ENGINEERS AND MACHINISTS

REFERENCE TABLES

Compiled for

FITTERS · DRAUGHTSMEN · APPRENTICES · TURNERS · TOOLMAKERS · INSPECTORS & Production Engineers

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ENGINEERS and MACHINISTS

Reference Tables

by

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CONTENTS

BA THREADS (British Association)

Dimensions in inches except where marked

BA No.	Threads per inch	Outside Dia	Core Dia	Pitch	Depth	Radius	Tapping Drill	Clearance Drill
0	25.38	.2362	.1890	.0394	.0236	.0072	5.1 mm	1/4"
1	28.25	.2087	.1663	.0354	.0212	.0064	4.5 mm	5.5 mm
2	31.36	.1850	.1468	.0319	.0191	.0058	4.0 mm	4.9 mm
3	34.84	1614	.1272	.0287	.0172	.0052	3.4 mm	11/64"
4	38.46	.1417	.1105	.0260	.0156	.0047	3.0 mm	3.8 mm
5	43.10	.1260	.0980	.0232	.0139	.0042	2.65 mm	3.4 mm
6	47.85	1102	.0852	.0209	.0125	.0038	2.3 mm	3.0 mm
7	52.91	.0984	.0758	.0189	.0113	.0034	2.05 mm	2.7 mm
8	59.17	.0866	.0664	.0169	.0101	.0031	1.8 mm	3/32"
9	64.94	.0748	.0564	.0154	.0092	.0028	1.65 mm	2.1 mm
10	72.46	.0669	.0503	.0138	.0083	.0025	1.4 mm	1.8 mm
11	81.97	.0591	.0445	.0122	.0073	.0022	1.2 mm	1/16"
12	90.91	.0511	.0375	.0110	.0066	.0020	1.05 mm	1.45 mm
13	102.0	.0472	.0354	.0098	.0059	.0018	.98 mm	1.3 mm
14	109.9	.0394	.0284	.0091	.0055	.0016	1/32"	1.1 mm
15	120.5	.0354	.0254	.0083	.0050	.0015	.7 mm	98 mm
16	133.3	.0311	.0221	.0075	.0045	.0014	.6 mm	88 mm
17	149.3	.0276	.0196	.0067	.0040	.0012	.5 mm	.78 mm
18	169.5	.0244	.0174	.0059	.0035	.0011	.45 mm	.68 mm
19	181.8	.0213	.0147	.0055	.0033	.0010	1/64"	.62 mm
20	212.8	.0189	.0133	.0047	.0028	.0009	.35 mm	.55 mm
21	232.6	.0165	.0113	.0043	.0026	.0008	.32 mm	.5 mm
22	256.4	.0146	.0100	.0039	.0023	.0007	.28 mm	.45 mm
23	285.7	.0130	.0088	.0035	.0021	.0006	.25 mm	.38 mm
24	323.6	0114	.0076	.0031	.0019	.0006	.22 mm	.35 mm

B.S.W. THREADS (British Standard Whitworth)

Dia	Outside Dia	Core Dia	Threads per inch	Pitch	Depth	Radius	Tapping Drill	Clearance Drill
1/16"	.0625	.0412	60	.0167	.0107	.0023	1.25 mm	1.85 mm
3/32"	.0937	.067	48	.0283	.0133	.0029	1.95 mm	2.6 mm
1/8"	.125	.093	40	.0250	.016	.0034	2.55 mm	3.5 mm
5/32"	.1562	.1162	32	.03125	.020	0043	1/8"	4.3 mm
3/16"	.1875	.1341	24	.04167	.0267	.0057	3.7 mm	5.1 mm
7/32"	.2187	.1653	24	.04167	.0267	.0057	4.5 mm	5.9 mm
1/4"	.250	.186	20	.0500	.032	.0069	5.1 mm	6.7 mm
5/16"	.3125	.2414	18	.0556	.0356	0076	6.5 mm	8.3 mm
3/8"	.375	.295	16	.0625	.040	0086	5/16"	25/64"
7/16"	.4375	.346	14	.07143	.0457	.0098	9.3 mm	11.5 mm
1/2"	.500	.3933	12	.0833	.0534	.0114	10.5 mm	33/64"
9/16"	.5625	.4558	12	.0833	.0534	.0114	12.1 mm	14.75 mm
5/8"	.625	.5086	11	.0909	.0582	.0125	13.5 mm	16.5 mm
11/10	.6875	.5711	11	.0909	.0582	.0125	15.25 mm	18.0 mm
3/4"	.750	.6219	10	.1000	.0640	.0137	41/64"	19.5 mm
13/16"	.8125	.6844	10	.1000	.0640	.0137	18.0 mm	21.25 mm
7/8"	.875	.7327	9	.1111	.0711	.0153	19.25 mm	22.75 mm
15/16"	.9375	.7952	9	.1111	.0711	.0153	21 mm	24.25 mm
1"	1.000	.8399	8	.125	.0800	.0172	22 mm	1 1/32"
1 1/8"	1.125	.942	7	.1428	.0915	.0196	24.75 mm	1 5/32"
1 1/4"	1.250	1.067	7	.1428	.0915	.0196	1 3/32"	1 9/32"
1 3/8"	1.375	1.1616	6	.1667	.1067	.0229	31 mm	1 13/32"
1 1/2"	1.500	1.2866	6	.1667	.1067	.0229	33.5 mm	1 17/32"
1 5/8"	1.625	1.3689	5	.200	.1281	.0275	36.5 mm	1 21/32"
1 3/4"	1.750	1.4939	5	.200	.1281	.0275	39.0 mm	1 25/32"
1 7/8"	1.875	1.5904	4½	.2222	.1423	.0305	41.5 mm	1 29/32"
2"	2.000	1.7154	4½	.2222	.1423	.0305	44.5 mm	2 1/32"

BRITISH STANDARD CYCLE SCREW THREADS

Size	Threads Per Inch	Outside Dia	Core Dia	Pitch	Depth	Radius	Tapping Drill	Clearance Drill
16	56 RH	.0735	.0545	.0179	.0095	.0030	1.5 mm	2 mm
15	56 RH	.0815	.0625	.0179	.0095	.0030	1.7 mm	2.2 mm
14	56 RH	.0895	.0705	.0179	.0095	.0030	1.9 mm	2.4 mm
13	56 RH	.1015	.0825	.0179	.0095	.0030	2.2 mm	2.7 mm
12	56 RH	.1135	.0945	.0179	.0095	.0030	2.55 mm	3 mm
1/8"	40 RH	.1250	.0984	.0250	.0133	.0041	2.65 mm	3.4 mm
11	44 RH	.1280	.1039	.0227	.0121	.0038	2.8 mm	3.5 mm
10	40 RH	.1413	.1147	.0250	.0133	.0041	3.1 mm	3.8 mm
5/32"	32 RH	.1562	.1231	.0312	.0166	.0052	3.4 mm	4.2 mm
9	40 RH	.1573	.1307	.0250	.0133	.0041	3.5 mm	4.3 mm
8	32 RH	.1766	.1434	.0312	.0166	.0052	3.9 mm	4.7 mm
3/16"	32 RH	.1875	.1543	.0312	.0166	.0052	4.1 mm	5.0 mm
7/32"	26 RH	.2188	.1778	.0385	.0205	.0064	4.8 mm	5.8 mm
1/4"	26 RH	.2500	.2090	.0385	.0205	.0064	5.6 mm	6.6 mm
17/64"	26 RH	.2656	.2246	.0385	.0205	.0064	6.0 mm	7.0 mm
9/32"	26 RH	.2813	.2403	.0385	.0205	.0064	6.4 mm	7.4 mm
5/16"	26 RH	.3125	.2715	.0385	.0205	.0064	7.2 mm	8.3 mm
3/8"	26 RH	.3750	.3340	.0385	.0205	.0064	8.8 mm	9.9 mm
7/16"	26 RH	.4375	.3965	.0385	.0205	.0064	10.4 mm	11.5 mm
7/16"	20 RH	.4375	.3843	.0500	.0266	.0083	10.3 mm	11.5 mm
1/2"	26 RH	.5000	.4590	.0385	.0205	.0064	12.0 mm	33/64"
1/2"	20 RH	.5000	.4468	.0500	.0266	.0083	11.9 mm	33/64"
9/16"	26 RH	.5625	.5215	.0385	.0205	.0064	13.5 mm	37/64"
9/16"	20 RH	.5625	.5093	.0500	.0266	.0083	13.4 mm	37/64"
5/8"	26 RH	.6250	.5840	.0385	.0205	.0064	15.0 mm	41/64"
5/8"	20 RH	.6250	.5719	.0500	.0266	.0083	14.75 mm	41/64"
11/16"	26 RH	.6875	.6464	.0385	.0205	.0064	21/32"	18 mm
11/16"	20 RH	.6875	.6343	.0500	.0266	.0083	16.5 mm	18 mm
3/4"	26 RH	.7500	.7091	.0385	.0205	.0064	23/32"	19.5 mm
3/4"	20 RH	.7500	.6969	.0500	.0266	.0083	18.0 mm	19.5 mm
7/8"	24 RH	.8750	.8306	.0417	.0222	.0070	21.5 mm	23 mm
31/32"	30 RH	.9688	.9332	.0333	.0178	.0055	24 mm	25 mm
1"	24 RH	1.000	.9556	.0417	.0222	.0070	31/32"	26 mm
1 1/8"	26 RH	1.125	1.0840	.0385	.0205	.0064	1 3/32"	29 mm
1.29"	24 LH	1.290	1.2456	.0417	.0222	.0070	32 mm	1 5/16"
1.37"	24 RH	1.370	1.3256	.0417	.0222	.0070	34 mm	35.5 mm
1.37"	24 LH	1.370	1.3256	.0417	.0222	.0070	34 mm	35.5 mm
1.45"	26 RH	1.450	1.4090	.0385	.0205	.0064	1 27/64"	37.5 mm
1.45"	26 LH	1.450	1.4090	.0385	.0205	.0064	1 27/64"	37.5 mm
1 9/16"	24 LH	1.562	1.5181	.0417	.0222	.0070	1 17/32"	1 19/32"
1 5/8"	24 RH	1.625	1.5806	.0417	.0222	.0070	40.5 mm	42 mm

B.S.F. THREADS (British Standard Fine)

Dia	Outside Dia	Core Dia	Threads per inch	Pitch	Depth	Radius	Tapping Drill	Clearance Drill
3/16"	.1875	.1475	32	.03125	.0200	.0037	5/32"	5 mm
7/32"	.2187	.1731	28	.03571	.0229	.0049	4.6 mm	5.7 mm
1/4"	.250	.2007	26	.0385	.0246	.0053	5.3 mm	6.5 mm
9/32"	.2812	.232	26	.0385	.0246	.0053	6.1 mm	7.4 mm
5/16"	.3125	.2543	22	.0454	.0291	.0062	6.8 mm	8.2 mm
3/8"	.375	.3110	20	.050	.0320	.0069	8.3 mm	9.7 mm
7/16"	.4375	.3664	18	.0556	.0356	.0076	9.7 mm	11.4 mm
1/2"	.500	.420	16	.0625	.040	.0086	7/16"	13 mm
9/16"	.5625	.4825	16	.0625	.040	.0086	1/2"	14.5 mm
5/8"	.625	.5335	14	.0714	.0457	.0098	14 mm	41/64"
11/16"	.6875	.596	14	.0714	.0457	.0098	15.75 mm	45/64"
3/4"	.750	.6433	12	.0833	.0534	.0114	16.75 mm	49/64"
13/16"	.8125	.7058	12	.0833	.0534	.0114	18.5 mm	21 mm
7/8"	.875	.7586	11	.0909	.0582	.0125	25/32"	57/64"
1"	1.000	.8719	10	.1000	.064	.0137	22.75 mm	1 1/64"
1 1/8"	1.125	.9827	9	.1111	.0711	.0153	25.5 mm	1 9/64"
1 1/4"	1.250	1.1077	9	.1111	.0711	.0153	1 1/8"	1 17/64"
1 3/8"	1.375	1.2149	8	.125	.080	.0172	31.5 mm	1 25/64"
1 1/2"	1.500	1.3399	8	.125	.080	.0172	1 23/64"	1 33/64"
1 5/8"	1.625	1.4649	8	.125	.080	.0172	1 31/64"	1 41/64"
1 3/4"	1.750	1.567	7	.1425	.0915	.0196	1 39/64"	1 49/64"
2"	2.000	1.817	7	.1425	.0915	.0196	1 27/32"	2 1/32"
2 1/4"	2.250	2.036	6	.1667	.1067	.0229	2 1/16"	2 9/32"
2 1/2"	2.500	2.286	6	.1667	.1067	.0229	2 5/16"	2 17/32"
2 3/4"	2.750	2.536	6	.1667	.1067	.0229	2 9/16"	2 25/32"
3"	3.000	2.743	5	.2000	.1281	.0275	2 25/32"	3 1/32"

METRIC TO DECIMAL INCH EQUIVALENTS

mm	inch	mm	inch	mm	inch	mm	inch
.01	.0004	.32	.0126	.63	.0248	.94	.0370
.02	.0008	.33	.013	.64	.0252	.95	.0374
.03	.0012	.34	.0134	.65	.0256	.96	.0378
.04	.0016	.35	.0138	.66	.0260	.97	.0382
.05	.0020	.36	.0142	.67	.0264	.98	.0386
.06	.0024	.37	.0146	.68	.0268	.99	.0390
.07	.0028	.38	.0150	.69	.0272	1	.0394
.08	.0032	.39	.0154	.70	.0276	2	.0787
.09	.0036	.40	.0158	.71	.0279	3	.1181
.10	.0040	.41	.0162	.72	.0283	4	.1575
.11	.0043	.42	.0166	.73	.0287	5	.1968
.12	.0047	.43	.0169	.74	.0291	6	.2362
.13	.0051	.44	.0173	.75	.0295	7	.2756
.14	.0055	.45	.0177	.76	.0299	8	.3150
.15	.0059	.46	.0181	.77	.0303	9	.3543
.16	.0063	.47	.0185	.78	.0307	10	.3937
.17	.0067	.48	.0189	.79	.0311	11	.4331
.18	.0071	.49	.0193	.80	.0315	12	.4724
.19	.0075	.50	.0197	.81	.0319	13	.5118
.20	.0079	.51	.0201	.82	.0323	14	.5512
.21	.0083	.52	.0205	.83	.0327	15	.5905
.22	.0087	.53	.0209	.84	.0331	16	.6299
.23	.0091	.54	.0213	.85	.0335	17	.6693
.24	.0095	.55	.0217	.86	.0339	18	.7082
.25	.0099	.56	.0221	.87	.0343	19	.7480
.26	.0103	.57	.0225	.88	.0347	20	.7874
.27	.0106	.58	.0228	.89	.0350	21	.8268
.28	.0110	.59	.0232	.90	.0354	22	.8661
.29	.0114	.60	.0236	.91	.0358	23	.9055
.30	.0118	.61	.0240	.92	.0362	24	.9449
.31	.0122	.62	.0244	.93	.0366	25	.9842

BRITISH STANDARD GAS THREAD

Size	Threads Per Inch	Outside Dia	Core Dia	Pitch	Depth	Radius	Tapping Drill	Clearance Drill
1/8"	28	.383	.337	.0357	.0229	.0049	8.8 mm	10.0 mm
1/4"	19	.518	.451	.0526	.0335	.0072	11.8 mm	13.5 mm
3/8"	19	.656	.589	.0526	.0335	.0072	15.25 mm	17.25 mm
1/2"	14	.825	.734	.0714	.0457	.0098	3/4"	21.25 mm
5/8"	14	.902	.811	.0714	.0457	.0098	53/64"	23.5 mm
3/4"	14	1.041	.950	.0714	.0457	.0098	24.5 mm	1 3/64"
7/8"	14	1.189	1.098	.0714	.0457	.0098	28.25 mm	1 13/64"
1"	11	1.309	1.193	.0909	.0582	.0125	30.75 mm	1 11/32"
1 1/4"	11	1.650	1.534	.0909	.0582	.0125	39.5 mm	1 11/16"
1 1/2"	11	1.882	1.766	.0909	.0582	.0125	1 25/32"	1 29/32"
1 3/4"	11	2.116	2.000	.0909	.0582	.0125	51 mm	2 5/32"
2"	11	2.347	2.231	.0909	.0582	.0125	2 1/4"	2 23/64"
2 1/4"	11	2.587	2.471	.0909	.0582	.0125	2 31/64"	2 5/8"
2 1/2"	11	2.960	2.844	.0909	.0582	.0125	2 55/64"	3"
2 3/4"	11	3.210	3.094	.0909	.0582	.0125	3 7/64"	3 15/64"
3"	11	3.460	3.344	.0909	.0582	.0125	3 23/64"	3 1/2"

NEWALL LIMIT AND FITS

Class	Limit	Up to ½"	9/16" to 1"	1 9/16" to 2"	2 1/16" to 3"	3 1/16" to 4"
	High	+ .0002	+ .0005	+ .0007	+ .001	+ .001
A	Low	− .0002	− .0002	− .0002	− .0005	− .0005
	Tol.	.0004	.0007	.0009	.0015	.0015
	High	+ .0005	+ .0007	+ .001	+ .0012	− .0015
B	Low	− .0005	− .0005	− .0005	− .0007	− .0007
	Tol.	.001	.0012	.0015	.0019	.0022
	High	+ .0005	+ .001	+ .0015	+ .0025	+ .003
D	Low	+ .0002	+ .0007	+ .001	+ .0015	+ .002
	Tol.	.0003	.0003	.0005	.001	.001
	High	+ .001	+ .002	+ .004	+ .006	+ .008
F	Low	+ .0005	+ .0015	+ .003	+ .0045	+ .006
	Tol.	.0005	.0005	.001	.0015	.002
	High	− .0002	− .0002	− .0002	− .0005	− .0005
P	Low	− .0007	− .0007	− .0007	− .001	− .001
	Tol.	.0005	.0005	.0005	.0005	.0005
	High	− .001	− .0012	− .0017	− .002	− .0025
X	Low	− .002	− .0027	− .0035	− .0042	− .005
	Tol.	.001	.0015	.0018	.0022	.0025
	High	− .0007	− .001	− .0012	− .0015	− .002
Y	Low	− .0012	− .002	− .0025	− .003	− .0035
	Tol.	.0005	.001	.0013	.0015	.0015
	High	− .0005	− .0007	− .0007	− .001	− .001
Z	Low	− .0007	− .0012	− .0015	− .002	− .0022
	Tol.	.0002	.0005	.0008	.001	.0012

ISO METRIC THREADS WITH AVAILABLE PITCHES

60° Form identical to Unified and American National Threads. All sizes shown in millimetres.

Dia	Pitches available				Dia	Pitches available					Dia	Pitches available			
0.25	.075				22	2.5	2	1.5	1		115	6	4	3	2
0.3	.08				24	3	2	1.5	1		120	6	4	3	2
0.35	.09				25	2	1.5	1			125	6	4	3	2
0.4	.1				26	1.5					130	6	4	3	2
0.45	.1				27	3	2	1.5	1		135	6	4	3	2
0.5	.125				28	2	1.5	1			140	6	4	3	2
0.55	.125				30	3.5	3	2	1.5		145	6	4	3	2
0.6	.15				32	2	1.5				150	6	4	3	2
0.7	.175				33	3.5	3	2	1.5		155	6	4	3	
0.8	.2				35	1.5					160	6	4	3	
0.9	.225				36	4	3	2	1.5		165	6	4	3	
1	.25	.2			38	1.5					170	6	4	3	
1.1	.25	.2			39	4	3	2	1.5		175	6	4	3	
1.2	.25	.2			40	3	2	1.5			180	6	4	3	
1.4	.3	.2			42	4.5	4	3	2	1.5	185	6	4	3	
1.6	.35	.2			45	4.5	4	3	2	1.5	190	6	4	3	
1.8	.35	.2			48	5	4	3	2	1.5	195	6	4	3	
2	.4	.25			50	3	2	1.5			200	6	4	3	
2.2	.45	.25			52	5	4	3	2	1.5	205	6	4	3	
2.5	.45	.35			55	4	3	2	1.5		210	6	4	3	
3	.5	.35			56	5.5	4	3	2	1.5	215	6	4	3	
3.5	.6	.35			58	4	3	2	1.5		220	6	4	3	
4	.7	.5			60	5.5	4	3	2	1.5	225	6	4	3	
4.5	.75	.5			62	4	3	2	1.5		230	6	4	3	
5	.8	.5			64	6	4	3	2	1.5	235	6	4	3	
5.5	.5				65	4	3	2	1.5		240	6	4	3	
6	1	.75			68	6	4	3	2	1.5	245	6	4	3	
7	1	.75			70	6	4	3	2	1.5	250	6	4	3	
8	1.25	1	.75		72	6	4	3	2	1.5	255	6	4		
9	1.25	1	.75		75	4	3	2	1.5		260	6	4		
10	1.5	1.25	1	.75	76	8	4	3	2	1.5	265	6	4		
11	1.5	1	.75		78	2					270	6	4		
12	1.75	1.5	1.25	1	80	6	4	3	2	1.5	275	6	4		
14	2	1.5	1.25	1	82	2					280	6	4		
15	1.5	1			85	6	4	3	2		285	6	4		
16	2	1.5	1		90	6	4	3	2		290	6	4		
17	1.5	1			95	6	4	3	2		295	6	4		
18	2.5	2	1.5	1	100	6	4	3	2		300	6	4		
20	2.5	2	1.5	1	110	6	4	3	2						

ISO METRIC THREADS

All dimensions in millimetres

Pitch in millimetres	To find Effective Dia reduce Outside Dia by–	To find Core Dia reduce Outside Dia by–
.075	.049 mm	.092 mm
.08	.052 mm	.098 mm
.09	.058 mm	.110 mm
.1	.065 mm	.123 mm
.125	.081 mm	.153 mm
.15	.097 mm	.184 mm
.175	.114 mm	.215 mm
.2	.130 mm	.245 mm
.225	.146 mm	.276 mm
.25	.162 mm	.307 mm
.3	.195 mm	.368 mm
.35	.227 mm	.429 mm
.4	.260 mm	.491 mm
.45	.292 mm	.552 mm
.5	.325 mm	.613 mm
.6	.390 mm	.736 mm
.7	.455 mm	.859 mm
.75	.487 mm	.920 mm
.8	.520 mm	.981 mm
1	.650 mm	1.227 mm
1.25	.812 mm	1.534 mm
1.5	.974 mm	1.840 mm
1.75	1.137 mm	2.147 mm
2	1.299 mm	2.454 mm
2.5	1.624 mm	3.067 mm
3	1.949 mm	3.681 mm
3.5	2.273 mm	4.294 mm
4	2.598 mm	4.907 mm
4.5	2.923 mm	5.521 mm
5	3.248 mm	6.134 mm
5.5	3.573 mm	6.748 mm
6	3.898 mm	7.362 mm

UNIFIED 4 THREAD (4UN) SERIES

4 THREADS PER INCH Flat = .031 Pitch = .250" Depth of Thread = .154"

Size	Outside Dia in inches	Effective Dia in inches	Core Dia in inches	Tapping Drill	Clearance Drill
2 5/8"	2.625	2.463	2.318	2 23/64"	2 21/32"
2 7/8"	2.875	2.713	2.568	2 39/64"	2 29/32"
3 1/8"	3.125	2.963	2.818	2 55/64"	3 5/32"
3 3/8"	3.375	3.213	3.068	3 7/64"	3 13/32"
3 5/8"	3.625	3.463	3.318	3 23/64"	3 21/32"
3 7/8"	3.875	3.713	3.568	3 39/64"	3 29/32"
4 1/8"	4.125	3.963	3.818	3 55/64"	4 5/32"
4 1/4"	4.250	4.088	3.943	3 63/64"	4 9/32"
4 3/8"	4.375	4.213	4.068	4 7/64"	4 13/32"
4 1/2"	4.500	4.338	4.193	4 15/64"	4 17/32"
4 5/8"	4.625	4.463	4.318	4 23/64"	4 21/32"
4 3/4"	4.750	4.588	4.443	4 31/64"	4 25/32"
4 7/8"	4.875	4.713	4.568	4 39/64"	4 29/32"
5"	5.000	4.838	4.693	4 47/64"	5 1/32"
5 1/8"	5.125	4.963	4.818	4 55/64"	5 5/32"
5 1/4"	5.250	5.088	4.943	4 63/64"	5 9/32"
5 3/8"	5.375	5.213	5.068	5 7/64"	5 13/32"
5 1/2"	5.500	5.338	5.193	5 15/64"	5 17/32"
5 5/8"	5.625	5.463	5.318	5 23/64"	5 21/32"
5 3/4"	5.750	5.588	5.443	5 31/64"	5 25/32"
5 7/8"	5.875	5.713	5.568	5 39/64"	5 29/32"
6"	6.000	5.838	5.693	5 47/64"	6 1/32"

RECOMMENDED CLEARANCE DRILL SIZES FOR ISO METRIC THREADS

All dimensions in millimetres.

Thread Dia in mm	Drill Size	Thread Dia in mm	Drill Size	Thread Dia in mm	Drill Size	Thread Dia in mm	Drill Size	Thread Dia in mm	Drill Size
.25	.3	5	5.2	35	36	82	83	205	208
.3	.35	5.5	5.7	36	37	85	86	210	213
.35	.4	6	6.3	38	39	90	91	215	218
.4	.45	7	7.3	39	40	95	96	220	223
.45	.5	8	8.3	40	41	100	101	225	228
.5	.55	9	9.3	42	43	110	112	230	233
.55	.6	10	10.4	45	46	115	117	235	238
.6	.65	11	11.4	48	49	120	122	240	243
.7	.75	12	12.4	50	51	125	127	245	248
.8	.85	14	14.5	52	53	130	132	250	253
.9	.95	15	15.5	55	56	135	137	255	258
1	1.1	16	16.5	56	57	140	142	260	263
1.1	1.2	17	17.5	58	59	145	147	265	268
1.2	1.3	18	18.5	60	61	150	152	270	273
1.4	1.5	20	20.5	62	63	155	157	275	278
1.6	1.7	22	22.5	64	65	160	162	280	283
1.8	1.9	24	24.5	65	66	165	167	285	288
2	2.15	25	25.5	68	69	170	172	290	293
2.2	2.35	26	26.5	70	71	175	177	295	298
2.5	2.65	27	27.5	72	73	180	182	300	303
3	3.2	28	28.5	75	76	185	187		
3.5	3.7	30	30.5	76	77	190	192		
4	4.2	32	32.5	78	79	195	197		
4.5	4.7	33	33.5	80	81	200	203		

BSI APPROVED TAPPING DRILL SIZES FOR ISO METRIC THREADS

The recommended Tapping Drill size for any ISO Metric Thread is most easily arrived at:– From the outside dia of the thread deduct the pitch measurement the resulting figure is the preferred tapping drill size.

example: 10 mm dia 1.5 mm pitch thread the Tapping Drill size is 10 – 1.5 = 8.5 mm.

Where an exact drill size is unobtaineble use the next higher diameter drill size available.

exemple 14 mm dia 1.25 mm pitch Tapping Drill size is 14 – 1.25 = 12.75 mm.

There is no standard 12.75 mm size drill so use 12.8 mm drill.

UNIFIED 32 THREAD (32UN) SERIES 32 THREADS PER INCH

Pitch = .031 Flat = .004" Depth of Thread = .019

Size	Outside Dia in inches	Effective Dia in inches	Core Dia in inches	Tapping Drill	Clearance Drill
7/16"	.4375	.417	.399	10.30 mm	11.20 mm
1/2"	.500	.480	.462	15/32"	12.90 mm
9/16"	.5625	.542	.524	17/32"	14.50 mm
5/8"	.625	.605	.587	19/32"	16.00 mm
11/16"	.6875	.667	.649	21/32"	45/64"
3/4"	.750	.730	.712	23/32"	49/64"
13/16"	.8125	.792	.774	25/32"	53/64"
7/8"	.875	.855	.837	27/32"	57/64"
15/16"	.9375	.917	.899	29/32"	61/64"
1"	1.000	.980	.962	31/32"	1 1/64"

UNIFIED EXTRA FINE (UNEF) SERIES

Size	TPI	Outside Dia in inches	Effective Dia in inches	Core Dia in inches	Pitch in inches	Depth of Thread	Tapping Drill	Clearance Drill
12	32	.216	.196	.178	.031	.019	4.70 mm	5.60 mm
1/4"	32	.250	.230	.212	.031	.019	7/32"	6.50 mm
5/16"	32	.3125	.292	.274	.031	.019	9/32"	8.10 mm
3/8"	32	.375	.355	.337	.031	.019	11/32"	9.70 mm
7/16"	28	.4375	.414	.394	.036	.022	10.20 mm	11.30 mm
1/2"	28	.500	.477	.456	.036	.022	11.80 mm	12.90 mm
9/16"	24	.5625	.535	.511	.042	.026	13.20 mm	14.50 mm
5/8"	24	.625	.598	.574	.042	.026	15.00 mm	41/64"
11/16"	24	.6875	.660	.636	.042	.026	16.50 mm	45/64"
3/4"	20	.750	.718	.689	.050	.031	45/64"	49/64"
13/16"	20	.8125	.780	.751	.050	.031	49/64"	53/64"
7/8"	20	.875	.843	.814	.050	.031	21.00 mm	57/64"
15/16"	20	.9375	.905	.876	.050	.031	22.50 mm	63/64"
1"	20	1.000	.968	.939	.050	.031	61/64"	1 1/64"
1 1/16"	18	1.0625	1.026	.994	.056	.034	1 1/64"	1 5/64"
1 1/8"	18	1.125	1.089	1.057	.056	.034	1 5/64"	1 9/64"
1 3/16"	18	1.1875	1.151	1.119	.056	.034	1 9/64"	1 13/64"
1 1/4"	18	1.250	1.214	1.182	.056	.034	1 13/64"	1 17/64"
1 5/16"	18	1.3125	1.276	1.244	.056	.034	1 17/64"	1 21/64"
1 3/8"	18	1.375	1.339	1.307	.056	.034	1 21/64"	1 25/64"
1 7/16"	18	1.4375	1.401	1.369	.056	.034	35 mm	1 29/64"
1 1/2"	18	1.500	1.464	1.432	.056	.034	1 29/64"	1 33/64"
1 9/16"	18	1.5625	1.526	1.494	.056	.034	1 33/64"	1 37/64"
1 5/8"	18	1.625	1.589	1.557	.056	.034	40 mm	1 41/64"
1 11/16"	18	1.6875	1.651	1.619	.056	.034	41.5 mm	1 45/64"

UNIFIED FINE (UNF) SERIES SCREW THREADS

Size	Thread per inch	Dia in inches	Effective Dia	Core Dia	Pitch	Depth of Thread	Tapping Drill Size	Clearance Drill Size
0	80	.060	.052	.045	.013	.008	1.75 mm	1.65 mm
1	72	.073	.064	.056	.014	.009	1.65 mm	1.95 mm
2	64	.086	.076	.067	.016	.010	1.90 mm	2.30 mm
3	56	.099	.087	.077	.018	.011	2.15 mm	2.65 mm
4	48	.112	.099	.088	.021	.013	2.40 mm	2.95 mm
5	44	.125	.110	.097	.023	.014	2.70 mm	3.3 mm
6	40	.138	.122	.107	.025	.015	2.95 mm	3.6 mm
8	36	.164	.146	.130	.028	.017	9/64"	4.3 mm
10	32	.190	.170	.152	.031	.019	4.10 mm	5.0 mm
12	28	.216	.193	.172	.036	.022	4.70 mm	5.6 mm
1/4"	28	.250	.227	.206	.036	.022	5.50 mm	6.5 mm
5/16"	24	.3125	.285	.261	.042	.026	6.90 mm	8.1 mm
3/8"	24	.375	.348	.324	.042	.026	8.50 mm	9.7 mm
7/16"	20	.4375	.405	.376	.050	.031	9.90 mm	11.3 mm
1/2"	20	.500	.468	.439	.050	.031	11.50 mm	12.9 mm
9/16"	18	.5625	.526	.494	.056	.034	12.90 mm	14.5 mm
5/8"	18	.625	.589	.557	.056	.034	14.50 mm	41/64"
3/4"	16	.750	.709	.673	.063	.038	11/16"	49/64"
7/8"	14	.875	.829	.787	.071	.044	.804"	57/64"
1"	12	1.000	.946	.898	.083	.051	23.75 mm	1 1/64"
1 1/8"	12	1.125	1.071	1.023	.083	.051	26.50 mm	1 9/64"
1 1/4"	12	1.250	1.196	1.148	.083	.051	29.50 mm	1 17/64"
1 3/8"	12	1.375	1.321	1.273	.083	.051	1.290"	1 25/64"
1 1/2"	12	1.500	1.446	1.398	.083	.051	36.00 mm	1 33/64"

UNIFIED MINIATURE SCREW THREADS (UNM)

All dimensions in millimetres

O/D Size mm	Pitch in mm	Effective Dia in mm	Core Dia in mm	Depth of Thread mm	Tapping Drill Size	Clearance Drill Size
.30	.080	.248	.204	.048	.22 mm	.35 mm
.35	.090	.292	.242	.054	.28 mm	.40 mm
.40	.100	.335	.280	.060	.30 mm	.45 mm
.45	.100	.385	.330	.060	.35 mm	.50 mm
.50	.125	.419	.350	.075	.38 mm	.55 mm
.55	.125	.469	.400	.075	.42 mm	.62 mm
.60	.150	.503	.420	.090	.45 mm	.68 mm
.70	.175	.586	.490	.105	.52 mm	.78 mm
.80	.200	.670	.560	.120	.60 mm	.90 mm
.90	.225	.754	.630	.135	.68 mm	1.00 mm
1.00	.250	.838	.700	.150	.75 mm	1.15 mm
1.10	.250	.938	.800	.150	.85 mm	1.25 mm
1.20	.250	1.038	.900	.150	.95 mm	1.40 mm
1.40	.300	1.205	1.040	.180	1.10 mm	1.60 mm

UNIFIED COARSE (UNC) SERIES THREADS

Size	TPI	Outside Dia in inches	Effective Dia in inches	Core Dia in inches	Pitch	Depth of Thread	Tapping Drill	Clearence Drill
1	64	.073	.063	.054	.016	.010	1.55 mm	1.95 mm
2	56	.086	.074	.064	.018	.011	1.85 mm	2.30 mm
3	48	.099	.086	.073	.021	.013	2.10 mm	2.65 mm
4	40	.112	.096	.081	.025	.015	2.35 mm	2.95 mm
5	40	.125	.109	.094	.025	.015	2.65 mm	3.30 mm
6	32	.138	.118	.100	.032	.019	2.85 mm	3.60 mm
8	32	.164	.144	.126	.032	.019	3.50 mm	4.30 mm
10	24	.190	.163	.139	.042	.026	3.90 mm	5.00 mm
12	24	.216	.189	.165	.042	.026	4.50 mm	5.60 mm
1/4"	20	.250	.218	.189	.050	.031	5.20 mm	6.50 mm
5/16"	18	.3125	.276	.244	.056	.034	6.60 mm	8.10 mm
3/8"	16	.375	.334	.298	.063	.038	8.00 mm	9.70 mm
7/16"	14	.4375	.391	.350	.071	.044	9.40 mm	11.30 mm
1/2"	13	.500	.450	.406	.077	.047	10.80 mm	12.90 mm
9/16"	12	.5625	.508	.460	.083	.051	12.20 mm	14.50 mm
5/8"	11	.625	.566	.514	.091	.056	13.50 mm	41/64"
3/4"	10	.750	.685	.627	.100	.061	16.50 mm	49/64"
7/8"	9	.875	.803	.739	.111	.068	49/64"	57/64"
1"	8	1.000	.919	.847	.125	.077	22.25 mm	1 1/64"
1 1/8"	7	1.125	1.032	.950	.143	.088	63/64"	1 9/64"
1 1/4"	7	1.250	1.157	1.075	.143	.088	1 7/64"	1 17/64"
1 3/8"	6	1.375	1.267	1.171	.167	.102	1 13/64"	1 25/64"
1 1/2"	6	1.500	1.392	1.296	.167	.102	1 21/64"	1 33/64"
1 3/4"	5	1.750	1.620	1.505	.200	.123	1 35/64"	1 49/64"
2"	4.5	2.000	1.856	1.727	.222	.136	1 25/32"	2 1/64"
2 1/4"	4.5	2.250	.2106	1.977	.222	.136	2 1/32"	2 7/64"
2 1/2"	4	2.500	2.338	2.193	.250	.154	2 15/64"	2 33/64"
2 3/4"	4	2.750	2.588	2.443	.250	.154	2 31/64"	2 49/64"
3"	4	3.000	2.838	2.693	.250	.154	2 47/64"	3 1/32"
3 1/4"	4	3.250	3.088	2.943	.250	.154	2 63/64"	3 9/32"
3 1/2"	4	3.500	3.338	3.193	.250	.154	3 15/64"	3 17/32"
3 3/4"	4	3.750	3.588	3.443	.250	.154	3 31/64"	3 25/32"
4"	4	4.000	3.838	3.693	.250	.154	3 47/64"	4 1/32"

UNIFIED 6 THREAD (6UN) SERIES — 6 THREADS PER INCH

Pitch = .1666" — Flat = .0208" = Pitch ÷ 8 — Depth of Thread = .1022"

Size	Outside Dia in inches	Effective Dia in inches	Core Dia in inches	Tapping Drill	Clearance Drill
1 7/16"	1.4375	1.329	1.233	1 17/64"	1 29/64"
1 9/16"	1.5625	1.454	1.358	1 25/64"	1 37/64"
1 5/8"	1.625	1.517	1.421	1 29/64"	1 41/64"
1 11/16"	1.6875	1.579	1.483	1 33/64"	1 45/64"
1 3/4"	1.75	1.642	1.546	1 37/64"	1 49/64"
1 13/16"	1.8125	1.704	1.608	1 41/64"	1 53/64"
1 7/8"	1.875	1.767	1.671	1 45/64"	1 57/64"
1 15/16"	1.9375	1.829	1.733	1 49/64"	1 61/64"
2"	2.00	1.892	1.796	1 53/64"	2 1/32"
2 1/8"	2.125	2.017	1.921	1 61/64"	2 5/32"
2 1/4"	2.250	2.142	2.046	2 5/64"	2 9/32"
2 3/8"	2.375	2.267	2.171	2 13/64"	2 13/32"
2 1/2"	2.500	2.392	2.296	2 21/64"	2 17/32"
2 5/8"	2.625	2.517	2.421	2 29/64"	2 21/32"
2 3/4"	2.750	2.642	2.546	2 37/64"	2 25/32"
2 7/8"	2.875	2.767	2.671	2 45/64"	2 29/32"
3"	3.00	2.892	2.796	2 53/64"	3 1/32"
3 1/8"	3.125	3.017	2.921	2 61/64"	3 5/32"
3 1/4"	3.250	3.142	3.046	3 5/64"	3 9/32"
3 3/8"	3.375	3.267	3.171	3 13/64"	3 13/32"
3 1/2"	3.500	3.392	3.296	3 21/64"	3 17/32"
3 5/8"	3.625	3.517	3.421	3.29/64"	3 21/32"
3 3/4"	3.750	3.642	3.546	3 37/64"	3 25/32"
3 7/8"	3.875	3.767	3.671	3 45/64"	3 29/32"
4"	4.00	3.892	3.796	3 53/64"	4 1/32"
4 1/8"	4.125	4.017	3.921	3 61/64"	4 5/32"
4 1/4"	4.250	4.142	4.046	4 5/64"	4 9/32"
4 3/8"	4.375	4.267	4.171	4 13/64"	4 13/32"
4 1/2"	4.500	4.392	4.296	4 21/64"	4 17/32"
4 5/8"	4.625	4.517	4.421	4 29/64"	4 21/32"
4 3/4"	4.750	4.642	4.546	4 37/64"	4 25/32"
4 7/8"	4.875	4.767	4.671	4 45/64"	4 29/32"
5"	5.00	4.892	4.796	4 53/64"	5 1/32"
5 1/8"	5.125	5.017	4.921	4 61/64"	5 5/32"
5 1/4"	5.250	5.142	5.046	5 5/64"	5 9/32"
5 3/8"	5.375	5.267	5.171	5 13/64"	5 13/32"
5 1/2"	5.500	5.392	5.296	5 21/64"	5 17/32"
5 5/8"	5.625	5.517	5.421	5 29/64"	5 21/32"
5 3/4"	5.750	5.642	5.546	5 37/64"	5 25/32"
5 7/8"	5.875	5.767	5.671	5 45/64"	5 29/32"
6"	6.00	5.892	5.796	5 53/64"	6 1/32"

UNIFIED 8 THREAD (8UN) SERIES — 8 THREADS PER INCH

Depth of Thread = .077" — Pitch = .125"

Size	Outside Dia in inches	Effective Dia in inches	Core Dia in inches	Tapping Drill	Clearance Drill
1 1/16"	1.0625	.981	.909	15/16"	1 5/64"
1 1/8"	1.125	1.044	.972	1"	1 9/64"
1 3/16"	1.1875	1.106	1.034	1 1/16"	1 13/64"
1 1/4"	1.250	1.169	1.097	1 1/8"	1 17/64"
1 5/16"	1.3125	1.231	1.159	1 3/16"	1 21/64"
1 3/8"	1.375	1.294	1.222	1 1/4"	1 25/64"
1 7/16"	1.4375	1.356	1.284	1 5/16"	1 29/64"
1 1/2"	1.500	1.419	1.347	1 3/8"	1 33/64"
1 9/16"	1.5625	1.481	1.409	1 7/16"	1 37/64"
1 5/8"	1.625	1.544	1.472	1 1/2"	1 41/64"
1 11/16"	1.6875	1.606	1.534	1 9/16"	1 45/64"
1 3/4"	1.750	1.669	1.597	1 5/8"	1 49/64"
1 13/16"	1.8125	1.731	1.659	1 11/16"	1 53/64"
1 7/8"	1.875	1.794	1.722	1 3/4"	1 57/64"
1 15/16"	1.9375	1.856	1.784	1 13/16"	1 63/64"
2"	2.000	1.919	1.847	1 7/8"	2 1/32"
2 1/8"	2.125	2.044	1.972	2"	2 5/32"
2 1/4"	2.250	2.169	2.097	2 1/8"	2 9/32"
2 3/8"	2.375	2.294	2.222	2 1/4"	2 13/32"
2 1/2"	2.500	2.419	2.347	2 3/8"	2 17/32"
2 5/8"	2.625	2.544	2.472	2 1/2"	2 21/32"
2 3/4"	2.750	2.669	2.597	2 5/8"	2 25/32"
2 7/8"	2.875	2.794	2.722	2 3/4"	2 29/32"
3"	3.000	2.919	2.847	2 7/8"	3 1/32"
3 1/8"	3.125	3.044	2.972	3"	3 5/32"
3 1/4"	3.250	3.169	3.097	3 1/8"	3 9/32"
3 3/8"	3.375	3.294	3.222	3 1/4"	3 13/32"
3 1/2"	3.500	3.419	3.347	3 3/8"	3 17/32"
3 5/8"	3.625	3.544	3.472	3 1/2"	3 21/32"
3 3/4"	3.750	3.669	3.597	3 5/8"	3 25/32"
3 7/8"	3.875	3.794	3.722	3 3/4"	3 29/32"
4"	4.000	3.919	3.847	3 7/8"	4 1/32"
4 1/8"	4.125	4.044	3.972	4"	4 5/32"
4 1/4"	4.250	4.169	4.097	4 1/8"	4 9/32"
4 3/8"	4.375	4.294	4.222	4 1/4"	4 13/32"
4 1/2"	4.500	4.419	4.347	4 3/8"	4 17/32"
4 5/8"	4.625	4.544	4.472	4 1/2"	4 21/32"
4 3/4"	4.750	4.669	4.597	4 5/8"	4 25/32"
4 7/8"	4.875	4.794	4.722	4 3/4"	4 29/32"
5"	5.000	4.919	4.847	4 7/8"	5 1/32"
5 1/8"	5.125	5.044	4.972	5"	5 5/32"
5 1/4"	5.250	5.169	5.097	5 1/8"	5 9/32"
5 3/8"	5.375	5.294	5.222	5 1/4"	5 13/32"
5 1/2"	5.500	5.419	5.347	5 3/8"	5 17/32"
5 5/8"	5.625	5.544	5.472	5 1/2"	5 21/32"
5 3/4"	5.750	5.669	5.597	5 5/8"	5 25/32"
5 7/8"	5.875	5.794	5.722	5 3/4"	5 29/32"
6"	6.000	5.919	5.847	5 7/8"	6 1/32"

UNIFIED 12 THREAD (12 UN) SERIES – 12 threads per inch

Pitch .0833" Depth of Thread .0511" 60° Flat = .0104" = Pitch ÷ 8

Size	Outside Die in inches	Effective Die in inches	Core Die in inches	Tapping Drill	Clearance Drill
5/8"	.625	.5709	.5228	13.7mm	41/64"
11/16"	.6875	.6334	.5853	15.25 mm	45/64"
3/4"	.75	.6959	.6478	17 mm	49/64"
13/16"	.8125	.7584	.7103	18.5 mm	53/64"
7/8"	.875	.8209	.7728	20 mm	57/64"
15/16"	.9375	.8834	.8353	21.75 mm	61/64"
1 1/16"	1.0625	1.008	.9603	24.75 mm	1 5/64"
1 3/16"	1.1875	1.133	1.085	28 mm	1 13/64"
1 5/16"	1.3125	1.258	1.210	1 15/64"	1 21/64"
1 7/16"	1.4375	1.383	1.335	1 23/64"	1 29/64"
1 9/16"	1.5625	1.508	1.460	1 31/64"	1 37/64"
1 5/8"	1.625	1.571	1.523	1 35/64"	1 41/64"
1 11/15"	1.6875	1.633	1.585	1 39/64"	1 45/64"
1 3/4"	1.75	1.696	1.648	1 43/64"	1 48/64"
1 13/16"	1.8125	1.758	1.710	1 47/64"	1 53/64"
1 7/8"	1.875	1.821	1.773	1 51/64"	1 57/64"
1 15/16"	1.9375	1.883	1.835	1 55/64"	1 61/64"
2"	2.00	1.946	1.898	1 59/64"	2 1/32"
2 1/8"	2.125	2.071	2.023	2 3/64"	2 5/32"
2 1/4"	2.25	2.196	2.148	2 11/69"	2 9/32"
2 3/8"	2.375	2.321	2.273	2 19/64"	2 13/32"
2 1/2"	2.50	2.446	2.398	2 27/64"	2 17/32"
2 5/8"	2.625	2.571	2.523	2 35/64"	2 21/32"
2 3/4"	2.76	2.696	2.648	2 43/64"	2 25/32"
2 7/8"	2.875	2.821	2.773	2 51/64"	2 29/32"
3"	3.00	2.946	2.898	2 59/64"	3 1/32"
3 1/8"	3.125	3.071	3.023	3 3/64"	3 5/32"
3 1/4"	3.25	3.196	3.148	3 11/64"	3 9/32"
3 3/8"	3.375	3.321	3.273	3 19/64"	3 13/32"
3 1/2"	3.50	3.446	3.398	3 27/64"	3 17/32"
3 5/8"	3.625	3.571	3.523	3 35/64"	3 21/32"
3 3/4"	3.75	3.696	3.648	3 43/64"	3 25/32"
3 7/8"	3.875	3.821	3.773	3 51/64"	3 29/32"
4"	4.00	3.946	3.898	3 59/64"	4 1/32"
4 1/8"	4.125	4.071	4.023	4 3/64"	4 5/32"
4 1/4"	4.25	4.196	4.148	4 11/64"	4 9/32"
4 3/8"	4.375	4.321	4.273	4 19/64"	4 13/32"
4 1/2"	4.50	4.446	4.398	4 27/64"	4 17/32"
4 5/8"	4.625	4.571	4.523	4 35/64"	4 21/32"
4 3/4"	4.75	4.696	4.648	4 43/64"	4 25/32"
4 7/8"	4.875	4.821	4.773	4 51/64"	4 29/32"
5"	5.00	4.946	4.898	4 59/64"	5 1/32"
5 1/8"	5.125	5.071	5.023	5 3/64"	5 5/32"
5 1/4"	5.25	5.196	5.148	5 11/64"	5 9/32"
5 3/8"	5.375	5.321	5.273	5 19/64"	5 13/32"
5 1/2"	5.50	5.446	5.398	5 27/64"	5 17/32"
5 5/8"	5.625	5.571	5.523	5 35/64"	5 21/32"
5 3/4"	5.75	5.696	5.648	5 43/64"	5 25/32"
5 7/8"	5.875	5.821	5.773	5 51/64"	5 29/32"
6"	6.00	5.946	5.898	5 59/64"	6 1/32"

UNIFIED 16 THREAD (16UN) 16 THREADS PER INCH

P = .063" Depth of Thread = .038" Flat = .008" = .125 pitch 60°

Size	Dia in inches	Effective Dia in inches	Core Dia in inchas	Tapping Drill	Clearance Drill
7/16"	.4375	.397	.361	3/8"	11.20 mm
1/2"	.500	.459	.423	7/16"	12.90 mm
9/16"	.5625	.522	.486	1/2"	14.50 mm
5/8"	.625	.584	.548	9/16"	41/64"
11/16"	.6875	.647	.611	5/8"	45/64"
13/16"	.8125	.772	.736	3/4"	53/64"
7/8"	.875	.834	.798	13/16"	57/64"
15/16"	.9375	.897	.861	7/8"	61/64"
1"	1.0000	.959	.923	15/16"	1 1/64"
1 1/16"	1.0625	1.022	.986	1"	1 5/64"
1 1/8"	1.125	1.084	1.048	1 1/16"	1 9/64"
1 3/16"	1.1875	1.147	1.111	1 1/8"	1 13/64"
1 1/4"	1.250	1.209	1.173	1 3/16"	1 17/64"
1 5/16"	1.3125	1.272	1.236	1 1/4"	1 21/64"
1 3/8"	1.375	1.334	1.298	1 5/16"	1 25/64"
1 7/16"	1.4375	1.397	1.361	1 3/8"	1 29/64"
1 1/2"	1.500	1.459	1.423	1 7/16"	1 33/64"
1 9/16"	1.5625	1.522	1.486	1 1/2"	1 37/64"
1 5/8"	1.625	1.584	1.548	1 9/16"	1 41/64"
1 11/16"	1.6875	1.647	1.611	1 5/8"	1 45/64"
1 3/4"	1.750	1.709	1.673	1 11/16"	1 49/64"
1 13/16"	1.8125	1.772	1.736	1 3/4"	1 53/64"
1 7/8"	1.875	1.834	1.798	1 13/16"	1 57/64"
1 15/16"	1.9375	1.897	1.861	1 7/8"	1 61/64"
2"	2.000	1.959	1.923	1 15/16"	2 1/32"
2 1/8"	2.125	2.084	2.048	2 1/16"	2 5/32"
2 1/4"	2.250	2.209	2.173	2 3/16"	2 9/32"
2 3/8"	2.375	2.334	2.298	2 5/16"	2 13/32"
2 1/2"	2.500	2.459	2.423	2 7/16"	2 17/32"
2 5/8"	2.625	2.584	2.548	2 9/16"	2 21/32"
2 3/4"	2.750	2.709	2.673	2 11/16"	2 25/32"
2 7/8"	2.875	2.834	2.798	2 13/16"	2 29/32"
3"	3.000	2.959	2.923	2 15/16"	3 1/32"
3 1/8"	3.125	3.084	3.048	3 1/16"	3 5/32"
3 1/4"	3.250	3.209	3.173	3 3/16"	3 9/32"
3 3/8"	3.375	3.334	3.298	3 5/16"	3 13/32"
3 1/2"	3.500	3.459	3.423	3 7/16"	3 17/32"
3 5/8"	3.625	3.584	3.548	3 9/16"	3 21/32"
3 3/4"	3.750	3.709	3.673	3 11/16"	3 25/32"
3 7/8"	3.875	3.834	3.798	3 13/16"	3 29/32"
4"	4.000	3.959	3.923	3 15/16"	4 1/32"
4 1/8"	4.125	4.084	4.048	4 1/16"	4 5/32"
4 1/4"	4.250	4.209	4.173	4 3/16"	4 9/32"
4 3/8"	4.375	4.334	4.298	4 5/16"	4 13/32"
4 1/2"	4.500	4.459	4.423	4 7/16"	4 17/32"
4 5/8"	4.625	4.584	4.548	4 9/16"	4 21/32"
4 3/4"	4.750	4.709	4.673	4 11/16"	4 25/32"
4 7/8"	4.875	4.834	4.798	4 13/16"	4 29/32"
5"	5.000	4.959	4.923	4 15/16"	5 1/32"
5 1/8"	5.125	5.084	5.048	5 1/16"	5 5/32"
5 1/4"	5.250	5.209	5.173	5 3/16"	5 9/32"
5 3/8"	5.375	5.334	5.298	5 5/16"	5 13/32"
5 1/2"	5.500	5.459	5.423	5 7/16"	5 17/32"
5 5/8"	5.625	5.584	5.548	5 9/16"	5 21/32"
5 3/4"	5.750	5.709	5.673	5 11/16"	5 25/32"
5 7/8"	5.875	5.834	5.798	5 13/16"	5 29/32"
6"	6.000	5.959	5.923	5 15/16"	6 1/32"

UNIFIED 20 THREAD (20 UN) SERIES 20 Threads per inch

Pitch = .05" Depth of Thread = .0307" Flat = .0062" = .125" pitch

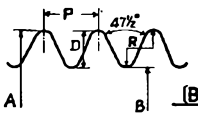
Size	Outside Dia in inches	Effective Dia in inches	Core Dia in inches	Tapping Drill	Clearance Drill
5/16"	.3125	.280	.2512	6.6 mm	8.10 mm
3/8"	.375	3425	.3137	8.2 mm	9.70 mm
9/16"	.5625	.530	.5012	13.0 mm	14.50 mm
5/8"	.625	.5925	.5637	37/64"	41/64"
11/16"	.6875	.655	.6262	16.25 mm	45/64"
1 1/16"	1.0625	1.030	1.001	1 1/64"	1 5/64"
1 1/8"	1.125	1.093	1.064	1 5/64"	1 9/64"
1 3/16"	1.1875	1.155	1.126	1 9/64"	1 13/64"
1 1/4"	1.250	1.218	1.189	1 13/64"	1 17/64"
1 5/16"	1.3125	1.280	1.251	1 17/64"	1 21/64"
1 3/8"	1.375	1.343	1.314	1 21/64"	1 25/64"
1 7/16"	1.4375	1.405	1.376	1 25/64"	1 29/64"
1 1/2"	1.500	1.468	1.439	1 29/64"	1 33/64"
1 9/16"	1.5625	1.530	1.501	1 33/64"	1 37/64"
1 5/8"	1.625	1.593	1.564	1 37/64"	1 41/64"
1 11/16"	1.6875	1.655	1.626	1 41/64"	1 45/64"
1 3/4"	1.750	1.718	1.689	1 45/64"	1 49/64"
1 13/16"	1.8125	1.780	1.751	1 49/64"	1 53/64"
1 7/8"	1.875	1.843	1.814	1 53/64"	1 57/64"
1 15/16"	1.9375	1.905	1.876	1 57/64"	1 63/64"
2"	2.000	1.968	1.939	1 61/64"	2 1/32"
2 1/8"	2.125	2.093	2.064	2 5/64"	2 5/32"
2 1/4"	2.250	2.218	2.189	2 13/64"	2 9/32"
2 3/8"	2.375	2.343	2.314	2 21/64"	2 13/32"
2 1/2"	2.500	2.468	2.439	2 29/64"	2 17/32"
2 5/8"	2.625	2.593	2.564	2 37/64"	2 21/32"
2 3/4"	2.750	2.718	2.689	2 45/64"	2 25/32"
2 7/8"	2.875	2.843	2.814	2 53/64"	2 29/32"
3"	3.000	2.968	2.939	2 61/64"	3 1/32"

UNIFIED 28 THREAD (28UN) SERIES 28 THREADS PER INCH

Flat = .0045" Pitch = .036" Depth of Thread = .022"

Size	Outside Dia in inches	Effective Dia in inches	Core Dia in inches	Tapping Drill	Clearance Drill
5/16"	.3125	.289	.269	7 mm	21/64"
3/8"	.375	.352	.331	8.60 mm	25/64"
9/16"	.5625	.539	.519	13.40 mm	37/64"
5/8"	.625	.602	.581	15 mm	41/64"
11/16"	.6875	.664	.644	21/32"	45/64"
3/4"	.750	.727	.706	23/32"	49/64"
13/16"	.8125	.789	.769	19.75 mm	53/64"
7/8"	.875	.852	.831	27/32"	57/64"
15/16"	.9375	.914	.894	23.0 mm	61/64"
1"	1.000	.977	.956	24.5 mm	1 1/64"
1 1/16"	1.063	1.039	1.019	1 1/32"	1 5/64"
1 1/8"	1.125	1.102	1.081	1 3/32"	1 9/64"
1 3/16"	1.188	1.164	1.144	1 5/32"	1 13/64"
1 1/4"	1.250	1.227	1.206	1 7/32"	1 17/64"
1 5/16"	1.313	1.289	1.269	1 9/32"	1 21/64"
1 3/8"	1.375	1.352	1.331	1 11/32"	1 25/64"
1 7/16"	1.438	1.414	1.394	1 13/32"	1 29/64"
1 1/2"	1.500	1.477	1.456	1 15/32"	1 33/64"

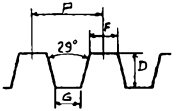
SCREW THREADS WITH BASIC FORM



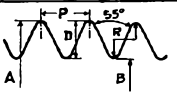
(B.A.)

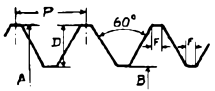
ACME

$D = .5P + .01"$
$F = .371P$
$G = .371P - .005"$



BRITISH STANDARD WHITWORTH



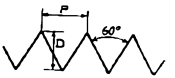


$F = P \times .125$
$D = P \times .6495$

UNIFIED, ISO METRIC AND AMERICAN NATIONAL

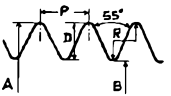
60° VEE

$D = .866 \times P$

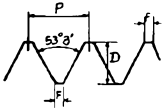


45° VEE

$D = 1.207 \times P$



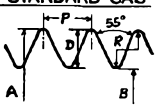
B.S.F.



LÖWENHERZ

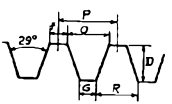
$F = .125 \times P$
$D = .754 \times P$

BRITISH STANDARD GAS

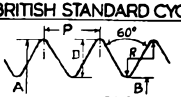


WORM

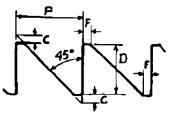
$F = .335 \times P \quad G = .310 \times P$
$D = .687 \times P$
$O = .665 \times P \quad R = .690 \times P$



BRITISH STANDARD CYCLE

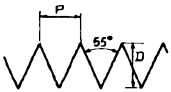


$R = P \times .1666$
$D = P \times .5327$
RH = RIGHT HAND
LH = LEFT HAND



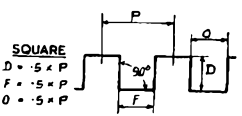
BUTTRESS

$C = .125 \times P$
$D = .75 \times P$
$F = .125 \times P$



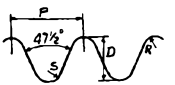
55° VEE

$D = .960 \times P$



SQUARE

$D = .5 \times P$
$F = .5 \times P$
$O = .5 \times P$



THURY

$R = .166 \times P$
$D = .600 \times P$
$S = .200 \times P$

FRACTIONS WITH METRIC AND DECIMAL EQUIVALENTS

Fraction in inches	Millimetres	Decimal inches	Fraction in inches	Millimetre	Decimal inches
1/64"	.3969	.0156	33/64"	13.0969	.5156
1/32"	.7938	.0312	17/32"	13.4938	.5313
3/64"	1.1906	.0469	35/64"	13.8906	.5469
1/16"	1.5875	.0625	9/16"	14.2875	.5625
5/64"	1.9844	.0781	37/64"	14.6844	.5781
3/32"	2.3812	.0938	19/32"	15.0812	.5938
7/64"	2.7781	.1094	39/64"	15.4781	.6094
1/8"	3.175	.1250	5/8"	15.8750	.6250
9/64"	3.5719	.1406	41/64"	16.2719	.6406
5/32"	3.9688	.1563	21/32"	16.6688	.6563
11/64"	4.3656	.1719	43/64"	17.0656	.6719
3/16"	4.7625	.1875	11/16"	17.4625	.6875
13/64"	5.1594	.2031	45/64"	17.8594	.7031
7/32"	5.5562	.2188	23/32"	18.2562	.7188
15/64"	5.9531	.2344	47/64"	18.6531	.7344
1/4"	6.35	.2500	3/4"	19.0500	.7500
17/84"	6.7469	.2656	49/64"	19.4469	.7656
9/32"	7.1438	.2813	25/32"	19.8437	.7813
19/64"	7.5406	.2969	51/64"	20.2406	.7969
5/16"	7.9375	.3125	13/16"	20.6375	.8125
21/64"	8.3344	.3281	53/64"	21.0344	.8281
11/32"	8.7312	.3438	27/32"	21.4312	.8438
23/64"	9.1281	.3594	55/64"	21.8281	.8594
3/8"	9.5250	.3750	7/8"	22.2250	.8750
25/64"	9.9219	.3906	57/64"	22.6219	.8906
13/32"	10.3188	.4063	29/32"	23.0188	.9063
27/64"	10.7156	.4219	59/64"	23.4156	.9219
7/16"	11.1125	.4375	15/16"	23.8125	.9375
29/64"	11.5094	.4531	61/64"	24.2094	.9531
15/32"	11.9062	.4688	31/32"	24.6062	.9688
31/64"	12.3031	.4844	63/64"	25.0031	9844
1/2"	12.7000	.5000	1"	25.4000	1.0000

BSI. APPROVED BRITISH AND METRIC DRILL SIZES

Drill Size	Dia in inches	Drill Size	Dia in inches	Drill Size	Dia in inches	Drill Size	Dia in inches
.2 mm	.0079	2.25 mm	.0886	6.60 mm	.2598	29/64"	.4531
.22 mm	.0087	2.30 mm	.0906	6.70 mm	.2638	11.60 mm	.4567
.25 mm	.0099	2.35 mm	.0925	17/64"	.2656	11.70 mm	.4606
.28 mm	.011	3/32"	.0938	6.80 mm	.2677	11.80 mm	.4646
.3 mm	.0118	2.40 mm	.0945	6.90 mm	.2717	11.90 mm	.4685
.32 mm	.0126	2.45 mm	.0965	7.00 mm	.2756	15/32"	.4688
.35 mm	.0138	2.50 mm	.0984	7.10 mm	.2795	12.00 mm	.4724
.38 mm	.0150	2.55 mm	.1004	9/32"	.2812	12.10 mm	.4764
1/64"	.0156	2.60 mm	.1024	7.20 mm	.2835	12.20 mm	.4803
.40 mm	.0157	2.65 mm	.1043	7.30 mm	.2874	12.30 mm	.4843
.42 mm	.0165	2.70 mm	.1063	7.40 mm	.2913	31/64"	.4844
.45 mm	.0177	2.75 mm	.1083	7.50 mm	.2953	12.40 mm	.4882
.48 mm	.0189	7/64"	.1094	19/64"	.2969	12.50 mm	.4921
.50 mm	.0197	2.80 mm	.1102	7.60 mm	.2992	12.60 mm	.4961
.52 mm	.0205	2.85 mm	.1122	7.70 mm	.3032	12.70 mm	.5000
.55 mm	.0217	2.90 mm	.1142	7.80 mm	.3071	1/2"	.5000
.58 mm	.0228	2.95 mm	.1161	7.90 mm	.3110	12.80 mm	.5039
.60 mm	.0236	3.00 mm	.1181	5/16"	.3125	12.90 mm	.5079
.62 mm	.0244	3.10 mm	.1220	8.00 mm	.3150	13.00 mm	.5118
.65 mm	.0256	1/8"	.1250	8.10 mm	.3189	33/64"	.5156
.68 mm	.0268	3.20 mm	.1260	8.20 mm	.3228	13.10 mm	.5157
.70 mm	.0276	3.30 mm	.1299	8.30 mm	.3268	13.20 mm	.5197
.72 mm	.0283	3.40 mm	.1339	21/64"	.3281	13.30 mm	.5236
.75 mm	.0295	3.50 mm	.1378	8.40 mm	.3307	13.40 mm	.5276
.78 mm	.0307	9/64"	.1406	8.50 mm	.3346	17/32"	.5312
1/32"	.0312	3.60 mm	.1417	8.60 mm	.3386	13.50 mm	.5315
.80 mm	.0315	3.70 mm	.1457	8.70 mm	.3425	13.60 mm	.5354
.82 mm	.0323	3.80 mm	.1496	11/32"	.3438	13.70 mm	.5394
.85 mm	.0335	3.90 mm	.1535	8.80 mm	.3465	13.80 mm	.5433
.88 mm	.0346	5/32"	.1562	8.90 mm	.3504	35/64"	.5469
.90 mm	.0354	4.00 mm	.1575	9.00 mm	.3543	13.90 mm	.5472
.92 mm	.0362	4.10 mm	.1614	9.10 mm	.3583	14.00 mm	.5512
.95 mm	.0374	4.20 mm	.1654	23/64"	.3594	14.25 mm	.5610
.98 mm	.0386	4.30 mm	.1693	9.20 mm	.3622	9/16"	.5625
1.00 mm	.0394	11/64"	.1719	9.30 mm	.3661	14.50 mm	.5709
1.05 mm	.0413	4.40 mm	.1732	9.40 mm	.3701	37/64"	.5781
1.10 mm	.0433	4.50 mm	.1772	9.50 mm	.3740	14.75 mm	.5807
1.15 mm	.0453	4.60 mm	.1811	3/8"	.3750	15.00 mm	.5906
3/64"	.0469	4.70 mm	.1850	9.60 mm	.3780	19/32"	.5938
1.20 mm	.0472	3/16"	.1875	9.70 mm	.3819	15.25 mm	.6004
1.25 mm	.0492	4.80 mm	.1890	9.80 mm	.3858	39/64"	.6094
1.30 mm	.0512	4.90 mm	.1929	9.90 mm	.3898	15.50 mm	.6102
1.35 mm	.0532	5.00 mm	.1968	25/64"	.3906	15.75 mm	.6201
1.40 mm	.0551	5.10 mm	.2008	10.00 mm	.3937	5/8"	.6250
1.45 mm	.0571	13/64"	.2031	10.10 mm	.3976	16.00 mm	.6299
1.50 mm	.0591	5.20 mm	.2047	10.20 mm	.4016	16.25 mm	.6398
1.55 mm	.0610	5.30 mm	.2087	10.30 mm	.4055	41/64"	.6406
1/16"	.0625	5.40 mm	.2126	13/32"	.4062	16.50 mm	.6496
1.60 mm	.0630	5.50 mm	.2165	10.40 mm	.4094	21/32"	.6562
1.65 mm	.0650	7/32"	.2188	10.50 mm	.4134	16.75 mm	.6594
1.70 mm	.0669	5.60 mm	.2205	10.60 mm	.4173	17.00 mm	.6693
1.75 mm	.0689	5.70 mm	.2244	10.70 mm	.4213	43/64"	.6719
1.80 mm	.0709	5.80 mm	.2283	27/64"	.4219	17.25 mm	.6791
1.85 mm	.0728	5.90 mm	.2323	10.80 mm	.4252	11/16"	.6875
1.90 mm	.0748	15/64"	.2344	10.90 mm	.4291	17.50 mm	.6890
1.95 mm	.0768	6.00 mm	.2362	11.00 mm	.4331	17.75 mm	.6988
5/64"	.0781	6.10 mm	.2402	11.10 mm	.4370	45/64"	.7031
2.00 mm	.0787	6.20 mm	.2441	7/16"	.4375	18.00 mm	.7087
2.05 mm	.0807	6.30 mm	.2480	11.20 mm	.4409	18.25 mm	.7185
2.10 mm	.0827	1/4"	.2500	11.30 mm	.4449	23/32"	.7188
2.15 mm	.0846	6.40 mm	.2520	11.40 mm	.4488	18.50 mm	.7283
2.20 mm	.0866	6.50 mm	.2559	11.50 mm	.4528	47/64"	.7344

BSI APPROVED BRITISH AND METRIC DRILL SIZES

Drill Size	Dia in inches	Drill Size	Dia in inches	Drill Size	Dia in inches
18.75 mm	.7382	28.00 mm	1.1024	1 9/16"	1.5625
19.00 mm	.7480	1 7/64"	1.1094	40.00 mm	1.5748
3/4"	.7500	28.50 mm	1.1220	1 37/64"	1.5781
19.25 mm	.7579	1 1/8"	1.1250	1 19/32"	1.5938
49/64"	.7656	1 9/64"	1.1406	40.50 mm	1.5945
19.50 mm	.7677	29.00 mm	1.1417	1 39/64"	1.6094
19.75 mm	.7776	1 5/32"	1.1562	41.00 mm	1.6142
25/32"	.7812	29.50 mm	1.1614	1 5/8"	1.6250
20.00 mm	.7874	1 11/64"	1.1719	41.50 mm	1.6339
51/64"	.7969	30.00 mm	1.1811	1 41/64"	1.6406
20.25 mm	.7972	1 3/16"	1.1875	42.00 mm	1.6535
20.50	.8071	30.50 mm	1.2008	1 21/32"	1.6562
13/16"	.8125	1 13/64"	1.2031	1 43/64"	1.6719
20.75 mm	.8169	1 7/32"	1.2188	42.50 mm	1.6732
21.00 mm	.8268	31.00 mm	1.2205	1 11/16"	1.6875
53/64"	.8281	1 15/64"	1.2344	43.00 mm	1.6929
21.25 mm	.8366	31.50 mm	1.2402	1 45/64"	1.7031
27/32"	.8438	1 1/4"	1.2500	43.50 mm	1.7126
21.50 mm	.8465	32.00 mm	1.2598	1 23/32"	1.7188
21.75 mm	.8563	1 17/64"	1.2656	44.00 mm	1.7323
55/64"	.8594	32.50 mm	1.2795	1 47/64"	1.7344
22.00 mm	.8661	1 9/32"	1.2812	1 3/4"	1.7500
7/8"	.8750	1 19/64"	1.2969	44.50 mm	1.7520
22.25 mm	.8760	33.00 mm	1.2992	1 49/64"	1.7656
22.50 mm	.8858	1 5/16"	1.3125	45.00 mm	1.7717
57/64"	.8906	33.50 mm	1.3189	1 25/32"	1.7812
22.75 mm	.8957	1 21/64"	1.3281	45.50 mm	1.7913
23.00 mm	.9055	34.00 mm	1.3386	1 51/64"	1.7969
29/32"	.9062	1 11/32"	1.3438	46.00 mm	1.8110
23.25 mm	.9154	34.50 mm	1.3583	1 13/16"	1.8125
59/64"	.9219	1 23/64"	1.3594	1 53/64"	1.8281
23.50 mm	.9252	1 3/8"	1.3750	46.50 mm	1.8307
23.75 mm	.9350	35.00 mm	1.3780	1 27/32"	1.8438
15/16"	.9375	1 25/64"	1.3906	47.00 mm	1.8504
24.00 mm	.9449	35.50 mm	1.3976	1 55/64"	1.8594
61/64"	.9531	1 13/32"	1.4062	47.50 mm	1.8701
24.25 mm	.9547	36.00 mm	1.4173	1 7/8"	1.8750
24.50 mm	.9646	1 27/64"	1.4219	48.00 mm	1.8898
31/32"	.9688	36.50 mm	1.4370	1 57/64"	1.8906
24.75 mm	.9744	1 7/16"	1.4375	1 29/32"	1.9062
25.00 mm	.9843	1 29/64"	1.4531	48.50 mm	1.9094
63/64"	.9844	37.00 mm	1.4567	1 59/64"	1.9219
1"	1.0000	1 15/32"	1.4688	49.00 mm	1.9291
25.50 mm	1.0039	37.50 mm	1.4764	1 15/16"	1.9375
1 1/64"	1.0156	1 31/64"	1.4844	49.50 mm	1.9488
26.00 mm	1.0236	38.00 mm	1.4961	1 61/64"	1.9531
1 1/32"	1.0312	1 1/2"	1.5000	50.00 mm	1.9685
26.50 mm	1.0433	1 33/64"	1.5156	1 31/32"	1.9688
1 3/64"	1.0469	38.50 mm	1.5157	1 63/64"	1.9844
1 1/16"	1.0625	1 17/32"	1.5312	50.50 mm	1.9882
27.00 mm	1.0630	39.00 mm	1.5354	2"	2.0000
1 5/64"	1.0781	1 35/64"	1.5469	51.00 mm	2.0079
27.50 mm	1.0827	39.50 mm	1.5551		
1 3/32"	1.0938				

Larger Diameters increasing in steps of 1/64" and 0.50 mm

OBSOLETE NUMBER & LETTER DRILLS WITH ALTERNATIVE APPROVED DRILL SIZES

Number or Letter Size	Dia in inches	Alternative Approved Size	Dia in inches	Number or Letter Size	Dia in inches	Alternative Approved Size	Dia in inches
80	.0135	.35 mm	.0138	27	.1440	3.70 mm	.1457
79	.0145	.38 mm	.0150	26	.1470	3.70 mm	.1457
78	.0160	.40 mm	.0157	25	.1495	3.80 mm	.1496
77	.0180	.45 mm	.0177	24	.1520	3.90 mm	.1535
76	.0200	.50 mm	.0197	23	.1540	3.90 mm	.1535
75	.0210	.52 mm	.0205	22	.1570	4.00 mm	.1575
74	.0225	.58 mm	.0228	21	.1590	4.00 mm	.1575
73	.0240	.60 mm	.0236	20	.1610	4.10 mm	.1614
72	.0250	.65 mm	.0256	19	.1660	4.20 mm	.1654
71	.0260	.65 mm	.0256	18	.1695	4.30 mm	.1693
70	.0280	.70 mm	.0276	17	.1730	4.40 mm	.1732
69	.0292	.75 mm	.0295	16	.1770	4.50 mm	.1772
68	.0310	1/32"	.0312	15	.1800	4.60 mm	.1811
67	.0320	.82 mm	.0323	14	.1820	4.60 mm	.1811
66	.0330	.85 mm	.0335	13	.1850	4.70 mm	.1850
65	.0350	.90 mm	.0354	12	.1890	4.80 mm	.1890
64	.0360	.92 mm	.0362	11	.1910	4.90 mm	.1929
63	.0370	.95 mm	.0374	10	.1935	4.90 mm	.1929
62	.0380	.98 mm	.0386	9	.1960	5.00 mm	.1968
61	.0390	1.00 mm	.0394	8	.1990	5.10 mm	.2008
60	.0400	1.00 mm	.0394	7	.2010	5.10 mm	.2008
59	.0410	1.05 mm	.0413	6	.2040	5.20 mm	.2047
58	.0420	1.05 mm	.0413	5	.2055	5.20 mm	.2047
57	.0430	1.10 mm	.0433	4	.2090	5.30 mm	.2087
56	.0465	3/64"	.0469	3	.2130	5.40 mm	.2126
55	.0520	1.30 mm	.0512	2	.2210	5.60 mm	.2205
54	.0550	1.40 mm	.0551	1	.2280	5.80 mm	.2283
53	.0595	1.50 mm	.0590	A	.2340	15/64"	.2344
52	.0635	1.60 mm	.0630	B	.2380	6.00 mm	.2362
51	.0670	1.70 mm	.0669	C	.2420	6.10 mm	.2402
50	.0700	1.80 mm	.0709	D	.2460	6.20 mm	.2441
49	.0730	1.85 mm	.0728	E	.2500	1/4"	.2500
48	.0760	1.95 mm	.0768	F	.2570	6.50 mm	.2559
47	.0785	2.00 mm	.0787	G	.2610	6.60 mm	.2598
46	.0810	2.05 mm	.0807	H	.2660	17/64"	.2656
45	.0820	2.10 mm	.0827	I	.2720	6.90 mm	.2717
44	.0860	2.20 mm	.0866	J	.2770	7.00 mm	.2756
43	.0890	2.25 mm	.0886	K	.2810	9/32"	.2812
42	.0935	3/32"	.0938	L	.2900	7.40 mm	.2913
41	.0960	2.45 mm	.0965	M	.2950	7.50 mm	.2953
40	.0980	2.50 mm	.0984	N	.3020	7.70 mm	.3031
39	.0995	2.55 mm	.1004	O	.3160	8.00 mm	.3150
38	.1015	2.60 mm	.1024	P	.3230	8.20 mm	.3228
37	.1040	2.65 mm	.1043	Q	.3320	8.40 mm	.3307
36	.1065	2.70 mm	.1063	R	.3390	8.60 mm	.3386
35	.1100	2.80 mm	.1102	S	.3480	8.80 mm	.3465
34	.1110	2.80 mm	.1102	T	.3580	9.10 mm	.3583
33	.1130	2.85 mm	.1122	U	.3680	9.30 mm	.3661
32	.1160	2.95 mm	.1161	V	.3770	3/8"	.3750
31	.1200	3.00 mm	.1181	W	.3860	9.80 mm	.3858
30	.1285	3.30 mm	.1299	X	.3970	10.10 mm	.3976
29	.1360	3.50 mm	.1378	Y	.4040	10.30 mm	.4055
28	.1405	9/64"	.1406	Z	.4130	10.50 mm	.4134

WIRE AND SHEET METAL GAUGES

Gauge No.	British Imperial Wire	Stubs Steel Wire	Birmingham Sheet Metal Gauge	Brown & Sharpe or American Gauge	Washburn & Meon Steel Wire Gauge	U.S. Standard Sheet Gauge	S & W American Music Wire Gauge	Birmingham Stubs Iron Wire Gauge
7'0	.500	–	.6666	–	.4900	–	–	–
6'0	.464	–	.625	–	.4615	.4687	.004	–
5'0	.432	–	.5883	–	.4305	.4375	.005	–
4'0	.400	–	.5416	.4600	.3938	.4062	.006	.454
3'0	.372	–	.5000	.4096	.3625	.3750	.007	.425
2'0	.348	–	.4452	.3648	.3310	.3437	.008	.380
0	.324	–	.3964	.3249	.3065	.3125	.009	.340
1	.300	.227	.3532	.2893	.2830	.2815	.010	.300
2	.276	.219	.3147	.2576	.2625	.2656	.011	.284
3	.252	.212	.2804	.2294	.2437	.2500	.012	.259
4	.232	.207	.2500	.2043	.2253	.2344	.013	.238
5	.212	.204	.2225	.1819	.2070	.2187	.014	.220
6	.192	.201	.1981	.1620	.1920	.2031	.016	.203
7	.176	.199	.1764	.1443	.1770	.1875	.018	.180
8	.160	.197	.1570	.1285	.1620	.1719	.020	.165
9	.144	.194	.1398	.1144	.1483	.1562	.022	.148
10	.128	.191	.1250	.1019	.1350	.1406	.024	.134
11	.116	.188	.1113	.0907	.1205	.1250	.026	.120
12	.104	.185	.0991	.0808	.1055	.1094	.029	.109
13	.092	.182	.0882	.0720	.0915	.0937	.031	.095
14	.080	.180	.0785	.0641	.0800	.0781	.033	.083
15	.072	.178	.0699	.0571	.0720	.0703	.035	.072
16	.064	.175	.0625	.0508	.0625	.0625	.037	.065
17	.056	.172	.0556	.0453	.0540	.0562	.039	.058
18	.048	.168	.0495	.0403	.0475	.0500	.041	.049
19	.040	.164	.0440	.0359	.0410	.0437	.043	.042
20	.036	.161	.0392	.0320	.0348	.0375	.045	.035
21	.032	.157	.0349	.0285	.0317	.0344	.047	.032
22	.028	.155	.0312	.0253	.0286	.0312	.049	.028
23	.024	.153	.0278	.0226	.0258	.0281	.051	.025
24	.022	.151	.0248	.0201	.0230	.0250	.055	.022
25	.020	.148	.0220	.0179	.0204	.0219	.059	.020
26	.018	.146	.0196	.0159	.0181	.0187	.063	.018
27	.0164	.143	.0174	.0142	.0173	.0172	.067	.016
28	.0148	.139	.0156	.0126	.0162	.0156	.071	.014
29	.0136	.134	.0139	.0113	.0150	.0141	.075	.013
30	.0124	.127	.0123	.0100	.0140	.0125	.080	.012
31	.0116	.120	.0110	.0089	.0132	.0109	.085	.010
32	.0108	.115	.0098	.0079	.0128	.0102	.090	.009
33	.0100	.112	.0087	.0071	.0118	.0094	.095	.008
34	.0092	.110	.0077	.0063	.0104	.0086	.100	.007
35	.0084	.108	.0069	.0056	.0095	.0078	.106	.005
36	.0076	.106	.0061	.005	.0090	.0070	.112	.004
37	.0068	.103	.0054	.0045	.0085	.0066	.118	–
38	.0060	.101	.0048	.004	.0080	.0062	.124	–
39	.0052	.099	.0043	.0035	.0075	–	.130	–
40	.0048	.097	.0039	.0031	.0070	–	.138	–
41	.0044	.095	.0034	–	–	–	.146	–
42	.0040	.092	.0031	–	–	–	.154	–
43	.0036	.088	.0027	–	–	–	.162	–
44	.0032	.085	.0024	–	–	–	.170	–
45	.0028	.081	.0021	–	–	–	.180	–
46	.0024	.079	.0019	–	–	–	–	–
47	.0020	.077	.0017	–	–	–	–	–
48	.0016	.075	.0015	–	–	–	–	–
49	.0012	.072	.0013	–	–	–	–	–
50	.0010	.069	.0012	–	–	–	–	–

DIVIDING CIRCLES

Where

D = Dia. of Circle

N = No. of Holes

P = Chordal Pitch

K = Constant

Then P = D x K

No.	K	No.	K	No.	K	No.	K
3	.86603	28	.11197	53	.05924	78	.04027
4	.70711	29	.10812	54	.05814	79	.03976
5	.58779	30	.10453	55	.05709	80	.03926
6	.50000	31	.10117	56	.05607	81	.03877
7	.43388	32	.09802	57	.05509	82	.03830
8	.38268	33	.09506	58	.05414	83	.03784
9	.34202	34	.09227	59	.05322	84	.03739
10	.30902	35	.08964	60	.05234	85	.03695
11	.28173	36	.08716	61	.05148	86	.03652
12	.25882	37	.08480	62	.05065	87	.03610
13	.23932	38	.08258	63	.04984	88	.03569
14	.22252	39	.08047	64	.04907	89	.03529
15	.20791	40	.07846	65	.04831	90	.03490
16	.19509	41	.07655	66	.04758	91	.03452
17	.18375	42	.07473	67	.04687	92	.03414
18	.17365	43	.07299	68	.04618	93	.03377
19	.16460	44	.07134	69	.04551	94	.03341
20	.15643	45	.06976	70	.04486	95	.03306
21	.14904	46	.06824	71	.04423	96	.03272
22	.14232	47	.06679	72	.04362	97	.03238
23	.13617	48	.06540	73	.04302	98	.03205
24	.13053	49	.06407	74	.04244	99	.03173
25	.12523	50	.06279	75	.04187	100	.03141
26	.12054	51	.06156	76	.04132		
27	.11609	52	.06038	77	.04079		

TAPERS AND ANGLES

Angle With C/L	Taper Per Foot Included	Taper Per Inch With C/L	Angle With C/L	Taper Per Foot Included	Taper Per Inch With C/L
0° 17' 54"	1/8"	.0052	2° 14' 12"	15/16"	.0391
0 26 52	3/16"	.0078	2 23 9	1"	.0417
0 35 48	1/4"	.0104	2 58 54	1 1/4"	.0521
0 44 45	5/16"	.013	3 34 35	1 1/2"	.0625
0 53 42	3/8"	.0156	4 10 13	1 3/4"	.0729
1 2 29	7/16"	.0182	4 46 48	2"	.0833
1 11 35	1/2"	.0208	5 56 48	2 1/2"	.1042
1 20 32	9/16"	.0234	7 7 30	3"	.125
1 29 51	5/8"	.026	8 7 50	3 1/2"	.1458
1 38 27	11/16"	.0286	9 27 46	4"	.1666
1 47 22	3/4"	.03125	10 37 10	4 1/2"	.1875
1 56 19	13/16"	.03386	11 46 6	5"	.2083
2 5 16	7/8"	.0365	14 2 10	6"	.25

TAPER PER FOOT AND INCLUDED ANGLE

Taper	Angle	Taper	Angle	Taper	Angle	Taper	Angle
1/64"	0° 4' 28"	23/32"	3° 25' 51"	1 7/8"	8° 56' 2"	4 5/8"	21° 48' 55"
1/32"	0 8 58	3/4"	3 34 48	1 15/16"	9 13 51	4 3/4"	22 23 28
1/16"	0 17 53	25/32"	3 43 44	2"	9 31 37	4 7/8"	22 57 50
3/32"	0 26 52	13/16"	3 52 42	2 1/8"	10 7 11	5"	23 32 12
1/8"	0 35 46	27/32"	4 1 38	2 1/4"	10 42 41	5 1/8"	24 6 28
5/32"	0 44 45	7/8"	4 10 32	2 3/8"	11 18 12	5 1/4"	24 40 43
3/16"	0 53 44	29/32"	4 19 31	2 1/2"	11 53 38	5 3/8"	25 14 51
7/32"	1 2 39	15/16"	4 28 26	2 5/8"	12 29 2	5 1/2"	25 48 53
1/4"	1 11 38	31/32"	4 37 25	2 3/4"	13 4 25	5 5/8"	26 22 52
9/32"	1 20 33	1"	4 46 19	2 7/8"	13 39 44	5 3/4"	26 56 48
5/16"	1 29 31	1 1/16"	5 4 13	3"	14 15 1	5 7/8"	27 30 35
11/32"	1 38 30	1 1/8"	5 22 2	3 1/8"	14 50 15	6"	28 4 21
3/8"	1 47 26	1 3/16"	5 39 55	3 1/4"	15 25 27	6 1/8"	28 37 59
13/32"	1 56 24	1 1/4"	5 57 45	3 3/8"	16 – 34	6 1/4"	29 11 36
7/16"	2 5 18	1 5/16"	6 15 38	3 1/2"	16 35 41	6 3/8"	29 45 4
15/32"	2 14 7	1 3/8"	6 33 29	3 5/8"	17 10 42	6 1/2"	30 18 28
1/2"	2 23 12	1 7/16"	6 51 21	3 3/4"	17 45 40	6 5/8"	30 51 49
17/32"	2 32 10	1 1/2"	7 9 11	3 7/8"	18 20 35	6 3/4"	31 25 2
9/16"	2 41 7	1 9/16"	7 27 –	4"	18 55 31	6 7/8"	31 58 11
19/32"	2 50 3	1 5/8"	7 44 49	4 1/8"	19 30 18	7"	32 31 14
5/8"	2 59 3	1 11/16"	8 2 38	4 1/4"	20 5 1	–	–
21/32"	3 7 57	1 3/4"	8 20 28	4 3/8"	20 39 44	–	–
11/16"	3 16 56	1 13/16"	8 38 17	4 1/2"	21 14 20	–	–

STOCK & TAPER FITS

Jarno	Dia Large End	Length Taper	Dia Small End	Taper Per Foot	Half Included Angle
1	.125"	.5"	.1"	.6"	1°26'
2	.250"	1"	.2"	.6"	1°26'
3	.375"	1.5"	.3"	.6"	1°26'
4	.5"	2"	.4"	.6"	1°26'
5	.625"	2.5"	.5"	.6"	1°26'
6	.75"	3"	.6"	.6"	1°26'
7	.875"	3.5"	.7"	.6"	1°26'
8	1.000"	4"	.8"	.6"	1°26'
9	1.125"	4.5"	.9"	.6"	1°26'
10	1.25"	5"	1.0"	.6"	1°26'
11	1.375"	5.5"	1.1"	.6"	1°26'
12	1.5"	6"	1.2"	.6"	1°26'
13	1.625"	6.5"	1.3"	.6"	1°26'
14	1.75"	7"	1.4"	.6"	1°26'
15	1.875"	7.5"	1.5"	.6"	1°26'
16	2.000"	8"	1.6"	.6"	1°26'
17	2.125"	8.5"	1.9"	.6"	1°26'
18	2.25"	9"	1.8"	.6"	1°26'
19	2.375"	9.5"	1.9"	.6"	1°26'
20	2.5"	10"	2.0"	.6"	1°26'

JARNO FORMULAE (S = SIZE NUMBER) LARGE DIA. = $\frac{S}{8}$ SMALL DIA. = $\frac{S}{10}$ LENGTH = $\frac{S}{2}$

STOCK AND TAPER FITS

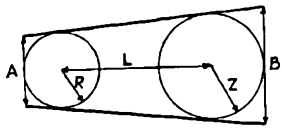
Cleveland	Large Dia	Taper per Foot	Small Dia	Taper per Inch	Length Taper
0	.356	.625	.2518	.05208	2.21875
1	.475	.6	.3688	.05	2.4375
2	.700	.602	.5714	.05017	2.9375
3	.938	.602	.7781	.05017	3.6875
4	1.231	.623	1.0201	.05191	4.625
5	1.748	.63	1.4757	.0525	5.875
6	2.494	.626	2.1158	.05216	8.25
7	3.27	.625	2.7497	.05208	11.25

Cincinnati Quick Release. 3 1/2" per foot included half the included angle 8°17'50". Large end dia. 2.75"

Morse	Dia Large End	Length Taper	Dia Small End	Taper per FOOT	Taper per INCH	Half Included Angle
0	.3561	2	.252	.6246	.05205	1° 29' 30"
1	.475	2.125	.369	.59858	.04988	1° 26'
2	.700	2.5625	.572	.59941	.04995	1° 26'
3	.938	3.1875	.778	.60235	.05019	1° 26' 15"
4	1.231	4.0625	1.020	.62326	.05193	1° 29'
5	1.748	5.1875	1.475	.63151	.05262	1° 30' 30"
6	2.494	7.25	2.166	.62565	.05213	1° 30'
7	3.270	10	2.75	.624	.052	1° 30'

Brown and Sharpe	Large End Dia	Taper per Foot in Inches	Small End Dia	Taper per Inch	Half Included Angle	Length Taper
1	.239	.5	.2	.0416	1° 12'	.9375
2	.299	.5	.25	.0416	1° 12'	1.1875
3	.375	.5	.312	.0416	1° 12'	1.5
4	.420	.5	.35	.0416	1° 12'	1.6875
5	.539	.5	.45	.0416	1° 12'	2.125
6	.599	.5	.5	.0416	1° 12'	2.375
7	.725	.5	.6	.0416	1° 12'	3.00
8	.898	.5	.75	.0416	1° 12'	3.5625
9	1.077	.5	.9	.0416	1° 12'	4.25
10	1.26	.5167	1.0446	.043	1° 14'	5.00
11	1.498	.5	1.25	.0416	1° 12'	5.9375
12	1.531	.5	1.5	.0416	1° 12'	6.75
13	2.073	.5	1.75	.0416	1° 12'	7.75
14	2.344	.5	2.00	.0416	1° 12'	8.25
15	2.615	.5	2.25	.0416	1° 12'	8.75
16	2.885	.5	2.5	.0416	1° 12'	9.25
17	3.156	.5	2.75	.0416	1° 12'	9.75
18	3.427	.5	3.00	.0416	1° 12'	10.25

FORMULAE FOR TAPERS



T = Taper per inch

$$L = \frac{Z-R}{T}\sqrt{1+T^2} \qquad \text{Taper per foot} = 24\left[\frac{Z-R}{\sqrt{L^2-(Z-R)^2}}\right]$$

$$R = \frac{A}{L}\left[\sqrt{L^2+(B-A)^2}+(B-A)\right]$$

$$Z = \frac{B}{L}\left[\sqrt{L^2+(B-A)^2}-(B-A)\right]$$

$$A = R\sqrt{\frac{L-(Z-R)}{L+(Z-R)}} \qquad B = Z\sqrt{\frac{L+(Z-R)}{L-(Z-R)}}$$

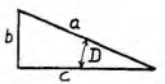
USEFUL CONSTANTS

$\pi = 3.14159$
$3 \div \pi = .95492$
$\pi^2 = 9.8696$
$\sqrt{\pi} = 1.77245$
$1 \div \sqrt[3]{\pi} = .68278$
$\pi \div 4 = .7854$
$2g = 64.32$
$1 \div \sqrt{g} = .17634$
$\pi \div 180 = .01745$
$2\pi = 6.28318$
$4\pi \div 3 = 4.18879$
$\pi^3 = 31.00628$
$1 \div \sqrt{\pi} = .56419$
$\sqrt[3]{\pi^2} = 2.14503$

$g = 32.16$
$1 \div g = .01555$
$\pi \div \sqrt{g} = .55399$
$\sqrt[3]{6 \div \pi} = 1.2407$
$\pi \div 3 = 1.0472$
$1 \div \pi = .31831$
$1 \div \pi^2 = .10132$
$\sqrt[3]{\pi} = 1.46459$
$\sqrt[3]{3 \div 4\pi} = .62035$
$\sqrt{2g} = 8.01998$
$g^2 = 1034.226$
$e = 2.71928$
$180^\circ \div \pi = 57.2958^\circ$

TRIGONOMETRY

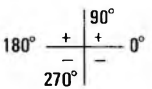
DEFINITIONS



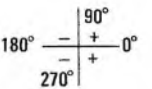
b/a = Sine D
c/a = Cosine D
c/b = Cotangent D
b/c = Tangent D
a/b = Cosecant D
a/c = Secant D

CHANGE IN SIGN OF TRIGONOMETRICAL FUNCTIONS

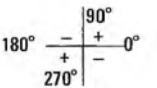
SINE



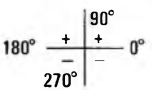
COSINE



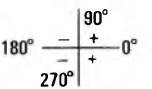
TANGENT



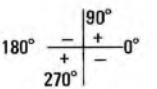
COSECANT



SECANT



COTANGENT



USEFUL FORMULAE

$\sin^2 A + \cos^2 A = 1$ $\qquad \tan A = \dfrac{\sin A}{\cos A} = \dfrac{1}{\cot A}$

$\cot A = \dfrac{\cos A}{\sin A} = \dfrac{1}{\tan A}$ $\qquad \sec A = \dfrac{1}{\cos A}$ $\qquad \operatorname{cosec} A = \dfrac{1}{\sin A}$

$\sin A = \sqrt{1 - \cos^2 A} = \dfrac{\tan A}{\sqrt{1 + \tan^2 A}} = \dfrac{1}{\sqrt{1 + \cot^2 A}}$

$\cos A = \sqrt{1 - \sin^2 A} = \dfrac{\cot A}{\sqrt{1 + \cot^2 A}} = \dfrac{1}{\sqrt{1 + \tan^2 A}}$

$\sin (A + B) + \sin (A - B) = 2 \sin A \cos B$
$\sin (A + B) - \sin (A - B) = 2 \cos A \sin B$
$\cos (A + B) + \cos (A - B) = 2 \cos A \cos B$
$\cos (A - B) - \cos (A + B) = 2 \sin A \sin B$

$$\sin (A \pm B) = \sin A \cos B \pm \cos A \sin B$$
$$\cos (A \pm B) = \cos A \cos B \mp \sin A \sin B$$

$$\tan (A \pm B) = \frac{\tan A \pm \tan B}{1 \mp \tan A \tan B} \qquad \cot (A \pm B) = \frac{\cot A \cot B \mp 1}{\cot B \pm \cot A}$$

$$\tan A \pm \tan B = \frac{\sin (A \pm B)}{\cos A \cos B} \qquad \cot A \pm \cot B = \frac{\sin (B \pm A)}{\sin A \sin B}$$

$$\sin^2 A - \sin^2 B = \cos^2 B - \cos^2 A = \sin (A + B) \sin (A - B)$$
$$\cos^2 A - \sin^2 B = \cos^2 B - \sin^2 A = \cos (A + B) \cos (A - B)$$

$$\sin A \sin B = \tfrac{1}{2} \cos (A - B) - \tfrac{1}{2} \cos (A + B)$$
$$\sin A \cos B = \tfrac{1}{2} \sin (A + B) + \tfrac{1}{2} \sin (A - B)$$

$$\tan A \tan B = \frac{\tan A + \tan B}{\cot A + \cot B} \qquad \cot A \cot B = \frac{\cot A + \cot B}{\tan A + \tan B}$$

$$\sin A = 2 \sin \tfrac{1}{2} A \cos \tfrac{1}{2} A \qquad \sin 2A = 2 \sin A \cos A$$
$$\cos 2A = \cos^2 A - \sin^2 A = 1 - 2 \sin^2 A = 2 \cos^2 A - 1$$

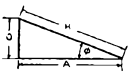
$$\tan 2A = \frac{2 \tan A}{1 - \tan^2 A} = \frac{2}{\cot A - \tan A} \qquad \sin A = \frac{2 \tan \tfrac{1}{2} A}{1 + \tan^2 \tfrac{1}{2} A}$$

$$\cot 2A = \frac{\cot^2 A - 1}{2 \cot A} = \frac{\cot A - \tan B}{2} \qquad \cos A = \frac{1 - \tan^2 \tfrac{1}{2} A}{1 + \tan^2 \tfrac{1}{2} A}$$

$$\sin 3A = 3 \sin A - 4 \sin^3 A$$

$$\cos 3A = 4 \cos^3 A - 3 \cos A \qquad \tan 3A = \frac{3 \tan A - \tan^3 A}{1 - 3 \tan^2 A}$$

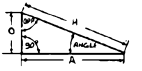
SOLUTION OF RIGHT-ANGLED TRIANGLES



A = Side Adjacent Ø
O = Side Opposite Ø
H = Hypotenuse

Sine Ø = O/H Tangent Ø = O/A Secant Ø = H/A

Cosine Ø = A/H Cotangent Ø = A/O Cosecant Ø = H/O

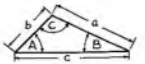


Given	To Be Found: Hyp.	Adj. Side	Opp. Side	Angle	Opp. Angle
Hypotenuse and Adjacent	—	—	$\sqrt{Hyp^2 - Adj^2}$	Cosine $= \frac{Adj}{Hyp}$	Sine $= \frac{Adj}{Hyp}$
Hypotenuse and Opposite	—	$\sqrt{Hyp^2 - Opp^2}$	—	Sine $= \frac{Opp}{Hyp}$	Cosine $= \frac{Opp}{Hyp}$
Hypotenuse and Angle	—	Hyp x Cosine	Hyp x Sine	—	90° − Angle
Adjacent and Opposite	$\sqrt{Adj^2 + Opp^2}$	—	—	—	Cotan $= \frac{Opp}{Adj}$
Adjacent and Angle	$\frac{Adj}{Cosine}$	—	Adj x Tangent	—	90° − Angle
Opposite and Angle	$\frac{Opp}{Sine}$	Opp x Cotan	—	—	90° − Angle

SOLUTION OF OBLIQUE-ANGLED TRIANGLES: ANGLES

Given	To Be Found Angle A	Angle B	Angle C
abc	$\frac{b^2+c^2-a^2}{2bc} = \cos A$	$\frac{a^2+c^2-b^2}{2ac} = \cos B$	$\frac{a^2+b^2-c^2}{2ab} = \cos C$
bc Angle A	—	$\frac{b \sin A}{c - b \cos A} = \tan B$	$\frac{c \sin A}{b - c \cos A} = \tan C$
ac Angle B	$\frac{a \sin B}{c - a \cos B} = \tan A$	—	$\frac{c \sin B}{a - c \cos B} = \tan C$
ab Angle C	$\frac{a \sin C}{b - a \cos C} = \tan A$	$\frac{b \sin C}{b - a \cos C} = \tan B$	—
ab Angle A	—	$\frac{b \sin A}{a} = \sin B$	$180° - (A + B)$
ab Angle B	$\frac{a \sin B}{b} = \sin A$	—	$180° - (A + B)$
ac Angle A	—	$180° - (A + C)$	$\frac{c \sin A}{a} = \sin C$
ac Angle C	$\frac{a \sin C}{c} = \sin A$	$180° - (A + C)$	—
bc Angle B	$180° - (B + C)$	—	$\frac{c \sin B}{b} = \sin C$
a Angles AB	—	—	$180° - (A + B)$
a Angles AC	—	$180° - (A + C)$	—
a Angles BC	$180° - (B + C)$	—	—
b Angles AB	—	—	$180° - (A + B)$
b Angles AC	—	$180° - (A + C)$	—
b Angles BC	$180° - (B + C)$	—	—
bc Angle C	$180° - (B + C)$	$\frac{b \sin C}{c} = \sin B$	—
c Angles AB	—	—	$180° - (A + B)$
c Angles AC	—	$180° - (A + C)$	—

SOLUTION OF OBLIQUE-ANGLED TRIANGLES: SIDES



Given	To Be Found side a =	side b =	side c =
bc Angle A	$\sqrt{b^2+c^2-2bc\cos A}$	—	—
ac Angle B	—	$\sqrt{a^2+c^2-2ac\cos B}$	—
ab Angle C	—	—	$\sqrt{a^2+b^2-2ab\cos C}$
ab Angle A	—	—	$\frac{a \sin C}{\sin A}$
ab Angle B	—	—	$\frac{b \sin C}{\sin B}$
ac Angle A	—	$\frac{a \sin B}{\sin A}$	—
ac Angle C	—	$\frac{c \sin B}{\sin C}$	—
bc Angle B	$\frac{b \sin A}{\sin B}$	—	—
bc Angle C	$\frac{c \sin A}{\sin C}$	—	—
a Angles AB	—	$\frac{a \sin B}{\sin A}$	$\frac{a \sin C}{\sin A}$
a Angles AC	—	$\frac{a \sin B}{\sin A}$	$\frac{a \sin C}{\sin A}$
a Angles BC	—	$\frac{a \sin B}{\sin A}$	$\frac{a \sin C}{\sin A}$
b Angles AB	$\frac{b \sin A}{\sin B}$	—	$\frac{b \sin C}{\sin B}$
b Angles AC	$\frac{b \sin A}{\sin B}$	—	$\frac{b \sin C}{\sin B}$
b Angles BC	$\frac{b \sin A}{\sin B}$	—	$\frac{b \sin C}{\sin B}$
c Angles AB	$\frac{c \sin A}{\sin C}$	$\frac{c \sin B}{\sin C}$	—
c Angles AC	$\frac{c \sin A}{\sin C}$	$\frac{c \sin B}{\sin C}$	—
c Angles BC	$\frac{c \sin A}{\sin C}$	$\frac{c \sin B}{\sin C}$	—

MENSURATION [1]

THE TRAPEZOIDAL RULE To obtain the area of irregular figures divide the base of the figure into a number of equal parts and erect ordinates at points of division. Measure the lengths of these ordinates, then

> Area = Length of one division x [(½ first + last ordinates) + sum of all remaining ordinates]

SIMPSON'S RULE For area of irregular figures. Divide base of figure into an even number of equal divisions. Then the

> Area = ⅓ width of one base division x [height of (first + last ordinates) + 4 (sum of even ordinates) + 2(sum of remaining odd ordinates)]

GENERAL FORMULAE

Radian = $\frac{360^\circ}{2\pi}$ = 57.3° and $\frac{\pi}{180}$ radians = 1°

Now in an angle of 1 radian, the arc is equal to the radius in length ∴ The length of arc of any angle is equal to radius x angle measured in radians.

In all the following formulae these abbreviations are used:–

R = Major Radius, r = Minor Radius,
D = Major Diameter, d = Minor Diameter,
C = Chord, H = Height,
S = Side,Length V = Volume,
A = Area

SPHERE $V = \frac{4\pi R^3}{3} = 4.189\ R^3 = \frac{\pi D^3}{6} = .524\ D^3$

$A = 4\pi R^2 = \pi D^2 = 12.5664\ R^2 = 3.1416\ D^2$

$R = \sqrt[3]{\frac{3V}{4\pi}} = .6204\sqrt[3]{V}$

TORUS or circular section ring. $V = 2\pi^2 R(r)^2 =$

$19.739\ Rr^2 = \frac{\pi^2}{4} D(d)^2 = 2.4674\ Dd^2$ $A = 4\pi^2 Rr =$

$39.478\ Rr = \pi^2 Dd = 9.8696\ Dd$. Where R = Main Radius of ring and 4 = Radius of Circular Section.

MENSURATION [2]

SPHERICAL SECTOR $V = \frac{2}{3}\pi R^2H = 2.0944R^2H = \frac{1}{3}R^2(R \pm \sqrt{R^2 - \frac{1}{4}C^2})$

$A = \pi R(2H + \frac{1}{2}C)$ $C = 2\sqrt{H(2R - H)}$ Where H = Height of segment above chord.

CONE $V = \frac{\pi R^2 H}{3} = 1.047R^2H = .2618D^2H$

$A = \pi R\sqrt{R^2 + H^2} = \pi RS = 1.5708DS$ $S = \sqrt{R^2 + H^2} = \sqrt{\frac{D^2}{4} + H^2}$

CONIC FRUSTRUM $V = \frac{1}{12}\pi H(D^2 + Dd + d^2) = \frac{1}{3}\pi H(R^2 + Rr + r^2)$

$A = \pi S(R + r) = 1.5708S(D + d)$ $S = \sqrt{(R - r)^2 + H^2}$

CYLINDER $V = \pi R^2H = .7854D^2H$. Circular Area $= 2\pi RH = \pi DH$.

Total Area $= 2\pi R(R + H) = \pi D(\frac{1}{2}D + H)$

PROLATE SPHEROID $V = \frac{4}{3}\pi Rr^2 = 4.189Rr^2 = \frac{1}{6}\pi Dd^2 = .5236Dd^2$

$A = \frac{4\pi}{\sqrt{2}} r\sqrt{R^2 + r^2}$

PARABOLOID $V = \frac{1}{2}R^2H = 1.5708R^2H = \frac{\pi}{8}D^2H = .3927D^2H$

$A = \frac{1}{2}$ Prolate Spheroid

PYRAMID $V = \frac{1}{3}H \times$ Area of Base $= \frac{\text{No. of side} \times SH}{6}\sqrt{R^2 - \frac{S^2}{4}}$

R = Radius of inscribed circle

PYRAMIDAL FRUSTRUM $V = \frac{H}{3}(A + a + \sqrt{Aa})$

A = Area of Top a = Area of Bottom

PORTION OF CYLINDER $V = 1.5708R^2(H + h) = .3927D^2(H + h)$

Cylindrical Surface $= \pi R(H + h)$ Where H = Major Height and h = Minor Height

HOLLOW CYLINDER $V = \pi H(R^2 - r^2) = .7854H(D^2 - d^2) =$

1.5708 x Thickness of Wall x (D − d)

SPHERICAL ZONE $V = .5236H(\frac{3C^2}{4} + \frac{3P^2}{4} + H^2)$

Where P = Major Chord C = Minor Chord

Area of spherical surface $= 2\pi RH$

$R = \sqrt{\frac{P^2}{4} + (P^2 + C^2 - 4H^2)^2}$

CIRCULAR WEDGE $V = \frac{M}{360} \times \frac{4\pi R^3}{3} = .0116MR^3$

$A = \frac{M}{360} \times 4\pi R^2 = .0349MR^2$ Where M = Angle of Wedge.

GEOMETRY

Angles. Fig. 1.

Are formed by the meeting of two straight lines. They are measured by degrees which are obtained by dividing the circle into 360 equal parts by means of radii, each part being an angle of one degree.

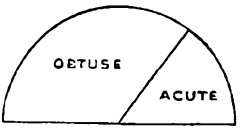


Fig.1.

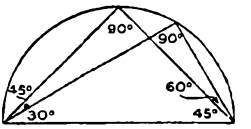


Fig.3.

Common Angles. Fig. 2.

The most common angles are:

½ of a circle	equals	90°
⅙th	"	60°
¼th	"	45°
1/12th	"	30°
1/24th	"	15°

Other angles are easily obtained from these.

The Triangle. Fig. 3.

The sum of the angles of any triangle equals 180°, and the sum of any two of the angles, subtracted from 180°, will give the third angle.

The Circle. Fig. 4.

The circle and its different parts are often used in marking out and solving problems; therefore it will be of great help to get a good understanding of its composition.

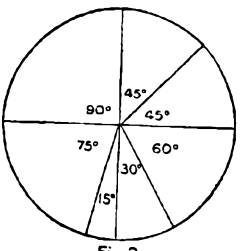


Fig.2.

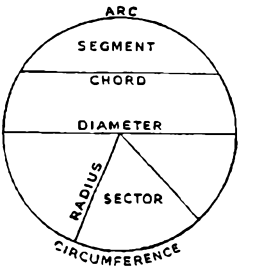


Fig.4.

A Polygon

Is a plane figure bounded by more than four straight sides, and may be either regular or irregular. The following are the most common polygons:

NAME	No. of sides	Angle at centre.	Angle at circumference.
Pentagon	5	72°	108°
Hexagon	6	60°	120°
Heptagon	7	51⅜°	128°
Octagon	8	45°	135°
Nonagon	9	40°	140°
Decagon	10	36°	144°

GEOMETRICAL PROBLEMS

To Bisect a Line. Fig. 5.

Let AB be the given line. Then, with A and B as centres, and any convenient radius, describe arcs to intersect at C and D. A line from C to D will bisect and also be perpendicular to AB.

To Bisect an Angle. Fig. 6.

Let ABC be the given angle. Then with B centre and any convenient radius, strike arcs at D and E. With D and E centres, strike arcs to intersect at F. A line from F to B bisects angle ABC.

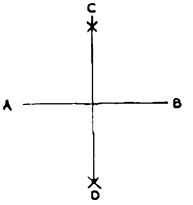


Fig 5.

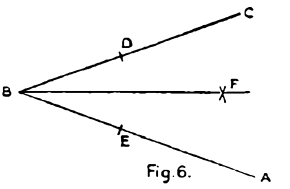


Fig.6.

To Divide a Line into Any Number or Equal Parts. Fig. 7.

Let AB be the given line, and the number of parts 6. Draw line AC at any angle to AB and any length. Then mark off on line AC beginning from A, 6 equal parts. From point 6 draw line to B, and from the other points draw lines parallel to 6B. AB will then be equally divided.

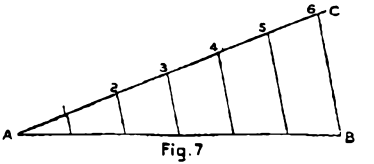


Fig.7

To Construct an Angle of 60°. Fig. 8.

Draw line AB any length. Then with A centre and any radius, describe arc CD. With D centre and same radius, intersect arc at E. A line from E to A makes 60° angle EAD. To get a 30° angle, bisect arc ED.

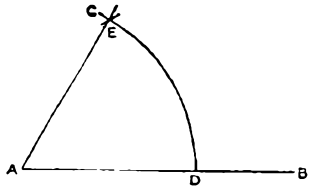


Fig. 8.

To Reproduce a Given Angle. Fig. 9.

Let ABC be the given angle. Draw line DE any length, and with D centre, and BA radius, describe arc FG. With F centre and AC radius, intersect arc FG and from point of intersection draw line to D. This makes angle FDG, equal to ABC. With variations, this method can be used to reproduce almost any figure.

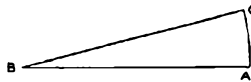
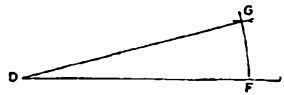


Fig. 9.



To Find the Centre of Segment of Circle. Fig. 10.

With A centre and AB radius, strike arc at C. Then, with B centre and same radius, strike arc to intersect at C. A perpendicular line from C will strike the centre of the segment.

To Find the Radius of an Arc. Fig. 11.

Let AB be the given arc. Make point C at roughly the middle of the arc. With A centre and any radius, strike arcs at D and E. With centre and same radius strike arcs at F and G. Then, with C centre and same radius, strike intersecting arcs at DEF and G. Where lines through DE and

FG intersect at H, will be found the point from which arc AB was described. This method is also used to describe an arc through any three points not in a straight line, with AB and C representing the points.

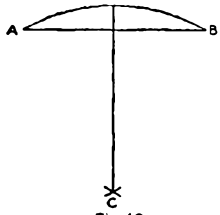


Fig.10.

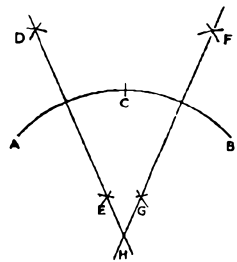


Fig.11.

To Find a Straight Line Equal in Length to an Arc. Fig. 12.

Let AB be the given arc. Then find the radius of the arc (Fig. 11) and from the centre O draw line to A. Then draw line AC at right angles to OA. Draw chord BA and prolong to D, making AD half the length of chord BA. With D centre and DB radius strike arc at C. Then straight line AC will equal length of arc AB.

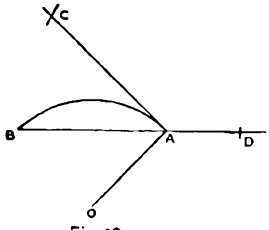


Fig. 12.

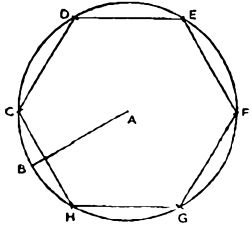


Fig. 13.

To Inscribe a Hexagon within a Circle. Fig. 13.

With radius of circle AB, make points C D E F G H Draw lines from point to point to form hexagon.

To Describe a Hexagon about a Circle. Fig. 14.

Draw line AB to pass through the centre of circle at C, and circumference at E. With E centre and EC radius, cut

circumference at F. Draw chord EF, and a line from C through F. Draw line HG parallel to chord EF. With C centre and CH radius, describe outer circle. Then hexagon formed within outer circle will also be described about inner circle.

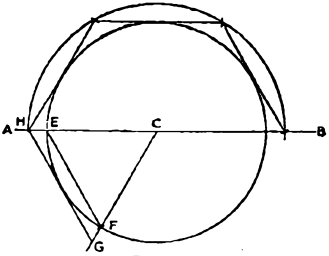


Fig.14.

To Construct an Oval. Fig. 15.

Draw major axis AB, and minor axis CD. Draw line CA. With E centre and EC radius cut AB at F. With C centre and FA radius, cut CA at G. Bisect GA and draw line through to cut minor axis line at H, and major axis at J. JA then gives radius for end arcs, and HC gives radius for side arcs of oval.

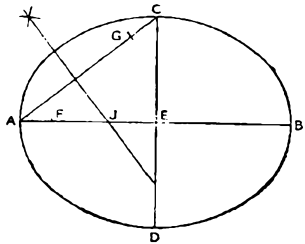


Fig.15

To Construct an Oval with only Major Axis Given. Fig. 16.

Divide major axis AB into 4 equal parts at C D E, and draw minor axis line through D. With E centre and EC radius, cut minor axis at F and G. Draw lines from F and G through E and C. With E and C centres and CA radius, describe end arcs XX and HH. Then, with F and G centres and FH radius, complete oval with side arcs HX.

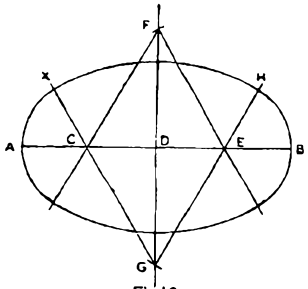


Fig.16.

To Construct an Oval of Egg Shape. Fig. 17.

Draw major axis AB. Then with A centre and half the minor axis as radius, strike point E. Draw minor axis CD through E. With E centre and ED radius, describe a three-quarter circle from D through A and C to F. Draw a line from D to B and erect a perpendicular from F to strike DB at G. Then from G draw a horizontal line to strike DE at H. With B centre and DH radius, strike point at J, and draw line from J to H. Bisect JH, and project bisecting line to K. KD then gives radius for arcs DX and CX. With J centre, complete oval with arc XX.

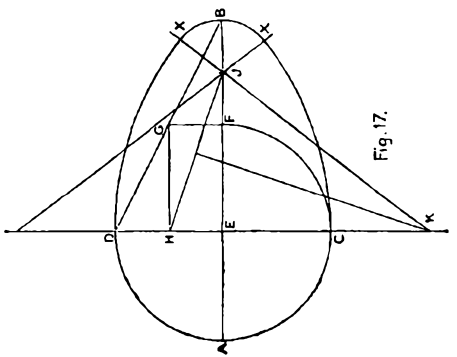


Fig. 17.

To Construct an Egg-shaped Oval, with only Minor Axis Given. Fig. 18.

Draw minor axis AEB, and with E centre, and EA radius, describe circle. Draw major axis line XX of indefinite length. Draw lines AD and BC through F. Then, with A centre and AB radius, describe arc BD. With B centre, and same radius, describe arc AC. Then, with F centre and FC radius, complete oval with arc CD.

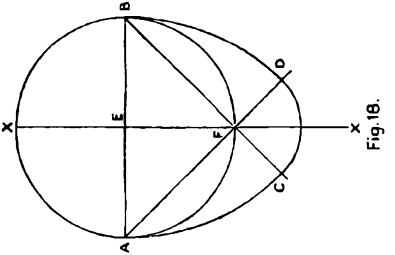


Fig. 18.

To Inscribe a Regular Polygon of Any Number of Sides within a Given Circle. Fig. 19.

Within the given circle draw two diameters AB and CD at right angles. Divide CD into as many equal parts as the polygon has sides (eight here, as an example). With A centre and three-quarter of length AO as radius, strike point E. Draw line from E through point 2 to strike circumference at F. Chord FD then gives one side of the required polygon.

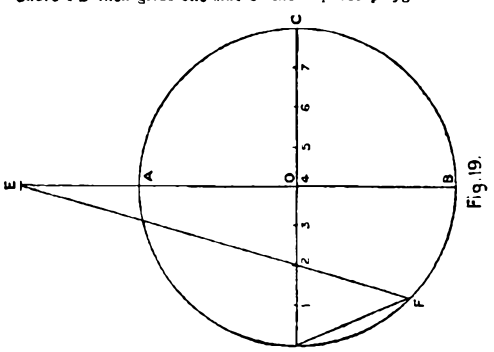


Fig. 19.

To Construct a Polygon with One Side Given. Fig. 20.

Let AB be the given side. Then, with B centre and BA radius, describe semi-circle, making diameter ABC. Divide semi-circle into as many equal parts as the polygon has sides (eight here, as an example). From B draw line to point 2. Bisect AB and B2 bisecting lines to intersect at D. With D centre and DA radius, describe circle within which the polygon is constructed.

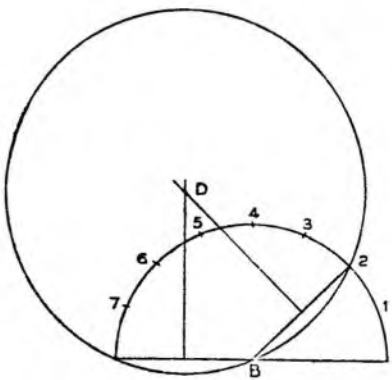


Fig. 20.

SETTING UP AND MEASURING OF ANGLES

The standard tools for laying-out and measuring of angles are the protractor and the sine bar. When issuing the sine bar for checking, the component has to be put on the sine bar or sine table and slip gauges are placed under one end of the bar until one angle face is parallel to the surface plate (fig. 2). To find the appropriate amount of slips which have to be used, the figures for "sine" in the trigonometric table have to be looked up. In case of a 10in. sine bar the figures in the table have to be multiplied by 10, if a 5in. bar has to be used, the figures have to be multiplied by 5.

EXAMPLE:

To set up a 30° angle, the sine of 30° has to be looked up in the trigonometric table.

Sine 30°=0.500, for 10in. sine bar a 5in. slip has to be used, for 5in. sine bar, 2.500 slips have to be used.

If the job in question is too bulky to be put on the sine bar, or an adjustable angle bracket has to be set up, the sine bar can be turned over and can be used as explained in fig. 3. In such a case, the height over the roller has to be taken with the height gauge and the difference in the heights has to correspond with the figures of the sine of the trigonometric table multiplied by 10 or 5 respectively.

If the faces are too small to permit the use of a 10in. or 5in. sine bar, an auxiliary 1in. sine bar is easily made up by two 1-in. rollers, as shown in fig. 4. The rollers are touching each other and the difference in heights taken over the rollers must correspond with the figures of the trigonometric table. A piece of plasticine helps to keep the rollers in position.

CHECK OF ANGLE WITH TWO ROLLERS (fig. 5).

Set up one face of angle perpendicular to surface plate and ascertain perpendicular centre-distance of rollers by means of a dial or height gauge. (Watch unequal roller diameters). The angle can be worked out by means of formula $\tan \frac{a}{2} = \frac{R-r}{Cp.}$

R=radius of larger roller.
r=radius of smaller roller.

If the perpendicular setting of the job cannot be achieved, ascertain the centre-distance (C) with slip gauges and the angle can be worked out by means of formula $\sin \frac{a}{2} = \frac{R-r}{C}$

ANGULAR POSITIONING OF PINS (KEY WAYS) TO CENTRE LINE OF CYLINDER BORE (fig. 6).

The problem to position a pin or key way in angular relation to the centre line of the bore can be solved as follows. The requested angle between pin and centre line=a, the radius (R) of the bore is known, drop a roller in the bore (r=radius of roller) so that it touches the pin. Radius of pin is also known (A). The angle (b) can be worked out sin $b = \frac{A+r}{R-r}$,

measure with height gauge perpendicular position of centre of roller for centre of bore (y), calculate (y) by means of formula $y=(R-r) \times \cos (a+b)$. If the calculated value of (y) agrees with the measured value of (y), the centre angle (a) is correct.

MEASURING OF DOVETAIL SLIDES (figs. 7 & 8).

$a = x - D\ (1 + \cot \frac{a}{2})$, $c = h \times \cot a$, $aft = a \div e$.

$b = y + D\ (1 \div \cot \frac{a}{2})$, $c = h \times \cot a$, $blt. = b - 2c$.

The value for (x) can be obtained through micing over the rollers.

The value for (y) can be obtained by means of slip gauges between the two rollers. D=roller diameter.

TAPERS

SETTING A PRECISION TAPER (fig. 9).

The amount of a taper is usually given on the drawing, either in inches per foot or in degrees. To find the angle in degrees for given taper per foot, divide the taper in inches per foot by 24, the result of this division represents the tangents of half of the included angle (= angle with centre line).

Example: What angle is equivalent to taper 1in. per foot? $\frac{1}{24} = .04166$, $\tan \frac{a}{2} = .04166$, look up under "tan" in trigonometric table.

Result: $\frac{a}{2} = 2°\ 23ft.\ 10in.$, $a = 4°\ 46ft.\ 20in.$

For setting up a taper on the lathe, look up under the column "tangents" the value of half of the included angle in the trigonometric table. This value represents the rise of the taper per inch and can easily be set up by means of a dial gauge which has to be fixed into the tool post on the centre line of the job. Use the lead screw nut (thread catching device) or slip gauges positioned against a stop to control the horizontal movement of the slide. If the rise of the clock per inch of the horizontal movement corresponds with the ascertained figure on the "tan" column, the taper is set up correctly.

Example: Set up included angle 4° 26ft. 20in., half included angle or angle with centre line=2° 13ft. 10in., tangents of this angle=.0416in., which figure represents the rise of the taper per inch of the clock fixed in the tool post.

CHECK OF TAPER.

The usual way of checking a taper is the sine bar. The job has to be put between the centres of the sine bar. Slips, corresponding to the angle with the centre line (see chapter—measuring of angles), have to be placed under the end of the sine bar. If the taper is correct, the face of the taper must be parallel to the surface plate.

TWO ROLLER METHOD: sleep taper (fig. 10).

The angle of a short and sleep taper can be checked by two micrometer readings over two pairs of rollers of different sizes. A=reading over large roller, B=reading over small roller, D and d=diameters of large and small rollers respectively.

$$\tan \frac{x}{2} = \frac{(D - d)}{(A - B) - (D - d)}$$

TWO ROLLER METHOD: small and long taper (fig. 11).

Taking two micrometer readings over a pair of rollers in a different heights, the taper can be worked out according to the formula:—

$$\tan x = \frac{A - B}{2y}$$

A=measurement over rollers placed on slip gauges.
B=measurement over roller on small end of taper.
y=amount of slip gauges, x=angle with centre line.

CHECK OF INTERNAL TAPER (fig. 12).

Two balls of different diameters are to be placed in the internal taper and the distances of the top of the ball to the upper end of the taper ring measured by means of a depth micrometer. The angle x may be found from the formula:—

$$\sin x \frac{R - r}{(A + r) - (B + R)}$$

A=reading of depth micrometer to the top of small roller.

B=reading of depth micrometer to the top of large roller.

r and R=radius of small and large roller respectively.

x=angle with centre line.

CHECK OF END DIAMETERS OF TAPER RING GAUGE (fig. 13).

Given: Angle with centre line of taper gauge x. Thickness of Ring Gauge D.

Place in the bore of the gauge one ball with known radius (R) slightly protruding over the top of the gauge and measure difference in heights from top of ball to the upper face of the gauge (U). The end diameters of the gauge may be found from formula:—

Top diameter $B = 2 (R \cos Ux + R - U) \tan x$.

Bottom diameter $A = B - (2D \tan x)$.

CYLINDRICAL BORES AND SEGMENTS

A system of checking bores not well enough known to operators and inspectors is explained in fig. 14. Build up the dimension of the bore in question with two well calibrated rollers and slip gauges and insert it in the bore, or slip the component over the built up dimension. With some practice, accuracy of .0001in. can be ascertained. Components in the machine can also be checked in the same way. Slight trouble may be encountered to keep the built up dimension, square in the bore when inserting. This can be simplified by means of a small gadget consisting of a well calibrated ball, sweated on a stem (fig. 15) which has to replace one roller and no difficulties when inserting will be encountered.

BORE OF CYLINDRICAL SEGMENT.

To find the diameter of the bore of a cylindrical segment the general known formula:—

$$\text{dia.} = \frac{(\frac{1}{2}\text{ chord})^2 + (\text{height})^2}{\text{height}}$$ has to be applied.

If the faces of the segment are square and flat and the job can be held down on the surface plate, the most precise and convenient method is the checking of the job with slip gauges and rollers of equal size in the vertical and horizontal direction. To obtain the height (y) and the chordal dimension (x) see fig. 16.

$x = \frac{1}{2}x$ (amount of slips + diameter of roller D).

y=amount of slips in vertical direction.

Diameter of bore $\frac{x^2 + y^2}{y}$ + diameter of roller.

If the faces are not flat or the job cannot be held down, position the job on the surface plate as shown in fig. 17. Level up the two rollers, after having inserted the appropriate amount of slips and ascertain in this way the chordal dimension (X). Measure with the height gauge the horizontal position of the centre line between the two rollers. To find the dimension (y), one roller of the same size has to be dropped into the lowest spot of the bore (see dotted lines) and the position of the centre

of the ball may be measured with the height gauge. The difference between the two height gauge readings is the requested height (y).

$$\text{Diameter of bore} = \frac{X^2 + y^2}{y}$$

OUTSIDE DIAMETER OF SEGMENT.

Sometimes broken parts of machines, gears, cylindrical discs, etc., are delivered into the tool room for replacement. Often only segments of such parts are available and the outside diameter has to be checked. Proceed as follows (fig. 19):—

Hold the component down on surface plate as shown on drawing and place two rollers of equal size under the outside diameter of the segment. Take a micrometer reading over the rollers (A). The reading (R) of the segment may be found from the formulas:—

$$B = \frac{A - 2r}{2}; \quad R = \frac{B^2}{4r}; \quad r = \text{radius of rollers.}$$

HINTS FOR TURNERS, GRINDERS, FITTERS, ETC.

With a little effort you can make yourself a few gadgets which will improve your efficiency considerably.

With a gadget sketched in fig. 20, you can transform an ordinary micrometer into a wall micrometer. The inserted steel ball is held in position by means of a cap, which can be slotted to fit the different sizes of anvils. By deducting the diameter of the ball from the micrometer reading, you can read directly the wall thickness of your bore and check the concentricity of the job. By measuring the wall thickness and deducting twice the amount from the outside diameter, the check of the size of the bore within accurate limits is now an easy matter.

Two-pointed caps are also easily made (fig. 21). The micrometer has now been transformed into a point micrometer, which enables you to check, precisely, recesses, core diameters of threads, etc.

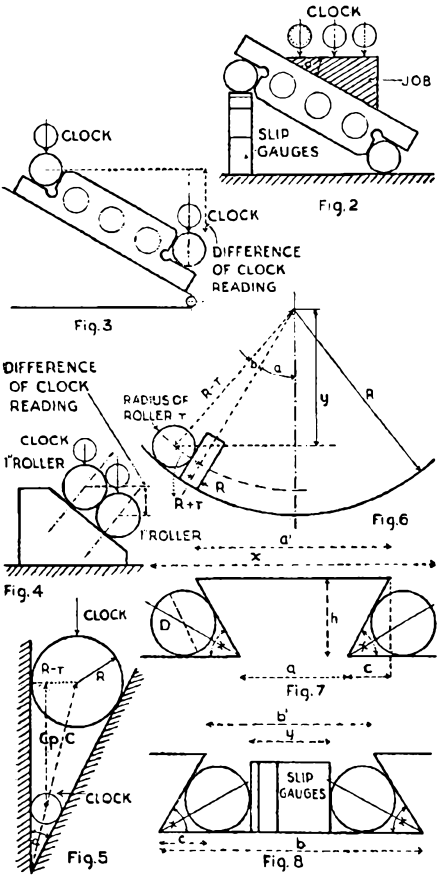
Even a thread micrometer can be replaced by making one cap pointed, to fit the spindle and another cap with a "V" slot to fit the anvil (fig 22). When producing these two caps, the thread angle has to be considered.

In shops where a lot of grinding of three-fluted tools has to be done, a small 60° "V" block, which is easily adjusted to fit the micrometer, will save you a considerable time when checking the diameter of the three-fluted tool. (fig. 23). Based on trigonometrical rules, the deduction of ¼ of the micrometer reading gives the outside diameter of the three-fluted tool.

When holes have to be drilled in accurate positions the following gadget (fig. 24) will be used very advantageously. Two gadgets are necessary and each consists of two parts, one oblong part, with a small reamed hole, and one cylindrical part with a cylindrical pip, which has a good push fit in the small cylindrical hole of the oblong. The pip has to be concentric to the outside diameter of the cylinder and the centre line must be square to the face of the oblong, which has to be hardened and ground, as the small bore has to be used as a guide for the drill.

When drilling holes in position, use the two gadgets as follows:—

Clamp the oblongs tightly on the job, and set up the requested distances by means of slip gauges between the cylindrical pins. After having ascertained the position, tighten up clamps and pull out the pins and use the small holes in the oblong as a drill guide.


CLOCK
JOB
SLIP GAUGES
Fig.2
CLOCK
CLOCK
DIFFERENCE OF CLOCK READING
Fig.3
DIFFERENCE OF CLOCK READING
CLOCK
1"ROLLER
RADIUS OF ROLLER r
R-r
R+r
R
b
a
y
R
1"ROLLER
a'
x
Fig.6
Fig.4
CLOCK
R-r
R
Cp.C
CLOCK
Fig.5
D
h
a
c
Fig.7
b'
y
SLIP GAUGES
c
b
Fig.8

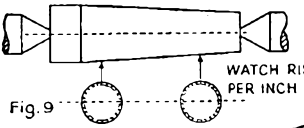


Fig. 9

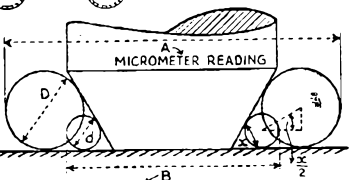
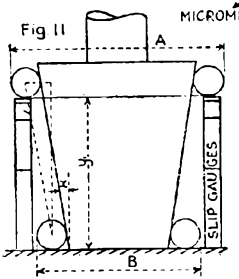


Fig. 10

Fig. 11



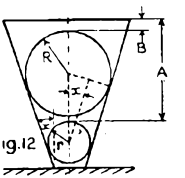


Fig.12

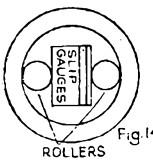


Fig.14

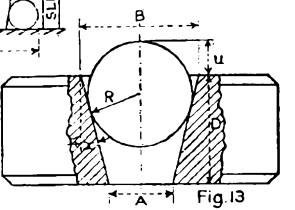


Fig.13

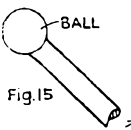


Fig.15

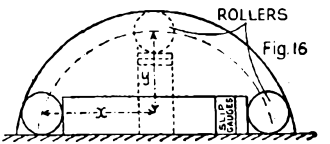


Fig.16

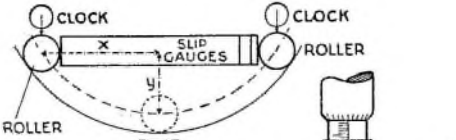


Fig.17

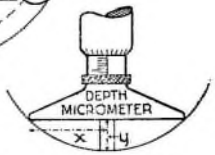


Fig.18

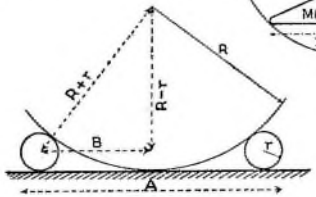


Fig.19

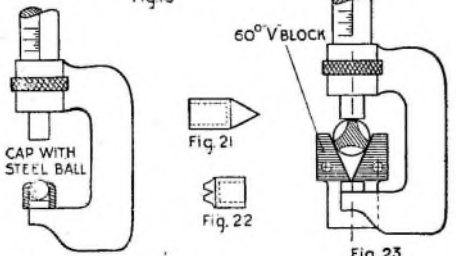


Fig. 20

Fig. 21

Fig. 22

Fig. 23

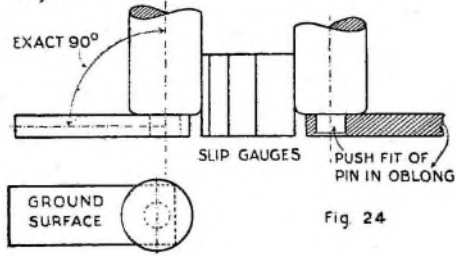


Fig. 24

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