Standards and other Regulations

Standardization and Standards terms

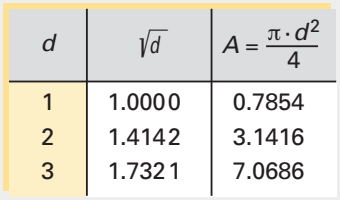
Standardization is the systematic achievement of uniformity of material and non-material objects, such as components, calculation methods, process flows and services for the benefit of the general public.

Standards term	Example	Explanation
Standard	DIN 7157	A standard is the published result of standardization, e.g. the selection of certain fits in DIN 7157.
Part	DIN 30910-2	The part of a standard associated with other parts with the same main number. DIN 30910-2 for example describes sintered materials for filters, while Part 3 and 4 describe sintered materials for bearings and formed parts.
Supplement	DIN 743 Suppl. 1	A supplement contains information for a standard, however no additional specifications. The supplement DIN 743 Suppl. 1, for example, contains application examples of load capacity calculations for shafts and axles described in DIN 743.
Draft	E DIN 6316 (2007-02)	A draft standard contains the preliminary finished results of a standardization; this version of the intended standard is made available to the public for comments. For example, the planned new version of DIN 6316 for goose-neck clamps has been available to the public since February 2007 as Draft E DIN 6316.
Preliminary standard	DIN V 66304 (1991-12)	A preliminary standard contains the results of standardization which are not released by DIN as a standard, because of certain provisos. DIN V 66304, for example, discusses a format for exchange of standard part data for computer-aided design.
Issue date	DIN 76-1 (2004-06)	Date of publication which is made public in the DIN publication guide; this is the date at which time the standard becomes valid. DIN 76-1, which sets undercuts for metric ISO threads has been valid since June 2004 for example.

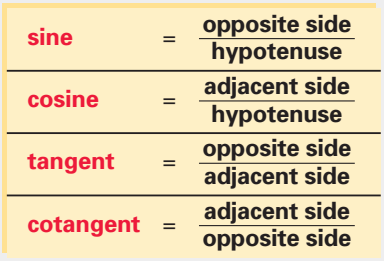
Types of Standards and Regulations (selection)

Type	Abbreviation	Explanation	Purpose and contents
International Standards (ISO standards)	ISO	**I**nternational **O**rganization for **S**tandardization, Geneva (O and S are reversed in the abbreviation)	Simplifies the international exchange of goods and services, as well as cooperation in scientific, technical and economic areas.
European Standards (EN standards)	EN	**E**uropean Committee for Standardization (Comité Européen de **N**ormalisation), Brussels	Technical harmonization and the associated reduction of trade barriers for the advancement of the European market and the coalescence of Europe.
German Standards (DIN standards)	DIN	**D**eutsches **I**nstitut für **N**ormung e.V., Berlin (German Institute for Standardization)	National standardization facilitates rationalization, quality assurance, environmental protection and common understanding in economics, technology, science, management and public relations.
	DIN EN	European standard for which the German version has attained the status of a German standard.	
	DIN ISO	German standard for which an international standard has been adopted without change.	
	DIN EN ISO	European standard for which an international standard has been adopted unchanged and the German version has the status of a German standard.	
	DIN VDE	Printed publication of the VDE, which has the status of a German standard.	
VDI Guidelines	VDI	**V**erein **D**eutscher **I**ngenieure e.V., Düsseldorf (Society of German Engineers)	These guidelines give an account of the current state of the art in specific subject areas and contain, for example, concrete procedural guidelines for the performing calculations or designing processes in mechanical or electrical engineering.
VDE printed publications	VDE	**V**erband **D**eutscher **E**lektrotechniker e.V., Frankfurt (Organization of German Electrical Engineers)	
DGQ publications	DGQ	**D**eutsche **G**esellschaft für **Q**ualität e.V., Frankfurt (German Association for Quality)	Recommendations in the area of quality technology.
REFA sheets	REFA	Association for Work Design/Work Structure, Industrial Organization and Corporate Development REFA e.V., Darmstadt	Recommendations in the area of production and work planning.

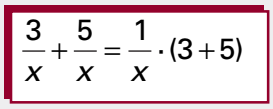
1 Mathematics



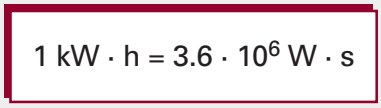
d	$\sqrt{d}$	$A = \frac{\pi \cdot d^2}{4}$
1	1.0000	0.7854
2	1.4142	3.1416
3	1.7321	7.0686



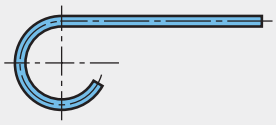
sine	=	opposite side / hypotenuse
cosine	=	adjacent side / hypotenuse
tangent	=	opposite side / adjacent side
cotangent	=	adjacent side / opposite side

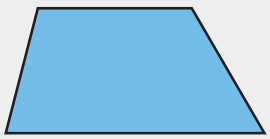


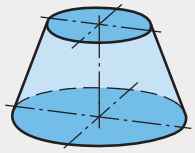
$$\frac{3}{x}+\frac{5}{x}=\frac{1}{x}\cdot(3+5)$$

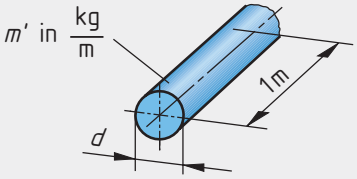


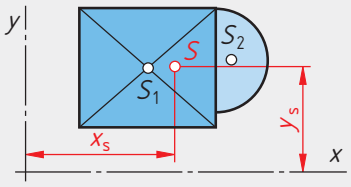
$$1\ \text{kW} \cdot \text{h} = 3.6 \cdot 10^6\ \text{W} \cdot \text{s}$$











M

Square root, Area of a circle

d	$\sqrt{d}$	$A = \frac{\pi \cdot d^2}{4}$	d	$\sqrt{d}$	$A = \frac{\pi \cdot d^2}{4}$	d	$\sqrt{d}$	$A = \frac{\pi \cdot d^2}{4}$	d	$\sqrt{d}$	$A = \frac{\pi \cdot d^2}{4}$
1	1.0000	0.7854	51	7.1414	2042.82	101	10.049 9	8011.85	151	12.2882	17907.9
2	1.4142	3.1416	52	7.2111	2123.72	102	10.0995	8171.28	152	12.3288	18145.8
3	1.7321	7.0686	53	7.2801	2206.18	103	10.1489	8332.29	153	12.3693	18385.4
4	2.0000	12.5664	54	7.3485	2290.22	104	10.1980	8494.87	154	12.4097	18626.5
5	2.236 1	19.6350	55	7.4162	2375.83	105	10.2470	8659.01	155	12.4499	18869.2
6	2.4495	28.2743	56	7.4833	2463.01	106	10.2956	8824.73	156	12.4900	19113.4
7	2.6458	38.4845	57	7.5498	2551.76	107	10.3441	8992.02	157	12.5300	19359.3
8	2.8284	50.2655	58	7.6158	2642.08	108	10.3923	9160.88	158	12.5698	19606.7
9	3.0000	63.6173	59	7.6811	2733.97	109	10.4403	9331.32	159	12.6095	19855.7
10	3.1623	78.5398	**60**	7.7460	2827.43	**110**	10.4881	9503.32	**160**	12.6491	20106.2
11	3.3166	95.0332	61	7.8102	2922.47	111	10.5357	9676.89	161	12.6886	20358.3
12	3.4641	113.097	62	7.8740	3019.07	112	10.5830	9852.03	162	12.7279	20612.0
13	3.6056	132.732	63	7.9373	3117.25	113	10.6301	10028.7	163	12.7671	20867.2
14	3.7417	153.938	64	8.0000	3216.99	114	10.6771	10207.0	164	12.8062	21124.1
15	3.8730	176.715	65	8.0623	3318.31	115	10.7238	10386.9	165	12.8452	21382.5
16	4.0000	201.062	66	8.1240	3421.19	116	10.7703	10568.3	166	12.8841	21642.4
17	4.1231	226.980	67	8.1854	3525.65	117	10.8167	10751.3	167	12.9228	21904.0
18	4.2426	254.469	68	8.2462	3631.68	118	10.8628	10935.9	168	12.9615	22167.1
19	4.3589	283.529	69	8.3066	3739.28	119	10.9087	11122.0	169	13.0000	22431.8
20	4.4721	314.159	**70**	8.3666	3848.45	**120**	10.9545	11309.7	**170**	13.0384	22698.0
21	4.5826	346.361	71	8.4261	3959.19	121	11.0000	11499.0	171	13.0767	22965.8
22	4.6904	380.133	72	8.4853	4071.50	122	11.0454	11689.9	172	13.1149	23235.2
23	4.7958	415.476	73	8.5440	4185.39	123	11.0905	11882.3	173	13.1529	23506.2
24	4.8990	452.389	74	8.6023	4300.84	124	11.1355	12076.3	174	13.1909	23778.7
25	5.0000	490.874	75	8.6603	4417.86	125	11.1803	12271.8	175	13.2288	24052.8
26	5.0990	530.929	76	8.7178	4536.46	126	11.2250	12469.0	176	13.2665	24328.5
27	5.1962	572.555	77	8.7750	4656.63	127	11.2694	12667.7	177	13.3041	24605.7
28	5.2915	615.752	78	8.8318	4778.36	128	11.3137	12868.0	178	13.3417	24884.6
29	5.3852	660.520	79	8.8882	4901.67	129	11.3578	13069.8	179	13.3791	25164.9
30	5.4772	706.858	**80**	8.9443	5026.55	**130**	11.4018	13273.2	**180**	13.4164	25446.9
31	5.5678	754.768	81	9.0000	5153.00	131	11.4455	13478.2	181	13.4536	25730.4
32	5.6569	804.248	82	9.0554	5281.02	132	11.4891	13684.8	182	13.4907	26015.5
33	5.7446	855.299	83	9.1104	5410.61	133	11.5326	13892.9	183	13.5277	26302.2
34	5.8310	907.920	84	9.1652	5541.77	134	11.5758	14102.6	184	13.5647	26590.4
35	5.9161	962.113	85	9.2195	5674.50	135	11.6190	14313.9	185	13.6015	26880.3
36	6.0000	1017.88	86	9.2736	5808.80	136	11.6619	14526.7	186	13.6382	27171.6
37	6.0828	1075.21	87	9.3274	5944.68	137	11.7047	14741.1	187	13.6748	27464.6
38	6.1644	1134.11	88	9.3808	6082.12	138	11.7473	14957.1	188	13.7113	27759.1
39	6.2450	1194.59	89	9.4340	6221.14	139	11.7898	15174.7	189	13.7477	28055.2
40	6.3246	1256.64	**90**	9.4868	6361.73	**140**	11.8322	15393.8	**190**	13.7840	28352.9
41	6.4031	1320.25	91	9.5394	6503.88	141	11.8743	15614.5	191	13.8203	28652.1
42	6.4807	1385.44	92	9.5917	6647.61	142	11.9164	15836.8	192	13.8564	28952.9
43	6.5574	1452.20	93	9.6437	6792.91	143	11.9583	16060.6	193	13.8924	29255.3
44	6.6332	1520.53	94	9.6954	6939.78	144	12.0000	16286.0	194	13.9284	29559.2
45	6.7082	1590.43	95	9.7468	7088.22	145	12.0416	16513.0	195	13.9642	29864.8
46	6.7823	1661.90	96	9.7980	7238.23	146	12.0830	16741.5	196	14.0000	30171.9
47	6.8557	1734.94	97	9.8489	7389.81	147	12.1244	16971.7	197	14.0357	30480.5
48	6.9282	1809.56	98	9.8995	7542.96	148	12.1655	17203.4	198	14.0712	30790.7
49	7.0000	1885.74	99	9.9499	7697.69	149	12.2066	17436.6	199	14.1067	31102.6
50	7.0711	1963.50	**100**	10.0000	7853.98	**150**	12.2474	17671.5	**200**	14.1421	31415.9

Table values of $\sqrt{d}$ and A are rounded off.

Values of Sine and Cosine Trigonometric Functions

degrees ↓	sine 0° to 45° — minutes → 0′	15′	30′	45′	60′	degrees ↓	sine 45° to 90° — minutes → 0′	15′	30′	45′	60′	degrees ↓
0°	0.0000	0.0044	0.0087	0.0131	0.0175	89°	45°	0.7071	0.7102	0.7133	0.7163	0.7193	44°
1°	0.0175	0.0218	0.0262	0.0305	0.0349	88°	46°	0.7193	0.7224	0.7254	0.7284	0.7314	43°
2°	0.0349	0.0393	0.0436	0.0480	0.0523	87°	47°	0.7314	0.7343	0.7373	0.7402	0.7431	42°
3°	0.0523	0.0567	0.0610	0.0654	0.0698	86°	48°	0.7431	0.7461	0.7490	0.7518	0.7547	41°
4°	0.0698	0.0741	0.0785	0.0828	0.0872	85°	49°	0.7547	0.7576	0.7604	0.7632	0.7660	**40°**
5°	0.0872	0.0915	0.0958	0.1002	0.1045	84°	**50°**	0.7660	0.7688	0.7716	0.7744	0.7771	39°
6°	0.1045	0.1089	0.1132	0.1175	0.1219	83°	51°	0.7771	0.7799	0.7826	0.7853	0.7880	38°
7°	0.1219	0.1262	0.1305	0.1349	0.1392	82°	52°	0.7880	0.7907	0.7934	0.7960	0.7986	37°
8°	0.1392	0.1435	0.1478	0.1521	0.1564	81°	53°	0.7986	0.8013	0.8039	0.8064	0.8090	36°
9°	0.1564	0.1607	0.1650	0.1693	0.1736	**80°**	54°	0.8090	0.8116	0.8141	0.8166	0.8192	35°
10°	0.1736	0.1779	0.1822	0.1865	0.1908	79°	55°	0.8192	0.8216	0.8241	0.8266	0.8290	34°
11°	0.1908	0.1951	0.1994	0.2036	0.2079	78°	56°	0.8290	0.8315	0.8339	0.8363	0.8387	33°
12°	0.2079	0.2122	0.2164	0.2207	0.2250	77°	57°	0.8387	0.8410	0.8434	0.8457	0.8480	32°
13°	0.2250	0.2292	0.2334	0.2377	0.2419	76°	58°	0.8480	0.8504	0.8526	0.8549	0.8572	31°
14°	0.2419	0.2462	0.2504	0.2546	0.2588	75°	59°	0.8572	0.8594	0.8616	0.8638	0.8660	**30°**
15°	0.2588	0.2630	0.2672	0.2714	0.2756	74°	**60°**	0.8660	0.8682	0.8704	0.8725	0.8746	29°
16°	0.2756	0.2798	0.2840	0.2882	0.2924	73°	61°	0.8746	0.8767	0.8788	0.8809	0.8829	28°
17°	0.2924	0.2965	0.3007	0.3049	0.3090	72°	62°	0.8829	0.8850	0.8870	0.8890	0.8910	27°
18°	0.3090	0.3132	0.3173	0.3214	0.3256	71°	63°	0.8910	0.8930	0.8949	0.8969	0.8988	26°
19°	0.3256	0.3297	0.3338	0.3379	0.3420	**70°**	64°	0.8988	0.9007	0.9026	0.9045	0.9063	25°
20°	0.3420	0.3461	0.3502	0.3543	0.3584	69°	65°	0.9063	0.9081	0.9100	0.9118	0.9135	24°
21°	0.3584	0.3624	0.3665	0.3706	0.3746	68°	66°	0.9135	0.9153	0.9171	0.9188	0.9205	23°
22°	0.3746	0.3786	0.3827	0.3867	0.3907	67°	67°	0.9205	0.9222	0.9239	0.9255	0.9272	22°
23°	0.3907	0.3947	0.3987	0.4027	0.4067	66°	68°	0.9272	0.9288	0.9304	0.9320	0.9336	21°
24°	0.4067	0.4107	0.4147	0.4187	0.4226	65°	69°	0.9336	0.9351	0.9367	0.9382	0.9397	**20°**
25°	0.4226	0.4266	0.4305	0.4344	0.4384	64°	**70°**	0.9397	0.9412	0.9426	0.9441	0.9455	19°
26°	0.4384	0.4423	0.4462	0.4501	0.4540	63°	71°	0.9455	0.9469	0.9483	0.9497	0.9511	18°
27°	0.4540	0.4579	0.4617	0.4656	0.4695	62°	72°	0.9511	0.9524	0.9537	0.9550	0.9563	17°
28°	0.4695	0.4733	0.4772	0.4810	0.4848	61°	73°	0.9563	0.9576	0.9588	0.9600	0.9613	16°
29°	0.4848	0.4886	0.4924	0.4962	0.5000	**60°**	74°	0.9613	0.9625	0.9636	0.9648	0.9659	15°
30°	0.5000	0.5038	0.5075	0.5113	0.5150	59°	75°	0.9659	0.9670	0.9681	0.9692	0.9703	14°
31°	0.5150	0.5188	0.5225	0.5262	0.5299	58°	76°	0.9703	0.9713	0.9724	0.9734	0.9744	13°
32°	0.5299	0.5336	0.5373	0.5410	0.5446	57°	77°	0.9744	0.9753	0.9763	0.9772	0.9781	12°
33°	0.5446	0.5483	0.5519	0.5556	0.5592	56°	78°	0.9781	0.9790	0.9799	0.9808	0.9816	11°
34°	0.5592	0.5628	0.5664	0.5700	0.5736	55°	79°	0.9816	0.9825	0.9833	0.9840	0.9848	**10°**
35°	0.5736	0.5771	0.5807	0.5842	0.5878	54°	**80°**	0.9848	0.9856	0.9863	0.9870	0.9877	9°
36°	0.5878	0.5913	0.5948	0.5983	0.6018	53°	81°	0.9877	0.9884	0.9890	0.9897	0.9903	8°
37°	0.6018	0.6053	0.6088	0.6122	0.6157	52°	82°	0.9903	0.9909	0.9914	0.9920	0.9925	7°
38°	0.6157	0.6191	0.6225	0.6259	0.6293	51°	83°	0.9925	0.9931	0.9936	0.9941	0.9945	6°
39°	0.6293	0.6327	0.6361	0.6394	0.6428	**50°**	84°	0.9945	0.9950	0.9954	0.9958	0.9962	5°
40°	0.6428	0.6461	0.6494	0.6528	0.6561	49°	85°	0.9962	0.9966	0.9969	0.9973	0.9976	4°
41°	0.6561	0.6593	0.6626	0.6659	0.6691	48°	86°	0.9976	0.9979	0.9981	0.9984	0.9986	3°
42°	0.6691	0.6724	0.6756	0.6788	0.6820	47°	87°	0.9986	0.9988	0.9990	0.9992	0.9994	2°
43°	0.6820	0.6852	0.6884	0.6915	0.6947	46°	88°	0.9994	0.9995	0.9997	0.9998	0.99985	1°
44°	0.6947	0.6978	0.7009	0.7040	0.7071	45°	89°	0.99985	0.99991	0.99996	0.99999	1.0000	**0°**
	60′	45′	30′	15′	0′	↑ degrees		60′	45′	30′	15′	0′	↑ degrees
	← minutes — **cosine 45° to 90°**							← minutes — **cosine 0° to 45°**					

Table values of the trigonometric functions are rounded off to four decimal places.

M

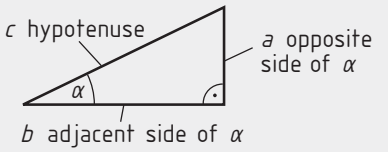
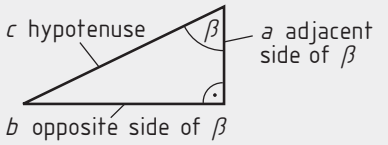
Values of Tangent and Cotangent Trigonometric Functions

degrees ↓	tangent 0° to 45° — minutes → 0′	15′	30′	45′	60′		degrees ↓	tangent 45° to 90° — minutes → 0′	15′	30′	45′	60′	
0°	0.0000	0.0044	0.0087	0.0131	0.0175	89°	45°	1.0000	1.0088	1.0176	1.0265	1.0355	44°
1°	0.0175	0.0218	0.0262	0.0306	0.0349	88°	46°	1.0355	1.0446	1.0538	1.0630	1.0724	43°
2°	0.0349	0.0393	0.0437	0.0480	0.0524	87°	47°	1.0724	1.0818	1.0913	1.1009	1.1106	42°
3°	0.0524	0.0568	0.0612	0.0655	0.0699	86°	48°	1.1106	1.1204	1.1303	1.1403	1.1504	41°
4°	0.0699	0.0743	0.0787	0.0831	0.0875	85°	49°	1.1504	1.1606	1.1708	1.1812	1.1918	**40°**
5°	0.0875	0.0919	0.0963	0.1007	0.1051	84°	**50°**	1.1918	1.2024	1.2131	1.2239	1.2349	39°
6°	0.1051	0.1095	0.1139	0.1184	0.1228	83°	51°	1.2349	1.2460	1.2572	1.2685	1.2799	38°
7°	0.1228	0.1272	0.1317	0.1361	0.1405	82°	52°	1.2799	1.2915	1.3032	1.3151	1.3270	37°
8°	0.1405	0.1450	0.1495	0.1539	0.1584	81°	53°	1.3270	1.3392	1.3514	1.3638	1.3764	36°
9°	0.1584	0.1629	0.1673	0.1718	0.1763	**80°**	54°	1.3764	1.3891	1.4019	1.4150	1.4281	35°
10°	0.1763	0.1808	0.1853	0.1899	0.1944	79°	55°	1.4281	1.4415	1.4550	1.4687	1.4826	34°
11°	0.1944	0.1989	0.2035	0.2080	0.2126	78°	56°	1.4826	1.4966	1.5108	1.5253	1.5399	33°
12°	0.2126	0.2171	0.2217	0.2263	0.2309	77°	57°	1.5399	1.5547	1.5697	1.5849	1.6003	32°
13°	0.2309	0.2355	0.2401	0.2447	0.2493	76°	58°	1.6003	1.6160	1.6319	1.6479	1.6643	31°
14°	0.2493	0.2540	0.2586	0.2633	0.2679	75°	59°	1.6643	1.6808	1.6977	1.7147	1.7321	**30°**
15°	0.2679	0.2726	0.2773	0.2820	0.2867	74°	**60°**	1.7321	1.7496	1.7675	1.7856	1.8040	29°
16°	0.2867	0.2915	0.2962	0.3010	0.3057	73°	61°	1.8040	1.8228	1.8418	1.8611	1.8807	28°
17°	0.3057	0.3105	0.3153	0.3201	0.3249	72°	62°	1.8807	1.9007	1.9210	1.9416	1.9626	27°
18°	0.3249	0.3298	0.3346	0.3395	0.3443	71°	63°	1.9626	1.9840	2.0057	2.0278	2.0503	26°
19°	0.3443	0.3492	0.3541	0.3590	0.3640	**70°**	64°	2.0503	2.0732	2.0965	2.1203	2.1445	25°
20°	0.3640	0.3689	0.3739	0.3789	0.3839	69°	65°	2.1445	2.1692	2.1943	2.2199	2.2460	24°
21°	0.3839	0.3889	0.3939	0.3990	0.4040	68°	66°	2.2460	2.2727	2.2998	2.3276	2.3559	23°
22°	0.4040	0.4091	0.4142	0.4193	0.4245	67°	67°	2.3559	2.3847	2.4142	2.4443	2.4751	22°
23°	0.4245	0.4296	0.4348	0.4400	0.4452	66°	68°	2.4751	2.5065	2.5386	2.5715	2.6051	21°
24°	0.4452	0.4505	0.4557	0.4610	0.4663	65°	69°	2.6051	2.6395	2.6746	2.7106	2.7475	**20°**
25°	0.4663	0.4716	0.4770	0.4823	0.4877	64°	**70°**	2.7475	2.7852	2.8239	2.8636	2.9042	19°
26°	0.4877	0.4931	0.4986	0.5040	0.5095	63°	71°	2.9042	2.9459	2.9887	3.0326	3.0777	18°
27°	0.5095	0.5150	0.5206	0.5261	0.5317	62°	72°	3.0777	3.1240	3.1716	3.2205	3.2709	17°
28°	0.5317	0.5373	0.5430	0.5486	0.5543	61°	73°	3.2709	3.3226	3.3759	3.4308	3.4874	16°
29°	0.5543	0.5600	0.5658	0.5715	0.5774	**60°**	74°	3.4874	3.5457	3.6059	3.6680	3.7321	15°
30°	0.5774	0.5832	0.5890	0.5949	0.6009	59°	75°	3.7321	3.7983	3.8667	3.9375	4.0108	14°
31°	0.6009	0.6068	0.6128	0.6188	0.6249	58°	76°	4.0108	4.0876	4.1653	4.2468	4.3315	13°
32°	0.6249	0.6310	0.6371	0.6432	0.6494	57°	77°	4.3315	4.4194	4.5107	4.6057	4.7046	12°
33°	0.6494	0.6556	0.6619	0.6682	0.6745	56°	78°	4.7046	4.8077	4.9152	5.0273	5.1446	11°
34°	0.6745	0.6809	0.6873	0.6937	0.7002	55°	79°	5.1446	5.2672	5.3955	5.5301	5.6713	**10°**
35°	0.7002	0.7067	0.7133	0.7199	0.7265	54°	**80°**	5.6713	5.8197	5.9758	6.1402	6.3138	9°
36°	0.7265	0.7332	0.7400	0.7467	0.7536	53°	81°	6.3138	6.4971	6.6912	6.8969	7.1154	8°
37°	0.7536	0.7604	0.7673	0.7743	0.7813	52°	82°	7.1154	7.3479	7.5958	7.8606	8.1443	7°
38°	0.7813	0.7883	0.7954	0.8026	0.8098	51°	83°	8.1443	8.4490	8.7769	9.1309	9.5144	6°
39°	0.8098	0.8170	0.8243	0.8317	0.8391	**50°**	84°	9.5144	9.9310	10.3854	10.8829	11.4301	5°
40°	0.8391	0.8466	0.8541	0.8617	0.8693	49°	85°	11.4301	12.0346	12.7062	13.4566	14.3007	4°
41°	0.8693	0.8770	0.8847	0.8925	0.9004	48°	86°	14.3007	15.2571	16.3499	17.6106	19.0811	3°
42°	0.9004	0.9083	0.9163	0.9244	0.9325	47°	87°	19.0811	20.8188	22.9038	25.4517	28.6363	2°
43°	0.9325	0.9407	0.9490	0.9573	0.9657	46°	88°	28.6363	32.7303	38.1885	45.8294	57.2900	1°
44°	0.9657	0.9742	0.9827	0.9913	1.0000	45°	89°	57.2900	76.3900	114.5887	229.1817	∞	**0°**
	60′	45′	30′	15′	0′	↑ degrees		60′	45′	30′	15′	0′	↑ degrees
	← minutes — **cotangent 45° to 90°**							← minutes — **cotangent 0° to 45°**					

Table values of the trigonometric functions are rounded off to four decimal places.

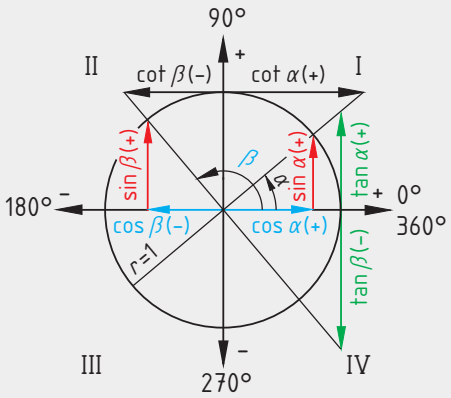
Trigonometric functions of right triangles

Definitions

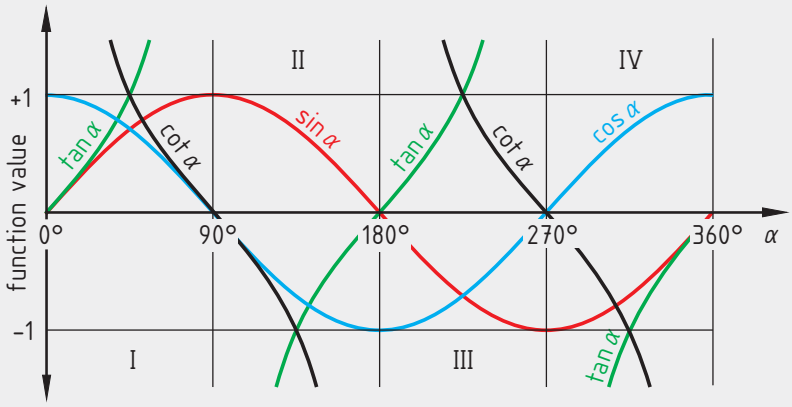
Designations in a right triangle	Definitions of the ratios of the sides	Application for $\sphericalangle \alpha$	Application for $\sphericalangle \beta$
	**sine** = **opposite side / hypotenuse**	$\sin\alpha = \frac{a}{c}$	$\sin\beta = \frac{b}{c}$
	cosine = **adjacent side / hypotenuse**	$\cos\alpha = \frac{b}{c}$	$\cos\beta = \frac{a}{c}$
	**tangent** = **opposite side / adjacent side**	$\tan\alpha = \frac{a}{b}$	$\tan\beta = \frac{b}{a}$
	cotangent = **adjacent side / opposite side**	$\cot\alpha = \frac{b}{a}$	$\cot\beta = \frac{a}{b}$

Graph of the trigonometric functions between 0° and 360°

Representation on a unit circle



Graph of the trigonometric functions



The values of the trigonometric functions of angles > 90° can be derived from the values of the angles between 0° and 90° and then read from the tables (pages 11 and 12). Refer to the graphed curves of the trigonometric functions for the correct sign. Calculators with trigonometric functions display both the value and sign for the desired angle.

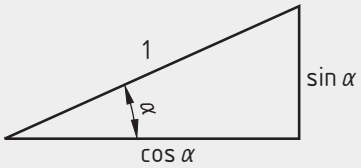
Example: Relationships for Quadrant II

Relationships	Example: Function values for the angle 120° (α = 30° in the formulae)	
$\sin(90° + \alpha) = +\cos\alpha$	$\sin(90° + 30°) = \sin 120° = +0.8660$	$\cos 30° = +0.8660$
$\cos(90° + \alpha) = -\sin\alpha$	$\cos(90° + 30°) = \cos 120° = -0.5000$	$-\sin 30° = -0.5000$
$\tan(90° + \alpha) = -\cot\alpha$	$\tan(90° + 30°) = \tan 120° = -1.7321$	$-\cot 30° = -1.7321$

Function values for selected angles

Function	0°	90°	180°	270°	360°	Function	0°	90°	180°	270°	360°
sin	0	+1	0	–1	0	tan	0	∞	0	∞	0
cos	+1	0	–1	0	+1	cot	∞	0	∞	0	∞

Relationships between the functions of an angle



$\sin^2\alpha + \cos^2\alpha = 1$

$\tan\alpha \cdot \cot\alpha = 1$

$\tan\alpha = \frac{\sin\alpha}{\cos\alpha}$

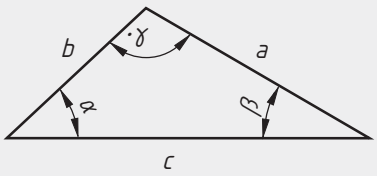
$\cot\alpha = \frac{\cos\alpha}{\sin\alpha}$

Example: Calculation of $\tan\alpha$ from $\sin\alpha$ and $\cos\alpha$ for α = 30°:
$\tan\alpha = \sin\alpha/\cos\alpha = 0.5000/0.8660 = 0.5774$

Trigonometric functions of oblique triangles, Angles, Theorem of intersecting lines

M

Law of sines and Law of cosines

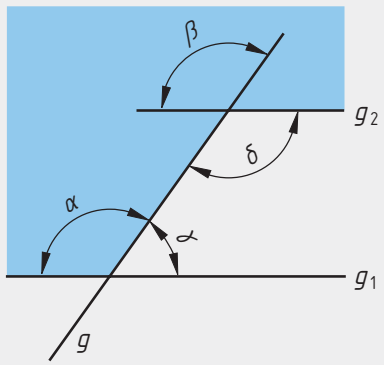


Law of sines	Law of cosines
$a : b : c = \sin\alpha : \sin\beta : \sin\gamma$ $\frac{a}{\sin\alpha} = \frac{b}{\sin\beta} = \frac{c}{\sin\gamma}$	$a^2 = b^2 + c^2 - 2 \cdot b \cdot c \cdot \cos\alpha$ $b^2 = a^2 + c^2 - 2 \cdot a \cdot c \cdot \cos\beta$ $c^2 = a^2 + b^2 - 2 \cdot a \cdot b \cdot \cos\gamma$

Application in calculating sides and angles

Calculation of sides		Calculation of angles	
using the Law of sines	using the Law of cosines	using the Law of sines	using the Law of cosines
$a = \frac{b \cdot \sin\alpha}{\sin\beta} = \frac{c \cdot \sin\alpha}{\sin\gamma}$ $b = \frac{a \cdot \sin\beta}{\sin\alpha} = \frac{c \cdot \sin\beta}{\sin\gamma}$ $c = \frac{a \cdot \sin\gamma}{\sin\alpha} = \frac{b \cdot \sin\gamma}{\sin\beta}$	$a = \sqrt{b^2 + c^2 - 2 \cdot b \cdot c \cdot \cos\alpha}$ $b = \sqrt{a^2 + c^2 - 2 \cdot a \cdot c \cdot \cos\beta}$ $c = \sqrt{a^2 + b^2 - 2 \cdot a \cdot b \cdot \cos\gamma}$	$\sin\alpha = \frac{a \cdot \sin\beta}{b} = \frac{a \cdot \sin\gamma}{c}$ $\sin\beta = \frac{b \cdot \sin\alpha}{a} = \frac{b \cdot \sin\gamma}{c}$ $\sin\gamma = \frac{c \cdot \sin\alpha}{a} = \frac{c \cdot \sin\beta}{b}$	$\cos\alpha = \frac{b^2 + c^2 - a^2}{2 \cdot b \cdot c}$ $\cos\beta = \frac{a^2 + c^2 - b^2}{2 \cdot a \cdot c}$ $\cos\gamma = \frac{a^2 + b^2 - c^2}{2 \cdot a \cdot b}$

Types of angles



If two parallels g_1 and g_2 are intersected by a straight line g, there are geometrical interrelationships between the corresponding, opposite, alternate and adjacent angles.

Corresponding angles

$\alpha = \beta$

Opposite angles

$\beta = \delta$

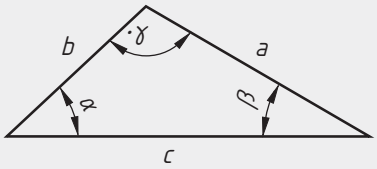
Alternate angles

$\alpha = \delta$

Adjacent angles

$\alpha + \gamma = 180°$

Sum of angles in a triangle

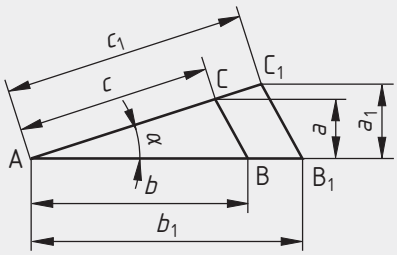


In every triangle the sum of the interior angles equals 180°.

Sum of angles in a triangle

$\alpha + \beta + \gamma = 180°$

Theorem of intersecting lines



If two lines extending from Point A are intersected by two parallel lines BC and B_1C_1, the segments of the parallel lines and the corresponding ray segments of the lines extending from A form equal ratios.

Theorem of intersecting lines

$\frac{a}{a_1} = \frac{b}{b_1} = \frac{c}{c_1}$

$\frac{a}{b} = \frac{a_1}{b_1}$ $\quad$ $\frac{b}{c} = \frac{b_1}{c_1}$

Using brackets, powers and roots

Calculations with brackets

Type	Explanation	Example
Factoring out	Common factors (divisors) in addition and subtraction are placed before a bracket.	$3 \cdot x + 5 \cdot x = x \cdot (3+5) = 8 \cdot x$ $\frac{3}{x} + \frac{5}{x} = \frac{1}{x} \cdot (3+5)$
	A fraction bar combines terms in the same manner as brackets.	$\frac{a+b}{2} \cdot h = (a+b) \cdot \frac{h}{2}$
Expanding bracketed terms	A bracketed term is multiplied by a value (number, variable, another bracketed term), by multiplying each term inside the brackets by this value.	$5 \cdot (b + c) = 5b + 5c$ $(a + b) \cdot (c - d) = ac - ad + bc - bd$
	A bracketed term is divided by a value (number, variable, another bracketed term), by dividing each term inside the bracket by this value.	$(a+b) : c = a : c + b : c$ $\frac{a-b}{5} = \frac{a}{5} - \frac{b}{5}$
Binomial formulae	A binomial formula is a formula in which the term $(a + b)$ or $(a - b)$ is multiplied by itself.	$(a + b)^2 = a^2 + 2ab + b^2$ $(a - b)^2 = a^2 - 2ab + b^2$ $(a + b) \cdot (a - b) = a^2 - b^2$
Multiplication/division and addition/subtraction calculations	In mixed equations, the bracketed terms must be solved first. Then multiplication and division calculations are performed, and finally addition and subtraction.	$a \cdot (3x - 5x) - b \cdot (12y - 2y)$ $= a \cdot (-2x) - b \cdot 10y$ $= -2ax - 10by$

Powers

Definitions	a base; x exponent; y exponential value Product of identical factors	$a^x = y$ $a \cdot a \cdot a \cdot a = a^4$ $4 \cdot 4 \cdot 4 \cdot 4 = 4^4 = 256$
Addition Subtraction	Powers with the same base and the same exponents are treated like equal numbers.	$3a^3 + 5a^3 - 4a^3$ $= a^3 \cdot (3 + 5 - 4) = 4a^3$
Multiplication Division	Powers with the same base are multiplied (divided) by adding (subtracting) the exponents and keeping the base.	$a^4 \cdot a^2 = a \cdot a \cdot a \cdot a \cdot a \cdot a = a^6$ $2^4 \cdot 2^2 = 2^{(4+2)} = 2^6 = 64$ $3^2 \div 3^3 = 3^{(2-3)} = 3^{-1} = 1/3$
Negative exponent	Numbers with negative exponents can also be written as fractions. The base is then given a positive exponent and is placed in the denominator.	$m^{-1} = \frac{1}{m^1} = \frac{1}{m}$ $a^{-3} = \frac{1}{a^3}$
Fractions in exponents	Powers with fractional exponents can also be written as roots.	$a^{\frac{4}{3}} = \sqrt[3]{a^4}$
Zero in exponents	Every power with a zero exponent has the value of one.	$(m + n)^0 = 1$ $a^4 \div a^4 = a^{(4-4)} = a^0 = 1$ $2^0 = 1$

Roots

Definitions	x root's exponent; a radicand; y root value	$\sqrt[x]{a} = y$ or $a^{1/x} = y$
Signs	Even number exponents of the root give positive and negative values, if the radicand is positive. A negative radicand results in an imaginary number.	$\sqrt[2]{9} = \pm 3$ $\sqrt[2]{-9} = +3\mathrm{i}$
	Odd number exponents of the root give positive values if the radicand is positive and negative values if the radicand is negative.	$\sqrt[3]{8} = 2$ $\sqrt[3]{-8} = -2$
Addition Subtraction	Identical root expressions can be added and subtracted.	$\sqrt{a} + 3\sqrt{a} - 2\sqrt{a} = 2\sqrt{a}$
Multiplication Division	Roots with the same exponents are multiplied (divided) by taking the root of the product (quotient) of the radicands.	$\sqrt[n]{a} \cdot \sqrt[n]{b} = \sqrt[n]{ab}$ $\frac{\sqrt[3]{a}}{\sqrt[3]{n}} = \sqrt[3]{\frac{a}{n}}$

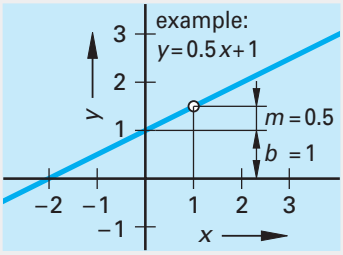
Types of equations, Rules of transformation

M

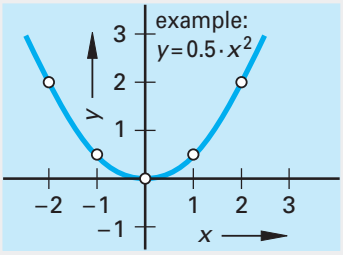
Equations

Type	Explanation	Example
Variable equation	Equivalent terms (formula terms of equal value) form relationships between variables (see also, Rules of transformation).	$v = \pi \cdot d \cdot n$ $(a+b)^2 = a^2 + 2ab + b^2$
Compatible units equation	Immediate conversion of units and constants to an SI unit in the result. Only used in special cases, e.g. if engineering parameters are specified or for simplification.	$P = \frac{M \cdot n}{9550}$; P in kW, if n in 1/min and M in Nm
Single variable equation	Calculation of the value of a variable.	$x + 3 = 8$ $x = 8 - 3 = 5$
Function equation	Assigned function equation: y is a function of x with x as the independent variable; y as the dependent variable. The number pair (x,y) of a value table form the graph of the function in the (x,y) coordinate system.	$y = f(x)$ $\Re \rightarrow$ real numbers
	Constant function The graph is a line parallel to the x-axis.	$y = f(x) = b$
	Proportional function The graph is a straight line through the origin.	$y = f(x) = mx$ $y = 2x$
	Linear function The graph is a straight line with slope m and y intercept b (example below).	$y = f(x) = mx + b$ $y = 0.5x + 1$
	Quadratic function Every quadratic function graphs as a parabola (example below).	$y = f(x) = x^2$ $y = a_2x^2 + a_1x + a_0$

linear function $y = mx + b$



quadratic function $y = x^2$



Rules of transformation

Equations are usually transformed to obtain an equation in which the unknown variable stands alone on the left side of the equation.

Addition Subtraction	The same number can be added or subtracted from both sides. In the equations $x + 5 = 15$ and $x + 5 - 5 = 15 - 5$, x has the same value, i.e. the equations are equivalent.	$x + 5 = 15 \quad \vert -5$ $x + 5 - 5 = 15 - 5$ $x = 10$ $y - c = d \quad \vert +c$ $y - c + c = d + c$ $y = d + c$
Multiplication Division	It is possible to multiply or divide each side of the equation by the same number.	$a \cdot x = b \quad \vert \div a$ $\frac{a \cdot x}{a} = \frac{b}{a}$ $x = \frac{b}{a}$
Powers	The expressions on both sides of the equations can be raised to the same exponential power.	$\sqrt{x} = a + b \quad \vert ()^2$ $(\sqrt{x})^2 = (a+b)^2$ $x = a^2 + 2ab + b^2$
Roots	The root of the expressions on both sides of the equation can be taken using the same root exponent.	$x^2 = a + b \quad \vert \sqrt{}$ $(\sqrt{x})^2 = \sqrt{a+b}$ $x = \pm\sqrt{a+b}$

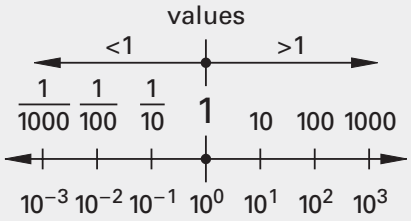
Decimal multiples and factors of units, Interest calculation

Decimal multiples and factors of units

cf. DIN 1301-1 (2002-10)

M

Mathematics			SI units			
Power of ten	Name	Multiplication factor	Prefix Name	Prefix Character	Examples Unit	Examples Meaning
10^{18}	quintillion	1 000 000 000 000 000 000	exa	E	Em	10^{18} meters
10^{15}	quadrillion	1 000 000 000 000 000	peta	P	Pm	10^{15} meters
10^{12}	trillion	1 000 000 000 000	tera	T	TV	10^{12} volts
10^{9}	billion	1 000 000 000	giga	G	GW	10^{9} watts
10^{6}	million	1 000 000	mega	M	MW	10^{6} watts
10^{3}	thousand	1 000	kilo	k	kN	10^{3} newtons
10^{2}	hundred	100	hecto	h	hl	10^{2} liters
10^{1}	ten	10	deca	da	dam	10^{1} meters
10^{0}	one	1	–	–	m	10^{0} meter
10^{-1}	tenth	0.1	deci	d	dm	10^{-1} meters
10^{-2}	hundredth	0.01	centi	c	cm	10^{-2} meters
10^{-3}	thousandth	0.001	milli	m	mV	10^{-3} volts
10^{-6}	millionth	0.000 001	micro	µ	µA	10^{-6} ampere
10^{-9}	billionth	0.000 000 001	nano	n	nm	10^{-9} meters
10^{-12}	trillionth	0.000 000 000 001	pico	p	pF	10^{-12} farad
10^{-15}	quadrillionth	0.000 000 000 000 001	femto	f	fF	10^{-15} farads
10^{-18}	quintillionth	0.000 000 000 000 000 001	atto	a	am	10^{-18} meters



Numbers greater than 1 are expressed with **positive exponents** and numbers less than 1 are expressed with **negative exponents**.

Examples: $4300 = 4.3 \cdot 1000 = 4.3 \cdot 10^3$

$14638 = 1.4638 \cdot 10^4$

$$0.07 = \frac{7}{100} = 7 \cdot 10^{-2}$$

Simple interest

P principle; A amount accumulated; I interest; r interest rate per year; t time in days, interest period

Interest

$$I = \frac{P \cdot r \cdot t}{100\,\% \cdot 360}$$

1 interest year (1 a) = 360 days (360 d)

360 d = 12 months

1 interest month = 30 days

1st example:

$P = \$\,2800.00;\ r = 6\,\frac{\%}{a};\ t = {}^1/_2\,a;\ I = ?$

$$I = \frac{\$\,2800.00 \cdot 6\,\frac{\%}{a} \cdot 0.5\,a}{100\,\%} = \mathbf{\$\,84.00}$$

2nd example:

$P = \$\,4800.00;\ r = 5.1\,\frac{\%}{a};\ t = 50\,d;\ I = ?$

$$I = \frac{\$\,4800.00 \cdot 5.1\,\frac{\%}{a} \cdot 50\,d}{100\,\% \cdot 360\,\frac{d}{a}} = \mathbf{\$\,34.00}$$

Compound interest calculation for one-time payment

P principle; A amount accumulated; I interest; r interest rate per year; n time; q compounding factor

Amount accumulated

$$A = P \cdot q^n$$

Compounding factor

$$q = 1 + \frac{r}{100\,\%}$$

Example:

$P = \$\,8000.00;\ n = 7\ \text{years};\ r = 6.5\,\%;\ A = ?$

$$q = 1 + \frac{6.5\,\%}{100\,\%} = 1.065$$

$$A = P \cdot q^n = \$\,8000.00 \cdot 1.065^7 = \$\,8000.00 \cdot 1.553986 = \mathbf{\$\,12\,431.89}$$

Percentage calculation, Proportion calculations

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Percentage calculation

The **percentage rate** gives the fraction of the base value in hundredths.
The **base value** is the value from which the percentage is to be calculated.
The **percent value** is the amount representing the percentage of the base value.

P_r percentage rate, in percent P_v percent value B_v base value.

Percent value

$$P_v = \frac{B_v \cdot P_r}{100\,\%}$$

Percentage rate

$$P_r = \frac{P_v}{B_v} \cdot 100\,\%$$

1st example:

Workpiece rough part weight 250 kg (base value); material loss 2% (percentage rate); material loss in kg = ? (percent value)

$$P_v = \frac{B_v \cdot P_r}{100\,\%} = \frac{250\ \text{kg} \cdot 2\,\%}{100\,\%} = \mathbf{5\ kg}$$

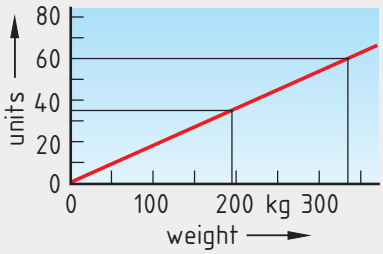
2nd example:

Rough weight of a casting 150 kg; weight after machining 126 kg; weight percent rate (%) of material loss?

$$P_r = \frac{P_v}{B_v} \cdot 100\,\% = \frac{150\ \text{kg} - 126\ \text{kg}}{150\ \text{kg}} \cdot 100\,\% = \mathbf{16\,\%}$$

Proportion calculations

Three steps for calculating direct proportional ratios



Example:

60 elbow pipes weigh 330 kg. What is the weight of 35 elbow pipes?

1st step: Known data — 60 elbow pipes weigh 330 kg.

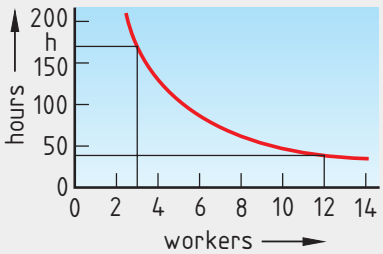
2nd step: Calculate the unit weight by dividing

1 elbow pipe weighs $\frac{330\ \text{kg}}{60}$

3rd step: Calculate the total by multiplying

35 elbow pipes weigh $\frac{330\ \text{kg} \cdot 35}{60} = \mathbf{192.5\ kg}$

Three steps for calculating inverse proportional ratios



Example:

It takes 3 workers 170 hours to process one order. How many hours do 12 workers need to process the same order?

Known data — It takes 3 workers 170 hours

2nd step: Calculate the unit time by multiplying

It takes 1 worker $3 \cdot 170$ hrs

3rd step: Calculate the total by dividing

It takes12 workers $\frac{3 \cdot 170\ \text{hrs}}{12} = \mathbf{42.5\ hrs}$

Using the three steps for calculating direct and inverse proportions

Example:

660 workpieces are manufactured by 5 machines in 24 days.

How much time does it take for 9 machines to produce 312 workpieces of the same type?

1st application of 3 steps:

5 machines produce 660 workpieces in 24 days
1 machine produces 660 workpieces in $24 \cdot 5$ days
9 machines produce 660 workpieces in $\frac{24 \cdot 5}{9}$ days

2nd application of 3 steps:

9 machines produce 660 workpieces in $\frac{24 \cdot 5}{9}$ days
9 machines produce 1 workpiece in $\frac{24 \cdot 5}{9 \cdot 660}$ days
9 machines produce 312 workpieces in $\frac{24 \cdot 5 \cdot 312}{9 \cdot 660} = \mathbf{6.3\ days}$

Formula symbols, Mathematical symbols

Formula symbols

cf. DIN 1304-1 (1994-03)

Formula symbol	Meaning	Formula symbol	Meaning	Formula symbol	Meaning
Length, Area, Volume, Angle					
l	Length	r, R	Radius	α, β, γ	Planar angle
w	Width	d, D	Diameter	Ω	Solid angle
h	Height	A, S	Area, Cross-sectional area	λ	Wave length
s	Linear distance	V	Volume		
Mechanics					
m	Mass	F	Force	G	Shear modulus
m'	Linear mass density	F_W, W	Gravitational force, Weight	μ, f	Coefficient of friction
m''	Area mass density	M	Torque	W	Section modulus
ϱ	Density	T	Torsional moment	I	Second moment of an area
J	Moment of inertia	M_b	Bending moment	W, E	Work, Energy
p	Pressure	σ	Normal stress	W_p, E_p	Potential energy
p_{abs}	Absolute pressure	τ	Shear stress	W_k, E_k	Kinetic energy
p_{amb}	Ambient pressure	ε	Normal strain	P	Power
p_g	Gage pressure	E	Modulus of elasticity	η	Efficiency
Time					
t	Time, Duration	f, ν	Frequency	a	Acceleration
T	Cycle duration	v, u	Velocity	g	Gravitational acceleration
n	Revolution frequency, Speed	ω	Angular velocity	α	Angular acceleration
				$Q, \dot{V}, q_v$	Volumetric flow rate
Electricity					
Q	Electric charge, Quantity of electricity	L	Inductance	X	Reactance
E	Electromotive force	R	Resistance	Z	Impedance
C	Capacitance	ϱ	Specific resistance	φ	Phase difference
I	Electric current	$\gamma, \varkappa$	Electrical conductivity	N	Number of turns
Heat					
T, Θ	Thermodynamic temperature	Q	Heat, Quantity of heat	$\Phi, \dot{Q}$	Heat flow
$\Delta T, \Delta t, \Delta\vartheta$	Temperature difference	λ	Thermal conductivity	a	Thermal diffusivity
t, ϑ	Celsius temperature	α	Heat transition coefficient	c	Specific heat
$\alpha_{l,}\alpha$	Coefficient of linear expansion	k	Heat transmission coefficient	H_{net}	Net calorific value
Light, Electromagnetic radiation					
E	Illuminance	f	Focal length	I	Luminous intensity
		n	Refractive index	Q, W	Radiant energy
Acoustics					
p	Acoustic pressure	L_P	Acoustic pressure level	N	Loudness
c	Acoustic velocity	I	Sound intensity	L_N	Loudness level

Mathematical symbols

cf. DIN 1302 (1999-12)

Math. symbol	Spoken	Math. symbol	Spoken	Math. symbol	Spoken
$\approx$	approx. equals, around, about	$\tilde{a}^n$	proportional a to the n-th power, the n-th power of a	log	logarithm (general)
$\triangleq$	equivalent to	$\sqrt{}$	square root of	lg	common logarithm
...	and so on, etc.	$\sqrt[n]{}$	n-th root of	ln	natural logarithm
∞	infinity			e	Euler number (e = 2.718281...)
=	equal to	$\lvert x \rvert$	absolute value of x	sin	sine
$\neq$	not equal to	$\perp$	perpendicular to	cos	cosine
$\overset{\text{def}}{=}$	is equal to by definition	$\parallel$	is parallel to	tan	tangent
<	less than	$\uparrow\uparrow$	parallel in the same direction	cot	cotangent
$\leq$	less than or equal to	$\uparrow\downarrow$	parallel in the opposite direction	(), [], {}	parentheses, brackets
>	greater than	$\sphericalangle$	angle		open and closed
$\geq$	greater than or equal to	$\triangle$	triangle	π	pi (circle constant = 3.14159...)
+	plus	$\cong$	congruent to		
−	minus	Δx	delta x (difference between two values)	$\overline{AB}$	line segment AB
·	times, multiplied by			$\overset{\frown}{AB}$	arc AB
−, /, :, ÷	over, divided by, per, to	%	percent, of a hundred	a′, a″	a prime, a double prime
Σ	sigma (summation)	‰	per mil, of a thousand	a_1, a_2	a sub 1, a sub 2

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SI quantities and units of measurement

SI[1] Base quantities and base units

cf. DIN 1301-1 (2002-10), -2 (1978-02), -3 (1979-10)

Base quantity	Length	Mass	Time	Electric current	Thermo-dynamic temperature	Amount of substance	Luminous intensity
Base units	meter	kilo-gram	second	ampere	kelvin	mole	candela
Unit symbol	m	kg	s	A	K	mol	cd

[1] The units for measurement are defined in the International System of Units SI (**S**ystème **I**nternational d'Unités). It is based on the seven basic units (SI units), from which other units are derived.

Base quantities, derived quantities and their units

Quantity	Symbol	Unit Name	Unit Symbol	Relationship	Remarks Examples of application
Length, Area, Volume, Angle					
Length	l	**meter**	m	1 m = 10 dm = 100 cm = 1000 mm 1 mm = 1000 µm 1 km = 1000 m	1 inch = 25.4 mm In aviation and nautical applications the following applies: 1 international nautical mile = 1852 m
Area	A, S	square meter are hectare	m^2 a ha	$1\ m^2 = 10000\ cm^2 = 1000000\ mm^2$ $1\ a = 100\ m^2$ $1\ ha = 100\ a = 10000\ m^2$ $100\ ha = 1\ km^2$	Symbol S only for cross-sectional areas Are and hectare only for land
Volume	V	cubic meter liter	m^3 l, L	$1\ m^3 = 1000\ dm^3 = 1000000\ cm^3$ $1\ l = 1\ L = 1\ dm^3 = 10\ dl = 0.001\ m^3$ $1\ ml = 1\ cm^3$	Mostly for fluids and gases
Plane angle (angle)	$\alpha, \beta, \gamma' \ldots$	radian degrees minutes seconds	rad ° ′ ″	$1\ rad = 1\ m/m = 57.2957\ldots° = 180°/\pi$ $1° = \frac{\pi}{180}\ rad = 60'$ $1' = 1°/60 = 60''$ $1'' = 1'/60 = 1°/3600$	1 rad is the angle formed by the intersection of a circle around the center of 1 m radius with an arc of 1 m length. In technical calculations instead of $\alpha = 33°\ 17'\ 27.6''$, better use is $\alpha = 33.291°$.
Solid angle	Ω	steradian	sr	$1\ sr = 1\ m^2/m^2$	An object whose extension measures 1 rad in one direction and perpendicularly to this also 1 rad, covers a solid angle of 1 sr.
Mechanics					
Mass	m	**kilogram** gram megagram metric ton	kg g Mg t	1 kg = 1000 g 1 g = 1000 mg 1 metric t = 1000 kg = 1 Mg 0.2 g = 1 ct	Mass in the sense of a scale result or a weight is a quantity of the type of mass (unit kg). Mass for precious stones in carat (ct).
Linear mass density	m'	kilogram per meter	kg/m	$1\ kg/m = 1\ g/mm$	For calculating the mass of bars, profiles, pipes.
Area mass density	m''	kilogram per square meter	kg/m^2	$1\ kg/m^2 = 0.1\ g/cm^2$	To calculate the mass of sheet metal.
Density	ϱ	kilogram per cubic meter	kg/m^3	$1000\ kg/m^3 = 1\ metric\ t/m^3 = 1\ kg/dm^3 = 1\ g/cm^3 = 1\ g/ml = 1\ mg/mm^3$	The density is a quantity independent of location.