5.08	5	38.5
1 7/8"	40.398	47.627	3.614	5.645	4 1/2	41.25
2"	43.573	50.802	3.614	5.645	4 1/2	44.5
2 1/4"	49.02	57.152	4.066	6.35	4	50
2 1/2"	55.37	63.502	4.066	6.35	4	56
2 3/4"	60.558	69.853	4.647	7.257	3 1/2	61.5
3"	66.909	76.203	4.647	7.257	3 1/2	68
3 1/4"	72.544	82.553	5.005	7.816	3 1/4	73.75
3 1/2"	78.894	88.903	5.005	7.816	3 1/4	80
3 3/4"	84.41	95.254	5.422	8.467	3	85.5
4"	90.76	101.604	5.422	8.467	3	92
4 1/4"	96.639	107.954	5.657	8.835	2 7/8	98
4 1/2"	102.99	114.304	5.657	8.835	2 7/8	104.2
4 3/4"	108.625	120.665	5.915	9.237	2 3/4	110
5"	115.176	127.005	5.915	9.237	2 3/4	116.5
5 1/4"	120.963	133.355	6.196	9.677	2 5/8	122.5
5 1/2"	127.313	139.705	6.196	9.677	2 5/8	128.5
5 3/4"	133.043	146.055	6.506	10.16	2 1/2	134.5
6"	139.394	152.406	6.506	10.16	2 1/2	141

Dimensions in mm unless otherwise stated

BSF British Standard Fine Thread Chart

Nominal Size	Minor Diameter	Major Diameter	Thread Height	Pitch	Threads per inch (TPI)	Tap Drill Diameter
3/16"	3.747	4.763	0.508	0.794	32	4
7/32"	4.394	5.556	0.581	0.907	28	4.6
1/4"	5.1	6.35	0.625	0.977	26	5.3
9/32"	5.893	7.142	0.625	0.977	26	6.1
5/16"	6.459	7.938	0.739	1.156	22	6.8
3/8"	7.899	9.525	0.813	1.27	20	8.3
7/16"	9.304	11.113	0.904	1.411	18	9.7
1/2"	10.668	12.7	1.017	1.588	16	11.1
9/16"	12.256	14.288	1.017	1.588	16	12.7
5/8"	13.549	15.875	1.162	1.814	14	14
11/16"	15.137	17.463	1.162	1.814	14	15.5
3/4"	16.336	19.05	1.355	2.117	12	16.75
13/16"	17.924	20.638	1.355	2.117	12	18.25
7/8"	19.269	22.225	1.479	2.309	11	19.75
1"	22.148	25.4	1.627	2.54	10	22.75
1 1/8"	24.963	28.575	1.807	2.822	9	26.5
1 1/4"	28.138	31.75	1.807	2.822	9	28.75
1 3/8"	30.861	34.925	2.033	3.175	8	31.5
1 1/2"	34.036	38.1	2.033	3.175	8	34.5
1 5/8"	37.211	41.275	2.033	3.175	8	38
1 3/4"	39.802	44.45	2.324	3.629	7	40.5
2"	46.152	50.8	2.324	3.629	7	47
2 1/4"	51.73	57.15	2.711	4.234	6	53
2 1/2"	58.08	63.5	2.711	4.234	6	59
2 3/4"	64.43	69.85	2.711	4.234	6	
3"	69.692	76.2	3.253	5.08	5	

Dimensions in mm unless otherwise stated

BA British Association Thread Chart

Nominal Size	Minor Diameter	Major Diameter	Thread Height	Pitch	Threads per inch (TPI)	Tap Drill Diameter
No. 16	0.56	0.79	0.115	0.668	133.68	0.6
No. 15	0.65	0.9	0.125	0.766	120.95	0.7
No. 14	0.72	1	0.14	0.853	110.4	0.75
No. 13	0.9	1.2	0.15	1.04	101.6	0.95
No. 12	0.96	1.3	0.17	1.121	90.71	1
No. 11	1.13	1.5	0.185	1.301	81.93	1.2
No. 10	1.28	1.7	0.21	1.476	72.57	1.35
No. 9	1.43	1.9	0.235	1.65	65.12	1.5
No. 8	1.68	2.2	0.26	1.925	59.07	1.8
No. 7	1.92	2.5	0.29	2.193	52.92	2
No. 6	2.16	2.8	0.32	2.461	47.92	2.3
No. 5	2.49	3.2	0.355	2.822	43.05	2.6
No. 4	2.81	3.6	0.395	3.177	38.48	2.95
No. 3	3.22	4.1	0.44	3.633	34.79	3.4
No. 2	3.73	4.7	0.485	4.181	31.35	3.9
No. 1	4.22	5.3	0.54	4.724	28.22	4.4
No. 0	4.8	6	0.6	5.36	25.4	5

Dimensions in mm unless otherwise stated

BSPB British Standard Pipe Parallel Thread Chart

Fraction Size	Minor Diameter	Major Diameter	Thread Height	Pitch	Threads per inch (TPI)	Tap Drill Diameter
1/16"	6.561	7.723	0.581	0.907	28	6.8
1/8"	8.566	9.728	0.581	0.907	28	8.8
1/4"	11.445	13.157	0.856	1.337	19	11.8
3/8"	14.95	16.662	0.856	1.337	19	15.25
1/2"	18.631	20.955	1.162	1.814	14	19
5/8"	20.587	22.911	1.162	1.814	14	21
3/4"	24.117	26.441	1.162	1.814	14	24.5
7/8"	27.877	30.201	1.162	1.814	14	28.25
1"	30.291	33.249	1.479	2.309	11	30.75
1 1/8"	34.939	37.897	1.479	2.309	11	35.5
1 1/4"	38.952	41.91	1.479	2.309	11	39.5
1 1/2"	44.845	47.803	1.479	2.309	11	47.4
1 3/4"	50.788	53.746	1.479	2.309	11	53.7
2"	56.656	59.614	1.479	2.309	11	60.1
2 1/4"	62.752	65.71	1.479	2.309	11	63.3
2 1/2"	72.226	75.184	1.479	2.309	11	72.8
2 3/4"	78.576	81.534	1.479	2.309	11	79.1
3"	84.926	87.884	1.479	2.309	11	85.5
3 1/2"	97.372	100.33	1.479	2.309	11	97.75
4"	110.072	113.03	1.479	2.309	11	110.5
4 1/2"	122.772	125.73	1.479	2.309	11	123
5"	135.472	138.43	1.479	2.309	11	136
5 1/2"	148.172	151.13	1.479	2.309	11	148.5
6"	160.872	163.83	1.479	2.309	11	161.5

Dimensions in mm unless otherwise stated

BSPT British Standard Pipe Taper Thread Chart

Fraction Size	Minor Diameter	Major Diameter	Thread Height	Pitch	Effective Thread Length	Threads per inch (TPI)	Tap Drill Diameter
1/16"	6.561	7.723	0.581	0.907	2.5	28	6.4
1/8"	8.566	9.728	0.581	0.907	2.5	28	8.4
1/4"	11.445	13.157	0.856	1.337	3.7	19	11.2
3/8"	14.95	16.662	0.856	1.337	3.7	19	14.75
1/2"	18.631	20.955	1.162	1.814	5	14	18.25
3/4"	24.117	26.441	1.162	1.814	5	14	23.75
1"	30.291	33.249	1.479	2.309	6.4	11	30
1 1/4"	38.952	41.91	1.479	2.309	6.4	11	38.5
1 1/2"	44.845	47.803	1.479	2.309	6.4	11	44.5
2"	56.656	59.614	1.479	2.309	7.5	11	56
2 1/2"	72.226	75.184	1.479	2.309	9.2	11	71
3"	84.926	87.884	1.479	2.309	9.2	11	85.5
4"	110.072	113.03	1.479	2.309	10.4	11	110.5
5"	135.472	138.43	1.479	2.309	11.5	11	136
6"	160.872	163.83	1.479	2.309	11.5	11	161.5

Dimensions in mm unless otherwise stated

UNC Unified Coarse Thread Chart

Nominal Diameter (Inch)	Major Diameter (Inch)	Major Diameter	Pitch	Threads per inch (TPI)	Tap Drill Diameter
1 - 64	0.073	1.854	0.397	64	1.5
2 - 56	0.086	2.184	0.453	56	1.8
3 - 48	0.099	2.515	0.529	48	2.1
4 - 40	0.112	2.845	0.635	40	2.35
5 - 40	0.125	3.175	0.635	40	2.65
6 - 32	0.138	3.505	0.794	32	2.85
8 - 32	0.164	4.166	0.794	32	3.5
10 - 24	0.19	4.826	1.058	24	4
12 - 24	0.216	5.486	1.058	24	4.65
1/4" - 20	0.25	6.35	1.27	20	5.35
5/16" - 18	0.313	7.938	1.411	18	6.8
3/8" - 16	0.375	9.525	1.587	16	8.25
7/16" - 14	0.438	11.112	1.814	14	9.65
1/2" - 13	0.5	12.7	1.954	13	11.15
9/16" - 12	0.563	14.288	2.117	12	12.6
5/8" - 11	0.625	15.875	2.309	11	14.05
3/4" - 10	0.75	19.05	2.54	10	17
7/8" - 9	0.875	22.225	2.822	9	20
1" - 8	1	25.4	3.175	8	22.85
1 1/8" - 7	1.125	28.575	3.628	7	25.65
1 1/4" - 7	1.25	31.75	3.628	7	28.85
1 3/8" - 6	1.375	34.925	4.233	6	31.55
1 1/2" - 6	1.5	38.1	4.233	6	34.7
1 3/4" - 5	1.75	44.45	5.08	5	40.4
2" - 4 1/2	2	50.8	5.644	4.5	46.3
2 1/4" - 4 1/2	2.25	57.15	5.644	4.5	52.65
2 1/2" - 4	2.5	63.5	6.35	4	58.5
2 3/4" - 4	2.75	69.85	6.35	4	64.75
3" - 4	3	76.2	6.35	4	71.1
3 1/4" - 4	3.25	82.55	6.35	4	77.45
3 1/2" - 4	3.5	88.9	6.35	4	83.8
3 3/4" - 4	3.75	95.25	6.35	4	90.15
4" - 4	4	101.6	6.35	4	96.5

Dimensions in mm unless otherwise stated

UNF Unified Fine Thread Chart

Nominal Diameter (Inch)	Major Diameter (Inch)	Major Diameter	Pitch	Threads per inch (TPI)	Tap Drill Diameter
0 - 80	0.06	1.524	0.317	80	1.25
1 - 72	0.073	1.854	0.353	72	1.55
2 - 64	0.068	2.184	0.397	64	1.9
3 - 56	0.099	2.515	0.453	56	2.15
4 - 48	0.112	2.845	0.529	48	2.4
5 - 44	0.125	3.175	0.577	44	2.7
6 - 40	0.138	3.505	0.635	40	2.95
8 - 36	0.164	4.166	0.705	36	3.5
10 - 32	0.19	4.826	0.794	32	4.1
12 - 28	0.216	5.486	0.907	28	4.7
1/4" - 28	0.25	6.35	0.907	28	5.5
5/16" - 24	0.313	7.938	1.058	24	6.9
3/8" - 24	0.375	9.525	1.058	24	8.5
7/16" - 20	0.438	11.112	1.27	20	9.9
1/2" - 20	0.5	12.7	1.27	20	11.5
9/16" - 18	0.563	14.288	1.411	18	12.9
5/8" - 18	0.625	15.875	1.411	18	14.5
3/4" - 16	0.75	19.05	1.587	16	17.5
7/8" - 14	0.875	22.225	1.814	14	20.4
1" - 12	1	25.4	2.117	12	23.25
1 1/8" - 12	1.125	28.575	2.117	12	26.5
1 1/4" - 12	1.25	31.75	2.117	12	29.5
1 3/8" - 12	1.375	34.925	2.117	12	32.75
1 1/2" - 12	1.5	38.1	2.117	12	36

Dimensions in mm unless otherwise stated

UNEF Unified Extra Fine Thread Chart

Nominal Diameter (Inch)	Major Diameter (Inch)	Major Diameter	Pitch	Threads per inch (TPI)	Tap Drill Diameter
12 - 80	0.216	5.486	0.794	32	4.8
1/4" - 32	0.25	6.35	0.794	32	5.7
5/16" - 32	0.313	7.938	0.794	32	7.25
3/8" - 32	0.375	9.525	0.794	32	8.85
7/16" - 28	0.438	11.112	0.907	28	10.35
1/2" - 28	0.5	12.7	0.907	28	11.8
9/16" - 24	0.563	14.288	1.058	24	13.4
5/8" - 24	0.625	15.875	1.058	24	15
11/16" - 24	0.688	17.462	1.058	24	16.6
3/4" - 20	0.75	19.05	1.27	20	18
13/16" - 20	0.813	20.638	1.27	20	19.6
7/8" - 20	0.875	22.225	1.27	20	21.15
15/16" - 20	0.938	23.812	1.27	20	22.7
1" - 20	1	25.4	1.27	20	24.3
1 1/16" - 18	1.063	26.988	1.411	18	25.8
1 1/8" - 18	1.125	28.575	1.411	18	27.35
1 1/4" - 18	1.25	31.75	1.411	18	30.55
1 5/16" - 18	1.313	33.338	1.411	18	32.1
1 3/8" - 18	1.375	34.925	1.411	18	33.7
1 7/16" - 18	1.438	36.512	1.411	18	35.3
1 1/2" - 18	1.5	38.1	1.411	18	36.9
1 9/16" - 18	1.563	39.688	1.411	18	38.55
1 5/8" - 18	1.625	41.275	1.411	18	40.1
1 11/16" - 18	1.688	42.862	1.411	18	41.6

Dimensions in mm unless otherwise stated

Reamer Drill Size

Reamer Size (mm)	Drill Size (mm)
1	0.85
2	1.85
3	2.85
4	3.85
5	4.85
6	5.75
7	6.75
8	7.75
9	8.75
10	9.75
11	10.75
12	11.75
13	12.75
14	13.75
15	14.75
16	15.75
17	16.75
18	17.75
19	18.75
20	19.75
21	20.7
22	21.75
23	22.75
24	23.75
25	24.75
26	25.75
28	27.75
30	29.75
32	31.75
34	33.5
36	35.5
38	37.5
40	39.5
42	41.5
44	43.5
46	45.5
48	47.5
50	49.5

Abbreviations

Abbreviations

Abbreviation	Definition
AC	across corners
AF	across flats
AFF	above finished floor
AISI	American Iron and Steel Institute
Al or AL	aluminium
ALY	alloy
AMER	American
AMS	Aerospace Material Standards
AN-	Army-Navy
ANN	anneal, annealed
ANSI	American National Standards Institute
APPROX	approximately
AQL	acceptable quality level
AR	as required
AS	Aerospace Standards; Australian Standards
APS	approved product supplier
APV	approved product vendor
ASA	American Standards Association
ASME	American Society of Mechanical Engineers
ASSY or ASY	assembly
ASTM	American Society for Testing and Materials
AVG	average
AWG	American Wire Gauge
BASIC	basic dimension
BC or B.C.	bolt circle
BHCS	button head cap screw
BHN	Brinell hardness number
BoM or BOM	bill of materials
BoP or BOP	bought out part
BP, B/P	blueprint
BRZ	bronze
BSC	basic dimension
CAD	computer-aided design
CAGE	Commercial and Government Entity
C-C or C-TO-C	centre-to-centre; on centres
CBN	cubic boron nitride
CDA	current design activity
CERT or cert	certification
CG	centerless ground, centerless grinding
CH	chamfer
CHAM	chamfer
CI	cast iron

Abbreviations

Abbreviation	Definition
CL or ¢	center line
CNC	computer numerical control
CR	controlled radius
CRES	corrosion-resistant
CRS	cold rolled steel; on centres
C/T	Correlation / Tracking
C'BORE or CBORE	counterbore
CSK or CSINK	countersink
CTN, ctn	carton
Ø	diameter
D	diameter; delta
DIA	diameter
DIP	ductile iron pipe
DIM	dimension, dimensioning
DO, do	ditto
DOD, DoD	[U.S.] Department of Defense
DPD	digital product definition
DWG, dwg	drawing
ED	edge distance
EO, ECO, ECN	engineering order
EQ	equal, equally
ERC	electrical rule check
f	finish
FAO	finish all over
FCF	feature control frame
FD or F/D	field of the drawing
FIM	full indicator movement
FL	flag note, flagnote
FL	Floor Level
FN or F/N	flag note, flagnote; find number
FoS	feature of size
FS	far side
FSCM	Federal Stock/Supply Code for Manufacturers
FTG	fitting
GCI	gray cast iron
GD&T or GDT	geometric dimensioning and tolerancing
GN or G/N	general note
HBW	hardness, Brinell, tungsten tip
HHCS	hex head cap screw
HRA	hardness, Rockwell, A scale
HRB	hardness, Rockwell, B scale
HRC	hardness, Rockwell, C scale

Abbreviations

Abbreviation	Definition
HRC	hardness, Rockwell, C scale
HRS	hot rolled steel
HT TR	heat treat, heat treatment
H&T or H/T or HT	hardened and tempered
IAW	in accordance with
ID	inner diameter; identity, identification number
IED	Insufficient Edge Distance
ISO	International Organization for Standardization
KEY	key
KPSI, kpsi	kilopounds per square inch
KSI, ksi	kilopounds per square inch
LDD	Limited Dimension Drawing
LH	left-hand
LM or L/M	list of materials
LMC	least material condition
MACH	machine; machined
MAJ	major
MAX	maximum
MBD	model-based definition
MBP	measurement between pins
MBW	measurement between wires
MF or M/F	make from
MFD	manufactured
MFG	manufacturing
MFR	manufacturer
MIL-	[U.S.] Military
MIN	minimum; minutes; minor
MMC	maximum material condition
MOD, MoD	Ministry of Defence [U.K. and others]
MOP, MoP	measurement over pins
MOW, MoW	measurement over wires
MPa, MPA	megapascals
MRB	material review board
MS-	[U.S.] Military Standard
NAS	National Aerospace Standards
NC	National Coarse; numerical control
NCM	nonconforming material
NCR	nonconformance report
NEC	not elsewhere classified; National Electrical Code
NEF	National Extra Fine
NF	National Fine
NL or N/L	notes list

Abbreviations

Abbreviation	Definition
NOM	nominal
NORM or NORMD	normalized
NPS	Naval Primary Standard
NPT	National Pipe Taper
NS	National Special; near side
NSCM	National Stock/Supply Code for Manufacturers
N&T or N/T or NT	normalized and tempered
NTS	not to scale
OAL	overall length
OC	on center
OD	outer diameter
ODA	original design activity
OHL	over high limit
OPP	opposite
ORIG	original
pc, pcs	piece, pieces
PD	pitch diameter
PDM	product data management
PH or P/H	precipitation hardening / pilot hole
PHR BRZ	phosphor bronze
PL or P/L	parts list
PLM	product lifecycle management
PN or P/N	part number
POI	point of intersection
P.F.	press fit
PSI	pounds per square inch
PTFE	polytetrafluoroethylene
PVC	polyvinyl chloride
QMS	quality management system
QTY or qty	quantity
R	radius
RA, Ra	roughness, average; Rockwell A scale
RB, Rb	Rockwell B scale
RC, Rc	Rockwell C scale
REF	reference
REQD or REQ'D	required
REV	revision
RFS	regardless of feature size
RH	right-hand
RHR	roughness height reading
RL	Reduced Level or Relative Level
RMA	return material authorization

Abbreviations

Abbreviation	Definition
RMS	root mean square
RT or R/T	rough turn, rough turned; room temperature
RTP	release to production
RTV	room-temperature vulcanizing; return to vendor
RZ, Rz	roughness, mean depth
SAE	Society of Automotive Engineers
SC or S/C	sharp corners
SF or S/F	spotface
SFACE or S/FACE	spotface
SHCS	socket head cap screw
SHN	shown
SHSS	socket head set screw
SI	Système international
SN or S/N	serial number
SOL ANN	solution anneal, solution annealed
SPEC or spec	specification
SPHER ANN	spheroidize anneal
SPOTFACE	Spot facing
SR	spherical radius
SS or S/S	stainless steel
SST	stainless steel
STD	Standard
STEP	Standard for the Exchange of Product Model Data
STA	solution treated and aged
STI	screw thread insert
STL	steel
STK	stock
TAP	Tapped hole
TB or T/B	title block
TDP	technical data package
THD or thd	thread
THK or thk	thickness
THRU	Through
THRU ALL	Through all
TIR	total indicator reading; total indicated run-out
TOL	tolerance, tolerancing
TSC	theoretical sharp corner
TY	type
TYP	Typical
UAI	use as-is
ULL	under low limit
UNC	Unified National Coarse

Abbreviations

Abbreviation	Definition
UNEF	Unified National Extra Fine
UNF	Unified National Fine
UNJC	Unified National "J" series Coarse
UNJF	Unified National "J" series Fine
UNO	unless noted otherwise
UNS	Unified National Special
UON	unless otherwise noted
UOS	unless otherwise specified
USASI	United States of America Standards Institute
USS	United States Standard; United States Steel
UTS	ultimate tensile strength; Unified Thread Standard
v	finish
WC	tungsten carbide
WI	wrought iron
W/I, w/i	within
W/O, w/o	without
X	used to indicate the word "by"
YS	yield strength

CNC Programming Reference

G Code Reference

G Code	Function	G Code	Function
G00	Positioning at rapid travel;	G58	Set Datum;
G01	Linear interpolation using a feed rate;	G59	Set Datum;
G02	Circular interpolation clockwise;	G70	Finish cycle (Lathe);
G03	Circular interpolation, counterclockwise;	G71	Rough turning cycle (Lathe);
G04	Dwell	G72	Rough facing cycle (Lathe);
G17	Select X-Y plane;	G73	Chip break drilling cycle;
G18	Select Z-X plane;	G74	Left hand tapping Mill);(
G19	Select Z-Y plane;	G74	Face grooving cycle;
G20	Imperial units;	G75	OD groove pecking cycle (Lathe);
G21	Metric units;	G76	Boring cycle (Mill);
G27	Reference return check;	G76	Screw cutting cycle (Lathe);
G28	Automatic return through reference point;	G80	Cancel cycles;
G29	Move to a location through reference point;	G81	Drill cycle;
G31	Skip function;	G82	Drill cycle with dwell;
G32	Thread cutting operation on a Lathe;	G83	Peck drilling cycle;
G33	Thread cutting operation on a Mill;	G84	Tapping cycle;
G40	Cancel cutter compensation;	G85	Bore in, bore out;
G41	Cutter compensation left;	G86	Bore in, rapid out;
G42	Cutter compensation right;	G87	Back boring cycle;
G43	Tool length compensation;	G90	Absolute programming;
G44	Tool length compensation;	G91	Incremental programming;
G50	Set coordinate system (Mill);	G92	Reposition origin point (Mill);
G50	Maximum RPM (Lathe);	G92	Screw thread cutting cycle (Lathe);
G52	Local coordinate system setting;	G94	Per minute feed;
G53	Machine coordinate system setting;	G95	Per revolution feed;
G54	Set Datum;	G96	Constant surface speed (Lathe);
G55	Set Datum;	G97	Constant surface speed cancel;
G56	Set Datum;	G98	Feed per minute (Lathe);
G57	Set Datum;	G99	Feed per revolution (Lathe);

M Code Reference

M Code	Function
M00	Program stop
M01	Optional program stop
M03	Spindle on clockwise
M04	Spindle on counterclockwise
M05	Spindle off
M06	Tool change
M08	Coolant on
M09	Coolant off
M30	Program end, return to start

Auxiliary Commands

Address	Function	Description
O	Program Number	4 digit number to define the program used for storage and identification in machine memory
N	Block Number	Block Numbers are used for search both manually and automatically
G	G Code	Machine control function. For a full list of G Codes refer to the G Code list page
M	M Code	Auxiliary machine control function. For a full list of M Codes refer to the M Code list page
X,Y,Z,U,V,W	Coordinates	Axis positional commands using the Cartesian coordinate system
R	Radial Coordinates	Defines the radii for corners and arcs
I,J,K	Centre point Coordinates	Defines the centre point of arcs and radius
S	Spindle Speed	Defines the spindle speed in RPM or if in surface speed mode the feet per min of surface of material
F	Feed Rate	Defines the motion speed of the tool
T	Tool	Defines the tool number and offset number i.e. T0101
I,K,P,Q,R	Cycle Definitions	Used within canned cycles with various functions. Refer to the section on cycles for uses.

G Code Canned Cycles Turning

G Code Cycles Lathe Reference

G70

Finishing Cycle

G70 P Q;

P = start of the contour

Q = end of the contour

Example:

```
G00 X70.0 Z2.0;  
G42;  
G70 P100 Q200;  
G00 X70.0 Z5.0;  
G53 X0.0 Z-210.0 M09;  
G40 M05;
```


G Code Cycles Lathe Reference

G71

Roughing Cycle

G71 U R;

G71 P Q U W F;

U = Depth of cut

R = Retract value

P = Sequence number for the start of the program contour

Q = Sequence number for the end of the program contour

U = Finishing allowance in X

W = Finishing allowance in Z

F = Feed rate

Example:

```
G71 U1.0 R1.0;  
G71 P100 Q200 U0.2 W.05 F0.2;  
N100 G00 X19.0;  
G01 G42 Z0.0 F0.2;  
Z-65.0 ,R5.0;  
X60.0;  
N200 G40 X70.0 Z5.0 F200;
```

G Code Cycles Lathe Reference

G72

Facing Cycle

G72 W(1) R;
G72 P Q U W(2) F;

W(1) = Depth of cut

R = Retract amount

P = Sequence number for the start of the program contour

Q = Sequence number for the end of the program contour

U = Finishing allowance in X

W(2) = Finishing allowance in Z

F = Feed rate

Example:

```
G72 W1000 R100;  
G72 P100 Q200 U0.03 W0.03 F0.01;  
N100 G00 Z-0.2 S500 P11;  
G01 X3.0 F0.01;  
X2.0 Z-0.5;  
Z-0.1;  
X0.5;  
N200 X0.0;
```

G Code Cycles Lathe Reference

G73

Pattern Repeating Cycle

G73 U(1) W(1) R;
G73 P Q U(2) W(2) F;

U(1) = Amount of material to be machined on the X-axis.

W(1) = Amount of material to be machined on the Z-axis

R = Amount of roughing passes

P = Sequence number for the beginning of the contour

Q = Sequence number for the end of the contour

U 2) = Finish allowance on the X-axis.

W 2)= Finish allowance on Z-axis

F = Feed rate.

Example:

```
G73 U0.5 W0.2 R0.03;  
G73 P100 Q200 U0.4 W0.01 F0.01;  
N100 G00 X1.0 S1000 P11;  
G01 Z-0.4 F0.01;  
X2.0 Z-1.0;  
Z-1.5;  
N200 X4.0;
```

G Code Cycles Lathe Reference

G74

Peck Drilling Cycle

G74 Z R Q F;

Z = Total depth of hole

R = Retract amount after each peck

Q = Depth of each peck (no decimal point)

F = Feed rate

Example:

```
G74 Z-2. R500 Q2000 F.007;  
G0 X40.0 Z50.0 ;
```

G Code Cycles Lathe Reference

G75

Peck Grooving Cycle

G75 X Z P Q F;

X = Depth of groove (dia)
Z = Distance to groove from datum
P = Depth of peck
Q = Step over amount on the Z axis
F = Feed rate

Example:

```
G00 X3.0 Z-6.0;  
G75 X2.0 Z-1.0 P0.1 Q0.15 F.002;  
G00 X10.0 Z12.0;
```

G Code Cycles Lathe Reference

G76

Screw Thread Cycle (Single Line)

G76 X Z I K D A F;

X = Core diameter of the thread

Z = End position of the thread

I = Taper

K = Depth of thread

D = Depth of first pass

A = Tool nose angle

F = Pitch of Thread

Example:

```
G97 S400 M03;
```

```
G00 X20.0 Z5.0 M08;
```

```
G76 X18.2 Z-18.0 I-.01 K900 D100 A60 F1.5;
```

```
G00 X25.0 Z10.0;
```

G Code Cycles Lathe Reference

G76**Screw Thread Cycle (Double Line)****G76 P (1) (2) (3) Q R;****G76 X Z P Q R F;**

P is a six digit character, two digits each for (1), (2) and (3)

(1) = number of finishing passes

(2) = chamfering amount

(3) = included angle of the tool tip

Q = Minimum cutting depth

R = Finishing allowance

X = Minor Diameter of the thread

Z = End position of the thread

P = Depth of thread

Q = Depth of first pass

R = Taper

F = Pitch

Example:

```
G00 X20.0 Z5.0 M08;
```

```
G76 P040060 Q100 R.02;
```

```
G76 X18.2 Z-18.0 P180 Q160 F1.5;
```

```
G00 X25.0 Z10.0;
```

G Code Cycles Lathe Reference

G83

Z-axis Peck Drilling Cycle

G83 Z Q R P F;

Z = Depth of hole

Q = Peck distance

R = Distance from initial point

P = Dwell time at bottom of hole (milliseconds)

F = Feed rate

Example:

```
Z1.0;
```

```
G83 Z-50.0 P500 Q2000 P1000 F0.08;
```

```
G80;
```


G Code Cycles Lathe Reference

G84

Z-axis Tapping Cycle

G84 Z Q R F;

Z = Depth of hole

Q = Peck distance

R = Distance from initial point

F = Feed rate

Example:

X0;

G84 Z-5.0 Q2000 R1000 F0.0625;

G80 G0 X5.0;

G Code Cycles Lathe Reference

G87

X-axis Peck Drilling Cycle

G87 X R Q P F;

X = Depth of hole

R = Retract Value

Q = Peck distance

P = Dwell time at bottom of hole (milliseconds)

F = Pitch

Example:

X42.0;

G87 X-19.5 R-5.0 P1000 Q2000 F30;

G80;

G Code Cycles Lathe Reference

G88

X-axis Tapping Cycle

G88 X R Q P F;

X = Depth of hole

R = Retract Value

Q = Peck distance

P = Dwell time at bottom of hole (milliseconds)

F = Pitch

Example:

X42.0;

G88 Z-48.0 C90.0 X30.0 R42.0 P200 S100 F1.0;

G80;

G Code Canned Cycles Milling

G Code Cycles Mill Reference

G81

Drilling Cycle

G81 X Y Z Q R F;

X = Rapid X-axis command (optional)
Y = Rapid Y-axis command (optional)
Z = Depth of hole
Q = Peck distance
R = Rapid position
F = Feed Rate

Example:

```
G43 Z2.0;  
G81 Z-0.5 R0.15 F10.0;  
X1.5 Y1.5;  
G80 G00 Z2.0;
```

G Code Cycles Mill Reference

G82

Counter bore Cycle

G82 (X) (Y) Z P R F;

X = Rapid X-axis command (optional)

Y = Rapid Y-axis command (optional)

Z = Depth of hole

P = Dwell at bottom of hole

R = Rapid position

F = Feed Rate

Example:

```
G43 Z2.0;
```

```
G82 Z-0.5 P1.0 R0.15 F10.0;
```

```
X2.0 Y2.0;
```

```
G80 G00 Z2.0;
```

G Code Cycles Mill Reference

G83

Deep Hole Peck Drilling Cycle

G83 (X) (Y) Z Q (I) (J) (K) P R F;

X = Rapid X-axis command (optional)

Y = Rapid Y-axis command (optional)

Z = Depth of hole

Q = Peck amount (incremental)

I = Depth of first cut (optional)

J = Amount to reduce cutting depth each peck (optional)

K = Minimum depth of cut (optional)

P = Dwell at bottom of hole

R = Rapid position

F = Feed Rate

Example:

```
G43 Z2.0;
```

```
G83 Z-2.5 I0.5 J0.1 K0.2 R0.1 F10.0;
```

```
X2.0 Y2.0;
```

```
G80 G00 Z2.0;
```

G Code Cycles Mill Reference

G84

Tapping Cycle

G84 Z R F;

Z = Depth of thread

R = Rapid position

F = Pitch

Example:

```
G00 Z2.0;  
G84 Z-5.0 R1.0 F36.0;  
X2.0 Y2.0;  
G80 G00 Z2.0;
```


G Code Cycles Mill Reference

G85

Bore in / Bore out Cycle

G85 Z R F K;

Z = Boring depth
R = Rapid position
F = feed rate
K = Number of repeats

Example:

```
G43 Z2.0;  
G85 Z-5.0 R1.0 F10.0;  
X2.0 Y2.0;  
G80 G00 Z2.0;
```

G Code Cycles Mill Reference

G86

Bore in / Rapid out Cycle

G86 Z R F K;

Z = Boring depth

R = Rapid position

F = feed rate

K = Number of repeats

Example:

```
G43 Z2.0;
```

```
G86 Z-5.0 R1.0 F10.0;
```

```
X2.0 Y2.0;
```

```
G80 G00 Z2.0;
```

Calculations

Speeds and Feeds Calculations

Cutting Speed $V_c = \frac{\pi \times D \times n}{1000}$

Spindle Speed $n = V_c \div \pi \div D \times 1000$

Feed $V_f = n \times f_z \times Z$

Feed per Tooth $f_z = \frac{V_f}{n \times Z}$

V_c = Cutting Speed (m/min)

V_f = Feed (mm/min)

π = Pi (3.14159)

f_z = Feed per Tooth (mm/Tooth)

D = Diameter (mm)

Z = Number of Flutes

n = Spindle Speed (min^{-1})

Tapping Drill Calculations

Tap Drill Size

Major Diameter - Pitch

Drill Size
(mm)Major Diameter - $\frac{\text{Pitch} \times \% \text{ of Full Thread}}{76.98}$ Drill Size
(inch)Major Diameter - $\frac{0.01299 \times \% \text{ of Full Thread}}{\text{TPI}}$

Form Tap Drill Size

Major Diameter - $\frac{\text{Pitch}}{2}$ Form Tap Drill Size
(inch)Major Diameter - $\frac{0.0068 \times \% \text{ of Full Thread}}{\text{Number of TPI}}$ Form Tap Drill Size
(mm)Major Diameter - $\frac{\text{Pitch} \times \% \text{ of Full Thread}}{147.06}$

Trigonometry Calculations

$$a = c \sin A$$

$$a = c \cos B$$

$$a = b \tan A$$

$$a = b \cot B$$

$$b = c \cos A$$

$$b = c \sin B$$

$$b = a \cot A$$

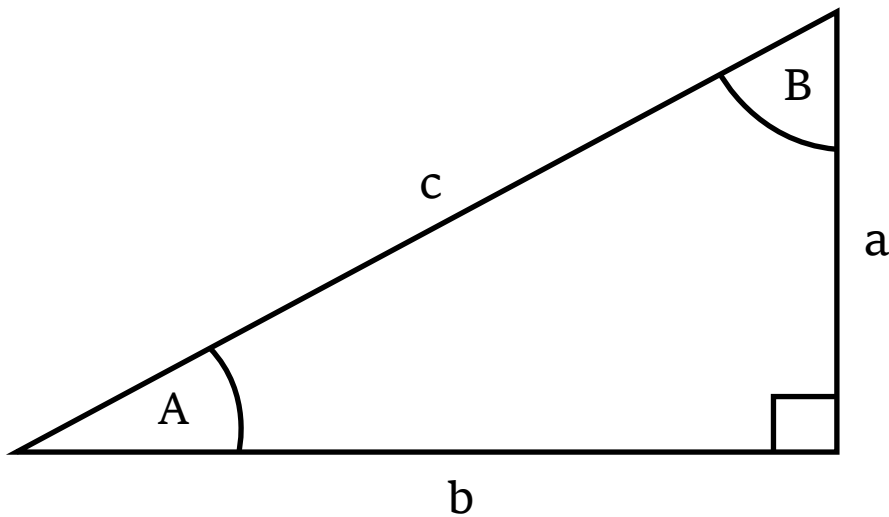
$$b = a \tan B$$

$$c = b \sec A$$

$$c = a \sec B$$

$$c = a \csc A$$

$$c = b \csc B$$



$$\sin A = \frac{a}{c}$$

$$\sin B = \frac{b}{c}$$

$$\cos A = \frac{b}{c}$$

$$\cos B = \frac{a}{c}$$

$$\tan A = \frac{a}{b}$$

$$\tan B = \frac{b}{a}$$

$$\cot A = \frac{b}{a}$$

$$\cot B = \frac{a}{b}$$

$$\sec A = \frac{c}{b}$$

$$\sec B = \frac{c}{a}$$

$$\csc A = \frac{c}{a}$$

$$\csc B = \frac{c}{b}$$

Trigonometry Charts

Angle	Sine	Cosine	Tangent
0°	0	1	0
1°	0.01745	0.99985	0.01746
2°	0.0349	0.99939	0.03492
3°	0.05234	0.99863	0.05241
4°	0.06976	0.99756	0.06993
5°	0.08716	0.99619	0.08749
6°	0.10453	0.99452	0.1051
7°	0.12187	0.99255	0.12278
8°	0.13917	0.99027	0.14054
9°	0.15643	0.98769	0.15838
10°	0.17365	0.98481	0.17633
11°	0.19081	0.98163	0.19438
12°	0.20791	0.97815	0.21256
13°	0.22495	0.97437	0.23087
14°	0.24192	0.9703	0.24933
15°	0.25882	0.96593	0.26795
16°	0.27564	0.96126	0.28675
17°	0.29237	0.9563	0.30573
18°	0.30902	0.95106	0.32492
19°	0.32557	0.94552	0.34433
20°	0.34202	0.93969	0.36397
21°	0.35837	0.93358	0.38386
22°	0.37461	0.92718	0.40403
23°	0.39073	0.9205	0.42447
24°	0.40674	0.91355	0.44523
25°	0.42262	0.90631	0.46631
26°	0.43837	0.89879	0.48773
27°	0.45399	0.89101	0.50953
28°	0.46947	0.88295	0.53171
29°	0.48481	0.87462	0.55431
30°	0.5	0.86603	0.57735

Trigonometry Charts

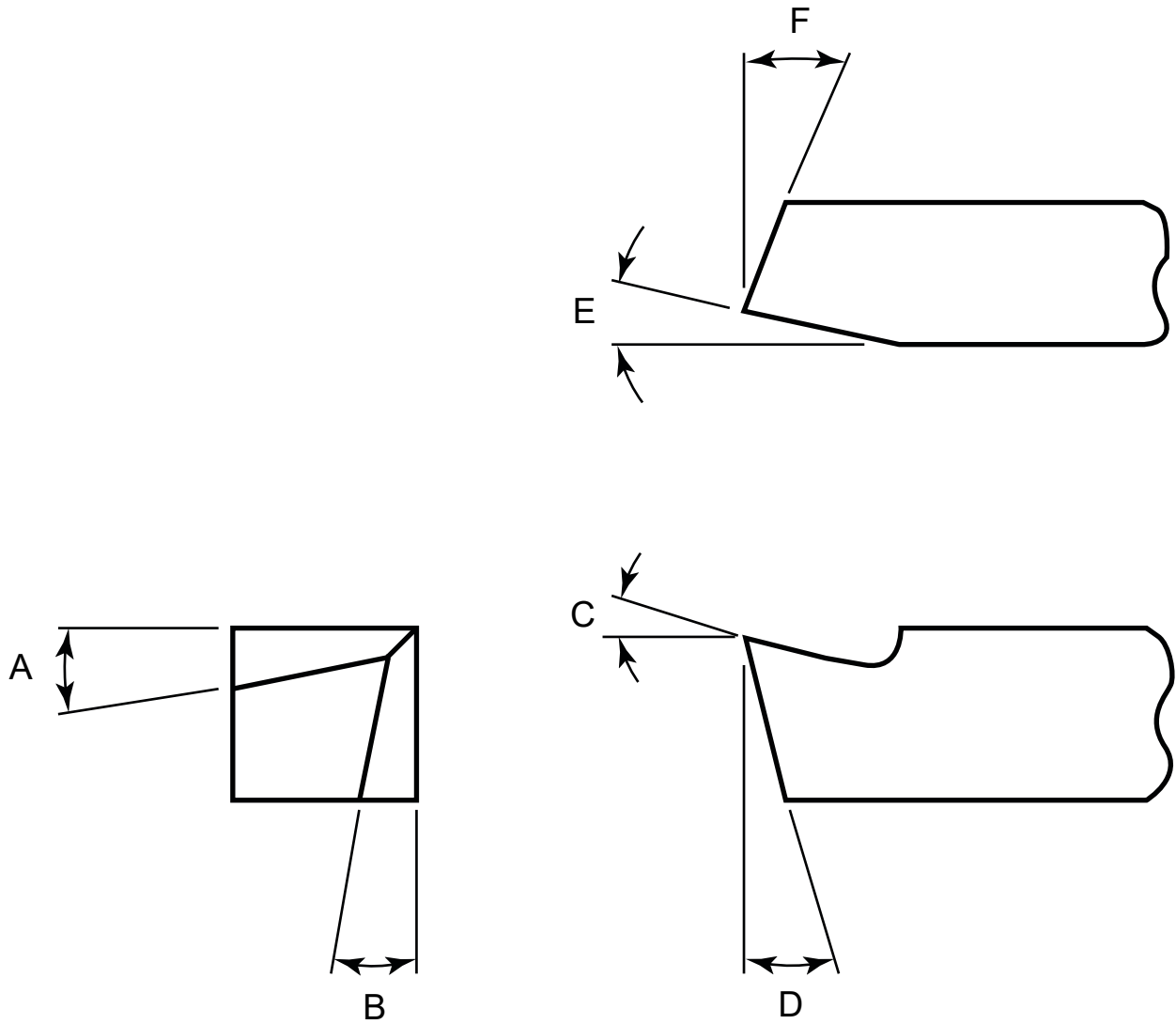
Angle	Sine	Cosine	Tangent
31°	0.51504	0.85717	0.60086
32°	0.52992	0.84805	0.62487
33°	0.54464	0.83867	0.64941
34°	0.55919	0.82904	0.67451
35°	0.57358	0.81915	0.70021
36°	0.58779	0.80902	0.72654
37°	0.60182	0.79864	0.75355
38°	0.61566	0.78801	0.78129
39°	0.62932	0.77715	0.80978
40°	0.64279	0.76604	0.8391
41°	0.65606	0.75471	0.86929
42°	0.66913	0.74314	0.9004
43°	0.682	0.73135	0.93252
44°	0.69466	0.71934	0.96569
45°	0.70711	0.70711	1
46°	0.71934	0.69466	1.03553
47°	0.73135	0.682	1.07237
48°	0.74314	0.66913	1.11061
49°	0.75471	0.65606	1.15037
50°	0.76604	0.64279	1.19175
51°	0.77715	0.62932	1.2349
52°	0.78801	0.61566	1.27994
53°	0.79864	0.60182	1.32704
54°	0.80902	0.58779	1.37638
55°	0.81915	0.57358	1.42815
56°	0.82904	0.55919	1.48256
57°	0.83867	0.54464	1.53986
58°	0.84805	0.52992	1.60033
59°	0.85717	0.51504	1.66428
60°	0.86603	0.5	1.73205

Trigonometry Charts

Angle	Sine	Cosine	Tangent
61°	0.87462	0.48481	1.80405
62°	0.88295	0.46947	1.88073
63°	0.89101	0.45399	1.96261
64°	0.89879	0.43837	2.0503
65°	0.90631	0.42262	2.14451
66°	0.91355	0.40674	2.24604
67°	0.9205	0.39073	2.35585
68°	0.92718	0.37461	2.47509
69°	0.93358	0.35837	2.60509
70°	0.93969	0.34202	2.74748
71°	0.94552	0.32557	2.90421
72°	0.95106	0.30902	3.07768
73°	0.9563	0.29237	3.27085
74°	0.96126	0.27564	3.48741
75°	0.96593	0.25882	3.73205
76°	0.9703	0.24192	4.01078
77°	0.97437	0.22495	4.33148
78°	0.97815	0.20791	4.70463
79°	0.98163	0.19081	5.14455
80°	0.98481	0.17365	5.67128
81°	0.98769	0.15643	6.31375
82°	0.99027	0.13917	7.11537
83°	0.99255	0.12187	8.14435
84°	0.99452	0.10453	9.51436
85°	0.99619	0.08716	11.43005
86°	0.99756	0.06976	14.30067
87°	0.99863	0.05234	19.08114
88°	0.99939	0.0349	28.63625
89°	0.99985	0.01745	57.28996
90°	1	0	Undefined

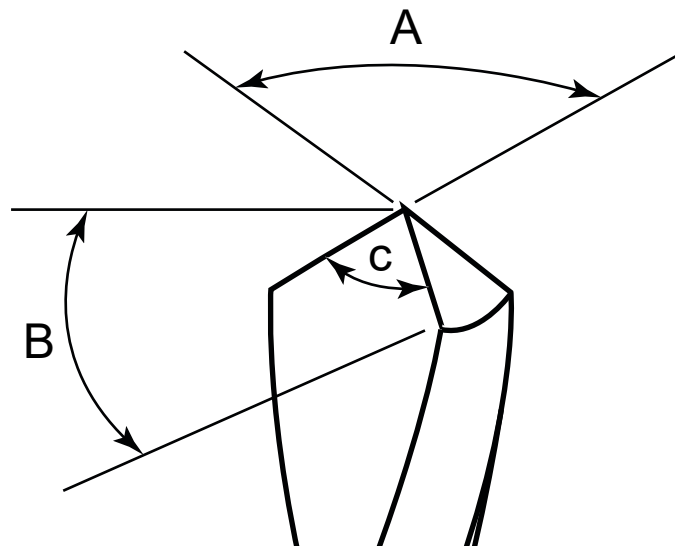
Tool Geometry

RH Knife Tool Geometry



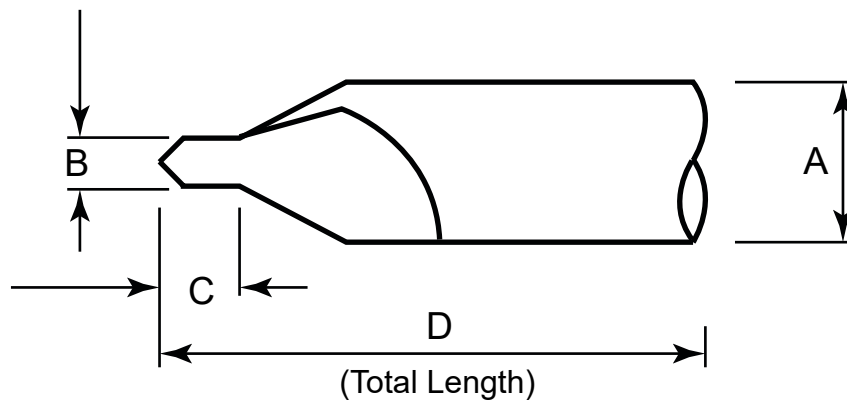
Material	A Side Rake	B Side Relief	C Back Rake	D End Relief	E Side Cut	F End Cut
Steel	15	12	12	8	15	17
Stainless Steel	17	10	8	8	15	17
Tool Steel	12	10	8	8	15	17
Cast Iron	12	10	5	8	15	17
Aluminum	16	12	35	8	15	17
Brass	2	10	0	8	15	17
Bronze	2	10	0	8	15	17
Copper	20	12	16	10	15	17

Drill Geometry



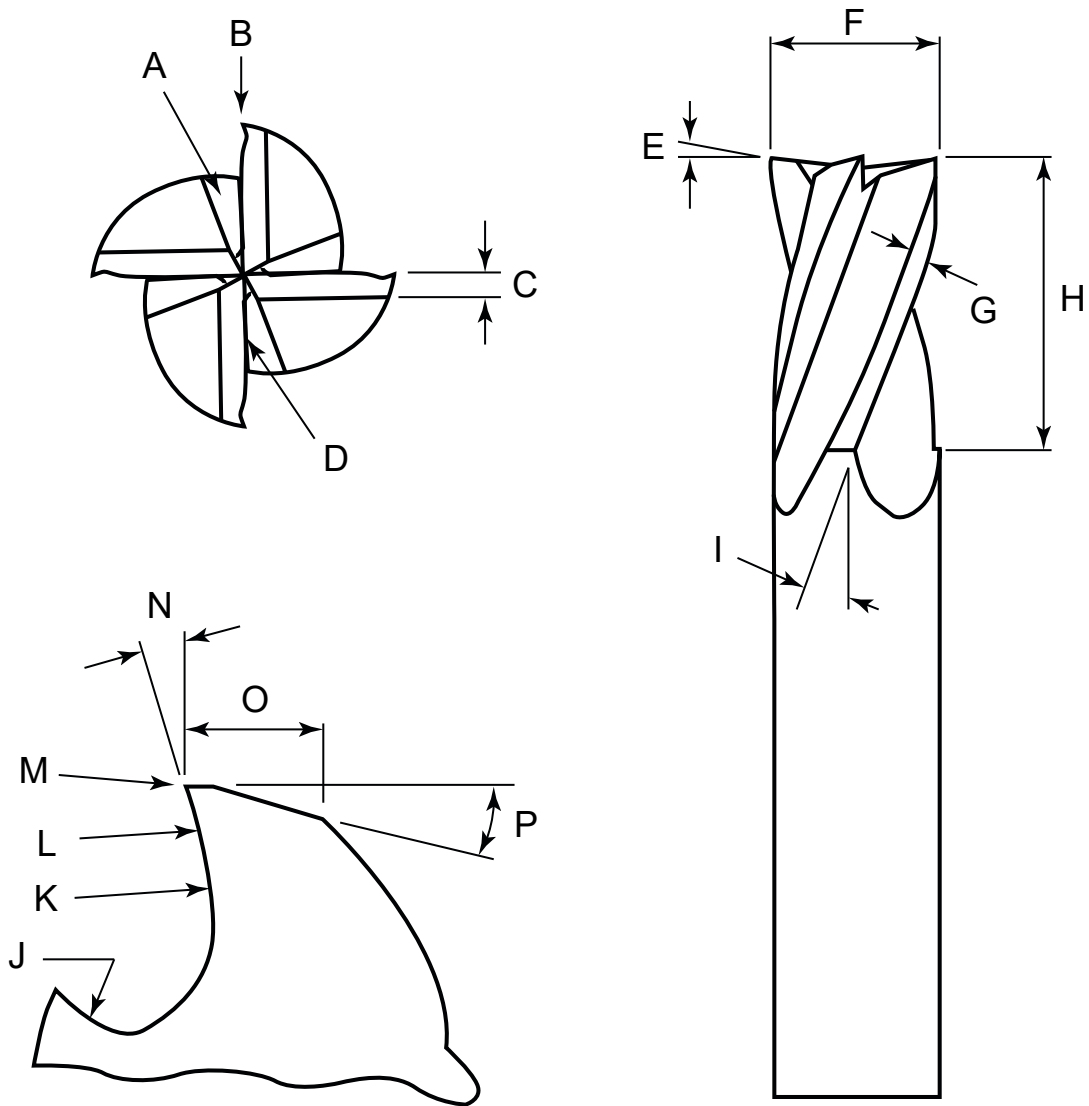
Material	A (deg)	B (deg)	C (deg)
Copper	100	12	50
Soft Brass and Bronzes	118	15	59
Hard Brass	100	15	50
Mild Steel	118	12	59
cast irons	90	12	45
Manganese steel	135	9	67.5
aluminum	118	12	59
Soft Aluminum	100	15	50
hard alloys	135	10	59
plastics	118	12	59
Bakelite	90	15	45
Wood	90	12	45
Fiber	90	12	45
hard rubber	90	15	45
Heat-treated steels	125	12	62.5

Centre Drill Geometry



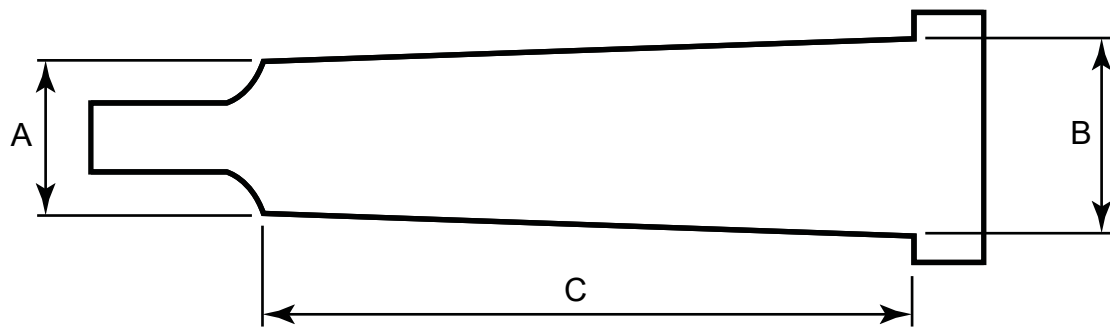
Size	A (inches)	A (mm)	B (inches)	B (mm)	C (Inches)	C (mm)	D (inches)	D (mm)
1	0.125	3.175	0.0468	1.18872	0.0468	1.18872	1.25	31.75
2	0.1875	4.7625	0.0781	1.98374	0.781	19.8374	1.875	47.625
3	0.25	6.35	0.1093	2.77622	0.1093	2.77622	2	50.8
4	0.3125	7.9375	0.125	3.175	0.125	3.175	2.125	53.975
5	0.4375	11.1125	0.1875	4.7625	0.1875	4.7625	2.75	69.85
6	0.5	12.7	0.2187	5.55498	0.2187	5.55498	3	76.2

End Mill Geometry



A	Rake Angle	I	Helix Angle
B	End Tooth	J	Gulet
C	Land	K	Flute
D	End Cutting Edge	L	Rake
E	Dish Angle	M	Cutting Edge
F	Cutting Diameter	N	Radial Rake
G	Primary Land	O	Land
H	Length of Cut	P	Secondary Relief

Morse Taper Geometry



Code	A inches	A millimeters	B inches	B millimeters	C inches	C millimeters
1 morse taper	0.475	12.065	0.369	9.373	2.13	54.1
2 morse taper	0.7	17.78	0.572	14.529	2.56	65.02
3 morse taper	0.938	23.825	0.778	19.761	3.19	81.06
4 morse taper	1.231	31.267	1.02	25.908	4.06	103.12
5 morse taper	1.748	44.399	1.475	37.465	5.19	131.83
6 morse taper	2.494	63.348	2.116	53.746	7.25	184.15

Afterword

For over 26 years I worked as a machinist. During that time I had a toolbox with more paper-work than I had measuring equipment.

Not only do I need charts for every kind of standard and conversion you could think of, but also bits of paper with scribbled notes on how to use cycles on CNC machines that I have not needed to program for years.

I have a few handbooks thrown in for good measure but none of them contained everything I needed.

Then the mobile phone became popular, so I started collecting my notes on my phone as all the information I needed took up a lot less space and was easier to find while rushing to get that part finished before my boss exploded.

I was always trying to arrange my notes and charts in a way that I could retrieve them quickly instead of emptying my toolbox or appear like I was playing on my phone instead of working.

That's when the idea hit me, what if someone made a handbook with everything I needed? What if someone made it available as an ebook and as a standard book for the times when I was working in factory's that didn't allow mobile phones on the shop floor.

For years I longed for such a book.

I waited for someone to make it, there are engineering books out there but they were not aimed at machinists and either contained too much information that was irreverent to my role or not the information that I needed.

I don't need a book to contain crack detection or stress and strain graphs. I needed a book that was written for machinists by a machinist.

No one made that book so I did.

I hope you find it as useful as I do.

- Marc Cronin

For more machinist tuition please visit my website:

<http://GCodeTutor.com>