

## GENERAL ENGINEERING INFORMATION

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# Kilowatt/Newton-Meters Horsepower/Torque



## History:

The Imperial units of measurement date as far back in time as the Roman Empire. Over the centuries these units developed names and definitions such as the mile, inch, hand, foot, yard, acre, rod, and many others. In the 1790's, following the French Revolution, the French introduced a new system of measurement called the "Metric System." The meter, the fundamental unit of length, was figured to be 1/10,000,000 part of the quadrant of the earth from the North Pole to the Equator - about 10 miles/16 kilometers longer than calculated with today's precision instruments. (By the time this was discovered, the unit was so well established, no one has tried to change it.)

In 1799 the French adapted the metric system called the centimeter-gram-second (cgs). This system was derived by the following:

unit of velocity	=	1 centimeter per second
acceleration due to gravity (at Paris)	=	981 centimeters per second per second
unit of force	=	1 dyne = 1/981 gram
unit of work	=	1 erg = 1 dyne - centimeter
unit of power	=	1 watt = 10,000,000 ergs per second

The International Electro-technical Commission (IEC) adapted another metric system (1935/1950) called the MKSA (meter-kilogram-second-ampere) system of units with the ampere being the unit of electric current.

Thus today, you have 7 base units which are as follows:

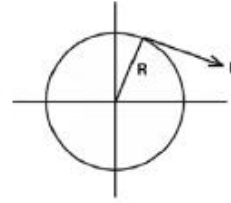
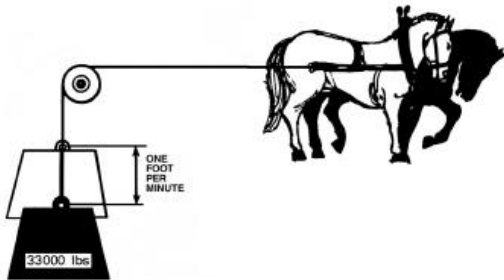
length	=	meter (m)
mass	=	kilogram (kg)
electric current	=	ampere (A)
thermodynamic temperature	=	kelvin (K)
amount of substance	=	mole (mol)
luminous intensity	=	candela (cd)
Time	=	Second

Other physical quantities are derived from these base units. For example, now the unit of velocity is the meter per second (m/s). The unit of acceleration is the meter per second squared ( $m/s^2$ ). By applying Newton's second Law of motion - force is proportional to mass multiplied by acceleration - the unit of force is obtained that is the kilogram-meter per second squared ( $kg\cdot m/s^2$ ). This unit is known as the newton or N. Work, or force time distance is the kilogram-meter squared per second squared ( $kg\cdot m^2/s^2$ ), which is the joule (1 joule [J] = 1 newton-meter) and energy is also expressed in these terms. Power or work per unit time is the kilogram-metersquared per second cubed ( $kg\cdot m^2/s^3$ ), which is the watt (1 watt [w] = 1 joule per second = 1 newton-meter per second).

For reference, the Imperial unit of power adapted for engineering work is Horsepower. James Watt (1736-1819) established the horsepower as a unit of measure. He determined that a horse, pulling for one minute, could lift about 32,400 pounds to a height of one foot. Later, he rounded this off to 33,000 pounds to make it easier to calculate the power of his steam engines. This power is the product of force by distance divided by time, work is the product of force by distance, force is any cause tending to produce or modify motion.

In the metric-system work, the joule or newton meter, is the unit for work energy or quantity of heat. This is defined as the work done when the point of application of a force of one newton is displaced through a distance of one meter in the direction of the force, force or newton is that force which, when applied to body having a mass of one kilogram, gives it an acceleration of one meter per second squared.

## Imperial System — Horsepower/Torque



Revolving Machinery: In the formulas below  $F$  = force in pounds. Distance in feet per minute equals  $2\pi$  Radius (in inches) divided by 12 for feet, and multiplied by RPM or  $(2\pi R \times \text{RPM}) \div 12$ . This power in minutes divided by 33,000 foot-pounds equals horsepower

$$\text{HP} = \frac{\text{Force} \times \text{FPM}}{33,000}$$

$$\text{HP} = \frac{F (\text{Pounds}) \times 2\pi \times R (\text{Inch}) \times \text{RPM}}{33,000 \times 12}$$

$$\text{HP} = \frac{F \times R \times \text{RPM}}{63,025}$$

$$\text{HP} = \frac{\text{Torque (Inch Pounds)} \times \text{RPM}}{63,025}$$

$$V (\text{Ft./Min.}) = \frac{\pi \times \text{P.D. (inch)} \times \text{RPM}}{12}$$

Torque: the twisting or turning effort around a shaft tending to cause rotation. Torque is determined by multiplying the applied force (Pounds) times the distance from the point where force is applied to the shaft center. Torque =  $F(\text{Force}) \times R(\text{Radius})$

## Metric System - Kilowatt/Newton-Meter

$$\begin{aligned} 1 \text{ Kilowatt Hour} &= 3\,600\,000 \text{ Joules} \\ &= 3,412 \text{ BTU} \\ &= 1.34 \text{ HP Hours} \end{aligned}$$

$$\text{Motor Power (kW)} \quad P = \frac{T \times \text{RPM}}{9550}$$

$$\text{Torque (Nm)} \quad T = \frac{9550 \times P}{\text{RPM}}$$

$$V (\text{m/s}) = \frac{\text{P.D. (mm)} \times \text{RPM}}{19100} \quad \text{or} \quad 5,2356^{-5} \times \text{P.D.} \times \text{RPM}$$

Timing Pulley/Chain Drive:

$$\text{Speed (m/s)} \quad V = \frac{Z \times p \times \text{RPM}}{60000}$$

Where:

$P$  = Power  
 $T$  = Torque  
 $V$  = Velocity  
 $Z$  = Number of Teeth  
 $p$  = Pitch  
 $\text{P.D.}$  = Pitch Diameter  
 $\text{HP}$  = Horsepower

## Overhung Loads

An overhung load is a bending force imposed on a shaft due to the torque transmitted by V-drives, chain drives, and other power transmission devices, other than flexible couplings.

Most motor and reducer manufacturers list the maximum values allowable for overhung loads. It is desirable that these figures be compared with the load actually imposed by the connected drive.

Weights of the drive components are usually negligible. The formula is based on the assumption that the load is applied at a point equal to one shaft diameter from the bearing face. Factor F depends on the type of drive used:

- 1,00 for single chain drives
- 1,10 for timing belt drives
- F = 1,25 for spur or helical gear or double chain drives
- 1,50 for V-belt drives
- 2,50 for flat belt drives

Overhung loads may be calculated as follows:

$$\text{O.H.L.} = \frac{63000 \times \text{HP} \times F}{N \times R}$$

- HP = Transmitted HP x Service Factor
- N = RPM of shaft
- R = Radius of sprocket, pulley, etc.
- F = Factor

**Inch Example:** Find the overhung load imposed on a reducer by a double chain drive transmitting 7 HP @ 30 RPM. The pitch diameter of the sprocket is 10 inches ; service factor is 1,25.

**Solution:**

$$\text{O.H.L.} = \frac{(63000)(7 \times 1,3)(1,25)}{(30)(5)} = 4,780 \text{ lbs.}$$

$$\text{O.H.L.} = \frac{376 \times \text{kW} \times F}{N \times R}$$

- kW = Transmitted kW x service factor
- N = RPM of shaft
- R = Radius of sprocket, pulley, etc. (mm)
- F = Factor

**Metric Example:** Find the overhung load imposed on a reducer by a double chain drive transmitting 10 kW @ 30 RPM. The pitch diameter of the sprocket is 254mm ; service factor is 1,25.

**Solution:**

$$\text{O.H.L.} = \frac{(376)(10 \times 1,3)(1,25)}{(30)(1,27)} = 160 \text{ N}$$

Horsepower/Speed/Torque Relationships		
HP	Speed (RPM)	Torque
Constant	Increases	Decreases
Constant	Decreases	Increases
Increases	Constant	Increases
Decreases	Constant	Decreases
Increases	Increases	Constant
Decreases	Decreases	Constant



# Torque (in Newton-Meters) For Kilowatts/RPM

## Torque for 1-50 kW @ 50-220 RPM

kW	Revolutions per Minute																	
	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220
1	191	159	136	119	106	96	87	80	73	68	64	60	56	53	50	48	45	43
2	382	318	273	239	212	191	174	159	147	136	127	119	112	106	101	96	91	87
3	573	478	409	358	318	287	260	239	220	205	191	179	169	159	151	143	136	130
4	764	637	546	478	424	382	347	318	294	273	255	239	225	212	201	191	182	174
5	955	796	682	597	531	478	434	398	367	341	318	298	281	265	251	239	227	217
6	1146	955	819	716	637	573	521	478	441	409	382	358	337	318	302	287	273	260
7	1337	1114	955	836	743	669	608	557	514	478	446	418	393	371	352	334	318	304
8	1528	1273	1091	955	849	764	695	637	588	546	509	478	449	424	402	382	364	347
9	1719	1433	1228	1074	955	860	781	716	661	614	573	537	506	478	452	430	409	391
10	1910	1592	1364	1194	1061	955	868	796	735	682	637	597	562	531	503	478	455	434
11	2101	1751	1501	1313	1167	1051	955	875	808	750	700	657	618	584	553	525	500	478
12	2292	1910	1637	1433	1273	1146	1042	955	882	819	764	716	674	637	603	573	546	521
13	2483	2069	1774	1552	1379	1242	1129	1035	955	887	828	776	730	690	653	621	591	564
14	2674	2228	1910	1671	1486	1337	1215	1114	1028	955	891	836	786	743	704	669	637	608
15	2865	2388	2046	1791	1592	1433	1302	1194	1102	1023	955	895	843	796	754	716	682	651
16	3056	2547	2183	1910	1698	1528	1389	1273	1175	1091	1019	955	899	849	804	764	728	695
17	3247	2706	2319	2029	1804	1624	1476	1353	1249	1160	1082	1015	955	902	854	812	773	738
18	3438	2865	2456	2149	1910	1719	1563	1433	1322	1228	1146	1074	1011	955	905	860	819	781
19	3629	3024	2592	2268	2016	1815	1650	1512	1396	1296	1210	1134	1067	1008	955	907	864	825
20	3820	3183	2729	2388	2122	1910	1736	1592	1469	1364	1273	1194	1124	1061	1005	955	910	868
21	4011	3343	2865	2507	2228	2006	1823	1671	1543	1433	1337	1253	1180	1114	1056	1003	955	912
22	4202	3502	3001	2626	2334	2101	1910	1751	1616	1501	1401	1313	1236	1167	1106	1051	1000	955
23	4393	3661	3138	2746	2441	2197	1997	1830	1690	1569	1464	1373	1292	1220	1156	1098	1046	998
24	4584	3820	3274	2865	2547	2292	2084	1910	1763	1637	1528	1433	1348	1273	1206	1146	1091	1042
25	4775	3979	3411	2984	2653	2388	2170	1990	1837	1705	1592	1492	1404	1326	1257	1194	1137	1085
26	4966	4138	3547	3104	2759	2483	2257	2069	1910	1774	1655	1552	1461	1379	1307	1242	1182	1129
27	5157	4298	3684	3223	2865	2579	2344	2149	1983	1842	1719	1612	1517	1433	1357	1289	1228	1172
28	5348	4457	3820	3343	2971	2674	2431	2228	2057	1910	1783	1671	1573	1486	1407	1337	1273	1215
29	5539	4616	3956	3462	3077	2770	2518	2308	2130	1978	1846	1731	1629	1539	1458	1385	1319	1259
30	5730	4775	4093	3581	3183	2865	2605	2388	2204	2046	1910	1791	1685	1592	1508	1433	1364	1302
31	5921	4934	4229	3701	3289	2961	2691	2467	2277	2115	1974	1850	1741	1645	1558	1480	1410	1346
32	6112	5093	4366	3820	3396	3056	2778	2547	2351	2183	2037	1910	1798	1698	1608	1528	1455	1389
33	6303	5253	4502	3939	3502	3152	2865	2626	2424	2251	2101	1970	1854	1751	1659	1576	1501	1433
34	6494	5412	4639	4059	3608	3247	2952	2706	2498	2319	2165	2029	1910	1804	1709	1624	1546	1476
35	6685	5571	4775	4178	3714	3343	3039	2785	2571	2388	2228	2089	1966	1857	1759	1671	1592	1519
36	6876	5730	4911	4298	3820	3438	3125	2865	2645	2456	2292	2149	2022	1910	1809	1719	1637	1563
37	7067	5889	5048	4417	3926	3534	3212	2945	2718	2524	2356	2208	2079	1963	1860	1767	1683	1606
38	7258	6048	5184	4536	4032	3629	3299	3024	2792	2592	2419	2268	2135	2016	1910	1815	1728	1650
39	7449	6208	5321	4656	4138	3725	3386	3104	2865	2660	2483	2328	2191	2069	1960	1862	1774	1693
40	7640	6367	5457	4775	4244	3820	3473	3183	2938	2729	2547	2388	2247	2122	2011	1910	1819	1736
41	7831	6526	5594	4894	4351	3916	3560	3263	3012	2797	2610	2447	2303	2175	2061	1958	1865	1780
42	8022	6685	5730	5014	4457	4011	3646	3343	3085	2865	2674	2507	2359	2228	2111	2006	1910	1823
43	8213	6844	5866	5133	4563	4107	3733	3422	3159	2933	2738	2567	2416	2281	2161	2053	1955	1867
44	8404	7003	6003	5253	4669	4202	3820	3502	3232	3001	2801	2626	2472	2334	2212	2101	2001	1910
45	8595	7163	6139	5372	4775	4298	3907	3581	3306	3070	2865	2686	2528	2388	2262	2149	2046	1953
46	8786	7322	6276	5491	4881	4393	3994	3661	3379	3138	2929	2746	2584	2441	2312	2197	2092	1997
47	8977	7481	6412	5611	4987	4489	4080	3740	3453	3206	2992	2805	2640	2494	2362	2244	2137	2040
48	9168	7640	6549	5730	5093	4584	4167	3820	3526	3274	3056	2865	2696	2547	2413	2292	2183	2084
49	9359	7799	6685	5849	5199	4680	4254	3900	3600	3343	3120	2925	2753	2600	2463	2340	2228	2127
50	9550	7958	6821	5969	5306	4775	4341	3979	3673	3411	3183	2984	2809	2653	2513	2388	2274	2170

# Torque (in Newton-Meters) For Kilowatts/RPM



## Torque for 1-50 kW @ 230-1000 RPM

kW	Revolutions per Minute																		
	230	240	250	260	270	280	290	300	350	400	450	500	550	600	650	700	800	900	1000
1	42	40	38	37	35	34	33	32	27	24	21	19	17	16	15	14	12	11	10
2	83	80	76	73	71	68	66	64	55	48	42	38	35	32	29	27	24	21	126
3	125	119	115	110	106	102	99	96	82	72	64	57	52	48	44	41	36	32	189
4	166	159	153	147	141	136	132	127	109	96	85	76	69	64	59	55	48	42	38
5	208	199	191	184	177	171	165	159	136	119	106	96	87	80	73	68	60	53	48
6	249	239	229	220	212	205	198	191	164	143	127	115	104	96	88	82	72	64	57
7	291	279	267	257	248	239	231	223	191	167	149	134	122	111	103	96	84	74	67
8	332	318	306	294	283	273	263	255	218	191	170	153	139	127	118	109	96	85	76
9	374	358	344	331	318	307	296	287	246	215	191	172	156	143	132	123	107	96	86
10	415	398	382	367	354	341	329	318	273	239	212	191	174	159	147	136	119	106	96
11	457	438	420	404	389	375	362	350	300	263	233	210	191	175	162	150	131	117	105
12	498	478	458	441	424	409	395	382	327	287	255	229	208	191	176	164	143	127	115
13	540	517	497	478	460	443	428	414	355	310	276	248	226	207	191	177	155	138	124
14	581	557	535	514	495	478	461	446	382	334	297	267	243	223	206	191	167	149	134
15	623	597	573	551	531	512	494	478	409	358	318	287	260	239	220	205	179	159	143
16	664	637	611	588	566	546	527	509	437	382	340	306	278	255	235	218	191	170	153
17	706	676	649	624	601	580	560	541	464	406	361	325	295	271	250	232	203	180	162
18	747	716	688	661	637	614	593	573	491	430	382	344	313	287	264	246	215	191	172
19	789	756	726	698	672	648	626	605	518	454	403	363	330	302	279	259	227	202	181
20	830	796	764	735	707	682	659	637	546	478	424	382	347	318	294	273	239	212	191
21	872	836	802	771	743	716	692	669	573	501	446	401	365	334	309	287	251	223	201
22	913	875	840	808	778	750	724	700	600	525	467	420	382	350	323	300	263	233	210
23	955	915	879	845	814	784	757	732	628	549	488	439	399	366	338	314	275	244	220
24	997	955	917	882	849	819	790	764	655	573	509	458	417	382	353	327	287	255	229
25	1038	995	955	918	884	853	823	796	682	597	531	478	434	398	367	341	298	265	239
26	1080	1035	993	955	920	887	856	828	709	621	552	497	451	414	382	355	310	276	248
27	1121	1074	1031	992	955	921	889	860	737	645	573	516	469	430	397	368	322	287	258
28	1163	1114	1070	1028	990	955	922	891	764	669	594	535	486	446	411	382	334	297	267
29	1204	1154	1108	1065	1026	989	955	923	791	692	615	554	504	462	426	396	346	308	277
30	1246	1194	1146	1102	1061	1023	988	955	819	716	637	573	521	478	441	409	358	318	287
31	1287	1234	1184	1139	1096	1057	1021	987	846	740	658	592	538	493	455	423	370	329	296
32	1329	1273	1222	1175	1132	1091	1054	1019	873	764	679	611	556	509	470	437	382	340	306
33	1370	1313	1261	1212	1167	1126	1087	1051	900	788	700	630	573	525	485	450	394	350	315
34	1412	1353	1299	1249	1203	1160	1120	1082	928	812	722	649	590	541	500	464	406	361	325
35	1453	1393	1337	1286	1238	1194	1153	1114	955	836	743	669	608	557	514	478	418	371	334
36	1495	1433	1375	1322	1273	1228	1186	1146	982	860	764	688	625	573	529	491	430	382	344
37	1536	1472	1413	1359	1309	1262	1218	1178	1010	883	785	707	642	589	544	505	442	393	353
38	1578	1512	1452	1396	1344	1296	1251	1210	1037	907	806	726	660	605	558	518	454	403	363
39	1619	1552	1490	1433	1379	1330	1284	1242	1064	931	828	745	677	621	573	532	466	414	372
40	1661	1592	1528	1469	1415	1364	1317	1273	1091	955	849	764	695	637	588	546	478	424	382
41	1702	1631	1566	1506	1450	1398	1350	1305	1119	979	870	783	712	653	602	559	489	435	392
42	1744	1671	1604	1543	1486	1433	1383	1337	1146	1003	891	802	729	669	617	573	501	446	401
43	1785	1711	1643	1579	1521	1467	1416	1369	1173	1027	913	821	747	684	632	587	513	456	411
44	1827	1751	1681	1616	1556	1501	1449	1401	1201	1051	934	840	764	700	646	600	525	467	420
45	1868	1791	1719	1653	1592	1535	1482	1433	1228	1074	955	860	781	716	661	614	537	478	430
46	1910	1830	1757	1690	1627	1569	1515	1464	1255	1098	976	879	799	732	676	628	549	488	439
47	1952	1870	1795	1726	1662	1603	1548	1496	1282	1122	997	898	816	748	691	641	561	499	449
48	1993	1910	1834	1763	1698	1637	1581	1528	1310	1146	1019	917	833	764	705	655	573	509	458
49	2035	1950	1872	1800	1733	1671	1614	1560	1337	1170	1040	936	851	780	720	669	585	520	468
50	2076	1990	1910	1837	1769	1705	1647	1592	1364	1194	1061	955	868	796	735	682	597	531	478



# Torque (in Newton-Meters) For Kilowatts/RPM

## Torque for 51-100 kW @ 50-220 RPM

kW	Revolutions per Minute																	
	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220
51	9741	8118	6958	6088	5412	4871	4428	4059	3747	3479	3247	3044	2865	2706	2563	2435	2319	2214
52	9932	8277	7094	6208	5518	4966	4515	4138	3820	3547	3311	3104	2921	2759	2614	2483	2365	2257
53	10123	8436	7231	6327	5624	5062	4601	4218	3893	3615	3374	3163	2977	2812	2664	2531	2410	2301
54	10314	8595	7367	6446	5730	5157	4688	4298	3967	3684	3438	3223	3034	2865	2714	2579	2456	2344
55	10505	8754	7504	6566	5836	5253	4775	4377	4040	3752	3502	3283	3090	2918	2764	2626	2501	2388
56	10696	8913	7640	6685	5942	5348	4862	4457	4114	3820	3565	3343	3146	2971	2815	2674	2547	2431
57	10887	9073	7776	6804	6048	5444	4949	4536	4187	3888	3629	3402	3202	3024	2865	2722	2592	2474
58	11078	9232	7913	6924	6154	5539	5035	4616	4261	3956	3693	3462	3258	3077	2915	2770	2638	2518
59	11269	9391	8049	7043	6261	5635	5122	4695	4334	4025	3756	3522	3314	3130	2966	2817	2683	2561
60	11460	9550	8186	7163	6367	5730	5209	4775	4408	4093	3820	3581	3371	3183	3016	2865	2729	2605
61	11651	9709	8322	7282	6473	5826	5296	4855	4481	4161	3884	3641	3427	3236	3066	2913	2774	2648
62	11842	9868	8459	7401	6579	5921	5383	4934	4555	4229	3947	3701	3483	3289	3116	2961	2820	2691
63	12033	10028	8595	7521	6685	6017	5470	5014	4628	4298	4011	3760	3539	3343	3167	3008	2865	2735
64	12224	10187	8731	7640	6791	6112	5556	5093	4702	4366	4075	3820	3595	3396	3217	3056	2910	2778
65	12415	10346	8868	7759	6897	6208	5643	5173	4775	4434	4138	3880	3651	3449	3267	3104	2956	2822
66	12606	10505	9004	7879	7003	6303	5730	5253	4848	4502	4202	3939	3708	3502	3317	3152	3001	2865
67	12797	10664	9141	7998	7109	6399	5817	5332	4922	4570	4266	3999	3764	3555	3368	3199	3047	2908
68	12988	10823	9277	8118	7216	6494	5904	5412	4995	4639	4329	4059	3820	3608	3418	3247	3092	2952
69	13179	10983	9414	8237	7322	6590	5990	5491	5069	4707	4393	4118	3876	3661	3468	3295	3138	2995
70	13370	11142	9550	8356	7428	6685	6077	5571	5142	4775	4457	4178	3932	3714	3518	3343	3183	3039
71	13561	11301	9686	8476	7534	6781	6164	5650	5216	4843	4520	4238	3989	3767	3569	3390	3229	3082
72	13752	11460	9823	8595	7640	6876	6251	5730	5289	4911	4584	4298	4045	3820	3619	3438	3274	3125
73	13943	11619	9959	8714	7746	6972	6338	5810	5363	4980	4648	4357	4101	3873	3669	3486	3320	3169
74	14134	11778	10096	8834	7852	7067	6425	5889	5436	5048	4711	4417	4157	3926	3719	3534	3365	3212
75	14325	11938	10232	8953	7958	7163	6511	5969	5510	5116	4775	4477	4213	3979	3770	3581	3411	3256
76	14516	12097	10369	9073	8064	7258	6598	6048	5583	5184	4839	4536	4269	4032	3820	3629	3456	3299
77	14707	12256	10505	9192	8171	7354	6685	6128	5657	5253	4902	4596	4326	4085	3870	3677	3502	3343
78	14898	12415	10641	9311	8277	7449	6772	6208	5730	5321	4966	4656	4382	4138	3921	3725	3547	3386
79	15089	12574	10778	9431	8383	7545	6859	6287	5803	5389	5030	4715	4438	4191	3971	3772	3593	3429
80	15280	12733	10914	9550	8489	7640	6945	6367	5877	5457	5093	4775	4494	4244	4021	3820	3638	3473
81	15471	12893	11051	9669	8595	7736	7032	6446	5950	5525	5157	4835	4550	4298	4071	3868	3684	3516
82	15662	13052	11187	9789	8701	7831	7119	6526	6024	5594	5221	4894	4606	4351	4122	3916	3729	3560
83	15853	13211	11324	9908	8807	7927	7206	6605	6097	5662	5284	4954	4663	4404	4172	3963	3775	3603
84	16044	13370	11460	10028	8913	8022	7293	6685	6171	5730	5348	5014	4719	4457	4222	4011	3820	3646
85	16235	13529	11596	10147	9019	8118	7380	6765	6244	5798	5412	5073	4775	4510	4272	4059	3865	3690
86	16426	13688	11733	10266	9126	8213	7466	6844	6318	5866	5475	5133	4831	4563	4323	4107	3911	3733
87	16617	13848	11869	10386	9232	8309	7553	6924	6391	5935	5539	5193	4887	4616	4373	4154	3956	3777
88	16808	14007	12006	10505	9338	8404	7640	7003	6465	6003	5603	5253	4944	4669	4423	4202	4002	3820
89	16999	14166	12142	10624	9444	8500	7727	7083	6538	6071	5666	5312	5000	4722	4473	4250	4047	3863
90	17190	14325	12279	10744	9550	8595	7814	7163	6612	6139	5730	5372	5056	4775	4524	4298	4093	3907
91	17381	14484	12415	10863	9656	8691	7900	7242	6685	6208	5794	5432	5112	4828	4574	4345	4138	3950
92	17572	14643	12551	10983	9762	8786	7987	7322	6758	6276	5857	5491	5168	4881	4624	4393	4184	3994
93	17763	14803	12688	11102	9868	8882	8074	7401	6832	6344	5921	5551	5224	4934	4674	4441	4229	4037
94	17954	14962	12824	11221	9974	8977	8161	7481	6905	6412	5985	5611	5281	4987	4725	4489	4275	4080
95	18145	15121	12961	11341	10081	9073	8248	7560	6979	6480	6048	5670	5337	5040	4775	4536	4320	4124
96	18336	15280	13097	11460	10187	9168	8335	7640	7052	6549	6112	5730	5393	5093	4825	4584	4366	4167
97	18527	15439	13234	11579	10293	9264	8421	7720	7126	6617	6176	5790	5449	5146	4876	4632	4411	4211
98	18718	15598	13370	11699	10399	9359	8508	7799	7199	6685	6239	5849	5505	5199	4926	4680	4457	4254
99	18909	15758	13506	11818	10505	9455	8595	7879	7273	6753	6303	5909	5561	5253	4976	4727	4502	4298
100	19100	15917	13643	11938	10611	9550	8682	7958	7346	6821	6367	5969	5618	5306	5026	4775	4548	4341

# Torque (in Newton-Meters) For Kilowatts/RPM



## Torque for 51-100 kW @ 230-1000 RPM

kW	Revolutions per Minute																			
	230	240	250	260	270	280	290	300	350	400	450	500	550	600	650	700	800	900	1000	
51	2118	2029	1948	1873	1804	1739	1679	1624	1392	1218	1082	974	886	812	749	696	609	541	487	
52	2159	2069	1986	1910	1839	1774	1712	1655	1419	1242	1104	993	903	828	764	709	621	552	497	
53	2201	2109	2025	1947	1875	1808	1745	1687	1446	1265	1125	1012	920	844	779	723	633	562	506	
54	2242	2149	2063	1983	1910	1842	1778	1719	1473	1289	1146	1031	938	860	793	737	645	573	516	
55	2284	2189	2101	2020	1945	1876	1811	1751	1501	1313	1167	1051	955	875	808	750	657	584	525	
56	2325	2228	2139	2057	1981	1910	1844	1783	1528	1337	1188	1070	972	891	823	764	669	594	535	
57	2367	2268	2177	2094	2016	1944	1877	1815	1555	1361	1210	1089	990	907	837	778	680	605	544	
58	2408	2308	2216	2130	2051	1978	1910	1846	1583	1385	1231	1108	1007	923	852	791	692	615	554	
59	2450	2348	2254	2167	2087	2012	1943	1878	1610	1409	1252	1127	1024	939	867	805	704	626	563	
60	2491	2388	2292	2204	2122	2046	1976	1910	1637	1433	1273	1146	1042	955	882	819	716	637	573	
61	2533	2427	2330	2241	2158	2081	2009	1942	1664	1456	1295	1165	1059	971	896	832	728	647	583	
62	2574	2467	2368	2277	2193	2115	2042	1974	1692	1480	1316	1184	1077	987	911	846	740	658	592	
63	2616	2507	2407	2314	2228	2149	2075	2006	1719	1504	1337	1203	1094	1003	926	860	752	669	602	
64	2657	2547	2445	2351	2264	2183	2108	2037	1746	1528	1358	1222	1111	1019	940	873	764	679	611	
65	2699	2586	2483	2388	2299	2217	2141	2069	1774	1552	1379	1242	1129	1035	955	887	776	690	621	
66	2740	2626	2521	2424	2334	2251	2173	2101	1801	1576	1401	1261	1146	1051	970	900	788	700	630	
67	2782	2666	2559	2461	2370	2285	2206	2133	1828	1600	1422	1280	1163	1066	984	914	800	711	640	
68	2823	2706	2598	2498	2405	2319	2239	2165	1855	1624	1443	1299	1181	1082	999	928	812	722	649	
69	2865	2746	2636	2534	2441	2353	2272	2197	1883	1647	1464	1318	1198	1098	1014	941	824	732	659	
70	2907	2785	2674	2571	2476	2388	2305	2228	1910	1671	1486	1337	1215	1114	1028	955	836	743	669	
71	2948	2825	2712	2608	2511	2422	2338	2260	1937	1695	1507	1356	1233	1130	1043	969	848	753	678	
72	2990	2865	2750	2645	2547	2456	2371	2292	1965	1719	1528	1375	1250	1146	1058	982	860	764	688	
73	3031	2905	2789	2681	2582	2490	2404	2324	1992	1743	1549	1394	1268	1162	1073	996	871	775	697	
74	3073	2945	2827	2718	2617	2524	2437	2356	2019	1767	1570	1413	1285	1178	1087	1010	883	785	707	
75	3114	2984	2865	2755	2653	2558	2470	2388	2046	1791	1592	1433	1302	1194	1102	1023	895	796	716	
76	3156	3024	2903	2792	2688	2592	2503	2419	2074	1815	1613	1452	1320	1210	1117	1037	907	806	726	
77	3197	3064	2941	2828	2724	2626	2536	2451	2101	1838	1634	1471	1337	1226	1131	1051	919	817	735	
78	3239	3104	2980	2865	2759	2660	2569	2483	2128	1862	1655	1490	1354	1242	1146	1064	931	828	745	
79	3280	3144	3018	2902	2794	2694	2602	2515	2156	1886	1677	1509	1372	1257	1161	1078	943	838	754	
80	3322	3183	3056	2938	2830	2729	2634	2547	2183	1910	1698	1528	1389	1273	1175	1091	955	849	764	
81	3363	3223	3094	2975	2865	2763	2667	2579	2210	1934	1719	1547	1406	1289	1190	1105	967	860	774	
82	3405	3263	3132	3012	2900	2797	2700	2610	2237	1958	1740	1566	1424	1305	1205	1119	979	870	783	
83	3446	3303	3171	3049	2936	2831	2733	2642	2265	1982	1761	1585	1441	1321	1219	1132	991	881	793	
84	3488	3343	3209	3085	2971	2865	2766	2674	2292	2006	1783	1604	1459	1337	1234	1146	1003	891	802	
85	3529	3382	3247	3122	3006	2899	2799	2706	2319	2029	1804	1624	1476	1353	1249	1160	1015	902	812	
86	3571	3422	3285	3159	3042	2933	2832	2738	2347	2053	1825	1643	1493	1369	1264	1173	1027	913	821	
87	3612	3462	3323	3196	3077	2967	2865	2770	2374	2077	1846	1662	1511	1385	1278	1187	1039	923	831	
88	3654	3502	3362	3232	3113	3001	2898	2801	2401	2101	1868	1681	1528	1401	1293	1201	1051	934	840	
89	3695	3541	3400	3269	3148	3036	2931	2833	2428	2125	1889	1700	1545	1417	1308	1214	1062	944	850	
90	3737	3581	3438	3306	3183	3070	2964	2865	2456	2149	1910	1719	1563	1433	1322	1228	1074	955	860	
91	3778	3621	3476	3343	3219	3104	2997	2897	2483	2173	1931	1738	1580	1448	1337	1242	1086	966	869	
92	3820	3661	3514	3379	3254	3138	3030	2929	2510	2197	1952	1757	1597	1464	1352	1255	1098	976	879	
93	3862	3701	3553	3416	3289	3172	3063	2961	2538	2220	1974	1776	1615	1480	1366	1269	1110	987	888	
94	3903	3740	3591	3453	3325	3206	3096	2992	2565	2244	1995	1795	1632	1496	1381	1282	1122	997	898	
95	3945	3780	3629	3489	3360	3240	3128	3024	2592	2268	2016	1815	1650	1512	1396	1296	1134	1008	907	
96	3986	3820	3667	3526	3396	3274	3161	3056	2619	2292	2037	1834	1667	1528	1410	1310	1146	1019	917	
97	4028	3860	3705	3563	3431	3308	3194	3088	2647	2316	2059	1853	1684	1544	1425	1323	1158	1029	926	
98	4069	3900	3744	3600	3466	3343	3227	3120	2674	2340	2080	1872	1702	1560	1440	1337	1170	1040	936	
99	4111	3939	3782	3636	3502	3377	3260	3152	2701	2364	2101	1891	1719	1576	1455	1351	1182	1051	945	
100	4152	3979	3820	3673	3537	3411	3293	3183	2729	2388	2122	1910	1736	1592	1469	1364	1194	1061	955	



## Electrical Formulas

Alternating Current			To Find	Alternating or Direct Current
To Find	Single-Phase	Three-Phase		
Amperes when horsepower is known	$\frac{HP \times 746}{E \times \text{Eff.} \times pf}$	$\frac{HP \times 746}{1,73 \times E \times \text{Eff.} \times pf}$	Amperes when voltage and resistance is known	$\frac{E}{R}$
Amperes when kilowatts are known	$\frac{Kw \times 1000}{E \times pf}$	$\frac{Kw \times 1000}{1,73 \times E \times pf}$	Voltage when resistance and current are known	IR
Amperes when Kva are known	$\frac{Kva \times 1000}{E}$	$\frac{Kva \times 1000}{1,73 \times E}$	Resistance when voltage and current are known	$\frac{E}{I}$
Kilowatts	$\frac{I \times E \times pf}{1000}$	$\frac{1,73 \times I \times E \times pf}{1000}$	<div>General Information (Approximation)</div> <div><div>All Values At 100% Load</div><div><div>{</div><div>At 1800 RPM, a motor develops 36 lb.-in. per hp At 1200 RPM, a motor develops 54 lb.-in. per hp At 575 volts, a 3-phase motor draws 1 amp per hp At 460 volts, a 3-phase motor draws 1,25 amp per hp At 230 volts, a 3-phase motor draws 2,5 amp per hp At 230 volts, a single-phase motor draws 5 amp per hp At 115 volts, a single-phase motor draws 10 amp per hp</div></div></div>	
Kva	$\frac{I \times E}{1000}$	$\frac{1,73 \times I \times E}{1000}$		
Horsepower = (Output)	$\frac{I \times E \times \text{Eff.} \times pf}{746}$	$\frac{1,73 \times I \times E \times \text{Eff.} \times pf}{746}$		
I = Amperes; E = Volts; Eff. = Efficiency; pf = power factor; Kva = Kilovolt amperes; Kw = Kilowatts; R = Ohms			Temperature Conversion:  Deg C = (Deg F - 32) x % Deg F = (Deg C x %/5) + 32	

## Motor Amps @ Full Load †

Kw	HP	Alternating Current		DC	Kw	HP	Alternating Current		DC	kW	HP	Alternating Current		DC
		Single Phase	3-Phase				Single Phase	3-Phase				Single Phase	3 Phase	
0,37	0,5	4,9	2,0	2,7	7,5	10	50	26	38	45	60	—	150	215
0,75	1,0	8,0	3,4	4,8	11	15	—	38	56	55	75	—	180	268
1,1	1,5	10	4,8	6,6	15	20	—	50	74	75	100	—	240	355
1,5	2,0	12,0	6,2	8,5	18,5	25	—	60	92	90	125	—	300	443
2,2	3,0	17,0	8,6	12,5	22	30	—	75	110	110	150	—	360	534
3,7	5,0	28,0	14,4	20	30	40	—	100	146	150	200	—	480	712
5,5	7,5	40,0	21,0	29	37	50	—	120	180	—	—	—	—	—

† Values are for all speeds and frequencies @ 230 volts.  
Amperage other than 230 volts can be figured:

$$V = \frac{230 \times \text{Amp from Table}}{\text{New Voltage}}$$

Example:

For 60 HP, 3 phase @ 550 volts:  $\frac{(230 \times 150)}{550} = 62$  amps.

Power Factor estimated @ 80% for most motors. Efficiency is usually 80-90%.

## NEMA Electrical Enclosure Types

Type	Description	Type	Description
NEMA Type 1 (General Purpose)	For indoor use wherever oil, dust, or water is not a problem	NEMA Type 5 Dust Tight (Non-Hazardous)	Used for excluding dust (All NEMA 12 and JIC enclosures are usually suitable for NEMA 5 use)
NEMA Type 2 (Driptight)	Used indoors to exclude falling moisture and dirt	NEMA Type 9 Dust Tight (Hazardous)*	For locations where combustible dusts are present
NEMA Type 3 (Weatherproof)	Provides protection against rain, sleet, and snow	NEMA Type 12 (Industrial Use)	Used for excluding oil, coolant, flying dust, lint, etc
NEMA Type 4 (Watertight)†	Needed when subject to great amounts of water from any angle — such as areas which are repeatedly hosed down		

NOTE: Joint Industry Conference (JIC) enclosures are similar in design to NEMA 12's.

For more complete details see NEMA or JIC Standards for enclosures.

† Not designed to be submerged.

\* Class II Groups E, F, and G.

# NEMA Frame Design

*Martin*

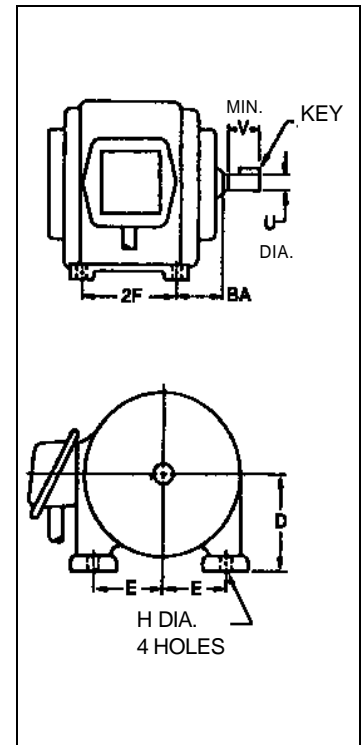
## NEMA Frame Designation

### Frame Assignments

HP	Motor Speed, RPM				HP	Motor Speed, RPM			
	3600	1800	1200	900		3600	1800	1200	900
$\frac{1}{6}$ - $\frac{1}{3}$	—	48	—	—	15	215T, 256U	254T, 284U	284T, 324U	286T, 326U
$\frac{1}{6}$ - $\frac{1}{2}$	48	—	56	—	20	254T, 284U	256T, 286U	286T, 326U	324T, 364U
$\frac{1}{6}$	—	—	48	—	25	256T, 286U	284T, 324U	324T, 364U	326T, 365U
$\frac{1}{3}$ -1	—	56	—	—	30	284TS, 324S	286T, 326U	326T, 365U	364T, 404U
$\frac{3}{4}$ -1	56	—	—	—	40	286TS, 326S	324T, 364U	364T, 404U	365T, 405U
$\frac{1}{2}$	—	—	—	143T	50	324TS, 364US	326T, 365U, 365US	365T, 405U	404T, 444U
$\frac{3}{4}$	—	—	143T	145T	60	326TS, 365US	364TS▲, 404U, 404US	404T, 444U	405T, 445U
1	—	143T	145T	182T	75	364TS, 404US	365TS▲, 405U, 405US	405T, 445U	444T
$1\frac{1}{2}$	143T	145T	182T	184T	100	365TS, 405US	404TS▲, 444US	444T	445T
2	145T	145T	184T	213T	125	404TS, 444US	405TS▲, 445US	445T	—
3	145T	182T	213T	215T, 254U	150	405TS, 445US	444TS▲	—	—
5	182T	184T	215T, 254U	254T, 256U	200	444TS	445TS▲	—	—
$7\frac{1}{2}$	184T	213T, 254U	254T, 256U	256T, 284U	250	445TS	—	—	—
10	213T, 254U	215T, 256U	256T, 284U	284T, 286U	—	—	—	—	—

### Motor Frame Dimensions

Frame Size	D	E	2F	H Dia. (4) Holes	U Dia.	BA	V Min.	Key
48	3	2 $\frac{1}{8}$	2 $\frac{3}{4}$	$\frac{1}{32}$	$\frac{1}{2}$	2 $\frac{1}{2}$	...	$\frac{3}{16}$ FLAT
56	3 $\frac{1}{2}$	2 $\frac{1}{8}$	3	$\frac{1}{32}$	$\frac{5}{8}$	2 $\frac{3}{4}$	...	$\frac{3}{16}$ x $\frac{7}{16}$ x 1 $\frac{1}{8}$
143T	3 $\frac{1}{2}$	2 $\frac{1}{4}$	4	$\frac{1}{32}$	$\frac{7}{8}$	2 $\frac{1}{4}$	2	$\frac{3}{16}$ x $\frac{3}{16}$ x 1 $\frac{1}{8}$
145T	3 $\frac{1}{2}$	2 $\frac{1}{4}$	5	$\frac{1}{32}$	$\frac{7}{8}$	2 $\frac{1}{4}$	2	$\frac{3}{16}$ x $\frac{3}{16}$ x 1 $\frac{3}{8}$
182T	4 $\frac{1}{2}$	3 $\frac{1}{4}$	4 $\frac{1}{2}$	$\frac{1}{32}$	$\frac{1}{8}$	2 $\frac{1}{4}$	2 $\frac{1}{2}$	$\frac{1}{8}$ x $\frac{1}{8}$ x 1 $\frac{1}{4}$
184T	4 $\frac{1}{2}$	3 $\frac{1}{4}$	5 $\frac{1}{2}$	$\frac{1}{32}$	$\frac{1}{8}$	2 $\frac{1}{4}$	2 $\frac{1}{2}$	$\frac{1}{8}$ x $\frac{1}{8}$ x 1 $\frac{1}{4}$
213T	5 $\frac{1}{4}$	4 $\frac{1}{4}$	5 $\frac{1}{2}$	$\frac{1}{32}$	$\frac{1}{8}$	3 $\frac{1}{2}$	3 $\frac{1}{8}$	$\frac{5}{16}$ x $\frac{3}{16}$ x 2 $\frac{1}{8}$
215T	5 $\frac{1}{4}$	4 $\frac{1}{4}$	7	$\frac{1}{32}$	$\frac{1}{8}$	3 $\frac{1}{2}$	3 $\frac{1}{8}$	$\frac{5}{16}$ x $\frac{3}{16}$ x 2 $\frac{3}{8}$
254U	6 $\frac{1}{4}$	5	8 $\frac{1}{4}$	$\frac{1}{32}$	$\frac{1}{8}$	4 $\frac{1}{4}$	3 $\frac{1}{2}$	$\frac{5}{16}$ x $\frac{3}{16}$ x 2 $\frac{1}{4}$
254T	6 $\frac{1}{4}$	5	8 $\frac{1}{4}$	$\frac{1}{32}$	$\frac{1}{8}$	4 $\frac{1}{4}$	3 $\frac{3}{4}$	$\frac{3}{16}$ x $\frac{3}{16}$ x 2 $\frac{1}{8}$
256U	6 $\frac{1}{4}$	5	10	$\frac{1}{32}$	$\frac{1}{8}$	4 $\frac{1}{4}$	3 $\frac{1}{2}$	$\frac{5}{16}$ x $\frac{3}{16}$ x 2 $\frac{3}{4}$
256T	6 $\frac{1}{4}$	5	10	$\frac{1}{32}$	$\frac{1}{8}$	4 $\frac{1}{4}$	3 $\frac{3}{4}$	$\frac{3}{16}$ x $\frac{3}{16}$ x 2 $\frac{1}{8}$
284U	7	5 $\frac{1}{2}$	9 $\frac{1}{2}$	$\frac{1}{32}$	$\frac{1}{8}$	4 $\frac{3}{4}$	4 $\frac{5}{8}$	$\frac{3}{16}$ x $\frac{3}{16}$ x 3 $\frac{1}{4}$
284T	7	5 $\frac{1}{2}$	9 $\frac{1}{2}$	$\frac{1}{32}$	$\frac{1}{8}$	4 $\frac{3}{4}$	4 $\frac{7}{8}$	$\frac{1}{2}$ x $\frac{1}{2}$ x 3 $\frac{1}{4}$
284TS	7	5 $\frac{1}{2}$	9 $\frac{1}{2}$	$\frac{1}{32}$	$\frac{1}{8}$	4 $\frac{3}{4}$	3	$\frac{3}{16}$ x $\frac{3}{16}$ x 1 $\frac{1}{8}$
286U	7	5 $\frac{1}{2}$	11	$\frac{1}{32}$	$\frac{1}{8}$	4 $\frac{3}{4}$	4 $\frac{5}{8}$	$\frac{3}{16}$ x $\frac{3}{16}$ x 3 $\frac{1}{4}$
286T	7	5 $\frac{1}{2}$	11	$\frac{1}{32}$	$\frac{1}{8}$	4 $\frac{3}{4}$	4 $\frac{7}{8}$	$\frac{1}{2}$ x $\frac{1}{2}$ x 3 $\frac{1}{4}$
286TS	7	5 $\frac{1}{2}$	11	$\frac{1}{32}$	$\frac{1}{8}$	4 $\frac{3}{4}$	3	$\frac{3}{16}$ x $\frac{3}{16}$ x 1 $\frac{1}{8}$
324U	8	6 $\frac{1}{4}$	10 $\frac{1}{2}$	$\frac{2}{32}$	$\frac{1}{8}$	5 $\frac{1}{4}$	5 $\frac{3}{8}$	$\frac{1}{2}$ x $\frac{1}{2}$ x 4 $\frac{1}{4}$
324T	8	6 $\frac{1}{4}$	10 $\frac{1}{2}$	$\frac{2}{32}$	$\frac{1}{8}$	5 $\frac{1}{4}$	5	$\frac{1}{2}$ x $\frac{1}{2}$ x 3 $\frac{1}{8}$
324TS	8	6 $\frac{1}{4}$	10 $\frac{1}{2}$	$\frac{2}{32}$	$\frac{1}{8}$	5 $\frac{1}{4}$	3 $\frac{1}{2}$	$\frac{1}{2}$ x $\frac{1}{2}$ x 2
326U	8	6 $\frac{1}{4}$	12	$\frac{2}{32}$	$\frac{1}{8}$	5 $\frac{1}{4}$	5 $\frac{3}{8}$	$\frac{1}{2}$ x $\frac{1}{2}$ x 4 $\frac{1}{4}$
326T	8	6 $\frac{1}{4}$	12	$\frac{2}{32}$	$\frac{1}{8}$	5 $\frac{1}{4}$	5	$\frac{1}{2}$ x $\frac{1}{2}$ x 3 $\frac{1}{8}$
326TS	8	6 $\frac{1}{4}$	12	$\frac{2}{32}$	$\frac{1}{8}$	5 $\frac{1}{4}$	3 $\frac{1}{2}$	$\frac{1}{2}$ x $\frac{1}{2}$ x 2
364U	9	7	11 $\frac{1}{4}$	$\frac{2}{32}$	$\frac{2}{8}$	5 $\frac{5}{8}$	6 $\frac{1}{8}$	$\frac{1}{2}$ x $\frac{1}{2}$ x 5
364US	9	7	11 $\frac{1}{4}$	$\frac{2}{32}$	$\frac{1}{8}$	5 $\frac{5}{8}$	3 $\frac{1}{2}$	$\frac{1}{2}$ x $\frac{1}{2}$ x 2
364T	9	7	11 $\frac{1}{4}$	$\frac{2}{32}$	$\frac{2}{8}$	5 $\frac{5}{8}$	5 $\frac{5}{8}$	$\frac{5}{16}$ x $\frac{5}{16}$ x 4 $\frac{1}{4}$
364TS	9	7	11 $\frac{1}{4}$	$\frac{2}{32}$	$\frac{1}{8}$	5 $\frac{5}{8}$	3 $\frac{1}{2}$	$\frac{1}{2}$ x $\frac{1}{2}$ x 2
365U	9	7	12 $\frac{1}{4}$	$\frac{2}{32}$	$\frac{2}{8}$	5 $\frac{5}{8}$	6 $\frac{1}{8}$	$\frac{1}{2}$ x $\frac{1}{2}$ x 5
365US	9	7	12 $\frac{1}{4}$	$\frac{2}{32}$	$\frac{1}{8}$	5 $\frac{5}{8}$	3 $\frac{1}{2}$	$\frac{1}{2}$ x $\frac{1}{2}$ x 2
365T	9	7	12 $\frac{1}{4}$	$\frac{2}{32}$	$\frac{2}{8}$	5 $\frac{5}{8}$	5 $\frac{5}{8}$	$\frac{5}{16}$ x $\frac{5}{16}$ x 4 $\frac{1}{4}$
365TS	9	7	12 $\frac{1}{4}$	$\frac{2}{32}$	$\frac{1}{8}$	5 $\frac{5}{8}$	3 $\frac{1}{2}$	$\frac{1}{2}$ x $\frac{1}{2}$ x 2
404U	10	8	12 $\frac{1}{4}$	$\frac{1}{16}$	$\frac{2}{8}$	6 $\frac{5}{8}$	6 $\frac{7}{8}$	$\frac{5}{16}$ x $\frac{5}{16}$ x 5 $\frac{1}{2}$
404US	10	8	12 $\frac{1}{4}$	$\frac{1}{16}$	$\frac{2}{8}$	6 $\frac{5}{8}$	4	$\frac{1}{2}$ x $\frac{1}{2}$ x 2 $\frac{1}{4}$
404T	10	8	12 $\frac{1}{4}$	$\frac{1}{16}$	$\frac{2}{8}$	6 $\frac{5}{8}$	7	$\frac{3}{4}$ x $\frac{3}{4}$ x 5 $\frac{5}{8}$
404TS	10	8	12 $\frac{1}{4}$	$\frac{1}{16}$	$\frac{2}{8}$	6 $\frac{5}{8}$	4	$\frac{1}{2}$ x $\frac{1}{2}$ x 2 $\frac{1}{4}$
405U	10	8	13 $\frac{1}{4}$	$\frac{1}{16}$	$\frac{2}{8}$	6 $\frac{5}{8}$	6 $\frac{7}{8}$	$\frac{5}{16}$ x $\frac{5}{16}$ x 5 $\frac{1}{2}$
405US	10	8	13 $\frac{1}{4}$	$\frac{1}{16}$	$\frac{2}{8}$	6 $\frac{5}{8}$	4	$\frac{1}{2}$ x $\frac{1}{2}$ x 2 $\frac{1}{4}$
405T	10	8	13 $\frac{1}{4}$	$\frac{1}{16}$	$\frac{2}{8}$	6 $\frac{5}{8}$	7	$\frac{3}{4}$ x $\frac{3}{4}$ x 5 $\frac{5}{8}$
405TS	10	8	13 $\frac{1}{4}$	$\frac{1}{16}$	$\frac{2}{8}$	6 $\frac{5}{8}$	4	$\frac{1}{2}$ x $\frac{1}{2}$ x 2 $\frac{1}{4}$
444U	11	9	14 $\frac{1}{2}$	$\frac{1}{16}$	$\frac{2}{8}$	7 $\frac{1}{2}$	8 $\frac{5}{8}$	$\frac{3}{4}$ x $\frac{3}{4}$ x 7
444US	11	9	14 $\frac{1}{2}$	$\frac{1}{16}$	$\frac{2}{8}$	7 $\frac{1}{2}$	4	$\frac{1}{2}$ x $\frac{1}{2}$ x 2 $\frac{1}{4}$
444T	11	9	14 $\frac{1}{2}$	$\frac{1}{16}$	$\frac{3}{8}$	7 $\frac{1}{2}$	8 $\frac{1}{4}$	$\frac{7}{16}$ x $\frac{7}{16}$ x 6 $\frac{1}{8}$
444TS	11	9	14 $\frac{1}{2}$	$\frac{1}{16}$	$\frac{2}{8}$	7 $\frac{1}{2}$	4 $\frac{1}{2}$	$\frac{3}{8}$ x $\frac{3}{8}$ x 3
445U	11	9	16 $\frac{1}{2}$	$\frac{1}{16}$	$\frac{2}{8}$	7 $\frac{1}{2}$	8 $\frac{5}{8}$	$\frac{3}{4}$ x $\frac{3}{4}$ x 7
445US	11	9	16 $\frac{1}{2}$	$\frac{1}{16}$	$\frac{2}{8}$	7 $\frac{1}{2}$	4	$\frac{1}{2}$ x $\frac{1}{2}$ x 2 $\frac{1}{4}$
445T	11	9	16 $\frac{1}{2}$	$\frac{1}{16}$	$\frac{3}{8}$	7 $\frac{1}{2}$	8 $\frac{1}{4}$	$\frac{7}{16}$ x $\frac{7}{16}$ x 6 $\frac{1}{8}$
445TS	11	9	16 $\frac{1}{2}$	$\frac{1}{16}$	$\frac{2}{8}$	7 $\frac{1}{2}$	4 $\frac{1}{2}$	$\frac{3}{8}$ x $\frac{3}{8}$ x 3



**Shaded area** indicates typical single phase standard squirrel-cage, open type, a-c motors. Balance of table same except three phase, design A and B.

▲ When these motors are used with V-belt or chain drives, the correct frame size is the one with the suffix "S" omitted — consult manufacturer.



# IEC / NEMA Cross Reference

## IEC / NEMA Frame Cross Reference

IEC / NEMA frame cross reference table is provided for reference only.

IEC Frame	Nearest NEMA Frame Reference
71M	48
80M	48 or 56
90S	56 or 143T
90L	56 or 145T
100S	145T
100L	145T
112S	182T
112M	184T
112L	184T
132S	213T
132M	215T
132L	215T
160S	254T
160M	254T
160L	256T
180S	284T
180M	284T
180L	286T
200S	324T
200M	324T
200L	326T
225S	364T
225M	365T
225L	365T
250S	404T
250M	405T
250L	405T
280S	444T
280M	445T
280K	447T
280H	449T

## Kw / HP Equivalent

Approximate corresponding Horsepower to Kw table is provided for reference only.

$$Kw = HP \times ,746$$

Kw	HP
,25	$\frac{1}{3}$
,37	$\frac{1}{2}$
,55	$\frac{3}{4}$
,75	1
1,1	1 $\frac{1}{2}$
1,5	2
2,2	3
3	4
4	5
5,5	7 $\frac{1}{2}$
7,5	10
11	15

Kw	HP
15	20
18,5	25
22	30
30	40
37	50
45	60
55	75
75	100
90	125
110	150
132	175
150	200
186	250

## 50 Hz vs. 60 Hz RPM Tables

Most IEC motors are 50 Hz. However, there are many applications, where IEC motors have three-phase, 60 Hz design. Most motor manufactures can provide IEC designs in either 50Hz or 60 Hz ratings.

50 Hz	
Poles	RPM
2	3000
4	1500
6	1000
8	750

60 Hz	
Poles	RPM
2	3600
4	1800
6	1200
8	900
10	720
12	600

# IEC Metric Frame Design

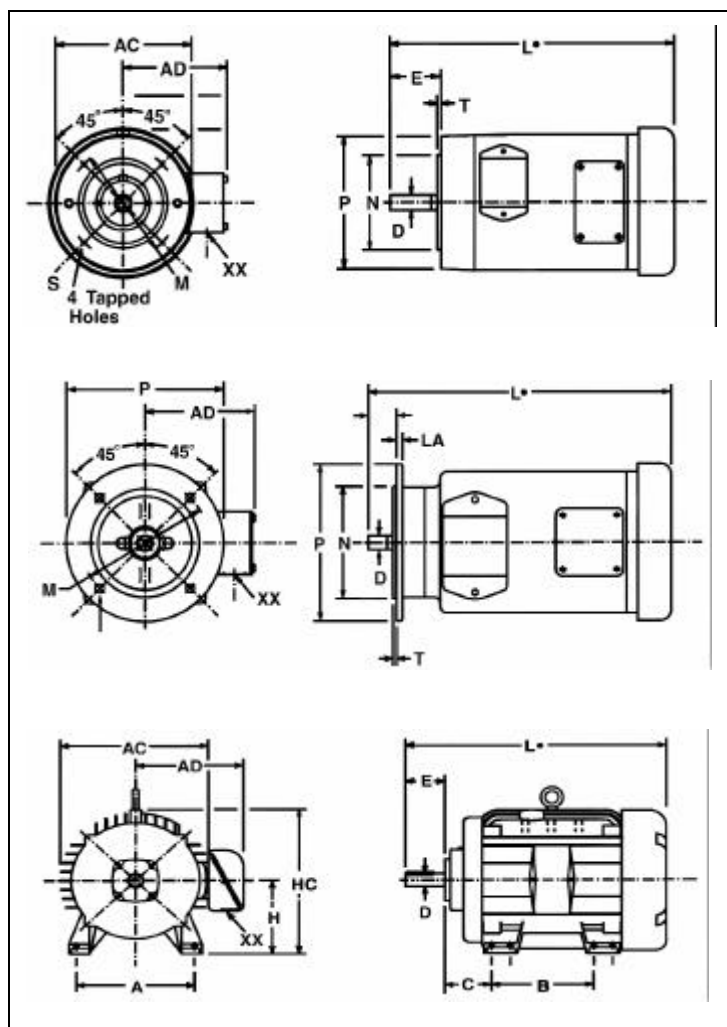


## IEC Quick Reference Chart

IEC Frame	Type	Foot Mounting				Shaft		B5 Flange						B14 Face					General				
		A	B	C	H	D	E	LA	M	N	P	S	T	M	N	P	S	T	L	AC	AD	HC	XX
<b>63</b>	300	100	80	40	63	11	23	8	115	95	140	9	3	75	60	90	M5	2,5	*	119	102 116d	121 136d	13 22d
<b>71</b>	300 400	112	90	45	71	14	30	8	130	110	160	10	3,5	85	70	105	M6	2,5	*	119 145d	102 4	131 149d	18 21d
<b>80</b>	400 500	125	100	50	80	19	40	13	165	130	200	11	3,5	100	80	120	M6	3	*	145 168d	116 130	152 162d	22 21d
<b>90</b>	S L	140	100 125	56	90	24	50	13	165	130	200	12	3,5	115	95	140	M8	3	*	168 144d	130 107d	173 165d	22 21d
<b>100</b>	S L	160	112 140	63	100	28	60	14	215	180	250	14	4	130	110	160	M8	3,5	*	200	149 153d	180 239d	27
<b>112</b>	S M	190	114 140	70	112	28	60	14	215	180	250	14	4	130	110	160	M8	3,5	*	200	149	214	27
<b>132</b>	S M	216	140 178	89	132	38	80	14	265	230	300	14	4	165	130	200	M8	3,5	*	243	187	256	27
<b>160</b>	M L	254	210 254	108	160	42	110	20	300	250	350	19	5	215	180	250	M12	4	*	329	242	329	35
<b>180</b>	M L	279	241 279	121	180	48	110	—	300	250	350	19	5	—	—	—	—	—	*	395	333	372	51
<b>200</b>	L M	318	267 305	133	200	55	110	—	350	300	400	19	—	—	—	—	—	—	*	441	359	416	63
<b>225</b>	S M	356	286 311	142	225	60	140	—	400	350	450	19	—	—	—	—	—	—	*	495	383	483	92
<b>250</b>	S M	406	311 349	168	250	70	140	—	—	—	—	—	—	—	—	—	—	—	*	520	457	513	92
<b>280</b>	S M	457	368 419	190	280	80	170	—	—	—	—	—	—	—	—	—	—	—	*	616	497	571	92
<b>315</b>	S M	508	406 457	216	315	85	170	—	—	—	—	—	—	—	—	—	—	—	*	759	683	682	102
<b>355</b>	S L	610	500 630	254	355	85	170	—	—	—	—	—	—	—	—	—	—	—	*	759	683	719	102

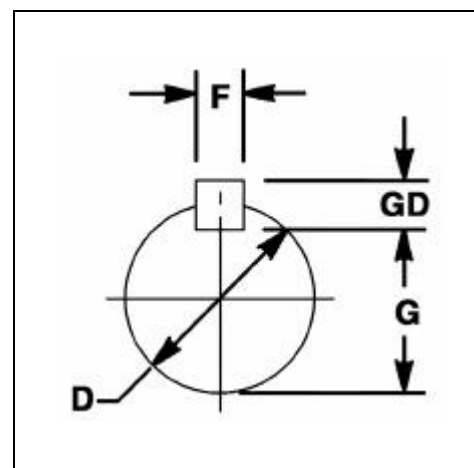
\* Indicates that this dimension varies depending upon manufacture.  
All dimensions in millimeters unless otherwise stated.  
d = DC Motors

### IEC Motor Frame Dimensions



Drawings represent standard TEFC general purpose motors.  
Dimensions are for reference only.

Key and Keyseat Dimensions				
Frame	D	G	F	GD
63	11	8.5	4	4
71	14	11	5	5
80	19	15.5	6	6
90	24	20	8	7
100	28	24	8	7
112	28	24	8	7
132	38	33	10	8
160	42	37	12	8
180	48	42.5	14	9
200	55	49	16	10
225	60	53	18	11
250	70	67.5	20	12
280	80	71	22	14
315	85	76	22	14
355	85	76	22	14



# Shaft Selection

*Martin*

## Shaft Selection

### Important factors to consider when calculating shaft size

- shafting is subject to a **bending moment** and a **torsional moment**.
- bending moment is that force which tends to **bend** a shaft.
- torsional moment is that force which tends to **twist** a shaft.
- shaft size is determined by the **combined action** of the bending and torsional moments.

Refer to Shaft Selection Charts 2 and 3 developed by the American Society of Mechanical Engineers to simplify selection. The charts should be used in conjunction with Service Factors (Table 1) to modify the selection for conditions under which the shaft will operate.

L = Unbalanced load in pounds

W = Suspended weight of elevator (chain, buckets, etc.) in pounds

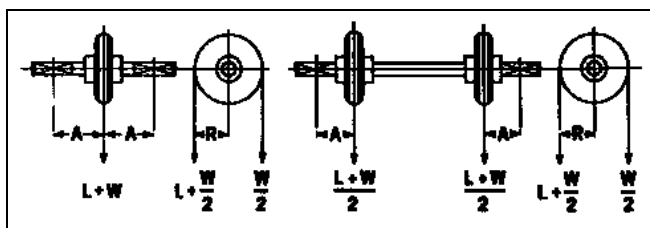
R = Radius of wheel in inches

B = Bending moment

T = Torsional moment

$B = A \frac{L + W}{2}$  inch pounds

$T = R \times L$  inch pounds



## Selection Procedure

- compute the Bending Moment from the above formula.
- determine the Service Factor for bending that will suit conditions from Table 1.
- compute the Torsional Moment from the above formula.
- determine the Service Factor for torsion that will suit conditions from Table 1.
- draw a horizontal line across Selection Chart 2 or 3 on pages L-10 and L-11, from the point where the **torsional moment intersects** its selected Service Factor line.
- draw a vertical lineup Selection Chart 2 or 3 from the point where the **bending moment intersects** its selected factor line.
- intersection of above lines will give required shaft size.
- for shafts not weakened by keyways, multiply the shaft size obtained by .91 for the corrected shaft size. See note at the bottom of Selection Chart 3.

Horsepower required may be computed directly from the righthand side of Selection Charts by correcting the figure in line with the horizontal torsional moment line by the speed in RPM.

Table 1 • Service Factors

Type of Loading	Service Factor	
	For Bending	For Torsion
Stationary Shafts – Gradually applied loads	1,0	1,0
Suddenly applied loads	1,5 to 2,0	1,5 to 2,0
Rotating Shafts – Gradually applied or steady loads	1,5	1,0
Suddenly applied loads – Minor shock only	1,5 to 2,0	1,0 to 1,5
Suddenly applied loads – Heavy shock	2,0 to 2,5	1,5 to 2,5

## Selection Example:

Select shaft size for head shaft of chain conveyor subject to following requirements:

- Torsion (inch/lbs) — 20,500
- Bending moment (inch/lbs) — 13,300
- Service Factors:  
torsion — 1,0  
bending — 1,5

At the extreme left on Selection Chart 2, the torsion moment may be found for the Service Factor of 1,0. Draw a horizontal line to the right from the 20,500 point. The bending moment is given at the bottom of the chart. Find the 13,300 point; draw a line from this point to the right on the diagonal until it intersects the 1,5 Service Factor line, then project the line upward vertically until it intersects the horizontal line drawn from the 20,500 torsion point. At this intersection point, it is found that a shaft of approximately  $2\frac{1}{8}$  inch diameter is required.

Select the nearest standard size shaft which is  $2\frac{1}{8}$  inch.

For a shaft subjected to the same conditions, but not weakened by keyways, the size of the shaft required would be (.91 x 2,8125) or 2,56 ( $2\frac{9}{16}$  inch). See note at the bottom of the charts.

On this same chart at the right, the horsepower ratings at 100 RPM are given based on the formula:

$$HP = \frac{T \times RPM}{63,000}$$

T = Torque in inch-pounds

The horsepower is directly proportional to the speed of the shaft in RPM.

Flywheels are occasionally used on a few machines, such as air compressors, to even out load pulsations. These formulas are useful in designing entire flywheel rims. It is also possible to use V-Belt sheaves as a flywheel thus eliminating the need for a separate flywheel in the system. Consult Martin with specific requirements.

## Formulas for Entire Flywheel

W = weight (pounds)  
R = radius of gyration (feet)  
N = speed (RPM)  
t = time to change from  $N_1$  to  $N_2$  (seconds)  
F = face of rim (inches)  
D = outside diameter of rim (inches)  
d = inside diameter of rim (inches)  
P = weight per cubic inch of material (pounds)

Kinetic energy of rotation of a flywheel (foot pounds) =  
 $.0001705 N^2(WR^2)^*$ .

Torque to accelerate or decelerate a flywheel  
uniformly =  $\frac{.03908(N_2 - N_1)(WR^2)^*}{t}$   
(pound inches)

where  $N_2$  = final RPM and  $N_1$  = initial RPM  
Velocity at outside diameter (feet per minute) =  $0.2618 ND$

\* $WR^2$  = flywheel effect (pounds x feet<sup>2</sup>). See table below for  $WR^2$  of rims. Ordinarily the  $WR^2$  of the rim only is considered. In unusual instances the relatively small  $WR^2$  values of the hub and arms or web can be added directly to the  $WR^2$  of the rim if desired. To find the  $WR^2$  of a hub or web use the  $WR^2$  formula for rims, substituting the hub or web outside diameter, inside diameter, and width for D, d, and F respectively. When arms are used instead of a web an approximate  $WR^2$  value of the arms is the total weight of the arms in pounds times the square of the radius in feet from the shaft center line to the mid-point of the arms between hub and rim.

**$WR^2$  (LB-FT<sup>2</sup>) = 0,0422 Kgm<sup>2</sup>**

## Formulas for Flywheel Rims

Property	Cast Iron Rim (Based on .26 lbs per cubic inch)	Steel Rim Rim (Based on .283 lbs per cubic inch)	Rim of any Material Weighing P Pounds per cubic inch
Volume (Cubic Inches)	$.7854F(D^2 - d^2)$	$.7854F(D^2 - d^2)$	$.7854F(D^2 - d^2)$
W Weight (Pounds)	$.2042F(D^2 - d^2)$	$.2223F(D^2 - d^2)$	$.7854FP(D^2 - d^2)$
R Radius of Gyration (Feet)	$\frac{.8681(D^2 + d^2)}{1000}$	$\frac{.8681(D^2 + d^2)}{1000}$	$\frac{.8681(D^2 + d^2)}{1000}$
$WR^2$ Wt. x Sq. of Radius of Gyration (Lbs. x Ft. <sup>2</sup> )	$\frac{.1773F(D^4 - d^4)}{1000}$	$\frac{.1929F(D^4 - d^4)}{1000}$	$\frac{.6818FP(D^4 - d^4)}{1000}$
$T_s$ Tensile Load in Rim (Lbs.)	$\frac{.3078FN^2(D^3 - d^3)}{1,000,000}$	$\frac{.3350FN^2(D^3 - d^3)}{1,000,000}$	$\frac{1,184PFN^2(D^3 - d^3)}{1,000,000}$

▲ Centrifugal force causes this tensile load at each and every section of the rim. Thus on rims split into two or more sections, the fastening at each joint should be designed to take the full load as calculated from the formula below.

## Centrifugal Force

R = Distance from the axis of rotation to the center of gravity of the body (feet)

N = Revolutions per minute (RPM)

v = Velocity of the center of gravity of the body (feet per second)

g = Acceleration due to gravity (32,16 commonly)

$$F = \frac{Wv^2}{gR} = \frac{WRN^2}{2933} = .000341 WRN^2$$

F = Centrifugal force tending to move the body outward from the axis of rotation (pounds)

W = Weight of body (pounds)

# Weights of Steel

*Martin*

NOTE: The steel weights in this section are nominal and are based on an approximate weight of 40,80 pounds per square foot, one inch thick. There may be differences between nominal weights and actual scale weights because of variation in manufacturing practices.

## Hot Rolled and Cold Finished Steel Products Nominal Weight

Product	Thickness	Width	Length	Formulas	Product	Thickness	Width	Formula
Plates, Strip and Flats	Centimeters	Centimeters	Centimeters	$0,017289 \times T \times W \times L$	Plate Circles	Centimeters	Centimeters	$,22110 \times T \times D^2$
	Centimeters	Centimeters	Meters	$1,7289 \times T \times W \times L$		Centimeters	Meters	$61,5805 \times T \times D^2$
	Centimeters	Meters	Meters	$172,89 \times T \times W \times L$	Sheet Circles	Centimeters	Centimeters	$,22656 \times T \times D^2$
	USS. Ga No.	Meters	Meters	$Wt./M^2 \times W \times L$		Centimeters	Meters	$63,1176 \times T \times D^2$
Hot and C.R. Sheets	Wt. per M <sup>2</sup>	Meters	Meters	$Wt./M^2 \times W \times L$	Bars { Square Round Hexagon Octagon	Diameter	Length	Formula
	Centimeters	Centimeters	Centimeters	$0,0177213 \times T \times W \times L$		Centimeters	Meters	$1,72890 \times D^2 \times L$
	Centimeters	Centimeters	Meters	$1,77213 \times T \times W \times L$		Centimeters	Meters	$1,35778 \times D^2 \times L$
	Centimeters	Meters	Meters	$177.213 \times T \times W \times L$		Centimeters	Meters	$1,49762 \times D^2 \times L$
	USS. Ga No.	Meters	Meters	$Wt./M^2 \times W \times L$		Centimeters	Meters	$1,43253 \times D^2 \times L$
	Wt. per M <sup>2</sup>	Meters	Meters	$Wt./M^2 \times W \times L$	T = thickness      L = length      W = width      D = diameter			

## Steel Rounds

Diameter MM	Weight Per Meter Kg.	Diameter MM	Weight Per Meter Kg.
10	0,616	42	10,864
11	0,745	45	12,472
12	0,887	48	14,190
13	1,041	50	15,397
14	1,207	55	18,631
15	1,386	60	22,172
16	1,577	65	26,021
18	1,995	70	30,178
20	2,464	75	34,644
22	2,981	80	39,417
24	3,547	85	44,498
25	3,849	90	49,887
25,4	3,973	95	55,584
26	4,163	100	61,589
28	4,829	110	74,522
30	5,543	120	88,687
32	6,307	130	104,085
35	7,545	140	120,713
38	8,893	150	138,574
40	9,854	160	157,667

## Standard Sheet Weights

Ga. Number	Thickness in MM	Weight Per Square Meter in kilograms
Over 4mm are Plates		
7	4,554	36,619
8	4,176	33,568
9	3,795	30,516
10	3,416	27,465
11	3,038	24,413
12	2,657	21,361
13	2,278	18,310
14	1,897	15,258
15	1,709	13,730
16	1,519	12,206

## Carbon Steel Plates

Size in MM	Weight Per Square Meter in Kilograms
5	39,21
6	47,06
7	54,90
8	62,74
10	78,43
12	94,11
14	109,80
16	125,48
18	141,17
19	149,01
20	156,85
22	172,54
24	188,22
25	196,07
25,4	199,20
26	203,91
28	219,59
30	235,28
32	250,96
35	274,49
38	298,02

NOTE: Stainless Steel Weights approximately 10% more than Carbon Steel.



## Properties of Steel

The information shown below is offered as a general guide to physical properties of steel in common use. Lower tensile properties are to be expected in large sections; the values of strength decrease as the size of the section increases. These values are not guaranteed and must **NOT** be used in specifying the raw materials or as a basis for acceptance or rejection of material. It must not be assumed that these properties will be obtained in all cases as they vary widely with permissible variations in analysis, size of section, rolling conditions, grain size and methods of heat treatment. Dependable physical properties can only be obtained through carefully controlled analysis and heat treatment.

### Average Properties of Standard Steels

AISI Number	SAE Number	Condition of Steel	Strength in 1000 PSI		% Elong. in 2"	% Red. of Area	Hardness		Machinability % of B1112 CD
			Tensile	Yield			Brinell	Rockwell	
B1112	1112	COLD DRAWN BESSEMER .....	75-90	60-70	12-16	40-50	170-185	80-95B	100
C1018	1018	NATURAL HOT ROLLED .....	55-70	40-50	25-35	50-65	120-140	.....	55
		COLD DRAWN .....	70-85	50-70	18-25	45-55	160-180	80-90B	65
		1• RD. CARBURIZED AT 1700°F., COOLED IN BOX, REHEATED, QUENCHED – CORE PROPERTIES .....	90-100	60-80	10-22	35-50	200-230	93-98B	.....
C1020	1020	NATURAL HOT ROLLED .....	60-80	40-50	25-35	50-65	120-145	60-98B	50
		COLD DRAWN .....	70-80	45-70	15-25	45-60	120-160	70-85B	60
C1117	1117	NATURAL HOT ROLLED .....	60-70	37-47	20-30	45-60	135-150	.....	80
		COLD DRAWN .....	80-90	60-75	15-20	40-50	160-190	80-90B	90
		1• RD. CARBURIZED AT 1700°F., COOLED IN BOX, REHEATED, QUENCHED – CORE PROPERTIES .....	95-110	60-85	10-25	35-50	210-240	15-22C	.....
C1035	1035	NATURAL HOT ROLLED .....	75-85	40-55	18-25	40-55	155-175	.....	60
		COLD DRAWN .....	85-95	65-80	15-25	40-50	170-200	85-95B	65
		1• RD. QUENCHED, TEMPERED 1000°F .....	95-105	70-80	20-25	55-60	195-220	93-98B	55
C1040	1040	NATURAL HOT ROLLED .....	80-90	45-55	18-25	35-50	165-185	.....	60
		COLD DRAWN .....	90-100	70-85	14-20	35-50	190-215	91-98B	62
		1• RD. QUENCHED, TEMPERED 1000°F .....	100-110	75-85	15-25	45-60	210-240	17-23C	52
C1042	1042	NATURAL HOT ROLLED .....	85-95	50-60	15-25	35-50	175-205	.....	58
		COLD DRAWN .....	90-105	75-90	12-20	30-45	185-215	.....	60
		1• RD. QUENCHED, TEMPERED 1000°F .....	105-120	80-90	15-25	40-60	215-250	.....	.....
C1045	1045	NATURAL HOT ROLLED .....	85-105	50-65	15-25	35-45	175-215	.....	55
		COLD DRAWN .....	90-110	75-90	12-20	30-45	195-230	95-99B	58
		1• RD. QUENCHED, TEMPERED 1000°F .....	110-130	80-95	12-25	40-55	235-260	22-26C	47
C1141	1141	NATURAL HOT ROLLED .....	90-110	60-80	15-25	25-45	180-220	.....	65
		COLD DRAWN .....	100-120	85-105	8-18	20-50	195-230	.....	70
		1• RD. QUENCHED, TEMPERED 1000°F .....	120-145	100-130	10-20	35-50	270-310	.....	.....
C1144	1144	NATURAL HOT ROLLED .....	95-110	60-85	15-25	30-45	200-240	.....	75
		COLD DRAWN .....	100-120	90-115	7-17	20-45	210-245	17-23C	85
		1• RD. QUENCHED, TEMPERED 1000°F .....	130-150	110-130	15	45	286-302	29-31C	.....
C1050	1050	NATURAL HOT ROLLED .....	95-110	55-70	15-20	25-40	210-325	.....	50
		1• RD. QUENCHED, TEMPERED 1000°F .....	115-135	85-100	10-22	35-50	240-265	23-27C	.....
4140	4140	HOT ROLLED, ANNEALED .....	90-100	60-70	20-30	50-60	185-210	91-95B	55
		COLD DRAWN, ANNEALED .....	110-120	85-95	15-25	45-55	230-250	20-25C	65
		HEAT TREATED, COLD DRAWN .....	140-155	125-140	12-20	45-55	270-300	26-30C	45
		1• RD. QUENCHED, TEMPERED 1000°F .....	150-160	130-140	15-20	50-60	320-350	34-37C	.....
		2• RD. QUENCHED, TEMPERED 1000°F .....	145-155	125-135	15-20	50-60	320-345	33-36C	.....
		3• RD. QUENCHED, TEMPERED 1000°F .....	130-145	115-125	15-20	55-65	280-310	28-32C	.....
E52100	52100	HOT ROLLED, ANNEALED .....	100-110	75-85	20-25	50-60	210-235	.....	45
		1• RD. QUENCHED, TEMPERED 1000°F .....	180-195	65-80	10-15	35-45	375-415	40-43C	.....
8620	8620	NATURAL HOT ROLLED .....	90-95	55-65	18-25	45-60	160-200	85-95B	55
		COLD DRAWN .....	90-105	65-80	15-25	40-50	185-215	90-96B	60-70
		1• RD. CARBURIZED 1700°F., COOLED IN BOX, REHEATED, QUENCHED – CORE PROPERTIES .....	120-135	90-110	15-20	40-50	285-350	28-40C	.....
8645	8645	NATURAL HOT ROLLED .....	105-125	55-75	15-25	35-50	220-270	20-28C	48-55
		HOT ROLLED, ANNEALED .....	100-110	50-60	20-25	40-55	210-230	17-21C	54
		2• RD. QUENCHED, TEMPERED 1000°F .....	140-150	110-125	15-20	45-55	300-320	30-34C	.....
		3• RD. QUENCHED, TEMPERED 1000°F .....	130-140	105-115	15-20	50-60	285-310	29-32C	.....
8742	8742	NATURAL HOT ROLLED .....	110-125	50-70	15-25	35-50	230-270	22-28C	45-50
		COLD DRAWN, ANNEALED .....	105-120	95-105	10-18	35-45	210-235	95-99B	60
		1• RD. QUENCHED, TEMPERED 1000°F .....	155-165	135-145	15-20	45-52	330-335	35-38C	.....
		2• RD. QUENCHED, TEMPERED 1000°F .....	135-145	110-120	15-20	50-60	290-320	30-33C	.....

## Physical Properties of Various Metals

Metals and Alloys	Stress in Thousands of Pounds per Square Inch				Modulus of Elasticity 1,000,000 Lbs.	Elongation %
	Tension Ultimate	Tension Yield Point	Compression Ultimate	Shear Ultimate		
ALUMINUM, TYPE 3003-0, ANNEALED. ....	16	6	.....	11	10	40
ALUMINUM, TYPE 3003-H18, HARD .....	29	27	.....	16	10	10
ALUMINUM, TYPE 5052-0, ANNEALED. ....	28	13	.....	18	10,2	30
ALUMINUM, TYPE 5052-H38, HARD .....	42	37	.....	24	10,2	8
ALUMINUM, TYPE 5056-0, ANNEALED. ....	42	22	.....	26	10,3	35
ALUMINUM, TYPE 2014-0, ANNEALED. ....	27	14	.....	18	10,6	18
ALUMINUM, TYPE 2014-T4, HEAT TREATED .....	62	42	.....	38	10,6	20
ALUMINUM, TYPE C4A, CASTING, SOLUTION HEAT TREAT .....	32	16	16▲	24	.....	8,5
ALUMINUM, TYPE 55C, AS DIE CAST .....	30	16	16▲	19	.....	9
BRASS, ALUMINUM, ANNEALED .....	60	27	.....	.....	16	55
BRASS, RED, 15% ZN, ANNEALED. ....	39	10	.....	31	17	48
BRASS, RED, 15% ZN, HARD .....	70	57	.....	42	17	5
BRASS, RED, LEADED, CAST, GRADE 4A. ....	33-46	17-24	10-12▲	.....	9,1-14,8	20-35
BRASS, RED, LEADED, CAST, GRADE 4B. ....	30-38	12-17	11-12▲	.....	.....	15-27
BRASS, YELLOW, 35% ZN, ANNEALED .....	46	14	.....	32	15	65
BRASS, YELLOW, 35% ZN, HARD .....	74	60	.....	43	15	8
BRONZE, ALUMINUM, AS CAST .....	67-95	27-45	.....	.....	15-18	5-35
BRONZE, COMMERCIAL, 10% ZN, ANNEALED. ....	37†	10†	.....	28†	17	45†
BRONZE, MANGANESE, ANNEALED .....	65†	30†	.....	42†	15	33†
BRONZE, PHOSPHOR, ANNEALED .....	40-66	14-24	.....	.....	16-17	48-70
BRONZE, TIN, HIGH LEADED, CAST .....	23-38	11-22	12-16▲	.....	8,5-13	7-20
BRONZE, TIN, LEADED, CAST .....	33-48	16-26	9-15▲	.....	10,6-16	15-40
COPPER, BERYLLIUM, ANNEALED .....	60-80†	25-35†	.....	50-60†	19	35-50†
INCONEL, CAST .....	65-90	.....	.....	.....	23	10-20
INCONEL, S, CAST .....	90-120	80-100	.....	.....	25	1-3
IRON, CAST, CLASS 30 .....	30-34	.....	115	44	15	.....
IRON, CAST, CLASS 35 .....	35-40	.....	125	43	16	.....
IRON, MALLEABLE, CLASS 32510 .....	50	33	90	46	25	10-18
IRON, MALLEABLE, CLASS 35018 .....	55	37	90	51	25	18-25
IRON, NODULAR (DUCTILE) CLASS 60-45-10. ....	60	45	120	.....	22-25	10-25
IRON, NODULAR (DUCTILE) CLASS 80-60-3. ....	80	60	160	.....	22-25	3-10
IRON, PEARLITIC, MALLEABLE. ....	60-90	40-70	.....	.....	28	3-12
IRON, WROUGHT, HOT ROLLED .....	34-47	23-24	.....	.....	29	7-35
LEAD, HARD, ROLLED .....	4,0-4,6	.....	.....	.....	.....	31-48
MONEL, CAST .....	65-90	32-45	.....	.....	23	20-50
MONEL, S, CAST .....	120-145	80-130	.....	.....	24,2	1-4
MONEL, SHAPES, PLATE, ETC., ANNEALED .....	70-85†	25-45†	.....	.....	26	35-50†
NICKEL, CAST .....	50-65	15-30	.....	.....	21,5	15-30
NICKEL, SILVER, ANNEALED .....	49-63†	18-30†	.....	.....	17-18	35-60†
STEEL, CAST CARBON, CLASS 70,000 NORMALIZED. ....	70	38	.....	.....	30	28
STEEL, CAST LOW ALLOY, CLASS 100,000, NORMALIZE & TEMPERED .....	100	68	.....	.....	29-30	20
STEEL, CAST LOW ALLOY, CLASS 120,000, QUENCHED AND TEMPERED .....	120	95	.....	.....	29-30	16
STEEL, CAST LOW ALLOY, CLASS 200,000, QUENCHED AND TEMPERED .....	200	170	.....	.....	29-30	5
STEEL, SHEETS .....	48	25	.....	.....	29-30	18-27
STEEL, STAINLESS, AUSTENITIC, TYPES 304, 316. ....	85	35	.....	.....	28	55-60
STEEL, STAINLESS, MARTENSITIC, TYPE 416. ....	75	40	.....	.....	29	30
STEEL, STRUCTURAL, BRIDGE AND BUILDING, ASTM A7. ....	60-72	33	33▲	45-54	29-30	21
STEEL, STRUCTURAL, HIGH STRENGTH, LOW ALLOY, ASTM A242. ....	63-72	42-50	42-50▲	47-53	29-30	18-24
ZINC, DIE CAST ALLOY, XXIII. ....	41	.....	60▲	31	.....	10

† When hardened, strength values are higher, elongation less.

▲ Compression yield point.



# Hardness Conversion Chart

## Brinell, Rockwell, and Scleroscope Hardness Numbers with Corresponding Tensile Strength

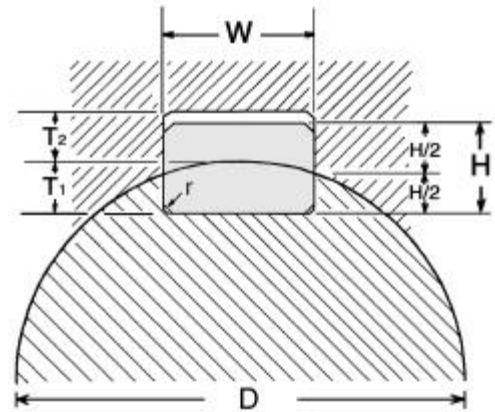
Brinell 10 MM Ball 3000 Kg.	Rockwell "C" 120 Cone 150 Kg.	Scleroscope Shore Model C	Tensile Strength 1000 Pound Per Square Inch
745	68	100	368
712	66	95	352
682	64	91	337
653	62	87	324
627	60	84	311
601	58	81	298
578	57	78	287
555	55	75	276
534	53	72	266
514	52	70	256
495	50	67	247
477	49	65	238
461	47	63	229
444	46	61	220
429	45	59	212
415	44	57	204
401	42	55	196
388	41	54	189
375	40	52	182
362	38	51	176
351	37	49	170
341	36	48	165
331	35	46	160
321	34	45	155
311	33	44	150
302	32	43	146
293	31	42	142
285	30	40	138
277	29	39	134
269	28	38	131
262	26	37	128
255	25	37	125
248	24	36	122
241	23	35	119
235	22	34	116
229	21	33	113
223	20	32	110
	Rockwell "B" .0625mm Ball 100 Kg.		
217	97	31	107
212	96	31	104
207	95	30	101
202	94	30	99
197	93	29	97
192	92	28	95
187	91	28	93
183	90	27	91
179	89	27	89
174	88	26	87

# Specifying Keyways

*Martin*

## Rectangular Keyways

Specifying and dimensioning metric keys and keyways varies significantly from the English and American systems. In the English and American system, it is the standard practice to specify the key size. In the English and American system, the keyway in the hub is dimensioned by the width and the depth at the side, but in the metric system the keyway is dimensioned by the width and the depth measured from the radius of the shaft to the center of the keyway. One of the following methods should be used to specify keyways:



Metric:  
W x H Key  
W x T<sub>2</sub> Keyway

British:  
W x H/2 Key  
W x H Keyway

### ISO Standard — mm

Shaft Diameter		Groove Width	H	T1	T2*
D					
≤	>	W			
6	8	2	2	1.2	1
8	10	3	3	1.8	1.4
10	12	4	4	2.5	1.8
12	17	5	5	3.0	2.3
17	22	6	6	3.5	2.8
22	30	8	7	4.0	3.3
30	38	10	8	5.0	3.3
38	44	12	8	5.0	3.3
44	50	14	9	5.5	3.8
50	58	16	10	6.0	4.3
58	65	18	11	7.0	4.4
65	75	20	12	7.5	4.9
75	85	22	14	9.0	5.4
85	95	25	14	9.0	5.4
95	110	28	16	10.0	6.4
110	130	32	18	11.0	7.4
130	150	36	20	12.0	8.4
150	170	40	22	13.0	9.4
170	200	45	25	15.0	10.4
200	230	50	28	17.0	11.4
230	260	56	32	20.0	12.4
260	290	63	32	20.0	12.4
290	330	70	36	22.0	14.4
330	380	80	40	25.0	15.4
380	440	90	45	28.0	17.4
440	500	100	50	31.0	19.5

\* Groove dimensions for woodruff keys DIN 6888 in accordance with DIN 6885 Sheet 1 (with back clearance)

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In the absence of specific details, manufacturing will be based upon DIN 6885 - T1

### Imperial Standard — Inches

Shaft Diameter		Groove Width	H	T1	T2*
D					
≤	>	W			
¼	½	⅛	⅛	0.072	0.060
½	¾	⅜ <sub>16</sub>	⅜ <sub>16</sub>	0.107	0.088
¾	1	¼	¼	0.142	0.115
1	1 ¼	⅜ <sub>16</sub>	¼	0.146	0.112
1 ¼	1 ½	⅜ <sub>16</sub>	¼	0.150	0.108
1 ½	1 ¾	7 <sub>16</sub>	5 <sub>16</sub>	0.186	0.135
1 ¾	2	½	5 <sub>16</sub>	0.190	0.131
2	2 ½	5 <sub>8</sub>	7 <sub>16</sub>	0.260	0.185
2 ½	3	¾	½	0.299	0.209
3	3 ½	7 <sub>8</sub>	5 <sub>8</sub>	0.370	0.264
3 ½	4	1	¾	0.441	0.318
4	5	1 ¼	7 <sub>8</sub>	0.518	0.366
5	6	1 ½	1	0.599	0.412
6	7	1 ¾	1 ¼	0.740	0.526
7	8	2	1 ⅜	0.818	0.573
8	9	2 ¼	1 ½	0.897	0.619
9	10	2 ½	1 5 <sub>8</sub>	0.975	0.666
10	11	2 ¾	1 7 <sub>8</sub>	1.114	0.777
11	12	3	2	1.195	0.823
12	13	3 ¼	2 ⅞	1.273	0.87
13	14	3 ½	2 ¾	1.413	0.98
14	15	3 ¾	2 ½	1.492	1.026
15	16	4	2 5 <sub>8</sub>	1.571	1.072
16	17	4 ¼	2 7 <sub>8</sub>	1.711	1.182
17	18	4 ½	3	1.791	1.229
18	19	4 ¾	3 ⅞	1.868	1.277
19	20	5	3 ⅞	2.010	1.385

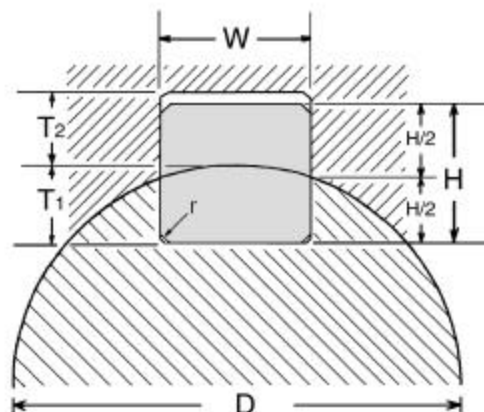
# Tolerance each on T1 and T2 (1" - 14") is - .000/+ .006"

# Tolerance each on T1 and T2 (16" - 20") is - .000/+ .010"

Keyway Dimensions to BS 46 Part 1 - 1958

## Square Keyways

Specifying and dimensioning metric keys and keyways varies significantly from the English and American systems. In the English and American system, it is the standard practice to specify the key size. In the English and American system, the keyway in the hub is dimensioned by the width and the depth at the side, but in the metric system the keyway is dimensioned by the width and the depth measured from the radius of the shaft to the center of the keyway. One of the following methods should be used to specify keyways:



British:  
W x H/2 Key  
W x H Keyway

American:  
W x H/2 Key  
W x H Keyway

### Imperial Standard — Inches

Shaft Diameter		Groove Width	H	T1#	T2#
D					
		W			
¼	½	⅜	⅜	0.072	0.060
½	¾	⅜ <sub>6</sub>	⅜ <sub>6</sub>	0.107	0.088
¾	1	¼	¼	0.142	0.115
1	1 ¼	⅝ <sub>6</sub>	⅝ <sub>6</sub>	0.177	0.142
1 ¼	1 ½	⅜	⅜	0.213	0.169
1 ½	1 ¾	⅞ <sub>6</sub>	⅞ <sub>6</sub>	0.248	0.197
1 ¾	2	½	½	0.283	0.224
2	2 ½	⅝	⅝	0.354	0.278
2 ½	3	¾	¾	0.424	0.333
3	3 ½	⅞	⅞	0.495	0.387
3 ½	4	1	1	0.566	0.442
4	5	1 ¼	1 ¼	0.707	0.551
5	6	1 ½	1 ½	0.848	0.661

# Tolerance each on T1 and T2 (1" - 14") is - .000/+ .006"

# Tolerance each on T1 and T2 (16" - 20") is - .000/+ .010"

Keyway Dimensions to BS 46 Part 1 - 1958

### American Standard — Inches

Shaft Diameter		Groove Width	H	T1#	T2#
D					
		W			
7/16	9/16	1/8	1/8	—	—
9/16	7/8	3/16	3/16	—	—
7/8	1 1/4	1/4	1/4	—	—
1 1/4	1 3/8	5/16	5/16	—	—
1 3/8	1 3/4	3/8	3/8	—	—
1 3/4	2 1/4	1/2	1/2	—	—
2 1/4	2 3/4	5/8	5/8	—	—
2 3/4	3 1/4	3/4	3/4	—	—
3 1/4	3 3/4	7/8	7/8	—	—
3 3/4	4 1/2	1	1	—	—
4 1/2	5 1/2	1 1/4	1 1/4	—	—
5 1/2	6 1/2	1 1/2	1 1/2	—	—
6 1/2	7 1/2	1 3/4	1 1/2	—	—
7 1/2	9	2	1 1/2	—	—
9	11	2 1/2	1 3/4	—	—
11	13	3	2	—	—
13	15	3 1/2	2 1/2	—	—
15	18	4	3	—	—
18	22	5	3 1/2	—	—
22	26	6	4	—	—
26	30	7	5	—	—

# Tolerance each on T1 and T2 is - .000/+ .010

$$T1 = \frac{D - \sqrt{D^2 - W^2}}{2} - \frac{H}{2}$$

$$T2 = \frac{H}{2} - \frac{D - \sqrt{D^2 - W^2}}{2}$$

# Decimal Equivalent Table

*Martin*

## Decimal and Millimeter Equivalents of Fractions

Inches			Inches			Inches		
Fractions	Decimals	Millimeters	Fractions	Decimals	Millimeters	Fractions	Decimals	Millimeters
$\frac{1}{64}$	,015625	,397	$\frac{11}{32}$	,34375	8,731	$\frac{11}{16}$	,6875	17,463
$\frac{1}{32}$	,03125	,794	$\frac{23}{64}$	,359375	9,128	$\frac{45}{64}$	,703125	17,859
$\frac{3}{64}$	,046875	1,191	$\frac{3}{8}$	,375	9,525	$\frac{23}{32}$	,71875	18,256
$\frac{1}{16}$	,0625	1,588	$\frac{25}{64}$	,390625	9,922	$\frac{47}{64}$	,734375	18,653
$\frac{5}{64}$	,078125	1,984	$\frac{13}{32}$	,40625	10,319	$\frac{3}{4}$	,750	19,050
$\frac{3}{32}$	,09375	2,381	$\frac{27}{64}$	,421875	10,716	$\frac{49}{64}$	,765625	19,447
$\frac{7}{64}$	,109375	2,778	$\frac{7}{16}$	,4375	11,113	$\frac{25}{32}$	,78125	19,844
$\frac{1}{8}$	,125	3,175	$\frac{29}{64}$	,453125	11,509	$\frac{51}{64}$	,796875	20,241
$\frac{9}{64}$	,140625	3,572	$\frac{15}{32}$	,46875	11,906	$\frac{13}{16}$	,8125	20,638
$\frac{5}{32}$	,15625	3,969	$\frac{31}{64}$	,484375	12,303	$\frac{53}{64}$	,828125	21,034
$\frac{11}{64}$	,171875	4,366	$\frac{1}{2}$	,500	12,700	$\frac{27}{32}$	,84375	21,431
$\frac{3}{16}$	,1875	4,763	$\frac{33}{64}$	,515625	13,097	$\frac{55}{64}$	,859375	21,828
$\frac{13}{64}$	,203125	5,159	$\frac{17}{32}$	,53125	13,494	$\frac{7}{8}$	,875	22,225
$\frac{7}{32}$	,21875	5,556	$\frac{35}{64}$	,546875	13,891	$\frac{57}{64}$	,890625	22,622
$\frac{15}{64}$	,234375	5,953	$\frac{9}{16}$	,5625	14,288	$\frac{29}{32}$	,90625	23,019
$\frac{1}{4}$	,250	6,350	$\frac{37}{64}$	,578125	14,684	$\frac{59}{64}$	,921875	23,416
$\frac{17}{64}$	,265625	6,747	$\frac{19}{32}$	,59375	15,081	$\frac{15}{16}$	,9375	23,813
$\frac{9}{32}$	,28125	7,144	$\frac{39}{64}$	,609375	15,478	$\frac{61}{64}$	,953125	24,209
$\frac{19}{64}$	,296875	7,541	$\frac{5}{8}$	,625	15,875	$\frac{31}{32}$	,96875	24,606
$\frac{5}{16}$	,3125	7,938	$\frac{41}{64}$	,640625	16,272	$\frac{63}{64}$	,984375	25,003
$\frac{21}{64}$	,328125	8,334	$\frac{21}{32}$	,65625	16,669	1	1,000	25,400
$\frac{43}{64}$	,671875	17,066	$\frac{43}{64}$	,671875	17,066			

## Decimal Equivalents of Millimeters

MM	Inches	MM	Inches	MM	Inches	MM	Inches	MM	Inches	MM	Inches	MM	Inches	MM	Inches
,1	,00394	9,5	,37401	22,5	,88582	35,5	1,39763	48,5	1,90944	61,5	2,42125	74,5	2,93306	87,5	3,44487
,2	,00787	10,	,39370	23,	,90551	36,	1,41732	49,	1,92913	62,	2,44094	75,	2,95275	88,	3,46456
,3	,01181	10,5	,41338	23,5	,92519	36,5	1,43700	49,5	1,94881	62,5	2,46062	75,5	2,97243	88,5	3,48424
,4	,01575	11,	,43307	24,	,94488	37,	1,45669	50,	1,96850	63,	2,48031	76,	2,99212	89,	3,50393
,5	,01968	11,5	,45275	24,5	,96456	37,5	1,47637	50,5	1,98818	63,5	2,49999	76,5	3,01180	89,5	3,52361
,6	,02362	12,	,47244	25,	,98425	38,	1,49606	51,	2,00787	6,	2,51968	77,	3,03149	90,	3,54330
,7	,02756	12,5	,49212	25,5	1,00393	38,5	1,51574	51,5	2,02755	64,5	2,53936	77,5	3,05117	90,5	3,56298
,8	,03149	13,	,51181	26,	1,02362	39,	1,53543	52,	2,04724	65,	2,55905	78,	3,07086	91,	3,58267
,9	,03543	13,5	,53149	26,5	1,04330	39,5	1,55511	52,5	2,06692	65,5	2,57873	78,5	3,09054	91,5	3,60235
1,	,03937	14,	,55118	27,	1,06299	40,	1,57480	53,	2,08661	66,	2,59842	79,	3,11023	92,	3,62204
1,5	,05905	14,5	,57086	27,5	1,08267	40,5	1,59488	53,5	2,10629	66,5	2,61810	79,5	3,12991	92,5	3,64172
2,	,07874	15,	,59055	28,	1,10236	41,	1,61417	54,	2,12598	67,	2,63779	80,	3,14960	93,	3,66141
2,5	,09842	15,5	,61023	28,5	1,12204	41,5	1,63385	54,5	2,14566	67,5	2,65747	80,5	3,16928	93,5	3,68109
3,	,11811	16,	,62992	29,	1,14173	42,	1,65354	55,	2,16535	68,	2,67716	81,	3,18897	94,	3,70078
3,5	,13779	16,5	,64960	29,5	1,16141	42,5	1,67322	55,5	2,18503	68,5	2,69684	81,5	3,20865	94,5	3,72046
4,	,15748	17,	,66929	30,	1,18110	43,	1,69291	56,	2,20472	69,	2,71653	82,	3,22834	95,	3,74015
4,5	,17716	17,5	,68897	30,5	1,20078	43,5	1,71259	56,5	2,22440	69,5	2,73621	82,5	3,24802	95,5	3,75983
5,	,19685	18,	,70866	31,	1,22047	44,	1,73228	57,	2,24409	70,	2,75590	83,	3,26771	96,	3,77952
5,5	,21653	18,5	,72834	31,5	1,24015	44,5	1,75196	57,5	2,26377	70,5	2,77558	83,5	3,28739	96,5	3,79920
6,	,23622	19,	,74803	32,	1,25984	45,	1,77165	58,	2,28346	71,	2,79527	84,	3,30708	97,	3,81889
6,5	,25590	19,5	,76771	32,5	1,27952	45,5	1,79133	58,5	2,30314	71,5	2,81495	84,5	3,32676	97,5	3,83857
7,	,27559	20,	,78740	33,	1,29921	46,	1,81102	59,	2,32283	72,	2,83464	85,	3,34645	98,	3,85826
7,5	,29527	20,5	,80708	33,5	1,31889	46,5	1,83070	59,5	2,34251	72,5	2,85432	85,5	3,36613	98,5	3,87794
8,	,31496	21,	,82677	34,	1,33858	47,	1,85039	60,	2,36220	73,	2,87401	86,	3,38682	99,	3,89763
8,5	,34464	21,5	,84645	34,5	1,35826	47,5	1,87007	60,5	2,38188	73,5	2,89369	86,5	3,40550	99,5	3,91731
9,	,35433	22,	,86614	35,	1,37795	48,	1,88976	61,	2,40157	74,	2,91338	87,	3,42519	100,	3,93700



# English Metric System Equivalents

## FORCE

Multiply By						TO OBTAIN
Kg f	Lb f	Metric Ton (1000 Kgf)	Tons (2240 Lbs)	Newton	Dyne	
1	0,45359	1000	1016,05	0,1019716	$1,019716 \times 10^{-6}$	Kg f
2,20462	1	2204,62	2240	0,224809	$2,24809 \times 10^{-6}$	Lb f
0,001	$453,59 \times 10^{-6}$	1	1,01605	$101,972 \times 10^{-6}$	—	Metric Ton (1000 Kgf)
$984,21 \times 10^{-6}$	$446,443 \times 10^{-6}$	0,98421	1	$100,361 \times 10^{-6}$	—	Ton (2240 Lbs)
9,80665	4,44822	9806,65	9964,02	1	$1 \times 10^{-5}$	Newton
$9,80665 \times 10^{-5}$	$4,44822 \times 10^{-5}$	—	—	100,000	1	Dyne
70,9316	32,174	70931,4439	72069,76	7,23301	$7,233014 \times 10^{-5}$	Poundal

## TORQUE

Multiply By						TO OBTAIN
gf - cm	kgf - m	N - m x 10 <sup>-4</sup>	N - m	lb - in	lb - ft	
1	1040,11	1,02	10200	1152	13830	gf - cm
$96,1436 \times 10^{-5}$	1	$1,02 \times 10^{-5}$	0,102	0,01152	0,1383	kgf - m
0,980665	98066,5	1	$10^{-4}$	1129,85	13560	N - m x 10 <sup>-4</sup>
$9,807 \times 10^{-5}$	9,80665	0,001	1	0,11298	1,355818	N - m
$8,6798 \times 10^{-4}$	86,798	$8,850 \times 10^{-4}$	8,8507	1	12	lb - in
$7,2333 \times 10^{-5}$	7,233167	$7,375 \times 10^{-5}$	0,737562	$8,333 \times 10^{-2}$	1	lb - ft

## PRESSURE

Multiply By						TO OBTAIN
atm	at	psi	Torr	bar	Pa	
1	0,967841	0,068046	$1,315789 \times 10^{-3}$	0,9869233	$9,86923 \times 10^{-6}$	atm
1,033227	1	0,070307	$1,35951 \times 10^{-3}$	1,019716	$1,019716 \times 10^{-5}$	at
14,69595	14,22334	1	0,0193368	14,50377	$1,45038 \times 10^{-4}$	psi
760	735,559	51,7149	1750	750,0617	$062 \times 10^{-3}$	Torr
1,01325	0,980665	0,0689476	$1,333224 \times 10^{-3}$	1	$1 \times 10^{-5}$	bar
$1,01325 \times 10^{-5}$	98066,5	6894,76	133,3224	$1 \times 10^{-5}$	1	Pa
1013,25	980,665	68,9476	1,333224	1000	0,01	millibar
29,92126	32,8084	2,30666	—	29,52999	$2,95299 \times 10^{-4}$	Foot of H <sub>2</sub> O (conv.)
10,33227	10	0,70307	—	10,19716	$1,019716 \times 10^{-4}$	Meter of H <sub>2</sub> O (conv.)
2116,22	2048,161	144	2,78449	2088,543	0,0208854	Pound- force/ft <sup>2</sup>

# English Metric System Equivalents



**Chart 1**

## POWER

Multiply By						TO OBTAIN
Btu/min	kW	Watt	Hp	CV	Nm/sec	
1	56,91965	0,056919	42,44498	41,83217	0,05687	Btu/min
0,0175686	1	0,001	0,745699	0,7354199	0,001	kW
17,56863	1000	1	745,699	735,294	1	Watt
0,0235599	1,341022	0,00134102	1	0,98632	$1,341 \times 10^{-3}$	Hp
0,023905	1,35962	$1,35962 \times 10^{-3}$	1,01387	1	$1,360 \times 10^{-3}$	CV
17,58396	1000	1	745,7	735,294	1	Nm/sec

**Chart 2**

Multiply By						TO OBTAIN
kW	Hp	N-m/sec	N-m/min	Lb-ft/min	Kgf-m/sec	
1	0,745699	0,001	$1,667 \times 10^{-5}$	$2,26 \times 10^{-5}$	0,0098	kW
1,341022	1	$1,341 \times 10^{-3}$	$2,235 \times 10^{-5}$	$3,0303 \times 10^{-5}$	0,01315	Hp
1000	745,7	1	60	0,0226	9,8061	N-m/sec
60000	44741,0	0,016667	1	1,35582		N-m/min
44253,73	33000	44,2546	2655,276	1		Lb-ft/min
101,972	76,0402	0,1020	$169,95 \times 10^{-5}$	$230,425 \times 10^{-5}$	1	Kgf-m/sec

**Chart 3**

Multiply By						TO OBTAIN
Btu/Hr	Ft,Lb/Hr	Ft,Lb/Min	Hp	Hp(Met)	Watt	
1	0,001285	0,077173	2544,43	2509,622	3,415179	Btu/Hr
778,168800	1	0,016667	1980000	1952914	2655,224	Ft,Lb/Hr
12,95795	60	1	33000	32548,56	44,25373	Ft,Ln/Min
0,000393	$5,05 \times 10^{-7}$	$3,0303 \times 10^{-5}$	1	0,986320	0,0013410	Hp
0,000398	$5,12 \times 10^{-7}$	$3,072 \times 10^{-5}$	1,01387	1	0,0013596	Hp(Met)
0,2928104	0,0003766	0,022597	745,6999	735,499	1	Watt

## STRESS

Multiply By						TO OBTAIN
Lbf/in <sup>2</sup>	Kgf/mm <sup>2</sup>	M/mm <sup>2</sup>	Tonf(2000)/in <sup>2</sup>	N/m <sup>2</sup>	Kgf/cm <sup>2</sup>	
1	1422,334	145,0373	2000	$1,45038 \times 10^{-4}$	14,22334	Lbf/in <sup>2</sup>
$7,0307 \times 10^{-4}$	1	0,1019716	1,40616	$0,10187 \times 10^{-6}$	0,01	Kgf/mm <sup>2</sup>
6,894767	9,80665	1	13,7895	$1 \times 10^{-6}$	0,0980665	N/mm <sup>2</sup>
0,0005	0,566928	0,057812	1	$725,18 \times 10^{-10}$	$7,11167 \times 10^{-3}$	Tonf(2000)/in <sup>2</sup>
$4,46429 \times 10^{-4}$	0,63496	0,06475	1,12	$812,2 \times 10^{-10}$	$6,34971 \times 10^{-3}$	Tonf(2240)/in <sup>2</sup>
6894,767	9,80665	$1 \times 10^{-6}$	$1,37895 \times 10^{-7}$	1	98066,5	N/m <sup>2</sup>
0,070307	100	10,197162	140,6139	$1,01972 \times 10^{-5}$	1	Kgf/cm <sup>2</sup>





# English Metric System Equivalents

**Chart 1**

## LENGTH

Multiply By						TO OBTAIN
mm	cm	meter	inch	ft.	yard	
1	10	1000	25,4	304,801	914,402	mm
0,1	1	100	2,54001	30,4801	91,4402	cm
0,001	0,01	1	0,0254	0,304801	0,914402	meter
0,03937	0,3937008	39,370079	1	12	36	inch
0,00328084	0,0328084	3,2808399	0,0833333	1	3	ft.
0,001094	0,010936	1,0936133	0,0277778	0,333333	1	yard

**Chart 2**

Multiply By						TO OBTAIN
meter	km	rod	Furlong	Mile(stat.)	Mile(Naut.)	
1	1000	5,02921	201,168	1609,344	1852	meter
.001	1	$5,02921 \times 10^{-3}$	0,201168	1,609344	1,852	km
0,1988384	198,83839	1	40	320	368,24928	rod
$4,97097 \times 10^{-3}$	4,97097	0,025	1	8	9,2062320	Furlong
$6,213712 \times 10^{-4}$	0,6213712	0,003125	0,125	1	1,150779	Mile(Stat.)
$5,399568 \times 10^{-4}$	0,5399568	$2,71557 \times 10^{-3}$	0,1189594	0,86897624	1	Mile(Naut.)

**Chart 1**

## AREA

Multiply By						TO OBTAIN
in <sup>2</sup>	ft <sup>2</sup>	yd <sup>2</sup>	mm <sup>2</sup>	cm <sup>2</sup>	m <sup>2</sup>	
1	144	1296	$1,550003 \times 10^{-3}$	0,1550003	1550,003	in <sup>2</sup>
$6,94444 \times 10^{-3}$	1	9	$1,0764 \times 10^{-5}$	$1,076391 \times 10^{-3}$	10,76391	ft <sup>2</sup>
$7,71604 \times 10^{-4}$	0,1111111	1	—	$1,195990 \times 10^{-4}$	1,195990	yd <sup>2</sup>
645,16	92903,04	—	1	100	$1 \times 10^6$	mm <sup>2</sup>
6,4516	929,0304	8361,2736	0,01	1	10000	cm <sup>2</sup>
$6,4516 \times 10^{-4}$	0,09290304	0,83612736	$1 \times 10^{-6}$	$1 \times 10^{-4}$	1	m <sup>2</sup>

**Chart 2**

Multiply By						TO OBTAIN
m <sup>2</sup>	km <sup>2</sup>	a	ha	acre	mile <sup>2</sup>	
1	1 <sup>12</sup>	100	10000	4046,8564	$2,58988 \times 10^{12}$	m <sup>2</sup>
$1 \times 10^{-6}$	1	$1 \times 10^{-4}$	0,01	$4,046856 \times 10^{-3}$	2,589988	km <sup>2</sup>
0,01	10000	1	100	40,4686	15,81473	a
0,0001	100	0,01	1	0,4046856	259	ha
$2,471054 \times 10^{-4}$	247,1054	0,024105	2,471054	1	640	acre
$3,861022 \times 10^{-7}$	0,38610216	$3,861 \times 10^{-5}$	$3,8594 \times 10^{-3}$	$1,5625 \times 10^{-3}$	1	mile <sup>2</sup>

# English Metric System Equivalents



**Chart 1**

## VOLUME

Multiply By						TO OBTAIN
cm <sup>3</sup>	in <sup>3</sup>	ft <sup>3</sup>	yd <sup>3</sup>	m <sup>3</sup>	liter	
1	16,387064	28316,847	764564,18	1 x 10 <sup>-6</sup>	1000	cm <sup>3</sup>
0,06102376	1	1728	46656	61023,74	61,02374	in <sup>3</sup>
3,5314 x 10 <sup>-5</sup>	5,78704 x 10 <sup>-4</sup>	1	27	35,31467	0,03531467	ft <sup>3</sup>
1,3079 x 10 <sup>-6</sup>	2,143347 x 10 <sup>-5</sup>	0,037037	1	1,307951	1,37951 x 10 <sup>-3</sup>	yd <sup>3</sup>
—	1,638706 x 10 <sup>-5</sup>	0,02831685	0,7645549	1	0,001	m <sup>3</sup>
0,001	0,163871	28,316847	764,5549	1000	1	liter
33,814 x 10 <sup>-3</sup>	0,05541	957,5065	—	—	33,81409	US fl oz
35,195 x 10 <sup>-3</sup>	0,5767440	996,6	—	—	35,19508	Imp fl oz
2,11338 X 10 <sup>-4</sup>	0,03463203	59,84416	1616,17706	2113,376	2,113376	US pint (lqd)
1,7598 x 10 <sup>-3</sup>	0,0288372	49,83068	1345,74883	1759,754	1,759754	Imp pint (lqd)
1,81617 X 10 <sup>-3</sup>	0,029762	51,42809	1388,8895	1816,166	1,816166	US pint (dry)
1,05668 x 10 <sup>-3</sup>	0,017316	29,92208	807,88295	1056,688	1,056688	US quart (lqd)
1,05667 X 10 <sup>-3</sup>	0,0144186	24,91534	672,71427	879,8770	0,8798770	Imp quart (lqd)
9,081 x 10 <sup>-4</sup>	0,01488081	25,71405	694,288	908,0830	0,90808	US quart (dry)
2,64172 x 10 <sup>-4</sup>	4,3290 x 10 <sup>-3</sup>	7,480519	201,9740	264,17210	0,2641720	US gal (lqd)
2,1997 X 10 <sup>-4</sup>	3,060465 x 10 <sup>-4</sup>	6,228835	168,1786	219,9692	0,2199692	Imp gal (lqd)
2,2702 X 10 <sup>-4</sup>	3,7202 X 10 <sup>-3</sup>	6,428507	173,5697	227,02058	0,22702	US gal (dry)
—	1,37429 X 10 <sup>-4</sup>	0,2374768	6,260938	8,38644	8,38644 X 10 <sup>-3</sup>	US barrel (lqd)



# English Metric System Equivalents

**Chart 2**

## **VOLUME**

Multiply By						TO OBTAIN
US (lqd) oz	Imp (lqd) oz	Imp (lqd) pint	US (lqd) gal.	Imp (lqd) gal.	US (lqd) barrel	
29,57353	28,41306	568,26125	3785,412	4546,0745	—	cm <sup>3</sup>
1,8046875	1,733871	34,67743	231	277,42	7276,5	in <sup>3</sup>
1,04439 x 10 <sup>-3</sup>	1,00341 x 10 <sup>-3</sup>	0,02	0,13368	0,1605	4,2109375	ft <sup>3</sup>
—	—	7,4308 x 10 <sup>-4</sup>	4,9511 x 10 <sup>-3</sup>	5,94601 x 10 <sup>-3</sup>	0,1597205	yd <sup>3</sup>
—	—	5,6826 x 10 <sup>-4</sup>	3,785 x 10 <sup>-3</sup>	4,54609 x 10 <sup>-3</sup>	0,1192405	m <sup>3</sup>
0,029574	0,02841306	0,568126	3,785441	4,546992	119,2405	liter
1	0,9607599	19,215	128	153,72	—	US fl oz
1,040843	1	20	133,2278	160	—	Imp fl oz
0,0625	0,06003	1,200950	8	9,607565	252,0004	US pint (lqd)
0,0520427	0,05	1	6,663031	8	209,8333	Imp pint (lqd)
0,0537110	0,0660285	1,032057	6,874913	8,25642	216,5598	US pint (dry)
0,03125	.03002376	0,600475	4	4,803797	126	US quart (lqd)
0,0260214	0,025	0,5	6,662	4	104,9166	Imp quart (lqd)
0,0	0,0257948	0,5158958	3,43743	4,12820	108,2796	US quart (dry)
7,8125 x 10 <sup>-3</sup>	7,5058 x 10 <sup>-3</sup>	0,1500819	1	1,200949	31,5	US gal (lqd)
6,5053 x 10 <sup>-3</sup>	6,25 x 10 <sup>-3</sup>	0,125	0,83267	1	26,22925	Imp gal (lqd)
—	—	0,1289739	0,8593568	1,0320497	27,06989	US gal (dry)
—	—	4,7657 x 10 <sup>-3</sup>	0,0317460	0,0381254	1	US barrel (lqd)

# English Metric System Equivalents



## SPEED

Multiply By						TO OBTAIN
mile/hr	ft/min	ft/sec	m/sec	m/min	km/hr	
1	0,0113636	0,6818182	2,236936	0,03728227	0,6213712	mile/hr
88,0	1	60	196,8504	3,28084	54,68066	ft/min
1,466667	0,0166667	1	3,28084	0,05468066	0,9113444	ft/sec
0,44704	$5,08 \times 10^{-3}$	0,3048	1	0,0166667	0,2777778	m/sec
26,8224	0,3048	18,288	60	1	16,66667	m/min
1,609344	0,018288	1,09728	3,6	0,060	1	km/hr
0,8689762	$9,87473 \times 10^{-3}$	0,5924838	1,943844	0,03239741	0,5399568	knot

## VOLUMETRIC (FLOW)

Multiply By							TO OBTAIN
ft <sup>3</sup> /min	ft <sup>3</sup> /sec	yd <sup>3</sup> /min	liter/min	liter/sec	gal(US)/min	gal(imp)/min	
1	60,0000000	27,0000	0,035315	2,118880	0,13368	0,160544	ft <sup>3</sup> /min
.01666667	1	0,450	$5,8858 \times 10^{-4}$	0,035315	$2,2280 \times 10^{-3}$	$2,6757 \times 10^{-3}$	ft <sup>3</sup> /sec
.03703704	2,222222	1	.011 x 30795	.078477	$4,9511 \times 10^{-3}$	$5,94606 \times 10^{-3}$	yd <sup>3</sup> /min
28.31685	1699.011	764.5549	1	60	3,785412	4.546092	liter/min
.4719474	28.31685	12,74258	0,0166667	1	0,0630902	0,07576817	liter/sec
7.480519	448,8312	201.974	0,2641721	15,85032	1	1.20095	gal (US)/min
6.228833	373,7301	168.1785	0,2199692	13,19815	0,83267	1	gal (imp)/min
60	3600	1620	2,118880	127,1328	8,020834	9,63262	ft <sup>3</sup> /hr
1.699011	101,9406	45.87329	.06	3.6	0,2271247	0,2727654	m <sup>3</sup> /hr
471.9474	28316.85	12742.58	16.66667	1000	63.0902	75.7682	cm <sup>3</sup> /sec
0,1246753	7.480519	3,366234	$4.40287 \times 10^{-3}$	$2.64172 \times 10^{-3}$	.0166667	0.001584	gal (US)/sec
0,1038139	6.228833	2,802976	$3.66615 \times 10^{-3}$	$.2199696 \times 10^{-3}$	.0138779	.0166667	gal (US)/sec

## Circle

**Area** = Square of Diameter x ,7854

or square of Radius x 3,1416

**Circumference** = Diameter x 3,1416

**Diameter** = Circumference x ,3183

Doubling diameter increases area four times; tripling diameter increases area nine times, etc.

## Square

**Area** = Square of Side

**Diagonal** = Side x 1,4142

**Side** = Diagonal x ,7071

## Square Inscribed in Circle

**Side of Square** = Diameter of Circle x ,7071

or Circumference of Circle x ,2251

**Diameter of Circle** = Side of Square x 1,4142

**Circumference of Circle** = Side of Square x 4,4429

## Square and Circle with Equal Area

**Side of Square** = Diameter of Circle x ,8862

**Diameter of Circle** = Side of Square x 1,128

**Circumference of Circle** = Side of Square x 3,545

## Rectangle

**Area** = Length x Width

**Diagonal** = Square root of sum of squares of Width and Length

## Triangle

**Area** = Base x  $\frac{1}{2}$  of Perpendicular Height

## Sphere

**Area of Surface** = Square of Diameter x 3,1416

**Volume** = Cube of Diameter x ,5236

## Cube

**Area of Surface** = Square of Side x 6

**Volume** = Cube of Side

**Diagonal** = Side x 1,732

## Cylinder

**Area of Curved Surface** = Diameter x Length x 3,1416

**Volume** = Square of Diameter x Length x ,7854

## Cone

**Area of Curved Surface** = Diameter of Base x Slant Height x 1,5708

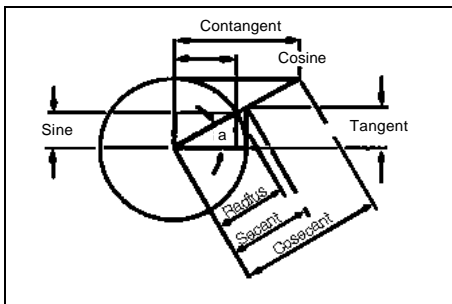
**Volume** = Diameter of Base Squared x Perpendicular Height x ,2618 or Area of Base x  $\frac{1}{3}$  Perpendicular Height

1 HP = 33,000 Foot-pounds of work per minute.  
 1 BTU = Heat required to raise 1 pound of water °F.  
 1 Kilowatt Hour = 3415 BTU  
 1 Radian = 57,296 degrees.  
 1 Register Ton = 100 cubic feet  
 1 U.S. Shipping Ton = 40 cubic feet  
 1 British Shipping Ton = 42 cubic feet  
 1 Cubic Foot/Minute = 471,9474 cubic cm/second  
 1 Cubic Foot/Minute = ,1246753 gallons (U.S.)/second  
 1 Cubic Foot/Second = 2,2222 cubic yards/minute  
 1 Gallon (U.S.)/Minute = 8,020834 cubic feet/hour  
 1 Gallon (U.S.)/Minute = 3,785412 liter/minute  
 1 Liter/Minute = 2,118880 cubic feet/hour  
 1 Cubic Metre/Minute = 264,1720 Gallons (U.S.)/Minute  
 1 Pound/Gallon (U.S.) = 7,480519 pound/cubic feet  
 1 Mile/Hour = 88 feet/minute  
 1 Foot/Minute = ,01136364 miles/hour

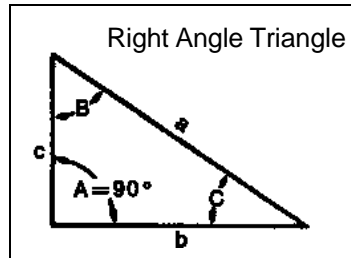
1 Pound per Square Inch Pressure (PSI) = 144 pounds/square foot = 2,3095 feet fresh water at 62°F = 2,0355 inches mercury at 32°F = 2,0416 inches mercury at 62°F = ,068 atmospheres.  
 Water Pressure (pounds per square inch) = ,433 x height of water in feet (Fresh water at 62°F).  
 Weight of 1 cubic foot of fresh water = 62,355 pounds at 62°F = 59,76 pounds at 212°F.  
 Weight of 1 gallon (U.S.) water = 8,34 pounds  
 Weight of 1 cubic foot of Air at 14,7 lbs per square inch Pressure = ,07608 pounds at 62°F = ,08703 pounds at 32°F.  
 Watts = Amperes x Volts  
 1 Watt-Hour = 3,41214 BTU = 859,845 Calorie = 3600 Joule.  
 g = Acceleration due to gravity at Sea Level, Latitude 45° = 32,1726 Feet/Second squared.  
 1 pound-foot (torque) = 1,355818 Newton-Meter.

# Trigonometric Functions

*Martin*



## Trigonometric Formulas (See pages that follow for functions)



### Formulas for Finding Functions of Angles

$$\frac{\text{Side Opposite}}{\text{Hypotenuse}} = \text{Sine}$$

$$\frac{\text{Side Adjacent}}{\text{Hypotenuse}} = \text{Cosine}$$

$$\frac{\text{Side Opposite}}{\text{Side Adjacent}} = \text{Tangent}$$

$$\frac{\text{Side Adjacent}}{\text{Side Opposite}} = \text{Cotangent}$$

$$\frac{\text{Hypotenuse}}{\text{Side Adjacent}} = \text{Secant}$$

$$\frac{\text{Hypotenuse}}{\text{Side Opposite}} = \text{Cosecant}$$

### Formulas for Finding Sides of Right Angle Triangles with an Angle and Side Known

To Find: Length of side opposite

$$\left\{ \begin{array}{l} \text{Hypotenuse} \times \text{Sine} \\ \text{Hypotenuse} \div \text{Cosecant} \\ \text{Side Adjacent} \times \text{Tangent} \\ \text{Side Adjacent} \div \text{Cotangent} \end{array} \right.$$

To Find: Length of side adjacent

$$\left\{ \begin{array}{l} \text{Hypotenuse} \times \text{Cosine} \\ \text{Hypotenuse} \div \text{Secant} \\ \text{Side Opposite} \times \text{Cotangent} \\ \text{Side Opposite} \div \text{Tangent} \end{array} \right.$$

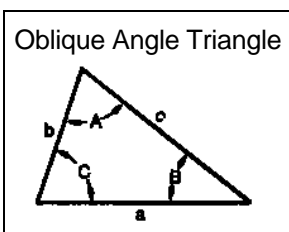
To Find: Length of hypotenuse

$$\left\{ \begin{array}{l} \text{Side Opposite} \times \text{Cosecant} \\ \text{Side Opposite} \div \text{Sine} \\ \text{Side Adjacent} \times \text{Secant} \\ \text{Side Adjacent} \div \text{Cosine} \end{array} \right.$$

### To Find Angles and Sides of Right Angle Triangles

To Find Angles		To Find Angles	
To Find:	Formulas	To Find:	Formulas
C	$\frac{c}{a} = \text{Sine C}$	a	$\sqrt{b^2 + c^2}$
C	$\frac{b}{a} = \text{Cosine C}$	a	$c \times \text{Cosec. C}$
C	$\frac{c}{b} = \text{Tan. C}$	a	$c \times \text{Secante B}$
C	$\frac{b}{c} = \text{Cotan. C}$	a	$b \times \text{Cosec. B}$
C	$\frac{a}{b} = \text{Secant C}$	a	$b \times \text{Secante C}$
C	$\frac{a}{c} = \text{Cosec. C}$	b	$\sqrt{a^2 - c^2}$
B	$\frac{b}{a} = \text{Sine B}$	b	$a \times \text{Sine B}$
B	$\frac{c}{a} = \text{Cosine B}$	b	$a \times \text{Cos. C}$
B	$\frac{b}{c} = \text{Tan. B}$	b	$c \times \text{Tan. B}$
B	$\frac{c}{b} = \text{Cotan. B}$	b	$c \times \text{Cot. C}$
B	$\frac{a}{c} = \text{Secant B}$	c	$\sqrt{a^2 - b^2}$
B	$\frac{a}{b} = \text{Cosec. B}$	c	$a \times \text{Cos. B}$
		c	$a \times \text{Sine C}$
		c	$b \times \text{Cot. B}$
		c	$b \times \text{Tan. C}$

### To Find Angles and Sides of Oblique Angle Triangles



To Find	Known	Formulas	To Find	Known	Formulas
C	A, B	$180^\circ - (A + B)$	A	B, C	$180^\circ - (B + C)$
b	a, B, A	$\frac{a \times \text{Sin. B}}{\text{Sin. A}}$	Cos. A	a, b, c	$\frac{b^2 + c^2 - a^2}{2bc}$
c	a, A, C	$\frac{a \times \text{Sin. C}}{\text{Sin. A}}$	Sin. C	c, A, a	$\frac{c \times \text{Sin. A}}{a}$
Tan. A	a, C, b	$\frac{a \times \text{Sin. C}}{b - (a \times \text{Cos. C})}$	Cot. B	a, C, b	$\frac{a \times \text{Cosec. C}}{b} - \text{Cot. C}$
B	A, C	$180^\circ - (A + C)$	c	b, C, B	$b \times \text{Sin. C} \times \text{Cosec. B}$
Sin. B	b, A, a	$\frac{b \times \text{Sin. A}}{a}$	—	—	—

## Trigonometric Functions

°	'	Sine	Tan.	Cotan.	Cosine	°	°	'	Sine	Tan.	Cotan.	Cosine	°	°	
0	0	.000000	.000000	INFINITE	1.000000	0	90	11	0	.190809	.194380	5.1445540	.981627	0	79
	10	.002909	.002909	343.77371	.999996	50			10	.913664	.197401	5.0658352	.981068	50	
	20	.005818	.005818	171.88540	.999983	40			20	.196517	.200425	4.9894027	.980500	40	
	30	.008727	.008727	114.58865	.999962	30			30	.199368	.203452	4.9151570	.979925	30	
	40	.011635	.011636	85.939791	.999932	20			40	.202218	.206483	4.8430045	.979341	20	
	50	.014544	.014545	68.750087	.999894	10			50	.205065	.209518	4.7728568	.978748	10	
1	0	.017452	.017455	57.289962	.999848	0	89	12	0	.207912	.212557	4.7046301	.978148	0	78
	10	.020361	.020365	49.103881	.999793	50			10	.210756	.215599	4.6382457	.977539	50	
	20	.023269	.023275	42.964077	.999729	40			20	.213599	.218645	4.5736287	.976921	40	
	30	.026177	.026186	38.188459	.999657	30			30	.216440	.221695	4.5107085	.976296	30	
	40	.029085	.029097	34.367771	.999577	20			40	.219279	.224748	4.4494181	.975662	20	
	50	.031992	.032009	31.241577	.999488	10			50	.222116	.227806	4.3896940	.975020	10	
2	0	.034899	.034921	28.636253	.999391	0	88	13	0	.224951	.230868	4.3314759	.974370	0	77
	10	.037806	.037834	26.431600	.999285	50			10	.227784	.233934	4.2747066	.973712	50	
	20	.040713	.040747	24.541758	.999171	40			20	.230616	.237004	4.2193318	.973045	40	
	30	.043619	.043661	22.903766	.999048	30			30	.233445	.240079	4.1652998	.972370	30	
	40	.046525	.046576	21.470401	.998917	20			40	.236273	.243158	4.1125614	.971687	20	
	50	.049431	.049491	20.205553	.998778	10			50	.239098	.246241	4.0610700	.970995	10	
3	0	.052336	.052408	19.081137	.998630	0	87	14	0	.241922	.249328	4.0107809	.970296	0	76
	10	.055241	.055325	18.074977	.998473	50			10	.244743	.252420	3.9616518	.969588	50	
	20	.058145	.058243	17.169337	.998308	40			20	.247563	.255517	3.9136420	.968872	40	
	30	.061049	.061163	16.349855	.998135	30			30	.250380	.258618	3.8667131	.968148	30	
	40	.063952	.064083	15.604784	.997957	20			40	.253195	.261723	3.8208281	.967415	20	
	50	.066854	.067004	14.924417	.997763	10			50	.256008	.264834	3.7759519	.966675	10	
4	0	.069756	.069927	14.300666	.997564	0	86	15	0	.258819	.267949	3.7320508	.965926	0	75
	10	.072658	.072851	13.726738	.997357	50			10	.261628	.271069	3.6890927	.965169	50	
	20	.075559	.075776	13.196888	.997141	40			20	.264434	.274195	3.6470467	.964404	40	
	30	.078459	.078702	12.706205	.996917	30			30	.267238	.277325	3.6058835	.963630	30	
	40	.081359	.081629	12.250505	.996685	20			40	.270040	.280460	3.5655749	.962849	20	
	50	.084258	.084558	11.826167	.996444	10			50	.272840	.283600	3.5260938	.962059	10	
5	0	.087156	.087489	11.430052	.996195	0	85	16	0	.275637	.286745	3.4874144	.961262	0	74
	10	.090053	.090421	11.059431	.995937	50			10	.278432	.289896	3.4495120	.960456	50	
	20	.092950	.093354	10.711913	.995671	40			20	.281225	.293052	3.4123626	.959642	40	
	30	.095846	.096289	10.385397	.995396	30			30	.284015	.296214	3.3759434	.958820	30	
	40	.098741	.099226	10.078031	.995113	20			40	.286803	.299380	3.3402326	.957990	20	
	50	.101635	.102164	9.7881732	.994822	10			50	.289589	.302553	3.3052091	.957151	10	
6	0	.104528	.105104	9.5143645	.994522	0	84	17	0	.292372	.305731	3.2708526	.956305	0	73
	10	.107421	.108046	9.2553035	.994214	50			10	.295152	.308914	3.2371438	.955450	50	
	20	.110313	.110990	9.0098261	.993897	40			20	.297930	.312104	3.2040638	.954588	40	
	30	.113203	.113936	8.7768874	.993572	30			30	.300706	.315299	3.1715948	.953717	30	
	40	.116093	.116883	8.5555468	.993238	20			40	.303479	.318500	3.1397194	.952838	20	
	50	.118982	.119833	8.3449558	.992896	10			50	.306249	.321707	3.1084210	.951951	10	
7	0	.121869	.122785	8.1443464	.992546	0	83	18	0	.309017	.324920	3.0776835	.951057	0	72
	10	.124756	.125738	7.9530224	.992187	50			10	.311782	.328139	3.0474915	.950154	50	
	20	.127642	.128694	7.7703506	.991820	40			20	.314545	.331364	3.0178301	.949243	40	
	30	.130526	.131653	7.5957541	.991445	30			30	.317305	.334595	2.9886850	.948324	30	
	40	.133410	.134613	7.4287064	.991061	20			40	.320062	.337833	2.9600422	.947397	20	
	50	.136292	.137576	7.2687255	.990669	10			50	.322816	.341077	2.9318885	.946462	10	
8	0	.139173	.140541	7.1153697	.990268	0	82	19	0	.325568	.344328	2.9042109	.945519	0	71
	10	.142053	.143508	6.9682335	.989859	50			10	.328317	.347585	2.8769970	.944568	50	
	20	.144932	.146478	6.8269437	.989442	40			20	.331063	.350848	2.8502349	.943609	40	
	30	.147809	.149451	6.6911562	.989016	30			30	.333807	.354119	2.8239129	.942641	30	
	40	.150686	.152426	6.5605538	.988582	20			40	.336547	.357396	2.7980198	.941666	20	
	50	.153561	.155404	6.4348428	.988139	10			50	.339285	.360680	2.7725448	.940684	10	
9	0	.156434	.158384	6.3137515	.987688	0	81	20	0	.342020	.363970	2.7474774	.939693	0	70
	10	.159307	.161368	6.1970279	.987229	50			10	.344752	.367268	2.7228076	.938694	50	
	20	.162178	.164354	6.0844381	.986762	40			20	.347481	.370573	2.6985254	.937687	40	
	30	.165048	.167343	5.9757644	.986286	30			30	.350207	.373885	2.6746215	.936672	30	
	40	.167916	.170334	5.8708042	.985801	20			40	.352931	.377204	2.6510867	.935650	20	
	50	.170783	.173329	5.7693688	.985309	10			50	.355651	.380530	2.6279121	.934619	10	
10	0	.173648	.176327	5.6712818	.984808	0	80	21	0	.358368	.383864	2.6050891	.933580	0	69
	10	.176512	.179328	5.5763786	.984298	50			10	.361082	.387205	2.5826094	.932534	50	
	20	.179375	.182332	5.4845052	.983781	40			20	.363793	.390554	2.5604649	.931480	40	
	30	.182236	.185339	5.3955172	.983255	30			30	.366501	.393911	2.5386479	.930418	30	
	40	.185095	.188359	5.3092793	.982721	20			40	.369206	.397275	2.5171507	.929348	20	
	50	.187953	.191363	5.2256647	.982178	10	79		50	.371908	.400647	2.4959661	.928270	10	68
°	'	Cosine	Cotan.	Tan.	Sine	°	°	'	Cosine	Cotan.	Tan.	Sine	°	°	

NOTE: For functions from 45°-0' to 68° read from bottom of table upward.

# Trigonometric Tables

*Martin*

## Trigonometric Functions

		Sine	Tan.	Cotan.	Cosine		°	°		Sine	Tan.	Cotan.	Cosine		°
22	0	.374607	.404026	2.4750869	.927184	0	68	34	0	.559193	.674509	1.4825610	.829038	0	56
	10	.377302	.407414	2.4545061	.926090	50			10	.561602	.678749	1.4732983	.827407	50	
	20	.379994	.410810	2.4342172	.924980	40			20	.564007	.683007	1.4641147	.825770	40	
	30	.382683	.414214	2.4142136	.923880	30			30	.566406	.687281	1.4550090	.824126	30	
	40	.385369	.417626	2.3944889	.922762	20			40	.568801	.691573	1.4459801	.822475	20	
23	50	.388052	.421046	2.3750372	.921638	10			50	.571191	.695881	1.4370268	.820817	10	
	0	.390731	.424475	2.3558524	.920505	0	67	35	0	.573576	.700208	1.4281480	.819152	0	55
	10	.393407	.427912	2.3369287	.919364	50			10	.575957	.704552	1.4193427	.817480	50	
	20	.396080	.431358	2.3182606	.918216	40			20	.578332	.708913	1.4106098	.815801	40	
	30	.398749	.434812	2.2998425	.917060	30			30	.580703	.713293	1.4019483	.814116	30	
24	40	.401415	.438276	2.2816693	.915896	20			40	.583069	.717691	1.3933571	.812423	20	
	50	.404078	.441748	2.2637357	.914725	10			50	.585429	.722108	1.3848355	.810723	10	
	0	.406737	.445229	2.2460368	.913545	0	66	36	0	.587785	.726543	1.3763810	.809017	0	54
	10	.409392	.448719	2.2285676	.912358	50			10	.590136	.730996	1.3679959	.807304	50	
	20	.412045	.452218	2.2113234	.911164	40			20	.592482	.735469	1.3596764	.805584	40	
25	30	.414693	.455726	2.1942997	.909961	30			30	.594823	.739961	1.3514224	.803857	30	
	40	.417338	.459244	2.1774920	.908751	20			40	.597159	.744472	1.3432331	.802123	20	
	50	.419980	.462771	2.1608958	.907533	10			50	.599489	.749003	1.3351075	.800383	10	
	0	.422618	.466308	2.1445069	.906308	0	65	37	0	.601815	.753554	1.3270448	.798636	0	53
	10	.425253	.469854	2.1283213	.905075	50			10	.604136	.758125	1.3190441	.796882	50	
26	20	.427884	.473410	2.1123348	.903834	40			20	.606451	.762716	1.3111046	.795121	40	
	30	.430511	.476976	2.0965436	.902585	30			30	.608761	.767327	1.3032254	.793353	30	
	40	.433125	.480551	2.0809438	.901329	20			40	.611067	.771959	1.2954057	.791579	20	
	50	.435755	.484137	2.0655318	.900065	10			50	.613367	.776612	1.2876447	.789798	10	
	0	.438371	.487733	2.0503038	.898794	0	64	38	0	.615661	.781286	1.2799416	.788011	0	52
27	10	.440984	.491339	2.0352565	.897515	50			10	.617951	.785981	1.2722957	.786217	50	
	20	.443593	.494955	2.0203862	.896229	40			20	.620235	.790698	1.2647062	.784416	40	
	30	.446197	.498582	2.0056897	.894934	30			30	.622515	.795436	1.2571723	.782608	30	
	40	.448799	.502219	1.9911637	.893633	20			40	.624789	.800196	1.2496933	.780794	20	
	50	.451397	.505867	1.9768050	.892323	10			50	.627057	.804980	1.2422685	.778973	10	
28	0	.453990	.509525	1.9626105	.891007	0	63	39	0	.629320	.809784	1.2348972	.777146	0	51
	10	.456580	.513195	1.9485772	.889682	50			10	.631578	.814612	1.2275786	.775312	50	
	20	.459166	.516876	1.9347020	.888350	40			20	.633831	.819463	1.2203121	.773472	40	
	30	.461749	.520567	1.9209821	.887011	30			30	.636078	.824336	1.2130970	.771625	30	
	40	.464327	.524270	1.9074147	.885664	20			40	.638320	.829234	1.2059327	.769771	20	
29	50	.466901	.527984	1.8939971	.884309	10			50	.640557	.834155	1.1988184	.767911	10	
	0	.469472	.531709	1.8807265	.882948	0	62	40	0	.642788	.839100	1.1917536	.766044	0	50
	10	.472038	.535547	1.8676003	.881578	50			10	.645013	.844069	1.1847376	.764171	50	
	20	.474600	.539195	1.8546159	.880201	40			20	.647233	.849062	1.1777698	.762292	40	
	30	.477149	.542956	1.8417709	.878817	30			30	.649448	.854081	1.1708496	.760406	30	
30	40	.479713	.546728	1.8290628	.877425	20			40	.651657	.859124	1.1639763	.758514	20	
	50	.482263	.550515	1.8164892	.876026	10			50	.653861	.864193	1.1571495	.756615	10	
	0	.484810	.554309	1.8040478	.874620	0	61	41	0	.656059	.869287	1.1503684	.754710	0	49
	10	.487352	.558118	1.7917362	.873206	50			10	.658252	.874407	1.1436326	.752798	50	
	20	.489890	.561939	1.7795524	.871784	40			20	.660439	.879553	1.1369414	.750880	40	
31	30	.492424	.565773	1.7674940	.870356	30			30	.662620	.884725	1.1302944	.748956	30	
	40	.494953	.569619	1.7555590	.868920	20			40	.664796	.889924	1.1236909	.747025	20	
	50	.497479	.573478	1.7437453	.867476	10			50	.666966	.895151	1.1171305	.745088	10	
	0	.500000	.577350	1.7320508	.866025	0	60	42	0	.669131	.900404	1.1106125	.743145	0	48
	10	.502517	.581235	1.7204736	.864567	50			10	.671289	.905685	1.1041365	.741195	50	
32	20	.505030	.585134	1.7090116	.863102	40			20	.673443	.910994	1.0977020	.739239	40	
	30	.507538	.589045	1.6976631	.861629	30			30	.675590	.916331	1.0913085	.737277	30	
	40	.510043	.592970	1.6864261	.860149	20			40	.677732	.921697	1.0849554	.735309	20	
	50	.512543	.596908	1.6752988	.858662	10			50	.679868	.927021	1.0786423	.733335	10	
	0	.515038	.600861	1.6642795	.857167	0	59	43	0	.681998	.932515	1.0723687	.731354	0	47
33	10	.517529	.604827	1.6533663	.855665	50			10	.684123	.937968	1.0661341	.729367	50	
	20	.520016	.608807	1.6425576	.854156	40			20	.686242	.943451	1.0599381	.727374	40	
	30	.522499	.612801	1.6318517	.852640	30			30	.688355	.948965	1.0537801	.725374	30	
	40	.524977	.616809	1.6212469	.851117	20			40	.690462	.954508	1.0476598	.723369	20	
	50	.527450	.620832	1.6107417	.849586	10			50	.692563	.960083	1.0415767	.721357	10	
34	0	.529919	.624869	1.6003345	.848048	0	58	44	0	.694658	.965689	1.0355303	.719340	0	46
	10	.532384	.628921	1.5900238	.846503	50			10	.696748	.971326	1.0295203	.717316	50	
	20	.534844	.632988	1.5798079	.844951	40			20	.698832	.976996	1.0235461	.715286	40	
	30	.537300	.637079	1.5696856	.843391	30			30	.700909	.982697	1.0176074	.713251	30	
	40	.539751	.641167	1.5596552	.841825	20			40	.702981	.988432	1.0117088	.711209	20	
35	50	.542197	.645280	1.4597155	.840251	10			50	.705047	.994199	1.0058348	.709161	10	
	0	.544639	.649408	1.5398650	.838671	0	57	45	0	.707107	1.000000	1.0000000	.707107	0	45
	10	.547076	.653551	1.5301025	.837083	50				—	—	—	—	50	
	20	.549509	.657710	1.5204261	.835488	40				—	—	—	—	40	
	30	.551937	.661886	1.5108352	.833886	30				—	—	—	—	30	
36	40	.554360	.666077	1.5013282	.832277	20				—	—	—	—	20	
	50	.556769	.670285	1.4919039	.830661	10	56	—		—	—	—	—	10	
°	'	Cosine	Cotan.	Tan.	Sine	°	°	°		Cosine	Cotan.	Tan.	Sine	°	°

NOTE: For functions from 45°-0' to 68° read from bottom of table upward.



## Greek Letters and Standard Abbreciations

The Greek letters are frequently used in mathematical expressions and formulas. The Greek alphabet is given below:

A	$\alpha$	Alpha	H	$\eta$	Eta	N	$\nu$	Nu	T	$\tau$	Tau
B	$\beta$	Beta	$\Theta$	$\vartheta \theta$	Theta	$\Xi$	$\xi$	Xi	$\Upsilon$	$\upsilon$	Upsilon
$\Gamma$	$\gamma$	Gamma	I	$\iota$	Iota	O	$\omicron$	Omicron	$\Phi$	$\phi$	Phi
$\Delta$	$\delta$	Delta	K	$\kappa$	Kappa	$\Pi$	$\pi$	Pi	$\Xi$	$\chi$	Chi
E	$\epsilon$	Epsilon	$\Lambda$	$\lambda$	Lambda	P	$\rho$	Rho	$\Psi$	$\psi$	Psi
Z	$\zeta$	Zeta	M	$\mu$	Mu	$\Sigma$	$\sigma \varsigma$	Sigma	$\Omega$	$\omega$	Omega

## Abbreviations for Scientific and Engineering Terms

Absolute	abs	Decibel	dB
Alternating current	ac	Degree	deg or °
Ampere	amp	Degree Centigrade	°C
Ampere-hour	amp hr	Degree Fahrenheit	°F
Angstrom unit	A	Degree Kelvin	K
Antilogarithm	antilog	Diameter	dia
Arithmetical average	aa	Direct current	dc
Atmosphere	atm	Dozen	doz
Atomic weight	at wt	Dram	dr
Avoirdupois	avdp	Efficiency	eff
Barometer	baro	Electric	elec
Board feet (feet board measure)	fbm	Electromotive force	emf
Boiler pressure	bopress	Elevation	el
Boiling point	bp	Engine	eng
Brinell hardness number	Bhn	Engineer	enr
British thermal unit	Btu or B	Engineering	engr
Bushel	bu	Equation	eq
Calorie	cal	External	ext
Candle	cd	Fluid	fl
Center to center	c to c	Foot	ft
Centimeter	cm	Foot-candle	fc
Centimeter-gram-second (system)	cgs	Foot-Lambert	fL or fl
Chemical	chem	Foot per minute	fpm
Chemically pure	cp	Foot per second	fps
Circular	circ	Foot-pound	ft lb
Circular mil	cmil	Foot-pound-second (system)	fps
Coefficient	coef	Free on board	fob
Cologarithm	colog	Freezing point	fp
Concentrate	conc	Frequency	freq
Conductivity	cndct	Fusion point	fnpt
Constant	const	Gallon	gal
Cord	cd	Gallon per minute	gpm
Cosecant	csc	Gallon per second	gps
Cosine	cos	Grain	gr
Cost, insurance, and freight	cif	Gram	g
Cotangent	ctn	Greatest common divisor	gcd
Counter electromotive force	cemf	High pressure	hp
Cubic	cu	Horsepower	hp
Cubic centimeter	cm <sup>3</sup> or cc	Horsepower-hour	hp hr
Cubic foot	ft <sup>3</sup> or cu ft	Hour	h or hr
Cubic feet per second	ft <sup>3</sup> or cfs	Hyperbolic cosine	cosh
Cubic inch	in <sup>3</sup> or cu in	Hyperbolic sine	sinh
Cubic meter	m <sup>3</sup> or cu m	Hyperbolic tangent	tanh
Cubic millimeter	mm <sup>3</sup> or cumm	pound-force foot	lb <sub>f</sub> - ft or lb ft
Cubic yard	yd <sup>3</sup> or cu yd	pound-force inch	lb <sub>f</sub> - in or lb in
Current density	cd	Inch	in
Cylinder	cyl	Inch per second	in/s or ips
Indicated horsepower-hour	iph	Intermediate pressure	ip

## Abbreviations for Scientific and Engineering Terms

Internal	intl	pound-force per square foot	lb <sub>f</sub> ft <sup>2</sup> or psf
Kilovolt-ampere/hour	KVA-h or kVah	pound-force per square inch	lb <sub>f</sub> /in <sup>2</sup> or psi
Kilowatt-hour meter	kwhm	pound per horsepower	lb/hp or php
Latitude	lat	Power factor	pf
Least common multiple	lcm	Quart	qt
Liquid	liq	Reactive volt-ampere meter	rva
Logarithm (common)	log	Revolution per minute	r/min or rpm
Logarithm (natural)	ln	Revolution per second	r/s or rps
Low pressure	lp	Root mean square	rms
Lumen per watt	lm/W or lpw	Round	rnd
Magnetomotive force	mmf	Secant	sec
Mathematics (ical)	math	Second	s or sec
Maximum	max	Sine	sin
Mean effective pressure	mep	Specific gravity	sp gr
Melting point	mp	Specific heat	sp ht
Meter	m	Square	sq
Meter-kilogram-second	mks	Square centimeter	cm <sup>2</sup> or sq cm
Microfarad	μF	Square foot	ft <sup>2</sup> or sq ft
Mile	mi	Square inch	in <sup>2</sup> or sq in
Mile per hour	mi/h or mph	Square kilometer	km <sup>2</sup> or sq km
Milliamper	m/A	Square root of mean square	rms
Minimum	min	Standard	std
Molecular weight	mol wt	Tangent	tan
Molecule	mo	Temperature	temp
National Electrical Code	NEC	Tensile strength	ts
Ounce	oz	Versed sine	vers
Ounce-inch	oz in	Volt	V
Pennyweight	dwt	Watt	W
Pint	pt	Watt-hour	Wh
Potential	pot	Week	wk
Potential difference	pd	Weight	wt
Pound	lb	Yard	yd
Inch-pound	in lb		

## Alternative Abbreciations

Alternative abbreviations conforming to the practice of the International Electrotechnical Commission.

Ampere	A	Kilovolt-ampere	kVA	Microwatt	μW	Volt	V
Ampere-hour	Ah	Kilowatt	kW	Milliamper	μA	Volt-ampere	VA
Coulomb	C	Kilowatthour	kWh	Millifarad	mF	Volt-coulomb	VC
Farad	F	Megawatt	MW	Millihenry	mH	Watt	W
Henry	H	Megohm	MΩ	Millivolt	mV	Watt-hour	Wh
Joule	J	Microampere	μA	Ohm	Ω	Volt	VA
Kilovolt	kV	Microfarad	mF	Milliamper	mA		

Only the most commonly used terms have been included. These forms are recommended for those whose familiarity with the terms used makes possible a maximum of abbreviations. For others, less contracted combinations made up from this list may be used. For example, the list gives the abbreviation of the term "feet per second" as "fps." To some, however, ft per sec will be more easily understood.

Abbreviations should be used sparingly and only where their meaning will be clear. If there is any doubt, then spell out the term or unit of measurement.

Given	Multiply By	To Find
ABAMPERE	10	AMPERE
ACRES	0,4046856	HECTARE
ACRES	43560	SQUARE FEET
ACRES	4046,8564	SQUARE METERS
ACRES	1,562x10 <sup>-3</sup>	SQUARE MILES
ARE	1076,391	SQUARE FEET
ATMOSPHERES	76	CMS. OF MERCURY
ATMOSPHERES	33,89854	FEET OF WATER
ATMOSPHERES	29,92	INCHES OF MERCURY
ATMOSPHERES	14,69595	POUNDS/SQUARE INCH
BAGS – CEMENT	94	POUNDS – CEMENT
BARRELS – OIL	5,614583	CUBIC FOOT
BARRELS – OIL	158,9873	LITER
BARRELS – OIL	42	GALLONS – OIL
BARRELS (US DRY)	3,281219	BUSHEL (US)
BARRELS (US DRY)	4,083333	CUBIC FEET
BARRELS (US DRY)	115,6271	LITER
BARRELS (US LIQ.)	4,2109375	CUBIC FEET
BARRELS (US LIQ.)	0,1192405	CUBIC METERS
BARRELS (US LIQ.)	26,22925	GALLONS (BRIT.)
BARRELS (US LIQ.)	31,5	GALLONS (US)
BARRELS – CEMENT	376	POUNDS – CEMENT
BTU	251,996	CALORIE
BTU	778,169	FOOT – POUNDS – FORCE
BTU	3,9302x10 <sup>-4</sup>	HORSEPOWER – HOURS
BTU	0,252	KILOGRAM – CALORIES
BTU	107,586	KILOGRAM – METERS
BTU	2,9307x10 <sup>-4</sup>	KILOWATT – HOURS
BTU	1055,056	JOULE
BTU/MIN.	12,96	FOOT – POUNDS/SEC.
BTU/MIN.	0,0235809	HORSEPOWER
BTU/MIN.	0,0175843	KILOWATTS
BTU/MIN.	17,5796	WATTS
BUSHEL (BRIT.)	1,032057	BUSHEL (US)
BUSHEL (BRIT.)	8	GALLONS (BRIT.)
BUSHEL (US)	0,3047647	BARREL (US DRY)
BUSHEL (US)	1,244456	CUBIC FEET
BUSHEL (US)	9,309177	GALLONS (US LIQ.)
CALORIE	4,1868	JOULE
CALORIE	3,96832x10 <sup>-3</sup>	BTU
CALORIE	3,08803	FOOT – POUND – FORCE
CENTARES (CENTIARES)	1	SQUARE METERS
CENTIMETERS	0,3937008	INCHES
CENTIMETERS	,3937008	INCH
CENTIMETERS	0,01	METERS
CENTIMETERS	10	MILLIMETERS
CENTIMTRS. OF MERCURY	0,01316	ATMOSPHERES
CENTIMTRS. OF MERCURY	0,4461	FEET OF WATER
CENTIMTRS. OF MERCURY	136	KGS./SQUARE METER
CENTIMTRS. OF MERCURY	27,85	POUNDS/SQUARE FT.
CENTIMTRS. OF MERCURY	0,1934	POUNDS/SQUARE INCH
CENTIPOISE	0,001	PASCAL – SECOND
CHAIN (RAMSDEN'S)	100	FEET
CHAIN (GUNTER'S)	66	FEET
CORD	128	CUBIC FEET
CORD	3,624	STERE
COULOMB	1	AMPERE – SECOND
CUBIC CENTIMETER	0,06102	CUBIC INCHES
CUBIC CENTIMETER	0,001	LITER
CUBIC CENTIMETER	1	MILLILETER
CUBIC DECIMETER	0,0353	CUBIC FEET
CUBIC FEET	12	BOARD FEET
CUBIC FEET	0,803564	BUSHEL (US)
CUBIC FEET	1728	CUBIC INCHES
CUBIC FEET	0,0283168	CUBIC METERS
CUBIC FEET	28,317	CUBIC DECIMETERS
CUBIC FEET	0,037037	CUBIC YARD
CUBIC FEET	6,228835	GALLONS (BRIT.)
CUBIC FEET	7,480519	GALLONS (US)
CUBIC FEET	28,316847	LITERS
CUBIC FEET	25,71405	QUARTS (US DRY)
CUBIC FEET/HOUR	7,865791	CUBIC CM./SEC.
CUBIC FEET/HOUR	0,4719474	LITER/MIN.
CUBIC FEET/MIN.	0,1246753	GALLONS (US)/SEC.
CUBIC FEET/POUND	0,0624279	CUBIC METER/KILOGRAM
CUBIC METER	8,64849	BARREL (US DRY)

Given	Multiply By	To Find
CUBIC METER	8,386414	BARREL (US LIQ.)
CUBIC METER	35,31467	CUBIC FEET
CUBIC METER	1,307951	CUBIC YARDS
CUBIC METER	264,1721	GALLONS (US)
CUBIC METER	1000	LITER
CUBIC YARDS	27	CUBIC FEET
CUBIC YARDS	0,7645548	CUBIC METER
CUBIC YARDS	201,974	GALLONS (US)
CUBIC YARDS/MIN.	0,45	CUBIC FEET/SEC.
CUBIC YARDS/MIN.	3,366234	GALLONS (US)/SEC.
CUBIT	18	INCH
CUP	236,588	MILLILITER
CUP (METRIC)	200	MILLILITER
DEGREE	0,017453	RADIAN
DEGREE/SEC.	0,166667	REVOLUTION/MIN.
DENIER	0,11111(1/9)	TEX
DRACHM (BRIT. FLUID)	0,9607599	GRAM (U.S. FLUID)
DRAM (APOTH)	60	GRAINS
DRAM (AVOIR)	27,34375	GRAINS
DRAM (U.S. FLUID)	0,2255859	CUBIC INCHES
ELL	45	INCH
ERG	1x10 <sup>-7</sup>	JOULE
FATHOM	6	FEET
FEET OF WATER	0,0295	ATMOSPHERES
FEET OF WATER	0,8826	INCHES OF MERCURY
FEET OF WATER	304,8	KGS./SQUARE METER
FEET OF WATER	62,43	POUNDS/SQUARE FT.
FEET OF WATER	0,4335	POUNDS/SQUARE INCH
FEET/MIN.	0,508	CENTIMETERS/SEC.
FEET/MIN.	0,01667	FEET/SEC.
FEET/MIN.	0,01829	KILOMETERS/HOUR
FEET/MIN.	0,3048	METERS/MIN
FEET/MIN.	0,01136	MILES/HOUR
FEET/SEC.	30,48	CENTIMETERS/SEC.
FEET/SEC.	1,097	KILOMETERS/HOUR
FEET/SEC.	0,5921	KNOTS
FEET/SEC.	18,29	METERS/MIN.
FEET/SEC.	0,6818	MILES/HOUR
FEET/SEC.	0,01136	MILES/MIN.
FERKIN (US)	9	GALLONS (US) DRY
FOOT	30,48	CENTIMETER
FOOT	12	INCH
FOOT/MINUTE	0,3048	METER
FOOT/MINUTE	0,018288	KILOMETER/HOUR
FOOT/SECOND	0,01136364	MILE/HOUR
FOOT/SECOND	0,3048	METER/SECOND
FOOT – POUNDS – FORCE	0,6818182	MILE/HOUR
FOOT – POUNDS – FORCE	5,050x10 <sup>-7</sup>	HORSEPOWER – HOURS
FOOT – POUNDS – FORCE	1,35582	JOULES
FOOT – POUNDS – FORCE	3,241x10 <sup>-4</sup>	KILOGRAM – CALORIES
FOOT – POUNDS – FORCE	0,1383	KILOGRAM – METERS
FOOT – POUNDS – FORCE	,766x10 <sup>-5</sup>	KILOWATT – HOURS
FOOT – POUNDS – FORCE	1,286x10 <sup>-3</sup>	BTU
FOOT – POUNDS/MIN.	1,286x10 <sup>-3</sup>	BTU/MIN.
FOOT – POUNDS/MIN.	0,01667	FOOT – POUNDS/SEC.
FOOT – POUNDS/MIN.	3,030x10 <sup>-4</sup>	HORSEPOWER
FOOT – POUNDS/MIN.	3,241x10 <sup>-4</sup>	KG. – CALORIES/MIN.
FOOT – POUNDS/MIN.	2,260x10 <sup>-5</sup>	KILOWATTS
FOOT – POUNDS/SEC.	7,717x10 <sup>-2</sup>	BTU/MIN.
FOOT – POUNDS/SEC.	1,818x10 <sup>-3</sup>	HORSEPOWER
FOOT – POUNDS/SEC.	1,945x10 <sup>-2</sup>	KG. – CALORIES/MIN.
FOOT – POUNDS/SEC.	1,355818	WATTS
FURLONG	660	FEET
FURLONG	10	CHAIN
GALLON (BRIT.)	9,632619	CUBIC FT./HOUR
GALLON (BRIT.)	0,2727654	CUBIC METER/HOUR
GALLONS (US)/MIN.	8,020834	CUBIC FEET/HOUR
GALLONS (US)/MIN.	0,2271247	CUBIC METER/HOUR
GALLON (DRY)	268,8025	CUBIC INCH
GALLONS (LIQ.)	3785,412	CUBIC CENTIMETERS
GALLONS (LIQ.)	0,1336805	CUBIC FEET
GALLONS (LIQ.)	231	CUBIC INCHES
GALLONS (LIQ.)	3,785x10 <sup>-3</sup>	CUBIC METERS
GALLONS (LIQ.)	4,951x10 <sup>-3</sup>	CUBIC YARDS
GALLONS (LIQ.)	0,8326742	GALLONS (BRIT.)
GALLONS (LIQ.)	3,785412	LITERS

# Conversion Tables

Given	Multiply By	To Find
GALLONS (LIQ.)	8	PINTS (LIQ.)
GALLONS (LIQ.)	4	QUARTS (LIQ.)
GALLONS WATER	8,3453	POUNDS OF WATER
GALLONS WATER/MIN.	6,0086	TONS WATER/24 HOURS
GALLONS – IMPERIAL	1,20095	U.S. GALLONS
GALLONS – U.S.	0,83267	IMPERIAL GALLONS
GALLONS (US)/MIN.	$2,228 \times 10^{-3}$	CUBIC FEET/SEC.
GALLONS (US)/MIN.	8,020834	CUBIC FEET/HOUR
GALLONS (US)/MIN.	0,06308	Litros/SEC.
GILL	7,21875	CUBIC INCH
GILL	4	OUNCE (U.S.)
GILL (BRIT.)	1,20095	GILL (U.S.)
GRAINS (TROY)	0,0648	GRAMS
GRAINS/U.S. GAL.	17,118	PARTS/MILLION
GRAINS/U.S. GAL.	142,86	POUNDS/MILLION GAL.
GRAINS/U.S. GAL.	14,254	PARTS/MILLION
GRAMS	980,7	DYNES
GRAMS	15,432358	GRAINS
GRAMS	$10^{-3}$	KILOGRAMS
GRAMS	$10^3$	MILLIGRAMS
GRAMS	0,0352739	OUNCES
GRAMS	0,03215	OUNCES (TROY)
GRAMS	$2,205 \times 10^{-3}$	POUNDS
GRAMS	0,7716179	SCRUPLE
GRAMS (TROY)	$2,0833 \times 10^{-3}$	OUNCES (TROY)
GRAMS/CM.	$5,600 \times 10^{-3}$	POUNDS/INCH
GRAMS/CU. CM.	62,43	POUNDS/CUBIC FOOT
GRAMS/CU. CM.	0,03613	POUNDS/CUBIC INCH
GRAMS/LITER	58,417	GRAINS/GAL.
GRAMS/LITER	8,345	POUNDS/1000 GALS.
GRAMS/LITER	0,062427	POUNDS/CUBIC FOOT
GRAMS/LITER	1000	PARTS/MILLION
GROSS	12	DOZEN
HAND	4	INCH
HECTARE	2,471054	ACRE
HECTARE	107639,1	SQUARE FT.
HOGSHEAD	63	GALLONS
HORSEPOWER	42,4072	BTU/MIN.
HORSEPOWER	33000	FOOT – POUNDS/MIN.
HORSEPOWER	550	FOOT – POUNDS/SEC.
HORSEPOWER	1,014	HORSEPOWER (METRIC)
HORSEPOWER	10,7	KG. – CALORIES/MIN.
HORSEPOWER	0,7457	KILOWATTS
HORSEPOWER	745,7	WATTS
HORSEPOWER (BOILER)	33479	BTU/HOUR
HORSEPOWER (BOILER)	9,8095	KILOWATT
HORSEPOWER – HOURS	2547	BTU
HORSEPOWER – HOURS	$1,98 \times 10^6$	FOOT – POUNDS
HORSEPOWER – HOURS	641,7	KILOGRAM – CALORIES
HORSEPOWER – HOURS	$2,737 \times 10^5$	KILOGRAM – METERS
HORSEPOWER – HOURS	0,7457	KILOWATT – HOURS
INCH	1000	MILS
INCH	25,4	MILLIMETERS
INCHES OF MERCURY	0,03342	ATMOSPHERES
INCHES OF MERCURY	1,133	FEET OF WATER
INCHES OF MERCURY	345,3	KGS./SQUARE METER
INCHES OF MERCURY	70,73	LBS./SQUARE FT.
INCHES OF MERCURY	0,4912	LBS./SQUARE INCH
INCHES OF WATER	0,002458	ATMOSPHERES
INCHES OF WATER	0,07355	INCHES OF MERCURY
INCHES OF WATER	25,4	KGS./SQUARE METER
INCHES OF WATER	0,5781	OUNCES/SQUARE INCH
INCHES OF WATER	5,202	POUNDS/SQUARE FOOT
INCHES OF WATER	0,03613	POUNDS/SQUARE INCH
JOULE	0,000948	BTU
JOULE	0,238846	CALORIE
KILOGRAMS	980665	DYNES
KILOGRAMS	2,2046226	POUNDS
KILOGRAMS	$1,102 \times 10^{-3}$	TONS (SHORT)
KILOGRAMS	$10^3$	GRAMS
KILOGRAMS – CALORIES	3,968	BTU
KILOGRAMS – CALORIES	3086	FOOT – POUNDS
KILOGRAMS – CALORIES	$1,558 \times 10^{-3}$	HORSEPOWER – HOURS
KILOGRAMS – CALORIES	$1,162 \times 10^{-3}$	KILOWATT – HOURS
KILOMETERS	$10^3$	CENTIMETERS
KILOMETERS	3280,84	FEET

Given	Multiply By	To Find
KILOMETERS	$10^3$	METERS
KILOMETERS	0,6213712	MILES
KILOMETROS	1094	YARDS
KILOMETERS/HOUR	27,78	CENTIMETERS/SEC.
KILOMETERS/HOUR	54,68	FEET/MIN.
KILOMETERS/HOUR	0,9113	FEET/SEC.
KILOMETERS/HOUR	0,5396	KNOTS
KILOMETERS/HOUR	16,67	METERS/MIN.
KILOMETROS/HOUR	0,6214	MILES/HOUR
KILOWATT – HOURS	3415	BTU
KILOWATT – HOURS	2,655x106	FOOT – POUNDS
KILOWATT – HOURS	1,341	HORSEPOWER – HOURS
KILOWATT – HOURS	$3,6 \times 10^6$	JOULE
KILOWATT – HOURS	860,5	KILOGRAM – CALORIES
KILOWATT – HOURS	$3,671 \times 10^6$	KILOGRAM – METERS
KILOWATTS	56,869	BTU/MIN.
KILOWATTS	44253,7	FOOT – POUNDS/MIN.
KILOWATTS	737,6	FOOT – POUNDS/SEC.
KILOWATTS	1,34102	HORSEPOWER
KILOWATTS	14,3308	KG. – CALORIES/MIN.
KILOWATTS	$10^{-3}$	WATTS
KNOTS	1,150779	MILES (STATUTE)/HOUR
LEAGUE (STATUTE)	3	MILES (STATUTE)
LIGHT YEAR	$5,8785 \times 10^{12}$	MILES
LINK	0,01	CHAIN
LINK	7,92	INCHES
LITERS	$10^3$	CUBIC CENTIMETERS
LITERS	0,03531	CUBIC FEET
LITERS	61,02	CUBIC INCHES
LITERS	$10^{-3}$	CUBIC METERS
LITERS	$1,308 \times 10^{-3}$	CUBIC YARDS
LITERS	0,2642	GALLONS
LITERS	2,113	PINTS (LIQ.)
LITERS	0,908	QUARTS (DRY)
LITERS	1,0567	QUARTS (LIQ.)
LITERS/MIN.	$5,886 \times 10^{-4}$	CUBIC FT./SEC.
LITERS/MIN.	13,19815	GALLON (BRIT.)/HOUR
LITERS/MIN.	$4,403 \times 10^{-3}$	GALLONS/SEC.
LITERS/SEC.	2,11888	CUBIC FT./MIN.
METERS	100	CENTIMETERS
METERS	3,2808399	FEET
METERS	39,37	INCHES
METERS	$10^{-3}$	KILOMETROS
METERS	$10^3$	MILLIMETERS
METERS	1,093613	YARDS
METERS/MIN.	1,667	CENTIMETERS/SEC.
METERS/MIN.	3,281	FEET/MIN.
METERS/MIN.	0,05468	FEET/SEC.
METERS/MIN.	0,06	KILOMETROS/HOUR
METERS/MIN.	0,03728	MILES/HOUR
METERS/SEC.	196,8	FEET/MIN.
METERS/SEC.	3,281	FEET/SEC.
METERS/SEC.	3,6	KILOMETER/HOUR
METERS/SEC.	0,06	KILOMETROS/MIN.
METERS/SEC.	2,236936	MILES/HOUR
METERS/SEC.	0,03728	MILES/MIN.
MIL	0,001	INCH
MIL	0,0254	MILLIMETER
MILES	320	ROD
MILES	$1,609 \times 10^6$	CENTIMETERS
MILES	5280	FEET
MILES	1,609	KILOMETROS
MILES	1760	YARDS
MILES/HOUR	44,7	CENTIMETERS/SEC.
MILES/HOUR	88	FEET/MIN.
MILES/HOUR	1,467	FEET/SEC.
MILES/HOUR	1,609	KILOMETROS/HOUR
MILES/HOUR	0,8684	KNOTS
MILES/HOUR	26,82	Metros/MIN.
MILES/HOUR	1,609344	KILOMETROS/HOUR
MILES/HOUR	0,8689762	KNOTS
MILES/MIN.	2682	CENTIMETERS/SEC.
MILES/MIN.	88	FEET/SEC.
MILES/MIN.	1,609	KILOMETROS/MIN.
MILES/MIN.	60	MILES/HOUR
MILLIGRAMS	$10^{-3}$	GRAMS

Given	Multiply By	To Find
MILLIGRAMS/LITER	1	PARTS/MILLION
MILLILITERS	0,0610237	CUBIC INCH
MILLILITERS	0,0338142	FLUID OUNCES
MILLILITERS	10 <sup>-3</sup>	LITERS
MILLIMETERS	0,1	CENTIMETERS
MILLIMETERS	0,03937	INCHES
MILLION GALS./DAY	1,54723	CUBIC FT./SEC.
MINER'S INCHES	1,5	CUBIC FT./MIN.
MINUTES (ANGLE)	2,909x10 <sup>-4</sup>	RADIANS
NEWTON – METER	0,737562	FOOT – POUNDS – FORCE
OUNCES	16	DRAMS
OUNCES	437,5	GRAINS
OUNCES	0,0625	POUNDS
OUNCES	28,349527	GRAMS
OUNCES	0,9115	OUNCES (TROY)
OUNCES	2,790x10 <sup>-5</sup>	TONS (LONG)
OUNCES	2,835x10 <sup>-5</sup>	TONS (METRIC)
OUNCES (FLUID)	1,805	CUBIC INCHES
OUNCES (FLUID)	0,02957	LITERS
OUNCES (FLUID)	30	MILLILITERS
OUNCES (FLUID)	1,040843	OUNCES (BRIT. FLUID)
OUNCES (TROY)	480	GRAINS
OUNCES (TROY)	20	PENNYWEIGHTS (TROY)
OUNCES (TROY)	0,08333	POUNDS (TROY)
OUNCES (TROY)	31,103481	GRAMS
OUNCES (TROY)	1,09714	OUNCES (AVOIR.)
OUNCES/SQUARE INCH	0,0625	POUNDS/SQUARE INCH
PACE	2,5	FEET
PALM	3	INCH
PARTS/MILLION	0,0584	GRAINS/U.S. GAL.
PARTS/MILLION	0,07016	GRAINS/IMP. GAL.
PARTS/MILLION	8,345	POUNDS/MILLION GAL.
PASCAL	0,0208854	POUNDS – FORCE/SQ. FT.
PECK (BRIT.)	2	GALLON (BRIT.)
PECKS (US)	8	QUARTS (US DRY)
PENNYWEIGHTS (TROY)	24	GRAINS
PENNYWEIGHTS (TROY)	1,55517	GRAMS
PENNYWEIGHTS (TROY)	0,05	OUNCES (TROY)
PENNYWEIGHTS (TROY)	4,1667x10 <sup>-3</sup>	POUNDS (TROY)
PERCH (MASONRY)	24,75	CUBIC FEET
POINT (U.S.-PRINT)	0,013837	INCH
POLE (BRIT.)	16,5	FEET
POTTLE (BRIT.)	,5	GALLONS
POUNDS	16	OUNCES
POUNDS	256	DRAMS
POUNDS	7000	GRAINS
POUNDS	0,0005	TONS (SHORT)
POUNDS	453,5924	GRAMS
POUNDS	1,21528	POUNDS (TROY)
POUNDS	14,5833	OUNCES (TROY)
POUNDS OF WATER	0,01602	CUBIC FEET
POUNDS OF WATER	27,68	CUBIC INCHES
POUNDS OF WATER	0,1198	GALLONS
POUNDS OF WATER/MIN.	2,670x10 <sup>-4</sup>	CUBIC FT./SEC.
POUNDS (TROY)	5760	GRAINS
POUNDS (TROY)	140	PENNYWEIGHTS (TROY)
POUNDS (TROY)	12	OUNCES (TROY)
POUNDS (TROY)	373,24177	GRAMS
POUNDS (TROY)	0,822857	POUNDS (AVOIR.)
POUNDS (TROY)	13,1657	OUNCES (AVOIR.)
POUNDS (TROY)	3,6735x10 <sup>-4</sup>	TONS (LONG)
POUNDS (TROY)	4,1143x10 <sup>-4</sup>	TONS (SHORT)
POUNDS (TROY)	4,1667x10 <sup>-3</sup>	TONS (METRIC)
POUNDS/CUBIC FOOT	0,01602	GRAMS/CUBIC CM.
POUNDS/CUBIC FOOT	16,02	KGS./CUBIC METERS
POUNDS/CUBIC FOOT	5,787x10 <sup>-4</sup>	POUNDS/CUBIC INCH
POUNDS/CUBIC INCH	27,68	GRAMS/CUBIC CM.
POUNDS/CUBIC INCH	2,768x10 <sup>4</sup>	KGS./CUBIC METER
POUNDS/CUBIC INCH	1728	POUNDS/CUBIC FOOT
POUNDS/FOOT	1,488	KGS./METER
POUNDS/INCH	178,6	GRAMS/CM.
POUNDS/SQUARE FOOT	0,01602	FEET OF WATER
POUNDS/SQUARE FOOT	4,883	KGS./SQUARE METER
POUNDS/SQUARE FOOT	6,945x10 <sup>-3</sup>	POUNDS/SQUARE INCH
POUNDS/SQUARE INCH	0,068046	ATMOSPHERES
POUNDS/SQUARE INCH	2,307	FEET OF WATER

Given	Multiply By	To Find
POUNDS/SQUARE INCH	2,03602	INCHES OF MERCURY
POUNDS/SQUARE INCH	703,1	KGS./SQUARE METER
PSI	1	POUND – FORCE/SQ. IN.
PUNCHEON	84	GALLONS
PUNCHEON (BRIT.)	70	GALLON (BRIT.)
QUARTS (DRY)	0,03125	BUSHEL
QUARTS (DRY)	67,200625	CUBIC INCHES
QUARTS (DRY)	1,101	LITERS
QUARTS (LIQ)	57,75	CUBIC INCHES
QUARTS (LIQ)	0,9463	LITER
QUARTS (LIQ)	0,8326742	QUART (BRIT.)
QUARTS (LIQ)	0,859367	QUART (DRY)
QUINTAL, ARGENTINE	101,28	POUNDS
QUINTAL, BRAZIL	129,54	POUNDS
QUINTAL, CASTILE, PERU	101,43	POUNDS
QUINTAL, CHILE	101,41	POUNDS
QUINTAL, METRIC	220,46	POUNDS
QUINTAL, MEXICO	101,47	POUNDS
RADIANS	57,29578	DEGREES
RADIANS	3437,747	MINUTES
RADIANS	0,63662	QUADRANTS
RADIANS/SEC.	57,3	DEGREES/SEC.
RADIANS/SEC.	0,1592	REVOLUTIONS/SEC.
RADIANS/SEC.	9,549297	REVOLUTIONS/MIN.
REAMS	500	SHEETS
REVOLUTIONS	360	DEGREES
REVOLUTIONS	4	QUADRANTS
REVOLUTIONS	6,283	RADIANS
REVOLUTIONS/MIN.	6	DEGREES/SEC.
REVOLUTIONS/MIN.	0,1047	RADIANS/SEC.
REVOLUTIONS/MIN.	0,01667	REVOLUTIONS/SEC.
REVOLUTIONS/SEC.	360	DEGREES/SEC.
REVOLUTIONS/SEC.	6,283	RADIANS/SEC.
REVOLUTIONS/SEC.	60	REVOLUTIONS/MIN.
RODS	16,5	FEET
ROPE	20	FEET
SCRUPLE	20	GRAINS
SEAM (BRIT.)	64	GALLON (BRIT.)
SLUG	14,5939	KILOGRAMS
SPAN	9	INCHES
SQUARE CM.	10 <sup>-4</sup>	SQUARE METERS
SQUARE CM.	100	SQUARE MILLIMETERS
SQUARE FEET	2,296x10 <sup>-5</sup>	ACRES
SQUARE FEET	929	SQUARE CENTIMETERS
SQUARE FEET	144	SQUARE INCHES
SQUARE FEET	0,0929	SQUARE METERS
SQUARE FEET	3,587x10 <sup>-3</sup>	SQUARE MILES
SQUARE FEET	1 <sup>1</sup> / <sub>49</sub>	SQUARE YARDS
SQUARE INCHES	6,452	SQUARE CENTIMETERS
SQUARE INCHES	6,944x10 <sup>-3</sup>	SQUARE FEET
SQUARE INCHES	645,2	SQUARE MILLIMETERS
SQUARE KILOMETERS	247,1	ACRES
SQUARE KILOMETERS	10,76x10 <sup>6</sup>	SQUARE FEET
SQUARE KILOMETER	10 <sup>6</sup>	SQUARE METERS
SQUARE KILOMETERS	0,3861	SQUARE MILES
SQUARE KILOMETERS	1,196x10 <sup>6</sup>	SQUARE YARDS
SQUARE METERS	2,471x10 <sup>-4</sup>	ACRES
SQUARE METERS	10,76	SQUARE FEET
SQUARE METERS	3,861x10 <sup>-7</sup>	SQUARE MILES
SQUARE METERS	1,196	SQUARE YARDS
SQUARE MILES	640	ACRES
SQUARE MILES	27,88x10 <sup>6</sup>	SQUARE FEET
SQUARE MILES	2,59	SQUARE KILOMETERS
SQUARE MILES	3,098x10 <sup>6</sup>	SQUARE YARDS
SQUARE MILLIMETERS	0,01	SQUARE CENTIMETERS
SQUARE MILLIMETERS	1,550x10 <sup>-3</sup>	SQUARE INCHES
SQUARE YARDS	2,066x10 <sup>-4</sup>	ACRES
SQUARE YARDS	9	SQUARE FEET
SQUARE YARDS	0,8361	SQUARE METERS
SQUARE YARDS	3,228x10 <sup>-7</sup>	SQUARE MILES
STERE	1	CUBIC METER
STERE	0,2759	CORD
STONE	14	POUNDS
TABLESPOON	14,79	MILLILITERS
TEASPOON	5	MILLILITERS
TEMP.(oC.)+17.78	1,8	TEMP.(oF.)

# Conversion Tables



Given	Multiply By	To Find
TEMP.(oF)-32	5/9	TEMP.(oC.)
THERM	100,000	BTU
TONS OF WATER/24 HRS.	83,333	POUNDS WATER/HOUR
TONS OF WATER/24 HRS.	0,16643	GALLONS/MIN.
TONS OF WATER/24 HRS.	1,3349	CUBIC FT./HOUR
TONS (LONG)	1016,0469	KILOGRAMS
TONS (LONG)	1,016047	TONS (METRIC)
TONS (LONG)	2240	POUNDS
TONS (LONG)	1,12	TONS (SHORT)
TONS (METRIC)	10 <sup>3</sup>	KILOGRAMS
TONS (METRIC)	2205	POUNDS
TONS (SHORT)	2000	POUNDS
TONS (SHORT)	32000	OUNCES
TONS (SHORT)	907,18486	KILOGRAMS
TONS (SHORT)	2430,56	POUNDS (TROY)
TONS (SHORT)	0,89287	TONS (LONG)
TONS (SHORT)	29166	OUNCES (TROY)
TONS (SHORT)	0,90718	TONS (METRIC)

Given	Multiply By	To Find
WATT – HOUR	3600	JOULE
WATTS	0,05692	BTU/MIN.
WATTS	44,26	FOOT – POUNDS/MIN.
WATTS	0,7376	FOOT – POUNDS/SEC.
WATTS	1,341x10 <sup>-3</sup>	HORSEPOWER
WATTS	0,01434	KG. – CALORIES/MIN.
WATTS	10 <sup>-3</sup>	KILOWATTS
WATTS – HOURS	3,41214	BTU
WATTS – HOURS	2655	FOOT – POUNDS – FORCE
WATTS – HOURS	1,341x10 <sup>-3</sup>	HORSEPOWER – HOURS
WATTS – HOURS	3600	JOULES
WATTS – HOURS	0,8605	KILOGRAM – CALORIES
WATTS – HOURS	367,1	KILOGRAM – Metros
WATTS – HOURS	10 <sup>-3</sup>	KILOWATT – HOURS
YARDS	91,44	CENTIMETERS
YARDS	36	INCHES
YARDS	0,9144	Metros

## Rules and Formulas For Spur Gear Calculations

Diametral Pitch  
Diametral Pitch is the Number of Teeth to Each Inch of the Pitch Diameter.

To Find	Having	Rule	Formula
The Diametrical Pitch	The Circular Pitch	Divide 3,1416 by the Circular Pitch	$DP = \frac{3.1416}{CP}$
The Diametrical Pitch	The Pitch Diameter and the Number of Teeth	Divide the Number of Teeth by Pitch Diameter	$DP = \frac{N}{D'}$
The Diametrical Pitch	The Outside Diameter and Number of Teeth	Divide the Number of Teeth plus 2 by Outside Diameter	$DP = \frac{N+2}{D}$
Pitch Diameter	The Number of Teeth and the Diametral Pitch	Divide Number of Teeth by the Diametral Pitch	$D' = \frac{N}{P}$
Pitch Diameter	The Number of Teeth and Outside Diameter	Divide the product of Outside Diameter and Number of Teeth by Number of Teeth plus 2	$D' = \frac{DN}{N+2}$
Pitch Diameter	The Outside Diameter and the Diametral Pitch	Subtract from the Outside Diameter the Quotient of 2 Divided by the Diametral Pitch	$D' = D - \frac{2}{P}$
Pitch Diameter	Addendum and the Number of Teeth	Multiply Addendum by the Number of Teeth	$D' = sN$
Outside Diameter	The Number of Teeth and the Diametral Pitch	Divide number of Teeth plus 2 by the Diametral Pitch	$D = \frac{N+2}{P}$
Outside Diameter	The Pitch Diameter and the Diametral Pitch	Add to the Pitch Diameter the quotient of 2 divided by the Diametral Pitch	$D = D' + \frac{2}{P}$
Outside Diameter	The Pitch Diameter and the Number of Teeth	Divide the Number of Teeth plus 2 by the quotient of Number of Teeth divided by Pitch Diameter	$D = \frac{N+2}{N \div D'}$
Outside Diameter	The Number of Teeth and Addendum	Multiply the Number of Teeth plus 2 by Addendum	$D = (N+2)s$
Number of Teeth	The Pitch Diameter and the Diametral Pitch	Multiply the Pitch Diameter by the Diametral Pitch	$N = D'P$
Number of Teeth	The Outside Diameter and the Diametral Pitch	Multiply Outside Diameter by the Diametral Pitch and subtract 2	$N = DP - 2$
Thickness of Tooth	The Diametral Pitch	Divide 1,5708 by the Diametral Pitch	$t = \frac{1.5708}{P}$
Addendum	The Diametral Pitch	Divide 1 by the Diametral Pitch or $A = \frac{D'}{N}$	$A = \frac{1}{P}$
Dedendum	The Diametral Pitch	Divide 1,157 by the Diametral Pitch	$A+L = \frac{1.157}{P}$
Working Depth	The Diametral Pitch	Divide 2 by the Diametral Pitch	$WD = \frac{2}{P}$
Whole Depth	The Diametral Pitch	Divide 2,157 by the Diametral Pitch	$D'' = \frac{2.157}{P}$
Clearance	The Diametral Pitch	Divide ,157 by the Diametral Pitch	$L = \frac{.157}{P}$
Clearance	Thickness of Tooth	Divide Thickness of Tooth at Pitch Line by 10	$L = \frac{t}{10}$

NOTE: Rules and Formulas Relating to Tooth Depth and Outside Diameter Apply to Full-Depth, Equal Addendum Gears.

# Diametral Pitch Tooth Dimensions

## Dimensions of Standard Full-depth Teeth

### Diametral Pitches and Equivalent Circular Pitches

Diametral Pitch	Circular Pitch	Module	Arc Thickness of Tooth on Pitch Line (mm)	Addendum (mm)	Working Depth of Tooth (mm)	Dedendum or Depth of Space Below Pitch Line (mm)	Whole Depth of Tooth* (mm)
1/2	6,2832	50,8000	79,79664	50,8000	101,6000	58,7807	109,5807
3/4	4,1888	33,8667	53,19776	33,8658	67,7316	39,1871	73,0529
1	3,1416	25,4000	39,89832	25,4000	50,8000	29,3903	54,7903
1 1/4	2,5133	20,3200	31,91764	20,3200	40,6400	23,5128	43,8328
1 1/2	2,0944	16,9333	26,59888	16,9316	33,8658	19,5936	36,5277
1 3/4	1,7952	14,5143	22,79904	14,5136	29,0297	16,7945	31,3080
2	1,5708	12,7000	19,94916	12,7000	25,4000	14,6939	27,3939
2 1/4	1,3963	11,2889	17,73174	11,2878	22,5755	13,0632	24,3510
2 1/2	1,2566	10,1600	15,95882	10,1600	20,3200	11,7551	21,9151
2 3/4	1,1424	9,2364	14,50848	9,2354	18,4734	10,6883	19,9238
3	1,0472	8,4667	13,29944	8,4658	16,9316	9,7968	18,2626
3 1/2	0,8976	7,2571	11,39952	7,2568	14,5136	8,3972	15,6540
4	0,7854	6,3500	9,97458	6,3500	12,7000	7,3482	13,6982
5	0,6283	5,0800	7,98068	5,0800	10,1600	5,8776	10,9576
6	0,5236	4,2333	6,64972	4,2316	8,4658	4,8971	9,1313
7	0,4488	3,6286	5,69976	3,6297	7,2568	4,1986	7,8257
8	0,3927	3,1750	4,98602	3,1750	6,3500	3,6728	6,8478
9	0,3491	2,8222	4,4323	2,8219	5,6439	3,2664	6,0884
10	0,3142	2,5400	3,99034	2,5400	5,0800	2,9388	5,4788
11	0,2856	2,3091	3,62712	2,3089	4,6177	2,6721	4,9809
12	0,2618	2,1167	3,32486	2,1158	4,2316	2,4486	4,5669
13	0,2417	1,9538	3,06832	1,9533	3,9065	2,2606	4,2139
14	0,2244	1,8143	2,84988	1,8136	3,6297	2,0980	3,9141
15	0,2094	1,6933	2,65938	1,6916	3,3858	1,9583	3,6525
16	0,1963	1,5875	2,49428	1,5875	3,1750	1,8364	3,4239
17	0,1848	1,4941	2,34696	1,4935	2,9870	1,7297	3,2233
18	0,1745	1,4111	2,21742	1,4097	2,8219	1,6332	3,0429
19	0,1653	1,3368	2,10058	1,3360	2,6746	1,5469	2,8829
20	0,1571	1,2700	1,9939	1,2700	2,5400	1,4707	2,7407
22	0,1428	1,1545	1,81356	1,1557	2,3089	1,3360	2,4892
24	0,1309	1,0583	1,66116	1,0592	2,1158	1,2243	2,2809
26	0,1208	0,9769	1,53416	0,9779	1,9533	1,1303	2,1057
28	0,1122	0,9071	1,42494	0,9068	1,8136	1,0490	1,9558
30	0,1047	0,8467	1,33096	0,8458	1,6916	0,9804	1,8263
32	0,0982	0,7938	1,24714	0,7925	1,5875	0,9195	1,7120
34	0,0924	0,7471	1,17348	0,7468	1,4935	0,8636	1,6104
36	0,0873	0,7056	1,10744	0,7061	1,4097	0,8153	1,5215
38	0,0827	0,6684	1,04902	0,6680	1,3360	0,7722	1,4427
40	0,0785	0,6350	0,99822	0,6350	1,2700	0,7341	1,3691

\*NOTE: Dimensions listed are for HOB CUT TEETH ONLY. Shaper cut teeth may be slightly larger. Consult factory for exact measurement.

All Gears In Stock U.S.A. Are Diametral Pitch



## Rules and Formulas For Spur Gear Calculations

### Circular Pitch

Circular Pitch is the Distance from the Center of One Tooth to the Center of the Next Tooth, Measured Along the Pitch Circle.

To Find	Having	Rule	Formula
The Circular Pitch	The Diametral Pitch	Divide 3,1416 by the Diametral Pitch	$C' = \frac{3,1416}{DP}$
The Circular Pitch	The Pitch Diameter and the Number of Teeth	Divide Pitch Diameter by the product of ,3183 and Number of Teeth	$C' = \frac{PD}{,3183N}$
The Circular Pitch	The Outside Diameter and the Number of Teeth	Divide Outside Diameter by the product of ,3183 and Number of Teeth plus 2	$C' = \frac{OD}{,3183N + 2}$
Pitch Diameter	The Number of Teeth and the Circular Pitch	The continued product of the Number of Teeth, the Circular Pitch and ,3183	$D' = NC' ,3183$
Pitch Diameter	The Number of Teeth and the Outside Diameter	Divide the product of Number of Teeth and Outside Diameter by Number of Teeth plus 2	$D = \frac{N \times OD}{N + 2}$
Pitch Diameter	The Outside Diameter and the Circular Pitch	Subtract from the Outside Diameter the product of the Circular Pitch and ,6366	$D' = OD - (C' ,6366)$
Pitch Diameter	Addendum and the Number of Teeth	Multiply the Number of Teeth by the Addendum	$D' = NA$
Outside Diameter	The Number of Teeth and the Circular Pitch	The continued product of the Number of Teeth plus 2, the Circular Pitch and ,3183	$D = (N + 2) C' ,3183$
Outside Diameter	The Pitch Diameter and the Circular Pitch	Add to the Pitch Diameter the product of the Circular Pitch and ,6366	$D = PD + (C' ,6366)$
Outside Diameter	The Number of Teeth and the Addendum	Multiply Addendum by Number of Teeth plus 2	$D = A (N + 2)$
Number of Teeth	The Pitch Diameter and the Circular Pitch	Divide the product of Pitch Diameter and 3,1416 by the Circular Pitch	$N = \frac{PD 3,1416}{C'}$
Thickness of Tooth	The Circular Pitch	One-half the Circular Pitch	$t = \frac{C'}{2}$
Addendum	The Circular Pitch	Multiply the Circular Pitch by ,3183 or $s = \frac{D'}{N}$	$A = C' ,3183$
Dedendum	The Circular Pitch	Multiply the Circular Pitch by ,3683	$A + L = C' ,3683$
Working Depth	The Circular Pitch	Multiply the Circular Pitch by ,6366	$WD = C' ,6366$
Whole Depth	The Circular Pitch	Multiply the Circular Pitch by ,6866	$D'' = C' ,6866$
Clearance	The Circular Pitch	Multiply the Circular Pitch by ,05	$L = C' ,05$
Clearance	Thickness of Tooth	One-Tenth the Thickness of Tooth at Pitch Line	$L = \frac{t}{10}$

NOTE: Rules and Formulas Relating to Tooth Depth and Outside Diameter Apply to Full-Depth, Equal Addendum Gears.

Circular Pitch Gears Made To Order Only

# Circular Pitch Tooth Dimensions



## Dimensions of Standard Full-depth Teeth

### Circular Pitches and Equivalent Diametral Pitches

Diametral Pitch	Circular Pitch	Module	Arc Thickness of Tooth on Pitch Line (mm)	Addendum (mm)	Working Depth of Tooth (mm)	Dedendum or Depth of Space Below Pitch Line (mm)	Whole Depth of Tooth* (mm)
4	0,7854	32,3402	50,8000	32,3393	64,6786	37,4193	69,7586
3 $\frac{1}{2}$	0,8976	28,2581	44,4500	28,2956	56,5937	32,7406	61,0387
3	1,0472	24,2552	38,1000	24,2545	48,5089	28,0645	52,3189
2 $\frac{3}{4}$	1,1424	22,2339	34,9250	22,2326	44,4652	25,7251	47,9577
2 $\frac{1}{2}$	1,2566	20,2117	31,7500	20,2108	40,4241	23,3858	43,5991
2 $\frac{1}{4}$	1,3963	18,1913	28,5750	18,1915	36,3804	21,0490	39,2379
2	1,5708	16,1701	25,4000	16,1696	32,3393	18,7096	34,8793
1 $\frac{7}{8}$	1,6755	15,1595	23,8125	15,1587	30,3200	17,5412	32,7000
1 $\frac{3}{4}$	1,7952	14,1488	22,2250	14,1478	28,2981	16,3703	30,5206
1 $\frac{5}{8}$	1,9333	13,1382	20,6375	13,1394	26,2763	15,2019	28,3413
1 $\frac{1}{2}$	2,0944	12,1276	19,0500	12,1285	24,2545	14,0335	26,1595
1 $\frac{7}{16}$	2,1855	11,6223	18,2550	11,6230	23,2435	13,4468	25,0698
1 $\frac{3}{8}$	2,2848	11,1169	17,4625	11,1176	22,2352	12,8626	23,9801
1 $\frac{5}{16}$	2,3936	10,6116	16,6675	10,6121	21,2242	12,2784	22,8905
1 $\frac{1}{4}$	2,5133	10,1062	15,8750	10,1067	20,2133	11,6942	21,8008
1 $\frac{3}{16}$	2,6456	9,6010	15,0800	9,6012	19,2024	11,1100	20,7112
1 $\frac{1}{8}$	2,7925	9,0958	14,2875	9,0957	18,1915	10,5232	19,6190
1 $\frac{1}{16}$	2,9568	8,5904	13,4925	8,5903	17,1806	9,9390	18,5293
1	3,1416	8,0851	12,7000	8,0848	16,1696	9,3548	17,4396
$\frac{15}{16}$	3,3510	7,5798	11,9050	7,5794	15,1587	8,7706	16,3500
$\frac{7}{8}$	3,5904	7,0744	11,1125	7,0739	14,1478	8,1864	15,2578
$\frac{13}{16}$	3,8666	6,5692	10,3175	6,5684	13,1394	7,6022	14,1707
$\frac{3}{4}$	4,1888	6,0639	9,5250	6,0630	12,1285	7,0155	13,0810
$\frac{11}{16}$	4,5696	5,5586	8,7300	5,5601	11,1176	6,4313	11,9888
$\frac{2}{3}$	4,7124	5,3903	8,4658	5,3899	10,7798	6,2357	11,6256
$\frac{5}{8}$	5,0265	5,0532	7,9375	5,0521	10,1067	5,8445	10,8991
$\frac{9}{16}$	5,5851	4,5479	7,1425	4,5466	9,0957	5,2603	9,8095
$\frac{1}{2}$	6,2832	4,0426	6,3500	4,0437	8,0848	4,6787	8,7198
$\frac{7}{16}$	7,1808	3,5373	5,5550	3,5382	7,0739	4,0919	7,6276
$\frac{2}{5}$	7,8540	3,2340	5,0800	3,2334	6,4668	3,7414	6,9748
$\frac{3}{8}$	8,3776	3,0319	4,7625	3,0328	6,0630	3,5077	6,5405
$\frac{1}{3}$	9,4248	2,6947	4,2316	2,6949	5,3899	3,1191	5,8141
$\frac{5}{16}$	10,0531	2,5266	3,9675	2,5273	5,0521	2,9235	5,4508
$\frac{2}{7}$	10,9956	2,3100	3,6297	2,3089	4,6203	2,6721	4,9835
$\frac{1}{4}$	12,5664	2,0213	3,1750	2,0218	4,0411	2,3393	4,3586
$\frac{2}{9}$	14,1372	1,7967	2,8219	1,7958	3,5941	2,0777	3,8760
$\frac{1}{5}$	15,7080	1,6170	2,5400	1,6180	3,2334	1,8720	3,4874
$\frac{3}{16}$	16,7552	1,5160	2,3800	1,5164	3,0328	1,7526	3,2690
$\frac{1}{6}$	18,8496	0,5053	2,1158	1,3487	2,6949	1,5596	2,9058

\*NOTE: Dimensions listed are for HOB CUT TEETH ONLY. Shaper cut teeth may be slightly larger. Consult factory for exact measurement.

All Gears In Stock Are Diametral Pitch

## Rules and Formulas For Module (Metric) Spur Gear Calculations

(Module Represents the Amount of Pitch Diameter per Tooth)

To Find	Having	Rule	Formula
Metric Module	Pitch Diameter and Number of Teeth	Divide Pitch Diameter in Millimeters by the Number of Teeth	$M = \frac{PD \text{ (Millimeters)}}{N}$
Metric Module	Circular Pitch in Millimeter	Divide Circular Pitch in Millimeters by Pi (3,1416)	$M = \frac{C \text{ (Millimeters)}}{3,1416}$
Metric Module	Diametral Pitch	Divide 25,4 by Diametral Pitch	$M = \frac{25,4}{DP}$
Metric Module	Outside Diameter and Number of Teeth	Divide Outside Diameter (in Millimeters) by the Number of Teeth plus 2	$M = \frac{OD}{N + 2}$
Pitch Diameter	Module and Number of Teeth	Multiply Module by Number of Teeth	$D' \text{ (In MM)} = M \times N$
Pitch Diameter	Number of Teeth and Outside Diameter	Divide the product of Outside Diameter and No. of Teeth by No. of Teeth plus 2	$D' = \frac{OD \times N}{N + 2}$
Pitch Diameter	Outside Diameter and the Module	Multiply Module by 2 and Subtract from Outside Diameter	$D' = OD - 2M$
Outside Diameter	Module and Number of Teeth	Number of Teeth plus 2 Multiplied by Module	$OD \text{ (In MM)} = (N + 2) \times M$
Diametral Pitch	Module	Divide 25,4 by Module	$DP = \frac{25,4}{M}$
Circular Pitch	Module	Multiply Module by Pi (3,1416)	$C' \text{ (In MM)} = M \times 3,1416$
Addendum	Module Known	The Addendum equals the Module	$A = M$
Whole Depth	Module Known	Multiply 2,157 by Module	$D'' \text{ (In MM)} = 2,157 \times M$
Thickness of Tooth	Module and Outside Diameter	Multiply Pitch Diameter (in Millimeters) by the Sine of the Angle of 90 Divided by the Number of Teeth	$t \text{ (In MM)} = PD \text{ (MM)} \times \text{Sine } \frac{90}{N}$
English Module	Pitch Diameter in Inches and Number of Teeth	Divide Pitch Diameter in Inches by Number of Teeth	$M = \frac{PD \text{ (Inches)}}{N}$

NOTE: Rules and Formulas Relating to Tooth Depth and Outside Diameter Apply to Full-Depth, Equal Addendum Gears.

# Module Pitch Tooth Dimensions



## Tooth Dimensions Based Upon Module System

(One millimeter equals 0.03937 inch)

Module DIN Standard Series	Equivalent Diametral Pitch	Circular Pitch		Addendum, Millimeters	Dedendum Millimeters †	Whole Depth, † Millimeters	Whole Depth, ‡ Millimeters
		Millimeters	Inches				
0,3	84,667	0,943	0,0371	0,30	0,35	0,650	0,647
0,4	63,500	1,257	0,0495	0,40	0,467	0,867	0,863
0,5	50,800	1,571	0,0618	0,50	0,583	1,083	1,079
0,6	42,333	1,885	0,0742	0,60	0,700	1,300	1,294
0,7	36,286	2,199	0,0865	0,70	0,817	1,517	1,510
0,8	31,750	2,513	0,0989	0,80	0,933	1,733	1,726
0,9	28,222	2,827	0,1113	0,90	1,050	1,950	1,941
1	25,400	3,142	0,1237	1,00	1,167	2,167	2,157
1,25	20,320	3,927	0,1546	1,25	1,458	2,708	2,697
1,5	16,933	4,712	0,1855	1,50	1,750	3,250	3,236
1,75	14,514	5,498	0,2164	1,75	2,042	3,792	3,774
2	12,700	6,283	0,2474	2,00	2,333	4,333	4,314
2,25	11,289	7,069	0,2783	2,25	2,625	4,875	4,853
2,5	10,160	7,854	0,3092	2,50	2,917	5,417	5,392
2,75	9,236	8,639	0,3401	2,75	3,208	5,958	5,932
3	8,466	9,425	0,3711	3,00	3,500	6,500	6,471
3,25	7,815	10,210	0,4020	3,25	3,791	7,041	7,010
3,5	7,257	10,996	0,4329	3,50	4,083	7,583	7,550
3,75	6,773	11,781	0,4638	3,75	4,375	8,125	8,089
4	6,350	12,566	0,4947	4,00	4,666	8,666	8,628
4,5	5,644	14,137	0,5566	4,50	5,25	9,750	9,707
5	5,080	15,708	0,6184	5,00	5,833	10,833	10,785
5,5	4,618	17,279	0,6803	5,50	6,416	11,916	11,864
6	4,233	18,850	0,7421	6,00	7,000	13,000	12,942
6,5	3,908	20,420	0,8035	6,50	7,583	14,083	14,021
7	3,628	21,991	0,8658	7,00	8,166	15,166	15,099
8	3,175	25,132	0,9895	8,00	9,333	17,333	17,256
9	2,822	28,274	1,1132	9,00	10,499	19,499	19,413
10	2,540	31,416	1,2368	10,00	11,666	21,666	21,571
11	2,309	34,558	1,3606	11,00	12,833	23,833	23,728
12	2,117	37,699	1,4843	12,00	14,000	26,000	25,884
13	1,954	40,841	1,6079	13,00	15,166	28,166	28,041
14	1,814	43,982	1,7317	14,00	16,332	30,332	30,198
15	1,693	47,124	1,8541	15,00	17,499	32,499	32,355
16	1,587	50,266	1,9790	16,00	18,666	34,666	34,512
18	1,411	56,549	2,2263	18,00	21,000	39,000	38,826
20	1,270	62,832	2,4737	20,00	23,332	43,332	43,142
22	1,155	69,115	2,7210	22,00	25,665	47,665	47,454
24	1,058	75,398	2,9685	24,00	28,000	52,000	51,768
27	0,941	84,823	3,339	27,00	31,498	58,498	58,239
30	0,847	94,248	3,711	30,00	35,000	65,000	64,713
33	0,770	103,673	4,082	33,00	38,498	71,498	71,181
36	0,706	113,097	4,453	36,00	41,998	77,998	77,652
39	0,651	122,522	4,824	39,00	45,497	84,497	84,123
42	0,605	131,947	5,195	42,00	48,997	90,997	90,594
45	0,564	141,372	5,566	45,00	52,497	97,497	97,065
50	0,508	157,080	6,184	50,00	58,330	108,330	107,855
55	0,462	172,788	6,803	55,00	64,163	119,163	118,635
60	0,423	188,496	7,421	60,00	69,996	129,996	129,426
65	0,391	204,204	8,040	65,00	75,829	140,829	140,205
70	0,363	219,911	8,658	70,00	81,662	151,662	150,997
75	0,339	235,619	9,276	75,00	87,495	162,495	161,775

† Dedendum and total depth when clearance = 0.1666 x module, or one-sixth module.

‡ Total Depth equivalent to American standard full-depth teeth. (Clearance = 0.157 x Module.)



# Bevel & Miter Gear Formulas

To Find	Rule	Formula
Pitch Diameter	Divide Number of Teeth by Diametral Pitch	$\text{Pitch Diameter} = \frac{\text{Number of Teeth}}{\text{Diametral Pitch}}$
Tangent of Pitch Angle Of Driven	Divide Number of Teeth in Driven by Number of Teeth in Driver	$\text{Tangent Pitch Angle of Driven} = \frac{\text{Number of Teeth in Driven}}{\text{Number of Teeth in Driver}} = \text{Ratio}$
Pitch Angle of Driver	Subtract Pitch Angle of Driven from 90 Degrees	$\text{Pitch Angle Of Driver} = 90 \text{ Degrees} - \text{Pitch Angle of Driven}$
Pitch Cone Radius	Divide Pitch Diameter by Twice the Sine of the Pitch Angle	$\text{Pitch Cone Radius} = \frac{\text{Pitch Diameter}}{2 \times \text{Sine Pitch Angle}}$
Tangent of Addendum Angle	Divide Addendum by the Pitch Cone Radius	$\text{Tangent of Addendum Angle} = \frac{\text{Addendum}}{\text{Pitch Cone Radius}}$
Face Angle	Add Addendum Angle to Pitch Angle	$\text{Face Angle} = \text{Addendum Angle} + \text{Pitch Angle}$
Tangent of Dedendum Angle	Divide Dedendum by the Pitch Cone Radius	$\text{Tangent of Dedendum Angle} = \frac{\text{Dedendum}}{\text{Pitch Cone Radius}}$
Root Angle	Subtract Dedendum Angle from Pitch Angle	$\text{Root Angle} = \text{Pitch Angle} - \text{Dedendum Angle}$
Angular Addendum	Multiply Addendum by Cosine of Pitch Angle	$\text{Angular Addendum} = \text{Addendum} \times \text{Cosine Pitch Angle}$
Outside Diameter	Add 2 Angular Addenda to Pitch Diameter	$\text{Outside Diameter} = 2 \text{ Angular Addenda} \times \text{Pitch Diameter}$
Mounting Distance	Add one-half the Pitch Diameter of Mating to Pitch Line	$\text{Mounting Distance} = \frac{\text{Pitch Diameter of Mate}}{2} + \text{Backing to Pitch Line}$
Distance From Cone Center to Crown	Multiply one-half Outside Diameter by Co-tangent of Face Angle	$\text{Cone Center to Crown} = \frac{\text{Outside Diameter}}{2} \times \text{Co-Tangent Face Angle}$
Backing to Crown	Subtract Cone Center to Crown from Mounting Distance	$\text{Backing to Crown} = \text{Mounting Distance} - \text{Cone Center to Crown}$
Ratio	Divide Teeth in Driven by Teeth in Driver	$\text{Ratio} = \frac{\text{Number of Teeth in Driven}}{\text{Number of Teeth in Driver}}$

# Formula for Worm Gears



(Based On Diametral Pitch)

To Find	Rule	Formula
Worm Gear Pitch Diameter	Divide Number of Teeth by Diametral Pitch	$\text{Pitch Diameter} = \frac{\text{Number of Teeth in Worm Gear}}{\text{Diametral Pitch}}$
Worm Gear Throat Diameter	Add 2 Addenda to Pitch Diameter	$\text{Throat Diameter} = (2 \times \text{Addendum}) + \text{Pitch Diameter}$
Worm Gear Outside Diameter	Add 3 Addenda to Pitch Diameter	$\text{Outside Diameter} = (3 \times \text{Addendum}) + \text{Pitch Diameter}$
Worm Pitch Diameter	Subtract the Worm Gear Pitch Diameter from Twice the Center Distance	$\text{Worm Pitch Diameter} = (2 \times \text{Center Distance}) - \text{Worm Gear Pitch Diameter}$
Worm Outside Diameter	Add 2 Addenda to Worm Pitch Diameter	$\text{Worm Outside Diameter} = \text{Worm Pitch Diameter} + 2 \times \text{Addendum}$
Worm Lead	Divide 3.1416 by Diametral Pitch and Multiply by Number of Threads in Worm	$\text{Worm Lead} = \frac{3.1416}{\text{Diametral Pitch}} \times \text{Number of Threads in Worm}$
Co-Tangent of Worm Helix Angle	Multiply Worm Pitch Diameter by Diametral Pitch and Divide by Number of Worm Threads	$\text{Co-Tangent Worm Helix Angle} = \frac{\text{Worm Pitch Diameter} \times \text{Diametral Pitch}}{\text{Number Worm Threads}}$
Center Distance	Add Worm Pitch Diameter to Worm Gear Pitch Diameter and Divide Sum by 2	$\text{Center Distance} = \frac{\text{Worm Pitch Diameter} + \text{Worm Gear Pitch Diameter}}{2}$
Ratio	Divide Number of Teeth in Worm Gear by Number of Worm Threads	$\text{Ratio} = \frac{\text{Number of Teeth in Worm Gear}}{\text{Number of Worm Threads}}$

NOTE: Tooth data (Addendum, Full Depth, Etc.) is same as for Spur Gears.

# Warning & Safety Reminder

The Martin logo is displayed in a stylized, white, cursive font on a black rectangular background.

## WARNING & SAFETY REMINDER

Safety must be considered a basic factor in machinery operation at all times. Most accidents are the result of carelessness or negligence. All rotating power transmission products are potentially dangerous and must be guarded by the contractor, installer, purchaser, owner, and user as required by applicable laws, regulations, standards, and good safety practice. Additional specific information must be obtained from your local authorities; other sources may include the latest editions of American Society of Mechanical Engineers at 345 East 47th Street, New York, NY 10017 (+1-212-705-7722)

It is the responsibility of the contractor, installer, purchaser, owner, and user to install, maintain, and operate the parts or components manufactured or supplied by *Martin* Sprocket & Gear, Inc., in such a manner as to comply with the requirements of your local laws, ordinances, regulations, authorities, and safety acts which are similar in spirit and intention of the Williams-Steiger Occupational Safety Act in the USA as well as the American National Standard Institute Safety Code.

## CAUTION

Guards, access doors, and covers must be securely fastened before operating any equipment.

If parts are to be inspected, cleaned, observed, or general maintenance performed, the following precautions must be taken.

1. Isolate the power source from the equipment.
2. Disconnect or reconnect any equipment only if the construction is fully visible and understood.
3. Wear eye protection.
4. Wear appropriate protective clothing, hats, gloves and safety shoes as warranted by the circumstances.
5. Check that all tools are used in good working condition only.
6. Loosen tensioning devices carefully.
7. Avoid sudden and unexpected movement of parts of the equipment and/or components.
8. Do not reuse individual components.
9. Do not reuse a damaged or faulty part.

Failure to follow these measures may result in personal injury or property damage.

## WARNING

### NOTE: CATALOG DIMENSIONS

Every effort is made to keep all catalog dimensions and styles current in the catalog. However, from time to time it is necessary because of manufacturing changes to alter stock products dimensionally.

If any stock product dimension or style shown in this catalog is critical to your application please consult factory for verification.