

ATICAL AND
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MATHEMATICAL AND PHYSICAL TABLES



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PHYSICAL TABLES

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JOHN B. CLARK, C.B.E., M.A., LL.D.

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NEW EDITION REVISED AND ENLARGED BY

ALEXANDER C. AITKEN, F.R.S.

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PREFACE TO TWENTY-FOURTH EDITION

In this Edition no alteration has been made to the Physical Tables, but the Mathematical Tables have been revised and enlarged. Tables of natural secants, natural cosecants, and natural cotangents have been added; the squares and reciprocals table has been expanded; there is a change in the presentation of logarithmic sines, logarithmic cosines, logarithmic tangents to conform with the usual examination requirements. The Publishers are indebted to Professor A. C. Aitken, F.R.S. for his work on this edition, especially for his re-checking of the accuracy of the tables.

June 1950

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-43	2692	2698	2704	2710	2716	2723	2729	2735	2742	2748	1	1	2	2	2	2	2	3	4	
-44	2754	2761	2767	2773	2780	2786	2793	2799	2805	2812	1	1	2	2	2	2	2	3	4	
-45	2818	2825	2831	2838	2844	2851	2858	2864	2871	2877	1	1	2	2	2	2	2	3	4	
-46	2884	2891	2897	2904	2911	2917	2924	2931	2938	2944	1	1	2	2	2	2	2	3	4	
-47	2951	2958	2965	2972	2979	2985	2992	2999	3006	3013	1	1	2	2	2	2	2	3	4	
-48	3020	3027	3034	3041	3048	3055	3062	3069	3076	3083	1	1	2	2	2	2	2	3	4	
-49	3090	3097	3105	3112	3119	3126	3133	3141	3148	3155	1	1	2	2	2	2	2	3	4	

	0	1	2	3	4	5	6	7	8	9	Mean Differences								
											1	2	3	4	5	6	7	8	9
-50	3162	3170	3177	3184	3192	3199	3206	3214	3221	3228	1	1	2	3	4	4	5	6	7
-51	3236	3243	3251	3258	3266	3273	3281	3289	3296	3304	1	2	2	3	4	5	5	6	7
-52	3311	3319	3327	3334	3342	3350	3357	3365	3373	3381	1	2	2	3	4	5	5	6	7
-53	3383	3396	3404	3412	3420	3428	3436	3443	3451	3459	1	2	2	3	4	5	5	6	7
-54	3467	3475	3483	3491	3499	3508	3516	3524	3532	3540	1	2	2	3	4	5	5	6	7
-55	3548	3556	3565	3573	3581	3589	3597	3606	3614	3622	1	2	2	3	4	5	5	6	7
-56	3631	3639	3648	3656	3664	3673	3681	3690	3698	3707	1	2	2	3	4	5	5	6	7
-57	3715	3724	3733	3741	3750	3758	3767	3776	3784	3793	1	2	2	3	4	5	5	6	7
-58	3802	3811	3819	3828	3837	3846	3855	3864	3873	3882	1	2	2	3	4	5	5	6	7
-59	3890	3899	3908	3917	3926	3936	3945	3954	3963	3972	1	2	2	3	4	5	5	6	7
-60	3981	3990	3999	4009	4018	4027	4036	4046	4055	4064	1	2	2	3	4	5	5	6	7
61	4074	4083	4093	4102	4111	4121	4130	4140	4150	4159	1	2	2	3	4	5	5	6	7
62	4169	4178	4188	4198	4207	4217	4227	4236	4246	4256	1	2	2	3	4	5	5	6	7
63	4266	4276	4286	4295	4305	4315	4325	4335	4345	4355	1	2	2	3	4	5	5	6	7
64	4365	4375	4385	4395	4406	4416	4426	4436	4446	4457	1	2	2	3	4	5	5	6	7
65	4467	4477	4487	4498	4508	4519	4529	4539	4550	4560	1	2	2	3	4	5	5	6	7
66	4571	4581	4592	4603	4613	4624	4634	4645	4656	4667	1	2	2	3	4	5	5	6	7
67	4677	4688	4699	4710	4721	4732	4742	4753	4764	4775	1	2	2	3	4	5	5	6	7
68	4786	4797	4808	4819	4831	4842	4853	4864	4875	4887	1	2	2	3	4	5	5	6	7
69	4898	4909	4920	4932	4943	4955	4966	4977	4989	5000	1	2	2	3	4	5	5	6	7
70	5012	5023	5035	5047	5058	5070	5082	5093	5105	5117	1	2	2	3	4	5	5	6	7
71	5129	5140	5152	5164	5176	5188	5200	5212	5224	5236	1	2	2	3	4	5	5	6	7
72	5248	5260	5272	5284	5297	5309	5321	5333	5346	5358	1	2	2	3	4	5	5	6	7
73	5370	5383	5395	5408	5420	5433	5445	5458	5470	5483	1	2	2	3	4	5	5	6	7
74	5495	5508	5521	5534	5546	5559	5572	5585	5598	5610	1	2	2	3	4	5	5	6	7
75	5623	5636	5649	5662	5675	5689	5702	5715	5728	5741	1	2	2	3	4	5	5	6	7
76	5754	5768	5781	5794	5808	5821	5834	5848	5861	5875	1	2	2	3	4	5	5	6	7
77	5888	5902	5916	5929	5943	5957	5970	5984	5998	6012	1	2	2	3	4	5	5	6	7
78	6026	6039	6053	6067	6081	6095	6109	6124	6138	6152	1	2	2	3	4	5	5	6	7
79	6166	6180	6194	6209	6223	6237	6252	6266	6281	6295	1	2	2	3	4	5	5	6	7
80	6310	6324	6339	6353	6368	6383	6397	6412	6427	6442	1	2	2	3	4	5	5	6	7
81	6457	6471	6486	6501	6516	6531	6546	6561	6577	6592	2	2	2	3	4	5	5	6	7
82	6607	6622	6637	6653	6668	6683	6699	6714	6730	6745	2	2	2	3	4	5	5	6	7
83	6761	6776	6792	6808	6823	6839	6855	6871	6887	6902	2	2	2	3	4	5	5	6	7
84	6918	6934	6950	6966	6982	6998	7015	7031	7047	7063	2	2	2	3	4	5	5	6	7
85	7079	7096	7112	7129	7146	7163	7178	7194	7211	7228	2	2	2	3	4	5	5	6	7
86	7244	7261	7278	7295	7311	7328	7345	7362	7379	7396	2	2	2	3	4	5	5	6	7
87	7413	7430	7447	7464	7482	7499	7516	7534	7551	7568	2	2	2	3	4	5	5	6	7
88	7586	7603	7621	7638	7656	7674	7691	7709	7727	7745	2	2	2	3	4	5	5	6	7
89	7762	7780	7798	7816	7834	7852	7870	7889	7907	7925	2	2	2	3	4	5	5	6	7
90	7943	7962	7980	7999	8017	8035	8054	8072	8091	8110	2	2	2	3	4	5	5	6	7
91	8128	8147	8166	8185	8204	8222	8241	8260	8279	8299	2	2	2	3	4	5	5	6	7
92	8318	8337	8356	8375	8395	8414	8433	8453	8472	8492	2	2	2	3	4	5	5	6	7
93	8511	8531	8551	8570	8590	8610	8630	8650	8670	8690	2	2	2	3	4	5	5	6	7
94	8710	8730	8750	8770	8790	8810	8831	8851	8872	8892	2	2	2	3	4	5	5	6	7
95	8913	8933	8954	8974	8995	9016	9036	9057	9078	9099	2	2	2	3	4	5	5	6	7
96	9120	9141	9162	9183	9204	9224	9245	9266	9287	9311	2	2	2	3	4	5	5	6	7
97	9333	9354	9375	9397	9419	9441	9462	9484	9506	9528	2	2	2	3	4	5	5	6	7
98	9550	9572	9594	9616	9638	9661	9683	9705	9727	9750	2	2	2	3	4	5	5	6	7
99	9772	9795	9817	9840	9863	9886	9908	9931	9954	9977	2	2	2	3	4	5	5	6	7

	0'	6'	12'	18'	24'	30'	36'	42'	48'	54'	Mean Differences				
											1'	2'	3'	4'	5'
0°	0000	0017	0035	0052	0070	0087	0105	0122	0140	0157	3	6	9	12	15
1	0175	0192	0209	0227	0244	0262	0279	0297	0314	0332	3	6	9	12	15
2	0319	0336	0354	0401	0419	0436	0454	0471	0488	0506	3	6	9	12	15
3	0523	0541	0558	0576	0593	0610	0628	0645	0663	0680	3	6	9	12	15
4	0698	0715	0732	0750	0767	0785	0802	0819	0837	0854	3	6	9	12	14
5	0872	0889	0906	0924	0941	0958	0976	0993	1011	1028	3	6	9	12	14
6	1045	1063	1080	1097	1115	1132	1149	1167	1184	1201	3	6	9	12	14
7	1210	1236	1253	1271	1288	1305	1323	1340	1357	1374	3	6	9	12	14
8	1392	1409	1426	1444	1461	1478	1495	1513	1530	1547	3	6	9	12	14
9	1564	1582	1599	1616	1633	1650	1668	1685	1702	1719	3	6	9	12	14
10°	1736	1754	1771	1788	1805	1822	1840	1857	1874	1891	3	6	9	11	14
11	1908	1925	1942	1959	1977	1994	2011	2028	2045	2062	3	6	9	11	14
12	2079	2096	2113	2130	2147	2164	2181	2198	2215	2233	3	6	9	11	14
13	2250	2267	2284	2300	2317	2334	2351	2368	2385	2402	3	6	8	11	14
14	2419	2436	2453	2470	2487	2504	2521	2538	2554	2571	3	6	8	11	14
15	2588	2605	2622	2639	2656	2672	2689	2706	2723	2740	3	6	8	11	14
16	2756	2773	2790	2807	2823	2840	2857	2874	2890	2907	3	6	8	11	14
17	2924	2940	2957	2974	2990	3007	3024	3040	3057	3074	3	6	8	11	14
18	3090	3107	3123	3140	3156	3173	3190	3206	3223	3239	3	6	8	11	14
19	3256	3272	3289	3305	3322	3338	3355	3371	3387	3404	3	5	8	11	14
20°	3420	3437	3453	3469	3486	3502	3518	3535	3551	3567	3	5	8	11	14
21	3584	3600	3616	3633	3649	3665	3681	3697	3714	3730	3	5	8	11	14
22	3746	3762	3778	3795	3811	3827	3843	3859	3875	3891	3	5	8	11	14
23	3907	3923	3939	3955	3971	3987	4003	4019	4035	4051	3	5	8	11	14
24	4067	4083	4099	4115	4131	4147	4163	4179	4195	4210	3	5	8	11	13
25	4226	4242	4258	4274	4289	4305	4321	4337	4352	4368	3	5	8	11	13
26	4384	4399	4415	4431	4446	4462	4478	4493	4509	4524	3	5	8	10	13
27	4540	4555	4571	4586	4602	4617	4633	4648	4664	4679	3	5	8	10	13
28	4695	4710	4726	4741	4756	4772	4787	4802	4818	4833	3	5	8	10	13
29	4848	4863	4879	4894	4909	4924	4939	4955	4970	4985	3	5	8	10	13
30°	5000	5015	5030	5045	5060	5075	5090	5105	5120	5135	3	5	8	10	13
31	5150	5165	5180	5195	5210	5225	5240	5255	5270	5284	2	5	7	10	12
32	5299	5314	5329	5344	5358	5373	5388	5402	5417	5432	2	5	7	10	12
33	5446	5461	5476	5490	5505	5519	5534	5548	5563	5577	2	5	7	10	12
34	5592	5606	5621	5635	5650	5664	5678	5693	5707	5721	2	5	7	10	12
35	5736	5750	5764	5779	5793	5807	5821	5835	5850	5864	2	5	7	9	12
36	5878	5892	5906	5920	5934	5948	5962	5976	5990	6004	2	5	7	9	12
37	6018	6032	6046	6060	6074	6088	6101	6115	6129	6143	2	5	7	9	12
38	6157	6170	6184	6198	6211	6225	6239	6252	6266	6280	2	5	7	9	11
39	6293	6307	6320	6334	6347	6361	6374	6388	6401	6414	2	4	7	9	11
40°	6428	6441	6455	6468	6481	6494	6508	6521	6534	6547	2	4	7	9	11
41	6561	6574	6587	6600	6613	6626	6639	6652	6665	6678	2	4	7	9	11
42	6691	6704	6717	6730	6743	6756	6769	6782	6794	6807	2	4	6	9	11
43	6820	6833	6845	6858	6871	6884	6896	6909	6921	6934	2	4	6	8	11
44	6947	6959	6972	6984	6997	7009	7022	7034	7046	7059	2	4	6	8	10

NATURAL SINES

	0'	6'	12'	18'	24'	30'	36'	42'	48'	54'	Mean Differences				
											1'	2'	3'	4'	5'
45°	7071	7083	7096	7108	7120	7133	7145	7157	7169	7181	2	4	6	8	10
46	7193	7206	7218	7230	7242	7254	7266	7278	7290	7302	2	4	6	8	10
47	7314	7325	7337	7349	7361	7373	7385	7396	7408	7420	2	4	6	8	10
48	7431	7443	7455	7467	7478	7490	7501	7513	7524	7536	2	4	6	8	10
49	7547	7559	7570	7581	7593	7604	7615	7627	7638	7649	2	4	6	8	9
50°	7660	7672	7683	7694	7705	7716	7727	7738	7749	7760	2	4	6	7	9
51	7771	7782	7793	7804	7815	7826	7837	7848	7859	7869	2	4	5	7	9
52	7880	7891	7902	7912	7923	7934	7944	7955	7965	7976	2	4	5	7	9
53	7986	7997	8007	8018	8028	8039	8049	8059	8070	8080	2	3	5	7	9
54	8090	8100	8111	8121	8131	8141	8151	8161	8171	8181	2	3	5	7	8
55	8192	8202	8211	8221	8231	8241	8251	8261	8271	8281	2	3	5	7	8
56	8290	8300	8310	8320	8329	8339	8348	8358	8368	8377	2	3	5	6	8
57	8387	8396	8406	8415	8425	8434	8443	8453	8462	8471	2	3	5	6	8
58	8480	8490	8499	8508	8517	8526	8536	8545	8554	8563	2	3	5	6	8
59	8572	8581	8590	8599	8607	8616	8625	8634	8643	8652	1	3	4	6	7
60°	8660	8669	8678	8686	8695	8704	8712	8721	8729	8738	1	3	4	6	7
61	8746	8755	8763	8771	8780	8788	8796	8805	8813	8821	1	3	4	6	7
62	8829	8838	8846	8854	8862	8870	8878	8886	8894	8902	1	3	4	5	7
63	8910	8919	8928	8934	8942	8949	8957	8965	8973	8980	1	3	4	5	6
64	8988	8996	9003	9011	9018	9026	9033	9041	9048	9056	1	3	4	5	6
65	9063	9070	9078	9085	9092	9100	9107	9114	9121	9128	1	2	4	5	6
66	9135	9143	9150	9157	9164	9171	9178	9184	9191	9198	1	2	3	5	6
67	9205	9212	9219	9225	9232	9239	9245	9252	9259	9265	1	2	3	4	6
68	9272	9278	9285	9291	9298	9304	9311	9317	9323	9330	1	2	3	4	5
69	9336	9342	9348	9354	9361	9367	9373	9379	9385	9391	1	2	3	4	5
70°	9397	9403	9409	9415	9421	9426	9432	9438	9444	9449	1	2	3	4	5
71	9455	9461	9466	9472	9478	9483	9489	9494	9500	9505	1	2	3	4	5
72	9511	9516	9521	9527	9532	9537	9542	9548	9553	9558	1	2	3	3	4
73	9563	9568	9573	9578	9583	9588	9593	9598	9603	9608	1	2	2	3	4
74	9613	9617	9622	9627	9632	9636	9641	9646	9650	9655	1	2	2	3	4
75	9659	9664	9668	9673	9677	9681	9686	9690	9694	9699	1	1	2	3	4
76	9703	9707	9711	9715	9720	9724	9728	9732	9736	9740	1	1	2	3	3
77	9744	9748	9751	9755	9759	9763	9767	9770	9774	9778	1	1	2	3	3
78	9781	9785	9789	9792	9796	9799	9803	9806	9810	9813	1	1	2	2	3
79	9816	9820	9823	9826	9829	9833	9836	9839	9842	9845	1	1	2	2	3
80°	9848	9851	9854	9857	9860	9863	9866	9869	9871	9874	0	1	1	2	2
81	9877	9880	9882	9885	9888	9890	9893	9895	9898	9900	0	1	1	2	2
82	9903	9905	9907	9910	9912	9914	9917	9919	9921	9923	0	1	1	2	2
83	9925	9928	9930	9932	9934	9936	9938	9940	9942	9943	0	1	1	2	2
84	9945	9947	9949	9951	9952	9954	9956	9957	9959	9960	0	1	1	2	2
85	9962	9963	9965	9966	9968	9969	9971	9972	9973	9974	0	1	1	1	1
86	9976	9977	9978	9979	9980	9981	9982	9983	9984	9985	0	0	1	1	1
87	9986	9987	9988	9989	9990	9990	9991	9992	9993	9993	0	0	0	1	1
88	9994	9995	9995	9996	9996	9997	9997	9997	9998	9998	0	0	0	0	0
89	9998	9999	9999	9999	9999	1-000	1-000	1-000	1-000	1-000	0	0	0	0	0

N.B.—Subtract Mean Differences

	0'	6'	12'	18'	24'	30'	36'	42'	48'	54'	Mean Differences				
											1'	2'	3'	4'	5'
0'	1-000	1-000	1-000	1-000	1-000	1-000	-9999	9999	9999	9999	0	0	0	0	0
1	-9998	9998	9998	9997	9997	9997	9996	9996	9995	9995	0	0	0	0	0
2	-9994	9993	9993	9992	9991	9990	9990	9989	9988	9987	0	0	0	1	1
3	-9986	9985	9984	9983	9982	9981	9980	9979	9978	9977	0	0	1	1	1
4	-9976	9974	9973	9972	9971	9969	9968	9966	9965	9963	0	0	1	1	1
5	-9962	9960	9959	9957	9956	9954	9952	9951	9949	9947	0	1	1	1	2
6	-9945	9943	9942	9940	9938	9936	9934	9932	9930	9928	0	1	1	1	2
7	-9925	9923	9921	9919	9917	9914	9912	9910	9907	9905	0	1	1	2	2
8	-9903	9900	9898	9895	9893	9890	9888	9885	9882	9880	0	1	1	2	2
9	-9877	9874	9871	9869	9866	9863	9860	9857	9854	9851	0	1	1	2	2
10'	-9848	9845	9842	9839	9836	9833	9829	9826	9823	9820	1	1	2	2	3
11	-9816	9813	9810	9806	9803	9799	9796	9792	9789	9785	1	1	2	2	3
12	-9781	9778	9774	9770	9767	9763	9759	9755	9751	9748	1	1	2	3	3
13	-9744	9740	9736	9732	9728	9724	9720	9715	9711	9707	1	1	2	3	3
14	-9703	9699	9694	9690	9686	9681	9677	9673	9668	9664	1	1	2	3	4
15	-9659	9655	9650	9646	9641	9636	9632	9627	9622	9617	1	2	2	3	4
16	-9613	9608	9603	9598	9593	9588	9583	9578	9573	9568	1	2	2	3	4
17	-9563	9558	9553	9548	9542	9537	9532	9527	9521	9516	1	2	3	3	4
18	-9511	9505	9500	9494	9489	9483	9478	9472	9466	9461	1	2	3	4	5
19	-9445	9440	9434	9428	9422	9416	9411	9405	9400	9403	1	2	3	4	5
20'	-9397	9391	9385	9379	9373	9367	9361	9354	9348	9342	1	2	3	4	5
21	-9336	9330	9323	9317	9311	9304	9298	9291	9285	9278	1	2	3	4	5
22	-9272	9265	9259	9252	9245	9239	9232	9225	9219	9212	1	2	3	4	6
23	-9205	9198	9191	9184	9178	9171	9164	9157	9150	9143	1	2	3	5	6
24	-9135	9128	9121	9114	9107	9100	9092	9085	9078	9070	1	2	4	5	6
25	-9003	9056	9048	9041	9033	9026	9018	9011	9003	8996	1	3	4	5	6
26	-8988	8980	8973	8965	8957	8949	8942	8934	8926	8918	1	3	4	5	6
27	-8910	8902	8894	8886	8878	8870	8862	8854	8846	8838	1	3	4	5	7
28	-8829	8821	8813	8805	8796	8788	8780	8771	8763	8755	1	3	4	6	7
29	-8746	8738	8729	8721	8712	8704	8695	8686	8678	8669	1	3	4	6	7
30'	-8660	8652	8643	8634	8625	8616	8607	8599	8590	8581	1	3	4	6	7
31	-8572	8563	8554	8545	8536	8528	8517	8508	8499	8490	2	3	5	6	8
32	-8480	8471	8462	8453	8443	8434	8425	8415	8406	8396	2	3	5	6	8
33	-8387	8377	8368	8358	8348	8339	8329	8320	8310	8300	2	3	5	6	8
34	-8290	8281	8271	8261	8251	8241	8231	8221	8211	8202	2	3	5	7	8
35	-8192	8181	8171	8161	8151	8141	8131	8121	8111	8100	2	3	5	7	8
36	-8000	8080	8070	8059	8049	8039	8028	8018	8007	7997	2	3	5	7	9
37	-7986	7976	7965	7955	7944	7934	7923	7912	7902	7891	2	4	5	7	9
38	-7880	7869	7859	7848	7837	7826	7815	7804	7793	7782	2	4	5	7	9
39	-7771	7760	7749	7738	7727	7716	7705	7694	7683	7672	2	4	6	7	9
40'	-7660	7649	7638	7627	7615	7604	7593	7581	7570	7559	2	4	6	8	9
41	-7547	7536	7524	7513	7501	7490	7478	7466	7455	7443	2	4	6	8	10
42	-7431	7420	7408	7396	7385	7373	7361	7349	7337	7325	2	4	6	8	10
43	-7314	7302	7290	7278	7266	7254	7242	7230	7218	7206	2	4	6	8	10
44	-7193	7181	7169	7157	7145	7133	7120	7108	7096	7083	2	4	6	8	10

N.B.—Subtract Mean Differences

	0'	6'	12'	18'	24'	30'	36'	42'	48'	54'	Mean Differences				
											1'	2'	3'	4'	5'
45°	.7071	7059	7046	7034	7022	7000	6997	6984	6972	6959	2	4	0	8	10
46	.6047	6934	6921	6909	6896	6884	6871	6858	6845	6833	2	4	0	8	11
47	.6820	6807	6794	6782	6769	6756	6743	6730	6717	6704	2	4	6	0	11
48	.6691	6678	6665	6652	6639	6626	6613	6600	6587	6574	2	4	7	9	11
49	.6561	6547	6534	6521	6508	6494	6481	6468	6455	6441	2	4	7	9	11
50°	.6428	6414	6401	6388	6374	6361	6347	6334	6320	6307	2	4	7	9	11
51	.6293	6280	6266	6252	6239	6225	6211	6198	6184	6170	2	5	7	9	11
52	.6157	6143	6129	6115	6101	6088	6074	6060	6046	6032	2	5	7	9	12
53	.6018	6004	5990	5976	5962	5948	5934	5920	5906	5892	2	5	7	9	12
54	.5878	5864	5850	5835	5821	5807	5793	5779	5764	5750	2	5	7	9	12
55	.5738	5724	5709	5695	5681	5667	5653	5639	5625	5611	2	5	7	10	12
56	.5592	5577	5563	5548	5534	5519	5505	5490	5476	5461	2	5	7	10	12
57	.5440	5425	5411	5396	5382	5367	5353	5338	5324	5310	2	5	7	10	12
58	.5290	5274	5259	5245	5230	5215	5201	5186	5172	5157	2	5	7	10	12
59	.5150	5133	5118	5103	5088	5073	5058	5043	5028	5013	3	5	8	10	13
60°	.5000	4985	4970	4955	4939	4924	4909	4894	4879	4863	3	5	8	10	13
61	.4848	4833	4818	4802	4787	4772	4756	4741	4726	4710	3	5	8	10	13
62	.4695	4679	4664	4648	4633	4617	4602	4586	4571	4555	3	5	8	10	13
63	.4540	4524	4509	4493	4478	4462	4446	4431	4415	4399	3	5	8	10	13
64	.4384	4368	4352	4337	4321	4305	4289	4274	4258	4242	3	5	8	11	13
65	.4226	4210	4195	4179	4163	4147	4131	4115	4099	4083	3	5	8	11	13
66	.4067	4051	4035	4019	4003	3987	3971	3955	3939	3923	3	5	8	11	14
67	.3907	3891	3875	3859	3843	3827	3811	3795	3778	3762	3	5	8	11	14
68	.3746	3730	3714	3698	3682	3666	3649	3633	3616	3600	3	5	8	11	14
69	.3584	3567	3551	3535	3518	3502	3486	3469	3453	3437	3	5	8	11	14
70°	.3420	3404	3387	3371	3355	3338	3322	3305	3289	3272	3	5	8	11	14
71	.3256	3239	3223	3206	3190	3173	3156	3140	3123	3107	3	6	8	11	14
72	.3090	3074	3057	3040	3024	3007	2990	2974	2957	2940	3	6	8	11	14
73	.2924	2907	2890	2874	2857	2840	2823	2807	2790	2773	3	6	8	11	14
74	.2756	2740	2723	2706	2689	2672	2656	2639	2622	2605	3	6	8	11	14
75	.2588	2571	2554	2538	2521	2504	2487	2470	2453	2436	3	6	8	11	14
76	.2419	2402	2385	2368	2351	2334	2317	2300	2284	2267	3	6	8	11	14
77	.2250	2233	2215	2198	2181	2164	2147	2130	2113	2096	3	6	8	11	14
78	.2079	2062	2045	2028	2011	1994	1977	1959	1942	1925	3	6	9	11	14
79	.1908	1891	1874	1857	1840	1823	1805	1788	1771	1754	3	6	9	11	14
80°	.1736	1719	1702	1685	1668	1650	1633	1616	1599	1582	3	6	9	12	14
81	.1564	1547	1530	1513	1495	1478	1461	1444	1426	1409	3	6	9	12	14
82	.1392	1374	1357	1340	1323	1305	1288	1271	1253	1236	3	6	9	12	14
83	.1219	1201	1184	1167	1149	1132	1115	1097	1080	1063	3	6	9	12	14
84	.1045	1028	1011	993	976	958	941	924	906	889	3	6	9	12	14
85	.0872	0854	0837	0819	0802	0785	0767	0750	0732	0715	3	6	9	12	14
86	.0698	0680	0663	0645	0628	0610	0593	0576	0558	0541	3	6	9	12	15
87	.0523	0506	0488	0471	0454	0436	0419	0401	0384	0366	3	6	9	12	15
88	.0349	0332	0314	0297	0279	0262	0244	0227	0209	0192	3	6	9	12	15
89	.0175	0157	0140	0122	0105	0087	0070	0052	0035	0017	3	6	9	12	15

	0'	6'	12'	18'	24'	30'	36'	42'	48'	54'	Mean Differences				
											1'	2'	3'	4'	5'
0°	0000	0017	0035	0052	0070	0087	0105	0122	0140	0157	3	0	0	12	15
1	-0175	0192	0209	0227	0244	0262	0279	0297	0314	0332	3	0	0	12	15
2	-0349	0367	0384	0402	0419	0437	0454	0472	0489	0507	3	0	9	12	15
3	-0524	0542	0559	0577	0594	0612	0629	0647	0664	0682	3	6	9	12	16
4	-0699	0717	0734	0752	0769	0787	0805	0822	0840	0857	3	6	0	12	15
5	-0875	0892	0910	0928	0945	0963	0981	0998	1016	1033	3	0	9	12	15
6	-1051	1069	1086	1104	1122	1139	1157	1175	1192	1210	3	6	9	12	15
7	-1228	1246	1263	1281	1299	1317	1334	1352	1370	1388	3	6	9	12	15
8	-1405	1423	1441	1459	1477	1495	1512	1530	1548	1566	3	6	9	12	15
9	-1584	1602	1620	1638	1655	1673	1691	1709	1727	1745	3	6	9	12	15
10°	-1763	1781	1799	1817	1835	1853	1871	1890	1908	1926	3	6	9	12	15
11	-1944	1962	1980	1998	2016	2035	2053	2071	2089	2107	3	6	9	12	15
12	-2126	2144	2162	2180	2199	2217	2235	2254	2272	2290	3	6	9	12	15
13	-2309	2327	2345	2364	2382	2401	2419	2438	2456	2475	3	6	9	12	15
14	-2493	2512	2530	2549	2568	2586	2605	2623	2642	2661	3	6	9	12	16
15	-2679	2698	2717	2736	2754	2773	2792	2811	2830	2849	3	6	9	13	16
16	-2867	2886	2905	2924	2943	2962	2981	3000	3019	3038	3	6	9	13	16
17	-3057	3076	3096	3115	3134	3153	3172	3191	3211	3230	3	6	10	13	16
18	-3240	3269	3288	3307	3327	3346	3365	3385	3404	3424	3	0	10	13	16
19	-3443	3463	3482	3502	3522	3541	3561	3581	3600	3620	3	7	10	13	16
20°	-3640	3659	3679	3699	3719	3739	3759	3779	3799	3819	3	7	10	13	17
21	-3839	3859	3879	3899	3919	3939	3959	3979	4000	4020	3	7	10	13	17
22	-4040	4061	4081	4101	4122	4142	4163	4183	4204	4224	3	7	10	14	17
23	-4245	4265	4286	4307	4327	4348	4369	4390	4411	4431	3	7	10	14	17
24	-4452	4473	4494	4515	4536	4557	4578	4599	4621	4642	4	7	11	14	18
25	-4663	4684	4706	4727	4748	4770	4791	4813	4834	4856	4	7	11	14	18
26	-4877	4899	4921	4942	4964	4986	5008	5029	5051	5073	4	7	11	15	18
27	-5095	5117	5139	5161	5184	5206	5228	5250	5272	5295	4	7	11	15	18
28	-5317	5340	5362	5384	5407	5430	5452	5475	5498	5520	4	8	11	15	19
29	-5543	5566	5589	5612	5635	5658	5681	5704	5727	5750	4	8	12	15	19
30°	-5774	5797	5820	5844	5867	5890	5914	5938	5961	5985	4	8	12	16	20
31	-6009	6032	6056	6080	6104	6128	6152	6176	6200	6224	4	8	12	16	20
32	-6249	6273	6297	6322	6346	6371	6395	6420	6445	6469	4	8	12	16	20
33	-6494	6519	6544	6569	6594	6619	6644	6669	6694	6720	4	8	13	17	21
34	-6745	6771	6796	6822	6847	6873	6899	6924	6950	6976	4	9	13	17	21
35	-7002	7028	7054	7080	7107	7133	7159	7186	7212	7239	4	9	13	18	22
36	-7265	7292	7319	7346	7373	7400	7427	7454	7481	7508	5	9	14	18	23
37	-7536	7563	7590	7618	7646	7673	7701	7729	7757	7785	5	9	14	18	23
38	-7813	7841	7869	7898	7926	7954	7983	8012	8040	8069	5	9	14	19	24
39	-8098	8127	8156	8185	8214	8243	8273	8302	8332	8361	5	10	15	20	24
40°	-8391	8421	8451	8481	8511	8541	8571	8601	8632	8662	5	10	15	20	25
41	-8893	8724	8754	8785	8816	8847	8878	8910	8941	8972	5	10	16	21	26
42	-9004	9036	9067	9099	9131	9163	9195	9228	9260	9293	5	11	16	21	27
43	-9325	9358	9391	9424	9457	9490	9523	9556	9590	9623	6	11	17	22	28
44	-9657	9691	9725	9759	9793	9827	9861	9896	9930	9965	6	11	17	23	29

	0'	6'	12'	18'	24'	30'	36'	42'	48'	54'	Mean Differences				
											1'	2'	3'	4'	5'
45°	1-0000	0035	0070	0105	0141	0176	0212	0247	0283	0319	6	12	18	24	30
46	1-0355	0392	0428	0464	0501	0538	0575	0612	0649	0686	6	12	18	25	31
47	1-0724	0761	0799	0837	0875	0913	0951	0990	1028	1067	6	13	19	25	32
48	1-1106	1145	1184	1224	1263	1303	1343	1383	1423	1463	7	13	20	27	33
49	1-1504	1544	1585	1626	1667	1708	1750	1792	1833	1875	7	14	21	28	34
50°	1-1918	1960	2002	2045	2088	2131	2174	2218	2261	2305	7	14	22	29	36
51	1-2340	2393	2437	2482	2527	2572	2617	2662	2708	2753	8	15	23	30	38
52	1-2799	2846	2892	2938	2985	3032	3079	3127	3175	3222	8	16	24	31	39
53	1-3270	3319	3367	3416	3465	3514	3564	3613	3663	3713	8	16	25	33	41
54	1-3764	3814	3865	3916	3968	4019	4071	4124	4176	4229	9	17	26	34	43
55	1-4281	4335	4388	4442	4496	4550	4605	4659	4715	4770	9	18	27	36	45
56	1-4820	4882	4938	4994	5051	5108	5166	5224	5282	5340	10	19	29	38	48
57	1-5399	5458	5517	5577	5637	5697	5757	5818	5880	5941	10	20	30	40	50
58	1-6003	6066	6128	6191	6255	6319	6383	6447	6512	6577	11	21	32	43	53
59	1-6643	6709	6775	6842	6909	6977	7045	7113	7182	7251	11	23	34	45	56
60°	1-7321	7391	7461	7532	7603	7675	7747	7820	7893	7966	12	24	36	48	60
61	1-8040	8115	8190	8265	8341	8418	8495	8572	8650	8728	13	26	38	51	64
62	1-8807	8887	8967	9047	9128	9210	9292	9375	9458	9542	14	27	41	55	68
63	1-9626	9711	9797	9883	9970	0057	0145	0233	0323	0413	15	29	44	58	73
64	2-0503	0594	0686	0778	0872	0965	1060	1155	1251	1348	16	31	47	63	78
65	2-1445	1543	1642	1742	1842	1943	2045	2148	2251	2355	17	34	51	68	85
66	2-2400	2560	2673	2781	2889	2998	3109	3220	3332	3445	18	37	55	73	92
67	2-3559	3673	3789	3906	4023	4142	4262	4383	4504	4627	20	40	60	79	99
68	2-4751	4876	5002	5129	5257	5386	5517	5649	5782	5916	22	43	65	87	108
69	2-6051	6187	6325	6464	6605	6746	6889	7034	7179	7326	24	47	71	95	119
70°	2-7475	7625	7770	7929	8083	8239	8397	8556	8710	8878	26	52	78	104	131
71	2-9042	9208	9375	9544	9714	9887	0061	0237	0415	0595	29	58	87	116	145
72	3-0777	0961	1146	1334	1524	1716	1910	2106	2305	2506	32	64	99	129	161
73	3-2709	2914	3122	3332	3544	3759	3977	4197	4420	4646	36	72	108	144	180
74	3-4874	5195	5339	5576	5816	6059	6305	6554	6806	7062	41	81	122	163	204
75	3-7321	7583	7848	8118	8391	8667	8947	9232	9520	9812	46	93	139	186	232
76	4-0108	0408	0713	1022	1335	1653	1976	2303	2635	2972					
77	4-3315	3662	4015	4374	4737	5107	5483	5864	6252	6646					
78	4-7046	7453	7867	8288	8716	9152	9594	0045	0504	0970					
79	5-1446	1929	2422	2924	3435	3955	4486	5026	5578	6140					
80°	5-0713	7207	7894	8592	9124	9758	0405	1066	1742	2432					
81	6-3138	3859	4596	5350	6122	6912	7720	8548	9395	0264	Mean differences no longer sufficiently accurate.				
82	7-1154	2066	3002	3962	4947	5958	6996	8062	9158	0285					
83	8-1443	2636	3663	4726	5827	6967	7769	9152	0579	0572					
84	9-514	9-677	0-845	10-02	10-20	10-39	10-58	10-78	10-99	11-20					
85	11-43	11-66	11-91	12-16	12-43	12-71	13-00	13-30	13-62	13-95					
86	14-30	14-67	15-06	15-46	15-89	16-35	16-83	17-34	17-89	18-46					
87	19-08	19-74	20-45	21-20	22-02	22-90	23-88	24-90	26-03	27-27					
88	28-64	30-14	31-82	33-69	35-80	38-19	40-92	44-07	47-74	52-08					
89	57-29	63-66	71-62	81-85	95-49	114-6	143-2	191-0	266-5	573-0					

	0'	6'	12'	18'	24'	30'	36'	42'	48'	54'	Mean Differences				
											1'	2'	3'	4'	5'
0°	—	3-2419	5429	7190	8439	9408	0200	0870	1450	1961					
1	3-2419	2832	3210	3558	3880	4170	4450	4723	4971	5206					
2	2-5428	5640	5842	6035	6220	6397	6567	6731	6889	7041					
3	2-7188	7330	7468	7602	7731	7857	7979	8098	8213	8326					
4	2-8436	8543	8647	8749	8849	8946	9042	9135	9226	9315	16	32	48	64	80
5	2-9403	9489	9573	9655	9736	9816	9894	9970	0046	0120	13	26	39	52	65
6	I-0192	0264	0334	0403	0472	0539	0605	0670	0734	0797	11	22	33	44	55
7	I-0859	0920	0981	1040	1099	1157	1214	1271	1326	1381	10	19	29	38	48
8	I-1436	1489	1542	1594	1646	1697	1747	1797	1847	1895	8	17	25	34	42
9	I-1943	1991	2038	2085	2131	2176	2221	2266	2310	2353	8	15	23	30	38
10°	I-2397	2439	2482	2524	2565	2606	2647	2687	2727	2767	7	14	20	27	34
11	I-2806	2845	2883	2921	2959	2997	3034	3070	3107	3143	6	12	19	25	31
12	I-3179	3214	3250	3284	3319	3353	3387	3421	3455	3488	6	11	17	23	28
13	I-3521	3554	3586	3618	3650	3682	3713	3745	3775	3806	5	11	16	21	26
14	I-3837	3867	3897	3927	3957	3986	4015	4044	4073	4102	5	10	15	20	24
15	I-4130	4158	4186	4214	4242	4269	4296	4323	4350	4377	5	9	14	18	23
16	I-4403	4430	4456	4482	4508	4533	4559	4584	4609	4634	4	9	13	17	21
17	I-4659	4684	4709	4733	4757	4781	4805	4829	4853	4876	4	8	12	16	20
18	I-4900	4923	4946	4969	4992	5015	5037	5060	5082	5104	4	8	11	15	19
19	I-5126	5148	5170	5192	5213	5235	5256	5278	5299	5320	4	7	11	14	18
20°	I-5441	5461	5482	5492	5423	5443	5463	5484	5504	5523	3	7	10	14	17
21	I-5543	5563	5583	5602	5621	5641	5660	5679	5698	5717	3	6	10	13	16
22	I-5736	5754	5773	5792	5810	5828	5847	5865	5883	5901	3	6	9	12	15
23	I-5919	5937	5954	5972	5990	6007	6024	6042	6059	6076	3	6	9	12	15
24	I-6093	6110	6127	6144	6161	6177	6194	6210	6227	6243	3	6	8	11	14
25	I-6259	6276	6292	6308	6324	6340	6356	6371	6387	6403	3	5	8	11	13
26	I-6418	6434	6449	6465	6480	6495	6510	6526	6541	6556	3	5	8	10	13
27	I-6570	6585	6600	6615	6629	6644	6659	6673	6687	6702	2	5	7	10	12
28	I-6716	6730	6744	6759	6773	6787	6801	6814	6828	6842	2	5	7	9	12
29	I-6856	6869	6883	6896	6910	6923	6937	6950	6963	6977	2	4	7	9	11
30°	I-6990	7003	7016	7029	7042	7055	7068	7080	7093	7106	2	4	6	9	11
31	I-7118	7131	7144	7156	7168	7181	7193	7205	7218	7230	2	4	6	8	10
32	I-7242	7254	7266	7278	7290	7302	7314	7326	7338	7349	2	4	6	8	10
33	I-7361	7373	7384	7396	7407	7419	7430	7442	7453	7464	2	4	6	8	10
34	I-7476	7487	7498	7509	7520	7531	7542	7553	7564	7575	2	4	6	7	9
35	I-7580	7597	7607	7618	7629	7640	7650	7661	7671	7682	2	4	5	7	9
36	I-7692	7703	7713	7723	7734	7744	7754	7764	7774	7785	2	3	5	7	9
37	I-7795	7805	7815	7825	7835	7844	7854	7864	7874	7884	2	3	5	7	8
38	I-7893	7903	7913	7922	7932	7941	7951	7960	7970	7979	2	3	5	6	8
39	I-7989	7998	8007	8017	8026	8035	8044	8053	8063	8072	2	3	5	6	8
40°	I-8081	8090	8099	8108	8117	8125	8134	8143	8152	8161	1	3	4	6	7
41	I-8169	8178	8187	8195	8204	8213	8221	8230	8238	8247	1	3	4	6	7
42	I-8255	8264	8272	8280	8289	8297	8305	8313	8322	8330	1	3	4	6	7
43	I-8338	8346	8354	8362	8370	8378	8386	8394	8402	8410	1	3	4	5	7
44	I-8411	8426	8433	8441	8449	8457	8464	8472	8480	8487	1	3	4	5	6

		0'	6'	12'	18'	24'	30'	36'	42'	48'	54'	Mean Differences				
												1'	2'	3'	4'	5'
45°	I-8495	8502	8510	8517	8525	8532	8540	8547	8555	8562	1	2	4	5	6	
46	I-8569	8577	8584	8591	8598	8606	8613	8620	8627	8634	1	2	4	5	6	
47	I-8641	8648	8655	8662	8669	8676	8683	8690	8697	8704	1	2	3	5	6	
48	I-8711	8718	8724	8731	8738	8745	8751	8758	8765	8771	1	2	3	4	6	
49	I-8778	8784	8791	8797	8804	8810	8817	8823	8830	8836	1	2	3	4	5	
50°	I-8843	8849	8855	8862	8868	8874	8880	8887	8893	8899	1	2	3	4	5	
51	I-8905	8911	8917	8923	8929	8935	8941	8947	8953	8959	1	2	3	4	5	
52	I-8965	8971	8977	8983	8989	8995	9000	9006	9012	9018	1	2	3	4	5	
53	I-9023	9029	9035	9041	9046	9052	9057	9063	9069	9074	1	2	3	4	5	
54	I-9080	9085	9091	9096	9101	9107	9112	9118	9123	9128	1	2	3	4	5	
55	I-9134	9139	9144	9149	9155	9160	9165	9170	9175	9181	1	2	3	3	4	
56	I-9188	9191	9196	9201	9206	9211	9216	9221	9226	9231	1	2	3	3	4	
57	I-9230	9241	9246	9251	9255	9260	9265	9270	9275	9279	1	2	2	3	4	
58	I-9284	9289	9294	9298	9303	9308	9312	9317	9322	9326	1	2	2	3	4	
59	I-9331	9335	9340	9344	9349	9353	9358	9362	9367	9371	1	1	2	3	4	
60°	I-9375	9380	9384	9388	9393	9397	9401	9406	9410	9414	1	1	2	3	4	
61	I-9418	9422	9427	9431	9435	9439	9443	9447	9451	9455	1	1	2	3	3	
62	I-9459	9463	9467	9471	9475	9479	9483	9487	9491	9495	1	1	2	3	3	
63	I-9499	9503	9507	9510	9514	9518	9522	9525	9529	9533	1	1	2	3	3	
64	I-9537	9540	9544	9548	9551	9555	9558	9562	9566	9569	1	1	2	2	3	
65	I-9573	9576	9580	9583	9587	9590	9594	9597	9601	9604	1	1	2	2	3	
66	I-9607	9611	9614	9617	9621	9624	9627	9631	9634	9637	1	1	2	2	3	
67	I-9640	9643	9647	9650	9653	9656	9659	9662	9666	9669	1	1	2	2	3	
68	I-9672	9675	9678	9681	9684	9687	9690	9693	9696	9699	0	1	1	2	2	
69	I-9702	9704	9707	9710	9713	9716	9719	9722	9724	9727	0	1	1	2	2	
70°	I-9730	9733	9736	9738	9741	9743	9746	9749	9751	9754	0	1	1	2	2	
71	I-9757	9759	9762	9764	9767	9770	9772	9775	9777	9780	0	1	1	2	2	
72	I-9782	9785	9787	9789	9792	9794	9797	9799	9801	9804	0	1	1	2	2	
73	I-9806	9808	9811	9813	9815	9817	9820	9822	9824	9826	0	1	1	2	2	
74	I-9828	9831	9833	9835	9837	9839	9841	9843	9845	9847	0	1	1	1	2	
75	I-9849	9851	9853	9855	9857	9859	9861	9863	9865	9867	0	1	1	1	2	
76	I-9869	9871	9873	9875	9876	9878	9880	9882	9884	9885	0	1	1	1	2	
77	I-9887	9889	9891	9892	9894	9896	9897	9899	9901	9902	0	1	1	1	1	
78	I-9904	9906	9907	9909	9910	9912	9913	9915	9916	9918	0	1	1	1	1	
79	I-9919	9921	9922	9924	9925	9927	9928	9929	9931	9932	0	0	1	1	1	
80°	I-9934	9935	9936	9937	9939	9940	9941	9943	9944	9945	0	0	1	1	1	
81	I-9946	9947	9949	9950	9951	9952	9953	9954	9955	9956	0	0	1	1	1	
82	I-9958	9959	9960	9961	9962	9963	9964	9965	9966	9967	0	0	1	1	1	
83	I-9968	9968	9969	9970	9971	9972	9973	9974	9975	9975	0	0	0	1	1	
84	I-9976	9977	9978	9978	9979	9980	9981	9981	9982	9983	0	0	0	0	1	
85	I-9983	9984	9985	9985	9986	9987	9987	9988	9988	9989	0	0	0	0	0	
85	I-9989	9990	9990	9991	9991	9992	9992	9993	9993	9994	0	0	0	0	0	
87	I-9994	9994	9995	9995	9996	9996	9996	9997	9997	9997	0	0	0	0	0	
87	I-9997	9998	9998	9998	9998	9999	9999	9999	9999	9999	0	0	0	0	0	
89	I-9999	9999	0000	0000	0000	0000	0000	0000	0000	0000	0	0	0	0	0	

LOGARITHMIC COSINES

Subtract Mean Differences

	0'	6'	12'	18'	24'	30'	36'	42'	48'	54'	Mean Differences					
											1'	2'	3'	4'	5'	
0	0.0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	1.9999	0	0	0	0	0
1	0.9999	0999	9999	9999	0999	9999	0908	0908	9998	9998	0998	0	0	0	0	0
2	0.9997	0997	9997	9996	9996	0996	9996	0995	9995	9994	0994	0	0	0	0	0
3	0.9994	0994	9993	9993	0992	9992	0991	9991	9990	9990	0990	0	0	0	0	0
4	0.9991	0989	9988	9988	0987	9987	0986	9985	9985	9984	0984	0	0	0	0	0
5	0.9988	0983	9982	9981	0981	9980	0979	9978	9978	9977	0977	0	0	0	0	1
6	0.9984	0976	9975	9974	0973	9972	0971	9970	9969	9968	0968	0	0	0	1	1
7	0.9980	0968	9967	9966	0965	9964	0963	9962	9961	9960	0959	0	0	1	1	1
8	0.9976	0958	9958	9955	0954	9953	0952	9951	9950	9949	0947	0	0	1	1	1
9	0.9971	0946	9945	9944	0943	9941	0940	9939	9937	9936	0935	0	0	1	1	1
10	0.9966	0934	9932	9931	0929	9928	0927	9925	9924	9922	0921	0	0	1	1	1
11	0.9961	0919	9918	9916	0915	9913	0912	9910	9909	9907	0906	0	1	1	1	1
12	0.9956	0901	9902	9901	0900	9897	0896	9894	9892	9891	0889	0	1	1	1	1
13	0.9951	0887	9885	9884	0882	9880	0878	9876	9875	9873	0871	0	1	1	1	2
14	0.9946	0869	9867	9865	0863	9861	0859	9857	9855	9853	0851	0	1	1	1	2
15	0.9941	0849	9847	9845	0843	9841	9839	9837	9835	9833	0831	0	1	1	1	2
16	0.9936	0828	9826	9824	0822	9820	0817	9815	9813	9811	0808	0	1	1	2	2
17	0.9931	0806	9804	9801	0799	9797	0794	9792	9789	9787	0785	0	1	1	2	2
18	0.9926	0782	9780	9777	0775	9772	0770	9767	9764	9762	0759	0	1	1	2	2
19	0.9921	0757	9754	9751	0749	9746	0743	9741	9738	9735	0733	0	1	1	2	2
20	0.9916	0730	9727	9724	0722	0719	0716	9713	9710	9707	0704	0	1	1	2	2
21	0.9911	0699	9696	9693	0690	9687	0684	9681	9678	9675	0672	0	1	1	2	2
22	0.9906	0672	9669	9666	0662	9659	0656	9653	9650	9647	0643	1	1	2	2	3
23	0.9901	0640	9637	9634	0631	9627	0624	9621	9617	9614	0611	1	1	2	2	3
24	0.9896	0607	9604	9601	0597	9594	0590	9587	9583	9580	0576	1	1	2	2	3
25	0.9891	0573	9569	9566	0562	9558	0555	9551	9548	9544	0540	1	1	2	2	3
26	0.9886	0537	9533	9529	0525	9522	0518	9514	9510	9507	0503	1	1	2	3	3
27	0.9881	0499	9495	0491	0487	9483	0479	9475	9471	9467	0463	1	1	2	3	3
28	0.9876	0459	9455	0451	0447	9443	0439	9435	9431	9427	0422	1	1	2	3	3
29	0.9871	0418	9414	0410	0406	9401	0397	9393	9388	9384	0380	1	1	2	3	4
30	0.9866	0375	9371	9367	0362	9358	0353	9349	9344	9340	0335	1	1	2	3	4
31	0.9861	0331	9326	9322	0317	9312	0308	9303	9298	9294	0289	1	2	2	3	4
32	0.9856	0281	9279	9275	0270	9265	0260	9255	9251	9246	0241	1	2	2	3	4
33	0.9851	0236	9231	9226	0221	9216	0211	9206	9201	9196	0191	1	2	2	3	4
34	0.9846	0186	9181	9175	0170	9165	0160	9155	9149	9144	0139	1	2	2	3	4
35	0.9841	0134	9128	9123	0118	9112	0107	9101	9096	9091	0085	1	2	2	3	4
36	0.9836	0080	9074	9069	0063	9057	0052	9046	9041	9035	0029	1	2	2	3	4
37	0.9831	0023	9018	9012	0006	9000	8993	8988	8983	8977	0071	1	2	2	3	4
38	0.9826	8965	8959	8953	8947	8941	8935	8929	8923	8917	0011	1	2	2	3	4
39	0.9821	8905	8899	8893	8887	8880	8874	8868	8862	8855	8849	1	2	2	3	4
40	0.9816	8843	8836	8830	8823	8817	8810	8804	8797	8791	8784	1	2	2	3	4
41	0.9811	8778	8771	8765	8758	8751	8745	8738	8731	8724	8718	1	2	2	3	5
42	0.9806	8711	8704	8697	8690	8683	8676	8669	8662	8655	8648	1	2	2	3	5
43	0.9801	8641	8634	8627	8620	8613	8606	8598	8591	8584	8577	1	2	2	3	5
44	0.9796	8569	8562	8555	8547	8540	8532	8525	8517	8510	8502	1	2	2	3	5

Subtract Mean Differences

	0'	6'	12'	18'	24'	30'	36'	42'	48'	54'	Mean Differences				
											1'	2'	3'	4'	5'
45°	I-8495	8487	8480	8472	8464	8457	8449	8441	8433	8420	1	3	4	5	6
46	I-8418	8410	8402	8394	8386	8378	8370	8362	8354	8346	1	3	4	5	7
47	I-8338	8330	8322	8313	8305	8297	8289	8280	8272	8264	1	3	4	6	7
48	I-8255	8247	8238	8230	8221	8213	8204	8195	8187	8178	1	3	4	6	7
49	I-8169	8161	8152	8143	8134	8125	8117	8108	8099	8090	1	3	4	6	7
50°	I-8081	8072	8063	8053	8044	8035	8026	8017	8007	7998	2	3	5	6	8
51	I-7989	7979	7970	7960	7951	7941	7932	7922	7913	7903	2	3	5	6	8
52	I-7893	7884	7874	7864	7854	7844	7835	7825	7815	7805	2	3	5	7	8
53	I-7795	7785	7774	7764	7754	7744	7734	7723	7713	7703	2	3	5	7	9
54	I-7692	7682	7671	7661	7650	7640	7629	7618	7607	7597	2	4	5	7	9
55	I-7586	7575	7564	7553	7542	7531	7520	7509	7498	7487	2	4	6	7	9
56	I-7476	7464	7453	7442	7430	7419	7407	7396	7384	7373	2	4	6	8	10
57	I-7361	7349	7338	7326	7314	7302	7290	7278	7266	7254	2	4	6	8	10
58	I-7242	7230	7218	7205	7193	7181	7168	7156	7144	7131	2	4	6	8	10
59	I-7118	7106	7093	7080	7068	7055	7042	7029	7016	7003	2	4	6	9	11
60°	I-6990	6977	6963	6950	6937	6923	6910	6896	6883	6869	2	4	7	9	11
61	I-6856	6842	6828	6814	6801	6787	6773	6759	6744	6730	2	5	7	9	12
62	I-6716	6702	6687	6673	6659	6644	6629	6615	6600	6585	2	5	7	10	12
63	I-6570	6556	6541	6526	6510	6495	6480	6465	6449	6434	3	5	8	10	13
64	I-6418	6403	6387	6371	6356	6340	6324	6308	6292	6276	3	5	8	11	13
65	I-6259	6243	6227	6210	6194	6177	6161	6144	6127	6110	3	6	8	11	14
66	I-6093	6076	6059	6042	6024	6007	5990	5972	5954	5937	3	6	9	12	15
67	I-5919	5901	5883	5865	5847	5828	5810	5792	5773	5754	3	6	9	12	15
68	I-5736	5717	5698	5679	5660	5641	5621	5602	5583	5563	3	6	10	13	16
69	I-5543	5523	5504	5484	5463	5443	5423	5402	5382	5361	3	7	10	14	17
70°	I-5341	5320	5299	5278	5256	5235	5213	5192	5170	5148	4	7	11	14	18
71	I-5126	5104	5082	5060	5037	5015	4992	4969	4946	4923	4	8	11	15	19
72	I-4900	4876	4853	4829	4805	4781	4757	4733	4709	4684	4	8	12	16	20
73	I-4659	4634	4609	4584	4559	4533	4508	4482	4456	4430	4	9	13	17	21
74	I-4403	4377	4350	4323	4296	4269	4242	4214	4186	4158	5	9	14	18	23
75	I-4130	4102	4073	4044	4015	3986	3957	3927	3897	3867	5	10	15	20	24
76	I-3837	3806	3775	3745	3713	3682	3650	3618	3586	3554	5	11	16	21	26
77	I-3521	3488	3455	3421	3387	3353	3319	3284	3250	3214	6	11	17	23	28
78	I-3179	3143	3107	3070	3034	2997	2959	2921	2883	2845	6	12	19	25	31
79	I-2806	2767	2727	2687	2647	2606	2565	2524	2482	2439	7	14	20	27	34
80°	I-2397	2353	2310	2266	2221	2176	2131	2085	2038	1991	8	15	23	30	38
81	I-1943	1895	1847	1797	1747	1697	1646	1594	1542	1489	8	17	25	34	42
82	I-1436	1381	1326	1271	1214	1157	1099	1040	981	920	10	19	29	38	48
83	I-0859	0797	0734	0670	0605	0539	0472	0403	0334	0264	11	22	33	44	55
84	I-0192	0120	0046	0970	9894	9818	9736	9655	9573	9489	13	26	39	52	65
85	Z-9403	9315	9226	9135	9042	8946	8849	8749	8647	8543	16	32	48	64	80
86	Z-8436	8326	8213	8098	7979	7857	7731	7602	7468	7330					
87	Z-7188	7041	6889	6731	6567	6397	6220	6035	5842	5640					
88	Z-5428	5206	4971	4723	4459	4179	3880	3558	3210	2832					
89	Z-2419	1961	1450	0870	0200	9408	8439	7190	5429	2410					

Mean	Differences	4	5
45	0	0-0000	0015
46	0	0-0152	0167
47	0	0-0303	0319
48	0	0-0454	0471
49	0	0-0605	0624
50	0	0-0757	0777
51	0	0-0910	0932
52	0	0-1062	1088
53	0	0-1229	1245
54	0	0-1387	1403
55	0	0-1548	1564
56	0	0-1710	1726
57	0	0-1875	1891
58	0	0-2042	2059
59	0	0-2212	2247
60	0	0-2386	2403
61	0	0-2562	2580
62	0	0-2743	2762
63	0	0-2928	2947
64	0	0-3118	3137
65	0	0-3313	3333
66	0	0-3514	3535
67	0	0-3721	3743
68	0	0-3936	3958
69	0	0-4158	4181
70	0	0-4389	4413
71	0	0-4630	4655
72	0	0-4882	4914
73	0	0-5147	5214
74	0	0-5425	5483
75	0	0-5719	5750
76	0	0-6032	6065
77	0	0-6365	6401
78	0	0-6725	6763
79	0	0-7113	7154
80	0	0-7537	7581
81	0	0-8003	8052
82	0	0-8522	8577
83	0	0-9109	9172
84	0	0-9784	9857
85	0	1-0580	0669
86	0	1-1554	1664
87	0	1-2806	2954
88	0	1-4566	4792
89	0	1-7581	7881
90	18	1893	1777
91	18	3240	3106
92	18	5275	5027
93	18	8000	7930
94	24	1194	1044
95	24	1612	1451
96	24	2157	1925
97	24	2838	2503
98	24	3564	3247
99	24	4435	4157
100	30	5460	5250
101	30	6648	6411
102	30	8000	7718
103	30	9537	9367
104	36	1138	9433
105	36	1352	1324
106	36	1601	1483
107	36	1885	1757
108	36	2205	2144
109	36	2560	2474
110	36	2950	2835
111	36	3375	3235
112	36	3835	3674
113	36	4330	4154
114	36	4860	4675
115	36	5425	5236
116	36	6025	5836
117	36	6660	6475
118	36	7330	7154
119	36	8035	7875
120	36	8775	8636
121	42	9550	9433
122	42	10370	10250
123	42	11235	11115
124	42	12145	12025
125	42	13100	13000
126	42	14100	14030
127	42	15145	15115
128	42	16235	16255
129	42	17370	17435
130	42	18550	18665
131	42	19775	19945
132	42	21045	21275
133	42	22360	22650
134	42	23720	24070
135	42	25135	25535
136	42	26605	27045
137	42	28130	28600
138	42	29710	30200
139	42	31345	31845
140	42	33035	33535
141	42	34780	35270
142	42	36580	37050
143	42	38435	38875
144	42	40345	40745
145	42	42310	42660
146	42	44330	44620
147	42	46405	46625
148	42	48535	48675
149	42	50720	50770
150	42	52960	52910
151	42	55255	55095
152	42	57605	57325
153	42	60010	60000
154	42	62470	62720
155	42	64985	64485
156	42	67555	67295
157	42	70180	70050
158	42	72860	72850
159	42	75595	75685
160	42	78385	78575
161	42	81230	81465
162	42	84130	84355
163	42	87085	87345
164	42	90095	90335
165	42	93160	93425
166	42	96280	96515
167	42	99455	99605
168	42	102685	102695
169	42	105970	105800
170	42	109310	109530
171	42	112705	112765
172	42	116155	116815
173	42	119660	120370
174	42	123220	124030
175	42	126835	127795
176	42	130505	131665
177	42	134230	135540
178	42	138010	139520
179	42	141845	143605
180	42	145735	147795
181	42	149680	152090
182	42	153680	156490
183	42	157735	160995
184	42	161845	165605
185	42	166010	170320
186	42	170230	175140
187	42	174505	180065
188	42	178835	185095
189	42	183220	190230
190	42	187660	195470
191	42	192155	200815
192	42	196705	206265
193	42	201310	211820
194	42	205970	217480
195	42	210685	223245
196	42	215455	229115
197	42	220280	235090
198	42	225160	241170
199	42	230095	247355
200	42	235085	253645
201	42	240130	260040
202	42	245230	266540
203	42	250385	273145
204	42	255595	279855
205	42	260860	286670
206	42	266180	293590
207	42	271555	300615
208	42	276985	307745
209	42	282470	314980
210	42	288010	322320
211	42	293605	329765
212	42	299255	337315
213	42	304960	344970
214	42	310720	352730
215	42	316535	360595
216	42	322405	368565
217	42	328330	376640
218	42	334310	384820
219	42	340345	393105
220	42	346435	401495
221	42	352580	410000
222	42	358780	418610
223	42	365035	427325
224	42	371345	436145
225	42	377710	445070
226	42	384130	454100
227	42	390605	463235
228	42	397135	472475
229	42	403720	481820
230	42	410360	491270
231	42	417055	500825
232	42	423805	510485
233	42	430610	520250
234	42	437470	530120
235	42	444385	540095
236	42	451355	550175
237	42	458380	560360
238	42	465460	570650
239	42	472595	581045
240	42	479785	591545
241	42	487030	602150
242	42	494330	612860
243	42	501685	623675
244	42	509095	634595
245	42	516560	645620
246	42	524080	656750
247	42	531655	667985
248	42	539285	679325
249	42	546970	690770
250	42	554710	702320
251	42	562505	713975
252	42	570355	725735
253	42	578260	737600
254	42	586220	749570
255	42	594235	761645
256	42	602305	773825
257	42	610430	786110
258	42	618610	798500
259	42	626845	811000
260	42	635135	823610
261	42	643480	836330
262	42	651880	849160
263	42	660335	862100
264	42	668845	875150
265	42	677410	888310
266	42	686030	901580
267	42	694705	914960
268	42	703435	928450
269	42	712220	942050
270	42	721060	955760
271	42	730955	969580
272	42	740905	983510
273	42	750910	997550
274	42	760970	1011700
275	42	771085	1025960
276	42	781255	1040330
277	42	791480	1054810
278	42	801760	1069400
279	42	812095	1084100
280	42	822485	1098910
281	42	832930	1113830
282	42	843430	1128860
283	42	853985	1144000
284	42	864595	1159250
285	42	875260	1174610
286	42	885980	1190080
287	42	896755	1205660
288	42	907585	1221350
289	42	918470	1237150
290	42	929410	1253060
291	42	940405	1269080
292	42	951455	1285210
293	42	962560	1301450
294	42	973720	1317800
295	42	984935	1334260
296	42	996205	1350830
297	42	1007530	1367510
298	42	1018910	1384300
299	42	1030345	1401200
300	42	1041835	1418210

	0'	6'	12'	18'	24'	30'	36'	42'	48'	54'	Mean Differences			
											1'	2'	3'	4' 5'
0°	—∞	3-2419	5429	7190	8439	9409	10200	10870	11450	11962				
1	I-2419	2833	3211	3559	3881	4181	4461	4725	4973	5208				
2	I-5431	5643	5845	6038	6223	6401	6571	6736	6894	7046				
3	I-7194	7337	7475	7609	7739	7865	7988	8107	8223	8336				
4	I-8446	8534	8659	8762	8862	8960	9056	9150	9241	9331	16	32	48	64 81
5	I-9420	9506	9591	9674	9756	9836	9915	9992	10068	10143	13	26	40	53 66
6	I-10216	10289	10360	10430	10499	10567	10633	10699	10764	10828	11	22	34	45 56
7	I-10891	10954	11015	11076	11135	11194	11252	11310	11367	11423	10	20	29	39 49
8	I-11478	11533	11587	11640	11693	11745	11797	11848	11898	11948	9	17	26	35 43
9	I-11997	12046	12094	12142	12189	12236	12282	12328	12374	12419	8	16	23	31 39
10°	I-12463	12507	12551	12594	12637	12680	12722	12764	12805	12846	7	14	21	28 35
11	I-12887	12927	12967	13006	13046	13085	13123	13162	13200	13237	6	13	19	26 32
12	I-13275	13312	13349	13385	13422	13458	13493	13529	13564	13599	6	12	18	24 30
13	I-13634	13668	13702	13736	13770	13804	13837	13870	13903	13935	6	11	17	22 28
14	I-13968	14000	14032	14064	14095	14127	14158	14189	14220	14250	5	10	16	21 26
15	I-14281	14311	14341	14371	14400	14430	14459	14488	14517	14546	5	10	15	20 25
16	I-14575	14603	14632	14660	14688	14716	14744	14771	14799	14826	5	9	14	19 23
17	I-14953	14980	15007	15034	15061	15087	15114	15140	15166	15192	4	9	13	18 22
18	I-15318	15343	15369	15395	15420	15445	15470	15495	15520	15545	4	8	13	17 21
19	I-15670	15694	15719	15743	15767	15791	15815	15839	15863	15887	4	8	12	16 20
20°	I-16011	16034	16058	16081	16104	16127	16150	16173	16196	16219	4	8	12	15 19
21	I-16442	16464	16486	16509	16532	16554	16576	16598	16620	16642	4	7	11	15 19
22	I-16864	16886	16908	16930	16952	16974	16996	17018	17040	17062	4	7	11	14 18
23	I-17279	17300	17321	17342	17363	17384	17404	17424	17445	17465	3	7	10	14 17
24	I-17686	17706	17726	17746	17766	17786	17806	17826	17846	17866	3	7	10	13 17
25	I-18087	18106	18126	18146	18166	18186	18206	18226	18246	18266	3	7	10	13 16
26	I-18482	18501	18520	18539	18558	18577	18596	18615	18634	18653	3	6	9	13 16
27	I-18872	18891	18910	18928	18946	18965	18983	19002	19020	19038	3	6	9	12 15
28	I-19257	19275	19293	19311	19329	19347	19365	19383	19401	19419	3	6	9	12 15
29	I-19638	19655	19673	19691	19709	19726	19744	19762	19779	19797	3	6	9	12 15
30°	I-20014	20032	20050	20067	20084	20101	20119	20136	20153	20170	3	6	9	12 14
31	I-20385	20402	20419	20436	20453	20470	20487	20504	20521	20538	3	6	9	11 14
32	I-20751	20767	20783	20799	20815	20831	20847	20863	20879	20895	3	6	8	11 14
33	I-21112	21128	21144	21160	21175	21191	21207	21222	21237	21252	3	5	8	11 14
34	I-21469	21484	21499	21514	21529	21544	21559	21574	21589	21604	3	5	8	11 14
35	I-21822	21837	21852	21867	21882	21897	21912	21927	21942	21957	3	5	8	11 13
36	I-22171	22186	22201	22216	22231	22246	22261	22276	22291	22306	3	5	8	11 13
37	I-22516	22531	22546	22561	22576	22591	22606	22621	22636	22651	3	5	8	10 13
38	I-22857	22872	22887	22902	22917	22932	22947	22962	22977	22992	3	5	8	10 13
39	I-23194	23209	23224	23239	23254	23269	23284	23299	23314	23329	3	5	8	10 13
40°	I-23528	23543	23558	23573	23588	23603	23618	23633	23648	23663	3	5	8	10 13
41	I-23859	23874	23889	23904	23919	23934	23949	23964	23979	23994	3	5	8	10 13
42	I-24186	24201	24216	24231	24246	24261	24276	24291	24306	24321	3	5	8	10 13
43	I-24509	24524	24539	24554	24569	24584	24599	24614	24629	24644	3	5	8	10 13
44	I-24828	24843	24858	24873	24888	24903	24918	24933	24948	24963	3	5	8	10 13

	0'	6'	12'	18'	24'	30'	36'	42'	48'	54'	Mean Differences				
											1'	2'	3'	4'	5'
45°	1.4142	4167	4192	4217	4242	4267	4293	4318	4344	4370	4	8	13	17	21
46	1.4396	4422	4448	4474	4501	4527	4554	4581	4608	4635	4	9	13	18	22
47	1.4603	4690	4718	4746	4774	4802	4830	4859	4887	4916	5	9	14	19	23
48	1.4945	4974	5003	5032	5062	5092	5121	5151	5182	5212	5	10	15	20	25
49	1.5243	5273	5304	5335	5366	5398	5429	5461	5493	5525	5	10	16	21	26
50°	1.5557	5500	5622	5656	5688	5721	5755	5788	5822	5856	6	11	17	22	28
51	1.5890	5925	5959	5994	6029	6064	6099	6135	6171	6207	6	12	18	24	29
52	1.6243	6279	6316	6353	6390	6427	6464	6502	6540	6578	6	12	19	25	31
53	1.6616	6655	6694	6733	6772	6812	6852	6892	6932	6972	7	13	20	26	33
54	1.7013	7054	7095	7137	7179	7221	7263	7305	7348	7391	7	14	21	28	35
55	1.7434	7478	7522	7566	7610	7655	7700	7745	7791	7837	7	15	22	30	37
56	1.7883	7929	7976	8023	8070	8118	8166	8214	8263	8312	8	16	24	32	40
57	1.8361	8410	8460	8510	8561	8612	8663	8714	8766	8818	8	17	25	34	42
58	1.8871	8924	8977	9031	9084	9138	9194	9249	9304	9360	9	18	27	36	45
59	1.9416	9473	9530	9587	9645	9703	9762	9821	9880	9940	10	19	29	39	49
60°	2.0000	0061	0122	0183	0245	0308	0371	0434	0498	0562	10	21	31	42	52
61	2.0627	0692	0757	0824	0890	0957	1025	1093	1162	1231	11	22	34	45	56
62	2.1301	1371	1441	1513	1584	1657	1730	1803	1877	1952	11	24	36	48	60
63	2.2027	2103	2179	2256	2333	2412	2490	2570	2650	2730	13	26	39	52	65
64	2.2812	2894	2976	3060	3144	3228	3314	3400	3486	3574	14	28	42	57	71
65	2.3662	3751	3841	3931	4022	4114	4207	4300	4395	4490	14	31	46	62	77
66	2.4586	4683	4780	4879	4978	5078	5180	5282	5384	5488					
67	2.5593	5699	5805	5913	6022	6131	6242	6354	6466	6580					
68	2.6695	6811	6927	7046	7165	7285	7407	7529	7653	7778					
69	2.7904	8032	8161	8291	8422	8555	8688	8824	8960	9099					
70°	2.9238	9370	9521	9665	9811	9957	10106	10256	10407	10561					
71	3.0716	0872	1030	1190	1352	1515	1681	1848	2017	2188					
72	3.2361	2535	2712	2891	3072	3255	3440	3628	3817	4009					
73	3.4203	4399	4598	4799	5003	5209	5418	5629	5843	6060					
74	3.6240	0502	6727	6955	7186	7420	7657	7897	8140	8386					
75	3.8377	8890	9147	9408	9672	9939	10211	10486	10765	11048					
76	4.1336	1627	1923	2223	2527	2837	3150	3469	3792	4121	Mean differences no longer sufficiently accurate.				
77	4.4454	4793	5137	5486	5841	6202	6569	6942	7321	7706					
78	4.8097	8496	8901	9313	9732	10159	10593	11034	11484	11942					
79	5.2408	2883	3367	3860	4362	4874	5396	5928	6470	7023					
80°	5.7588	8164	8751	9351	9963	10589	11227	11880	12546	13228					
81	6.3925	4637	5366	6111	6874	7655	8454	9273	10112	10972					
82	7.1853	2757	3684	4635	5611	6613	7642	8700	9787	10905					
83	8.2055	3238	4457	5711	7004	8337	9711	11229	12993	14105					
84	9.5668	7283	8955	10685	12477	14334	16261	18260	20336	22493					
85	11.474	11.71	11.95	12.20	12.47	12.75	13.03	13.34	13.65	13.99					
86	14.34	14.70	15.09	15.50	15.93	16.38	16.86	17.37	17.91	18.49					
87	19.11	19.77	20.47	21.23	22.04	22.93	23.88	24.92	26.05	27.29					
88	28.65	30.16	31.84	33.71	35.81	38.20	40.93	44.08	47.75	52.09					
89	57.30	63.66	71.62	81.85	95.49	114.6	143.2	191.0	286.5	573.0					

	0°	6'	12'	18'	24'	30'	36'	42'	48'	54'	Mean Differences					
											1'	2'	3'	4'	5'	
0°	1.0000	0000	0000	0000	0000	0000	0001	0001	0001	0001	0001	0	0	0	0	0
1	1.0002	0002	0002	0003	0003	0003	0004	0004	0005	0006	0006	0	0	0	0	0
2	1.0006	0007	0007	0008	0009	0010	0010	0011	0012	0013	0013	0	0	0	1	1
3	1.0014	0015	0016	0017	0018	0019	0020	0021	0022	0023	0023	0	0	1	1	1
4	1.0024	0026	0027	0028	0030	0031	0032	0034	0035	0037	0037	0	0	1	1	1
5	1.0038	0040	0041	0043	0045	0046	0048	0050	0051	0053	0053	0	1	1	1	2
6	1.0055	0057	0059	0061	0063	0065	0067	0069	0071	0073	0073	0	1	1	1	2
7	1.0075	0077	0079	0082	0084	0086	0089	0091	0093	0096	0096	0	1	1	2	2
8	1.0098	0101	0103	0106	0108	0111	0114	0116	0119	0122	0122	0	1	1	2	2
9	1.0125	0127	0130	0133	0136	0139	0142	0145	0148	0151	0151	0	1	1	2	2
10°	1.0154	0157	0161	0164	0167	0170	0174	0177	0180	0184	0184	1	1	2	2	3
11	1.0187	0191	0194	0198	0201	0205	0209	0212	0216	0220	0220	1	1	2	2	3
12	1.0223	0227	0231	0235	0239	0243	0247	0251	0255	0259	0259	1	1	2	3	3
13	1.0263	0267	0271	0276	0280	0284	0288	0293	0297	0302	0302	1	1	2	3	4
14	1.0306	0311	0315	0320	0324	0329	0334	0338	0343	0348	0348	1	2	2	3	4
15	1.0353	0358	0363	0367	0372	0377	0382	0388	0393	0398	0398	1	2	3	3	4
16	1.0403	0408	0413	0419	0424	0429	0435	0440	0446	0451	0451	1	2	3	4	4
17	1.0457	0463	0468	0474	0480	0485	0491	0497	0503	0509	0509	1	2	3	4	5
18	1.0515	0521	0527	0533	0539	0545	0551	0557	0564	0570	0570	1	2	3	4	5
19	1.0576	0583	0589	0595	0602	0608	0615	0622	0628	0635	0635	1	2	3	4	5
20°	1.0642	0649	0655	0662	0669	0676	0683	0690	0697	0704	0704	1	2	3	5	6
21	1.0711	0719	0726	0733	0740	0748	0755	0763	0770	0778	0778	1	2	4	5	6
22	1.0785	0793	0801	0808	0816	0824	0832	0840	0848	0856	0856	1	3	4	5	7
23	1.0864	0872	0880	0888	0896	0904	0913	0921	0929	0938	0938	1	3	4	5	7
24	1.0946	0955	0963	0972	0981	0989	0998	1007	1016	1025	1025	1	3	4	6	7
25	1.1034	1043	1052	1061	1070	1079	1088	1098	1107	1117	1117	2	3	5	6	8
26	1.1128	1138	1145	1155	1164	1174	1184	1194	1203	1213	1213	2	3	5	6	8
27	1.1223	1233	1243	1253	1264	1274	1284	1294	1305	1315	1315	2	3	5	7	9
28	1.1326	1336	1347	1357	1368	1379	1390	1401	1412	1423	1423	2	4	5	7	9
29	1.1434	1445	1456	1467	1478	1490	1501	1512	1524	1535	1535	2	4	6	8	9
30°	1.1547	1559	1570	1582	1594	1606	1618	1630	1642	1654	1654	2	4	6	8	10
31	1.1666	1679	1691	1703	1716	1728	1741	1753	1766	1779	1779	2	4	6	8	10
32	1.1792	1805	1818	1831	1844	1857	1870	1883	1897	1910	1910	2	4	7	9	11
33	1.1924	1937	1951	1964	1978	1992	2006	2020	2034	2048	2048	2	5	7	9	11
34	1.2062	2076	2091	2105	2120	2134	2149	2163	2178	2193	2193	2	5	7	10	12
35	1.2208	2223	2238	2253	2268	2283	2299	2314	2329	2345	2345	3	5	8	10	13
36	1.2361	2376	2392	2408	2424	2440	2456	2472	2489	2505	2505	3	5	8	11	13
37	1.2521	2538	2554	2571	2588	2605	2622	2639	2656	2673	2673	3	6	8	11	14
38	1.2690	2708	2725	2742	2760	2778	2796	2813	2831	2849	2849	3	6	9	12	15
39	1.2868	2886	2904	2923	2941	2960	2978	2997	3016	3035	3035	3	6	9	12	15
40°	1.3054	3073	3093	3112	3131	3151	3171	3190	3210	3230	3230	3	7	10	13	16
41	1.3250	3270	3291	3311	3331	3352	3373	3393	3414	3435	3435	3	7	10	14	17
42	1.3450	3478	3499	3520	3542	3563	3585	3607	3629	3651	3651	4	7	11	14	18
43	1.3653	3696	3718	3741	3763	3786	3809	3832	3855	3878	3878	4	8	11	15	19
44	1.3902	3925	3949	3972	3996	4020	4044	4069	4093	4118	4118	4	8	12	16	20

NATURAL COSECANTS

A.

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N. B.—Subtract Mean Differences

	0'	6'	12'	18'	24'	30'	36'	42'	48'	54'	Mean Differences				
											1'	2'	3'	4'	5'
45°	1-4142	4118	4093	4069	4044	4020	3996	3972	3949	3925	4	8	12	16	20
46	1-3902	3878	3855	3832	3809	3786	3763	3741	3718	3696	4	8	11	15	19
47	1-3673	3651	3629	3607	3585	3563	3542	3520	3499	3478	4	7	11	14	18
48	1-3456	3435	3414	3393	3373	3352	3331	3311	3291	3270	3	7	10	14	17
49	1-3250	3230	3210	3190	3171	3151	3131	3112	3093	3073	3	7	10	13	16
50°	1-3054	3035	3016	2997	2978	2960	2941	2923	2904	2886	3	6	9	12	15
51	1-2868	2849	2831	2813	2796	2778	2760	2742	2725	2708	3	6	9	12	15
52	1-2690	2673	2656	2639	2622	2605	2588	2571	2554	2538	3	6	8	11	14
53	1-2521	2505	2489	2472	2456	2440	2424	2408	2392	2376	3	5	8	11	13
54	1-2361	2345	2329	2314	2299	2283	2268	2253	2238	2223	3	5	8	10	13
55	1-2208	2193	2178	2163	2148	2134	2120	2105	2091	2076	2	5	7	10	12
56	1-2062	2048	2034	2020	2006	1992	1978	1964	1951	1937	2	5	7	9	11
57	1-1921	1910	1897	1883	1870	1857	1844	1831	1818	1805	2	4	7	9	11
58	1-1792	1779	1766	1753	1741	1728	1716	1703	1691	1679	2	4	6	8	10
59	1-1666	1654	1642	1630	1618	1606	1594	1582	1570	1559	2	4	6	8	10
60°	1-1547	1535	1524	1512	1501	1490	1478	1467	1456	1445	2	4	6	8	9
61	1-1434	1423	1412	1401	1390	1379	1368	1357	1347	1336	2	4	5	7	9
62	1-1326	1315	1305	1294	1284	1274	1264	1253	1243	1233	2	3	5	7	9
63	1-1223	1213	1203	1194	1184	1174	1164	1155	1145	1136	2	3	5	6	8
64	1-1126	1117	1107	1098	1089	1079	1070	1061	1052	1043	2	3	5	6	8
65	1-1034	1025	1016	1007	998	989	981	972	963	955	1	3	4	6	7
66	1-0948	0938	0929	0921	0913	0904	0896	0888	0880	0872	1	3	4	5	7
67	1-0864	0856	0848	0840	0832	0824	0816	0808	0801	0793	1	3	4	5	7
68	1-0785	0778	0770	0763	0755	0748	0740	0733	0726	0719	1	2	4	5	6
69	1-0711	0704	0697	0690	0683	0676	0669	0662	0655	0649	1	2	3	5	6
70°	1-0642	0635	0628	0622	0615	0608	0602	0595	0589	0583	1	2	3	4	5
71	1-0576	0570	0564	0557	0551	0545	0539	0533	0527	0521	1	2	3	4	5
72	1-0515	0509	0503	0497	0491	0485	0480	0474	0468	0463	1	2	3	4	5
73	1-0457	0451	0446	0440	0435	0429	0424	0419	0413	0408	1	2	3	4	4
74	1-0403	0398	0393	0388	0382	0377	0372	0367	0363	0358	1	2	3	3	4
75	1-0353	0348	0343	0338	0334	0329	0324	0320	0315	0311	1	2	2	3	4
76	1-0306	0302	0297	0293	0288	0284	0280	0276	0271	0267	1	1	2	3	4
77	1-0263	0259	0255	0251	0247	0243	0239	0235	0231	0227	1	1	2	3	3
78	1-0223	0220	0216	0212	0209	0205	0201	0198	0194	0191	1	1	2	2	3
79	1-0187	0184	0180	0177	0174	0170	0167	0164	0161	0157	1	1	2	2	3
80°	1-0154	0151	0148	0145	0142	0139	0136	0133	0130	0127	0	1	1	2	2
81	1-0125	0122	0119	0116	0114	0111	0108	0106	0103	0101	0	1	1	2	2
82	1-0098	0096	0093	0091	0089	0086	0084	0082	0079	0077	0	1	1	1	2
83	1-0075	0073	0071	0069	0067	0065	0063	0061	0059	0057	0	1	1	1	2
84	1-0055	0053	0051	0050	0048	0046	0045	0043	0041	0040	0	0	1	1	1
85	1-0038	0037	0035	0034	0032	0031	0030	0028	0027	0026					
86	1-0024	0023	0022	0021	0020	0019	0018	0017	0016	0015	0	0	1	1	1
87	1-0014	0013	0012	0011	0010	0010	0009	0008	0007	0007	0	0	0	1	1
88	1-0006	0006	0005	0004	0004	0003	0003	0003	0002	0002	0	0	0	0	0
89	1-0002	0001	0001	0001	0001	0000	0000	0000	0000	0000	0	0	0	0	0

N.B.—Subtract Mean Differences

	0'	6'	12'	18'	24'	30'	36'	42'	48'	54'	Mean Differences				
											1'	2'	3'	4'	5'
0°	∞	573.0	286.5	191.0	143.2	114.0	95.49	81.85	71.02	63.00					
1	57.30	52.09	47.75	44.08	40.93	38.20	35.81	33.71	31.84	30.16					
2	28.05	27.20	26.05	24.92	23.88	22.93	22.04	21.23	20.47	19.77					
3	19.11	18.49	17.91	17.37	16.86	16.38	15.93	15.50	15.09	14.70					
4	14.84	13.99	13.65	13.34	13.03	12.75	12.47	12.20	11.95	11.71					
5	11.474	2493	0336	8260	6261	4334	2477	0685	8955	7283					
6	9.5668	4105	2592	1129	9711	8337	7004	5711	4457	3238					
7	8.2055	0005	9797	8700	7642	6613	5611	4635	3684	2757					
8	7.1853	0972	0112	9273	8454	7655	6874	6111	5366	4637					
9	6.3925	3228	2546	1880	1227	0589	9963	9351	8751	8164					
10°	5.7588	7028	6170	5928	5300	4874	4302	3660	3307	2883					
11	5.2408	1942	1484	1034	0593	0159	0732	9313	8901	8400					
12	4.8097	7706	7321	6942	6569	6202	5841	5486	5137	4793					
13	4.4454	4121	3792	3469	3150	2837	2527	2223	1923	1627					
14	4.1336	1048	0705	0486	0211	9039	8072	7408	6147	8990					
15	3.8637	8387	8140	7897	7657	7420	7186	6955	6727	6502					
16	3.6280	6060	5843	5629	5418	5209	5003	4799	4598	4399					
17	3.4203	4009	3817	3628	3440	3255	3072	2891	2712	2535					
18	3.2361	2188	2017	1848	1681	1515	1352	1190	1030	8872					
19	3.0716	0561	0407	0256	0106	9957	9811	9665	9521	9379					
20°	2.9238	9099	8960	8824	8688	8555	8422	8291	8161	8032					
21	2.7904	7778	7653	7529	7407	7285	7165	7046	6927	6811					
22	2.6695	6580	6466	6354	6242	6131	6022	5913	5805	5699					
23	2.5593	5488	5384	5282	5180	5078	4978	4879	4780	4683					
24	2.4596	4490	4395	4300	4207	4114	4022	3931	3841	3751	15	31	46	62	77
25	2.3662	3574	3486	3400	3314	3228	3144	3060	2976	2894	14	28	42	57	71
26	2.2812	2730	2650	2570	2490	2412	2333	2256	2179	2103	13	26	39	52	65
27	2.2027	1952	1877	1803	1730	1657	1584	1513	1441	1371	11	24	36	48	60
28	2.1301	1231	1162	1093	1025	957	8900	8224	7557	6892	11	22	34	45	56
29	2.0627	0562	0498	0434	0371	0308	0245	0183	0122	0061	10	21	31	42	52
30°	2.0000	0940	0880	9821	9762	9703	9645	9587	9530	9473	10	19	29	39	49
31	1.9416	0360	0301	0240	0194	0139	0084	9031	8977	8924	9	18	27	36	45
32	1.8871	8818	8766	8714	8663	8612	8561	8510	8460	8410	8	17	25	34	42
33	1.8361	8312	8263	8214	8166	8118	8070	8023	7976	7929	8	16	24	32	40
34	1.7885	7837	7791	7745	7700	7655	7610	7566	7522	7478	7	15	22	30	37
35	1.7434	7391	7348	7305	7263	7221	7179	7137	7095	7054	7	14	21	28	35
36	1.7013	6972	6932	6892	6852	6812	6772	6733	6694	6655	7	13	20	26	33
37	1.6616	6578	6540	6502	6464	6427	6390	6353	6316	6279	6	12	19	25	31
38	1.6243	6207	6171	6135	6099	6064	6029	5994	5959	5925	6	12	18	24	29
39	1.5890	5856	5822	5788	5755	5721	5688	5655	5622	5590	6	11	17	22	28
40°	1.5557	5525	5493	5461	5429	5398	5366	5335	5304	5273	5	10	16	21	26
41	1.5243	5212	5182	5151	5121	5092	5062	5032	5003	4974	5	10	15	20	25
42	1.4945	4916	4887	4859	4830	4802	4774	4746	4718	4690	5	9	14	19	23
43	1.4663	4635	4608	4581	4554	4527	4501	4474	4448	4422	4	9	13	18	22
44	1.4396	4370	4344	4318	4293	4267	4242	4217	4192	4167	4	8	13	17	21

Mean differences
not sufficiently
accurate.

NATURAL COTANGENTS

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N.B.—Subtract Mean Differences

	0'	6'	12'	18'	24'	30'	36'	42'	48'	54'	Mean Differences				
											1' 2' 3'		4' 5'		
											1'	2'	3'	4'	5'
45°	1.0000	0965	9930	9896	9861	9827	9793	9759	9725	9691	6	11	17	23	29
46	0.9657	9623	9590	9556	9523	9490	9457	9424	9391	9358	6	11	17	22	28
47	0.9325	9293	9260	9228	9195	9163	9131	9099	9067	9036	5	11	16	21	27
48	0.9004	8972	8941	8910	8878	8847	8816	8785	8754	8724	5	10	16	21	26
49	0.8693	8662	8632	8601	8571	8541	8511	8481	8451	8421	5	10	15	20	25
50°	0.8391	8361	8332	8302	8273	8243	8214	8185	8156	8127	5	10	15	20	24
51	0.8098	8069	8040	8012	7983	7954	7926	7898	7869	7841	5	9	14	19	24
52	0.7813	7785	7757	7729	7701	7673	7646	7618	7590	7563	5	9	14	18	23
53	0.7536	7508	7481	7454	7427	7400	7373	7346	7319	7292	5	9	14	18	23
54	0.7265	7239	7212	7186	7159	7133	7107	7080	7054	7028	4	9	13	18	22
55	0.7002	6976	6950	6924	6899	6873	6847	6822	6796	6771	4	9	13	17	21
56	0.6745	6720	6694	6669	6644	6619	6594	6569	6544	6519	4	8	13	17	21
57	0.6494	6469	6445	6420	6395	6371	6346	6322	6297	6273	4	8	12	16	20
58	0.6249	6224	6200	6176	6152	6128	6104	6080	6056	6032	4	8	12	16	20
59	0.6009	5985	5961	5938	5914	5890	5867	5844	5820	5797	4	8	12	16	20
60°	0.5774	5750	5727	5704	5681	5658	5635	5612	5589	5566	4	8	12	15	19
61	0.5543	5520	5498	5475	5452	5430	5407	5384	5362	5340	4	8	11	15	19
62	0.5317	5295	5272	5250	5228	5206	5184	5161	5139	5117	4	7	11	15	18
63	0.5095	5073	5051	5029	5008	4986	4964	4942	4921	4899	4	7	11	15	18
64	0.4877	4856	4834	4813	4791	4770	4748	4727	4706	4684	4	7	11	14	18
65	0.4663	4642	4621	4599	4578	4557	4536	4515	4494	4473	4	7	11	14	18
66	0.4452	4431	4411	4390	4369	4348	4327	4307	4286	4265	3	7	10	14	17
67	0.4245	4224	4204	4183	4163	4142	4122	4101	4081	4061	3	7	10	14	17
68	0.4040	4020	4000	3979	3959	3939	3919	3899	3879	3859	3	7	10	13	17
69	0.3839	3819	3799	3779	3759	3739	3719	3699	3679	3659	3	7	10	13	17
70°	0.3640	3620	3600	3581	3561	3541	3522	3502	3482	3463	3	7	10	13	16
71	0.3443	3424	3404	3385	3365	3346	3327	3307	3288	3269	3	6	10	13	16
72	0.3249	3230	3211	3191	3172	3153	3134	3115	3096	3076	3	6	10	13	16
73	0.3057	3038	3019	3000	2981	2962	2943	2924	2905	2886	3	6	9	13	16
74	0.2867	2849	2830	2811	2792	2773	2754	2736	2717	2698	3	6	9	13	16
75	0.2679	2661	2642	2623	2605	2586	2568	2549	2530	2512	3	6	9	12	16
76	0.2493	2475	2456	2438	2419	2401	2382	2364	2345	2327	3	6	9	12	15
77	0.2309	2290	2272	2254	2235	2217	2199	2180	2162	2144	3	6	9	12	15
78	0.2126	2107	2089	2071	2053	2035	2016	1998	1980	1962	3	6	9	12	15
79	0.1944	1926	1908	1890	1871	1853	1835	1817	1799	1781	3	6	9	12	15
80°	0.1763	1745	1727	1709	1691	1673	1655	1638	1620	1602	3	6	9	12	15
81	0.1584	1566	1548	1530	1512	1495	1477	1459	1441	1423	3	6	9	12	15
82	0.1405	1388	1370	1352	1334	1317	1299	1281	1263	1246	3	6	9	12	15
83	0.1228	1210	1192	1175	1157	1139	1122	1104	1086	1069	3	6	9	12	15
84	0.1051	1033	1016	998	981	963	945	928	910	892	3	6	9	12	15
85	0.0875	0857	0840	0822	0805	0787	0769	0752	0734	0717	3	6	9	12	15
86	0.0699	0682	0664	0647	0629	0612	0594	0577	0559	0542	3	6	9	12	15
87	0.0524	0507	0489	0472	0454	0437	0419	0402	0384	0367	3	6	9	12	15
88	0.0349	0332	0314	0297	0279	0262	0244	0227	0209	0192	3	6	9	12	15
89	0.0175	0157	0140	0122	0105	0087	0070	0052	0035	0017	3	6	9	12	15

N. B.—Subtract Mean Differences

	0 ^{Ac}	6'	12'	18'	24'	30'	36'	42'	48'	54'	Mean Differences				
											1'	2'	3'	4'	5'
0°	∞	573.0	286.5	101.0	143.2	114.6	95.49	81.85	71.62	63.06					
1	57.29	52.08	47.74	44.07	40.92	38.10	35.80	33.60	31.82	30.14					
2	28.64	27.27	26.03	24.90	23.86	22.90	22.02	21.20	20.45	19.74					
3	19.08	18.46	17.89	17.34	16.83	16.35	15.89	15.43	15.06	14.67					
4	14.30	13.95	13.62	13.30	13.00	12.71	12.43	12.16	11.91	11.66					
5	11.43	11.20	10.99	10.78	10.58	10.39	10.20	10.02	9.845	9.677					
6	9.5144	3572	2052	0579	9152	7769	6427	5126	3863	2636					
7	8.1443	0285	9158	8062	6996	5938	4947	3962	3002	2066					
8	7.1154	0264	9395	8548	7720	6912	6122	5350	4596	3859					
9	6.3138	2432	1742	1066	0405	9758	9124	8502	7894	7297					
10°	5.6713	6140	5578	5026	4486	3955	3435	2924	2422	1929					
11	5.1446	0970	0504	0045	9594	9152	8716	8288	7867	7453					
12	4.7046	6646	6252	5864	5483	5107	4737	4374	4015	3662					
13	4.3315	2972	2635	2303	1976	1653	1335	1022	0713	0408					
14	4.0108	9812	9520	9232	8947	8667	8391	8118	7848	7583					
15	3.7321	7062	6806	6554	6305	6059	5816	5576	5339	5105					
16	3.4874	4646	4420	4107	3977	3759	3544	3332	3122	2914					
17	3.2709	2506	2305	2106	1910	1716	1524	1334	1146	0961					
18	3.0777	0505	0415	0237	0061	9887	9714	9544	9375	9208					
19	2.9042	8878	8716	8556	8397	8239	8083	7929	7776	7625					
20°	2.7475	7326	7179	7034	6889	6746	6605	6464	6325	6187					
21	2.6051	5916	5782	5649	5517	5386	5257	5129	5002	4876					
22	2.4751	4627	4504	4383	4262	4142	4023	3906	3789	3673					
23	2.3559	3445	3332	3220	3109	2998	2889	2781	2673	2566					
24	2.2460	2355	2251	2148	2045	1943	1842	1742	1642	1543					
25	2.1445	1348	1251	1155	1060	9655	8872	8078	7268	6454	17 34 51	68 85			
26	2.0503	0413	0323	0233	0145	0057	9970	9883	9797	9711	15 29 44	58 73			
27	1.9626	9542	9458	9375	9292	9210	9128	9047	8967	8887	14 27 41	55 68			
28	1.8807	8728	8650	8572	8495	8418	8341	8265	8190	8115	13 20 38	51 64			
29	1.8040	7966	7893	7820	7747	7675	7603	7532	7461	7391	12 24 36	48 60			
30°	1.7321	7251	7182	7113	7045	6977	6909	6842	6775	6709	11 23 34	45 56			
31	1.6643	6577	6512	6447	6383	6319	6255	6191	6128	6066	11 21 32	43 53			
32	1.6003	5941	5880	5818	5757	5697	5637	5577	5517	5458	10 20 30	40 50			
33	1.5399	5340	5282	5224	5166	5108	5051	4994	4938	4882	10 19 29	38 48			
34	1.4828	4770	4715	4659	4605	4550	4496	4442	4388	4335	9 18 27	36 45			
35	1.4281	4229	4176	4124	4071	4019	3968	3916	3865	3814	9 17 26	34 43			
36	1.3764	3713	3663	3613	3564	3514	3465	3416	3367	3319	8 16 25	33 41			
37	1.3270	3222	3175	3127	3079	3032	2985	2938	2892	2846	8 16 24	31 39			
38	1.2799	2753	2708	2662	2617	2572	2527	2482	2437	2393	8 15 23	30 38			
39	1.2349	2305	2261	2218	2174	2131	2088	2045	2002	1960	7 14 22	29 36			
40°	1.1918	1875	1833	1792	1750	1708	1667	1626	1585	1544	7 14 21	28 34			
41	1.1504	1463	1423	1383	1343	1303	1263	1224	1184	1145	7 13 20	27 33			
42	1.1106	1067	1028	0990	0951	0913	0875	0837	0799	0761	6 13 19	25 32			
43	1.0724	0686	0649	0612	0575	0538	0501	0464	0428	0392	6 12 18	25 31			
44	1.0355	0319	0283	0247	0212	0176	0141	0105	0070	0035	6 12 18	24 30			

Mean differences
not sufficiently
accurate.

	0'	6'	12'	18'	24'	30'	36'	42'	48'	54'	
45°	.7854	7871	7880	7906	7924	7941	7959	7976	7994	8011	
46	.8020	8046	8063	8081	8098	8116	8133	8151	8168	8186	
47	.8203	8221	8238	8255	8273	8290	8308	8325	8343	8360	
48	.8378	8395	8412	8430	8447	8465	8482	8500	8517	8535	
49	.8552	8570	8587	8604	8622	8639	8657	8674	8692	8709	
50°	.8727	8744	8762	8779	8796	8814	8831	8849	8866	8884	
51	.8901	8919	8936	8954	8971	8988	9006	9023	9041	9058	
52	.9078	9093	9111	9128	9146	9163	9180	9198	9215	9233	
53	.9250	9268	9285	9303	9320	9338	9355	9372	9390	9407	
54	.9425	9442	9460	9477	9495	9512	9529	9547	9564	9582	
55	.9599	9617	9634	9652	9669	9687	9704	9721	9739	9756	
56	.9774	9791	9809	9826	9844	9861	9879	9896	9913	9931	
57	.9948	9966	9983	1.0001	1.0018	1.0036	1.0053	1.0071	1.0088	1.0105	
58	1.0123	1.0140	1.0158	1.0175	1.0193	1.0210	1.0228	1.0245	1.0263	1.0280	
59	1.0297	1.0315	1.0332	1.0350	1.0367	1.0385	1.0402	1.0420	1.0437	1.0455	
60°	1.0472	1.0489	1.0507	1.0524	1.0542	1.0559	1.0577	1.0594	1.0612	1.0629	
61	1.0647	1.0664	1.0681	1.0699	1.0716	1.0734	1.0751	1.0769	1.0786	1.0804	
62	1.0821	1.0838	1.0856	1.0873	1.0891	1.0908	1.0926	1.0943	1.0961	1.0978	
63	1.0996	1.1013	1.1030	1.1048	1.1065	1.1083	1.1100	1.1118	1.1135	1.1153	
64	1.1170	1.1188	1.1205	1.1222	1.1240	1.1257	1.1275	1.1292	1.1310	1.1327	
65	1.1345	1.1362	1.1380	1.1397	1.1414	1.1432	1.1449	1.1467	1.1484	1.1502	
66	1.1519	1.1537	1.1554	1.1572	1.1589	1.1606	1.1624	1.1641	1.1659	1.1676	
67	1.1694	1.1711	1.1729	1.1746	1.1764	1.1781	1.1798	1.1816	1.1833	1.1851	
68	1.1868	1.1886	1.1903	1.1921	1.1938	1.1956	1.1973	1.1990	1.2008	1.2025	
69	1.2043	1.2060	1.2078	1.2095	1.2113	1.2130	1.2147	1.2165	1.2182	1.2200	
70°	1.2217	1.2235	1.2252	1.2270	1.2287	1.2305	1.2322	1.2339	1.2357	1.2374	
71	1.2392	1.2409	1.2427	1.2444	1.2462	1.2479	1.2497	1.2514	1.2531	1.2549	
72	1.2566	1.2584	1.2601	1.2619	1.2636	1.2654	1.2671	1.2689	1.2706	1.2723	
73	1.2741	1.2758	1.2776	1.2793	1.2811	1.2828	1.2846	1.2863	1.2881	1.2898	
74	1.2915	1.2933	1.2950	1.2968	1.2985	1.3003	1.3020	1.3038	1.3055	1.3073	
75	1.3090	1.3107	1.3125	1.3142	1.3160	1.3177	1.3195	1.3212	1.3230	1.3247	
76	1.3265	1.3282	1.3299	1.3317	1.3334	1.3352	1.3369	1.3387	1.3404	1.3422	
77	1.3439	1.3456	1.3474	1.3491	1.3509	1.3526	1.3544	1.3561	1.3579	1.3596	
78	1.3614	1.3631	1.3648	1.3666	1.3683	1.3701	1.3718	1.3736	1.3753	1.3771	
79	1.3788	1.3806	1.3823	1.3840	1.3858	1.3875	1.3893	1.3910	1.3928	1.3945	
80°	1.3963	1.3980	1.3998	1.4015	1.4032	1.4050	1.4067	1.4085	1.4102	1.4120	
81	1.4137	1.4155	1.4172	1.4190	1.4207	1.4224	1.4242	1.4259	1.4277	1.4294	
82	1.4312	1.4329	1.4347	1.4364	1.4382	1.4399	1.4416	1.4434	1.4451	1.4469	
83	1.4486	1.4504	1.4521	1.4539	1.4556	1.4573	1.4591	1.4608	1.4626	1.4643	
84	1.4661	1.4678	1.4696	1.4713	1.4731	1.4748	1.4765	1.4783	1.4800	1.4818	
85	1.4835	1.4853	1.4870	1.4888	1.4905	1.4923	1.4940	1.4957	1.4975	1.4992	
86	1.5010	1.5027	1.5045	1.5062	1.5080	1.5097	1.5115	1.5132	1.5149	1.5167	
87	1.5184	1.5202	1.5219	1.5237	1.5254	1.5272	1.5289	1.5307	1.5324	1.5341	
88	1.5359	1.5376	1.5394	1.5411	1.5429	1.5446	1.5464	1.5481	1.5499	1.5516	
89	1.5533	1.5551	1.5568	1.5586	1.5603	1.5621	1.5638	1.5656	1.5673	1.5691	

Difference

For

Is

1'

3

2'

6

3'

9

4'

12

5'

15

	0'	6'	12'	18'	24'	30'	36'	42'	48'	54'	
0°	0000	0017	0035	0052	0070	0087	0105	0122	0140	0157	
1	0175	0192	0209	0227	0244	0262	0279	0297	0314	0332	
2	0349	0367	0384	0401	0419	0436	0454	0471	0489	0506	
3	0524	0541	0559	0576	0593	0611	0628	0646	0663	0681	
4	0698	0716	0733	0750	0768	0785	0803	0820	0838	0855	
5	0873	0890	0908	0925	0942	0960	0977	0995	1012	1030	
6	1047	1065	1082	1100	1117	1134	1152	1169	1187	1204	
7	1222	1239	1257	1274	1292	1309	1326	1344	1361	1379	
8	1396	1414	1431	1449	1468	1484	1501	1518	1536	1553	
9	1571	1588	1606	1623	1641	1658	1676	1693	1710	1728	
10'	1745	1763	1780	1798	1815	1833	1850	1868	1885	1902	
11	1920	1937	1955	1972	1990	2007	2025	2042	2059	2077	
12	2094	2112	2129	2147	2164	2182	2199	2217	2234	2251	
13	2269	2286	2304	2321	2339	2356	2374	2391	2409	2426	
14	2443	2461	2478	2496	2513	2531	2548	2566	2583	2601	
15	2618	2635	2653	2670	2688	2705	2723	2740	2758	2775	
16	2793	2810	2827	2845	2862	2880	2897	2915	2932	2950	
17	2967	2985	3002	3019	3037	3054	3072	3089	3107	3124	
18	3142	3159	3176	3194	3211	3229	3246	3264	3281	3299	
19	3316	3334	3351	3368	3386	3403	3421	3438	3456	3473	
20°	3491	3508	3526	3543	3560	3578	3595	3613	3630	3648	
21	3665	3683	3700	3718	3735	3752	3770	3787	3805	3822	
22	3840	3857	3875	3892	3910	3927	3944	3962	3979	3997	
23	4014	4032	4049	4067	4084	4102	4119	4136	4154	4171	
24	4189	4206	4224	4241	4259	4276	4294	4311	4328	4346	
25	4363	4381	4398	4416	4433	4451	4468	4485	4503	4520	
26	4538	4555	4573	4590	4608	4625	4643	4660	4677	4695	
27	4712	4730	4747	4765	4782	4800	4817	4835	4852	4869	
28	4887	4904	4922	4939	4957	4974	4992	5009	5027	5044	
29	5061	5079	5096	5114	5131	5149	5166	5184	5201	5219	
30°	5236	5253	5271	5288	5306	5323	5341	5358	5376	5393	
31	5411	5428	5445	5463	5480	5498	5515	5533	5550	5568	
32	5585	5603	5620	5637	5655	5672	5690	5707	5725	5742	
33	5760	5777	5794	5812	5829	5847	5864	5882	5899	5917	
34	5934	5952	5969	5986	6004	6021	6039	6056	6074	6091	
35	6109	6126	6144	6161	6178	6196	6213	6231	6248	6266	
36	6283	6301	6318	6336	6353	6370	6388	6405	6423	6440	
37	6458	6475	6493	6510	6528	6545	6562	6580	6597	6615	
38	6632	6650	6667	6685	6702	6720	6737	6754	6772	6789	
39	6807	6824	6842	6859	6877	6894	6912	6929	6946	6964	
40°	6981	6999	7016	7034	7051	7069	7086	7103	7121	7138	
41	7156	7173	7191	7208	7226	7243	7261	7278	7295	7313	
42	7330	7348	7365	7383	7400	7418	7435	7453	7470	7487	
43	7505	7522	7540	7557	7575	7592	7610	7627	7645	7662	
44	7679	7697	7714	7732	7749	7767	7784	7802	7819	7837	

Difference

for	is
1'	3
2'	6
3'	9
4'	12
5'	15

SQUARES, CUBES, SQUARE ROOTS, CUBE ROOTS, RECIPROALS AND RECIPROCAL SQUARE ROOTS

n	n^2	n^3	\sqrt{n}	$\sqrt[3]{n}$	$\frac{1}{n}$	$\sqrt{10n}$	$\frac{1}{\sqrt{n}}$	$\frac{1}{\sqrt{10n}}$
51	2601	132651	7.1414	3.7084	0.01961	22.5832	0.14008	0.04428
52	2704	140608	7.2111	3.7325	0.01923	22.8035	0.13869	0.04385
53	2809	148577	7.2802	3.7563	0.01887	23.0217	0.13736	0.04344
54	2916	157464	7.3485	3.7798	0.01852	23.2379	0.13608	0.04303
55	3025	166375	7.4162	3.8030	0.01818	23.4521	0.13484	0.04264
56	3136	175616	7.4833	3.8259	0.01786	23.6643	0.13363	0.04226
57	3249	185193	7.5498	3.8485	0.01754	23.8747	0.13245	0.04189
58	3364	195112	7.6158	3.8709	0.01724	24.0832	0.13131	0.04152
59	3481	205379	7.6811	3.8930	0.01695	24.2899	0.13019	0.04117
60	3600	216000	7.7460	3.9149	0.01667	24.4949	0.12910	0.04082
61	3721	226981	7.8102	3.9365	0.01639	24.6982	0.12804	0.04049
62	3844	238328	7.8740	3.9579	0.01613	24.8998	0.12700	0.04016
63	3969	250047	7.9373	3.9791	0.01587	25.0998	0.12599	0.03984
64	4096	262144	8.0000	4.0000	0.01563	25.2982	0.12500	0.03953
65	4225	274625	8.0623	4.0207	0.01538	25.4951	0.12403	0.03922
66	4356	287486	8.1240	4.0412	0.01515	25.6905	0.12309	0.03892
67	4489	300763	8.1854	4.0615	0.01493	25.8844	0.12217	0.03863
68	4624	314432	8.2462	4.0817	0.01471	26.0768	0.12127	0.03835
69	4761	328509	8.3066	4.1016	0.01449	26.2679	0.12039	0.03807
70	4900	343000	8.3666	4.1213	0.01429	26.4575	0.11952	0.03780
71	5041	357911	8.4261	4.1408	0.01408	26.6458	0.11868	0.03753
72	5184	373248	8.4853	4.1602	0.01389	26.8328	0.11785	0.03727
73	5329	389017	8.5440	4.1793	0.01370	27.0185	0.11704	0.03701
74	5476	405224	8.6023	4.1983	0.01351	27.2029	0.11625	0.03676
75	5625	421875	8.6603	4.2172	0.01333	27.3861	0.11547	0.03651
76	5776	438976	8.7178	4.2358	0.01316	27.5681	0.11471	0.03627
77	5929	456533	8.7750	4.2543	0.01299	27.7489	0.11396	0.03604
78	6084	474552	8.8318	4.2727	0.01282	27.9285	0.11323	0.03581
79	6241	493039	8.8882	4.2908	0.01266	28.1069	0.11251	0.03558
80	6400	512000	8.9443	4.3089	0.01250	28.2843	0.11180	0.03536
81	6561	531441	9.0000	4.3267	0.01235	28.4604	0.11111	0.03514
82	6724	551368	9.0554	4.3445	0.01220	28.6356	0.11043	0.03492
83	6889	571787	9.1104	4.3621	0.01205	28.8097	0.10976	0.03471
84	7056	592704	9.1652	4.3795	0.01190	28.9828	0.10911	0.03450
85	7225	614125	9.2195	4.3968	0.01176	29.1548	0.10847	0.03430
86	7396	636056	9.2736	4.4140	0.01163	29.3258	0.10783	0.03410
87	7569	658503	9.3274	4.4310	0.01149	29.4958	0.10721	0.03390
88	7744	681472	9.3808	4.4480	0.01136	29.6648	0.10660	0.03371
89	7921	704969	9.4340	4.4647	0.01124	29.8329	0.10600	0.03352
90	8100	729000	9.4868	4.4814	0.01111	29.9999	0.10541	0.03333
91	8281	753571	9.5394	4.4979	0.01099	30.1662	0.10483	0.03315
92	8464	778688	9.5917	4.5144	0.01087	30.3315	0.10426	0.03297
93	8649	804357	9.6437	4.5307	0.01075	30.4959	0.10370	0.03279
94	8836	830584	9.6954	4.5468	0.01064	30.6594	0.10314	0.03262
95	9025	857375	9.7468	4.5629	0.01053	30.8221	0.10260	0.03244
96	9216	884736	9.7980	4.5789	0.01042	30.9839	0.10206	0.03227
97	9409	912673	9.8489	4.5947	0.01031	31.1448	0.10153	0.03211
98	9604	941192	9.8995	4.6104	0.01020	31.3050	0.10102	0.03194
99	9801	970299	9.9499	4.6261	0.01010	31.4643	0.10050	0.03178
100	10000	1000000	10.0000	4.6416	0.01000	31.6228	0.10000	0.03162

SQUARES, CUBES, SQUARE ROOTS, CUBE ROOTS, RECIPROCAL AND RECIPROCAL OF SQUARE ROOTS

n	n^2	n^3	\sqrt{n}	$\sqrt[3]{n}$	$\frac{1}{n}$	$\sqrt{10n}$	$\frac{1}{\sqrt{n}}$	$\frac{1}{\sqrt{10n}}$
1	1	1	1.0000	1.0000	1.00000	3.1623	1.00000	0.31623
2	4	8	1.4142	1.2599	0.50000	4.4721	0.70711	0.22381
3	9	27	1.7321	1.4422	0.33333	5.4772	0.57735	0.18257
4	16	64	2.0000	1.5874	0.25000	6.3245	0.50000	0.15811
5	25	125	2.2361	1.7100	0.20000	7.0711	0.44721	0.14142
6	36	216	2.4495	1.8171	0.16667	7.7460	0.40825	0.12910
7	49	343	2.6458	1.9129	0.14286	8.3668	0.37796	0.11952
8	64	512	2.8284	2.0000	0.12500	8.9443	0.35355	0.11180
9	81	729	3.0000	2.0801	0.11111	9.4868	0.33333	0.10541
10	100	1000	3.1623	2.1544	0.10000	10.0000	0.31623	0.10000
11	121	1331	3.3166	2.2240	0.09091	10.4881	0.30151	0.09535
12	144	1728	3.4641	2.2894	0.08333	10.9545	0.28868	0.09129
13	169	2197	3.6056	2.3513	0.07692	11.4018	0.27735	0.08771
14	196	2744	3.7417	2.4101	0.07143	11.8322	0.26726	0.08452
15	225	3375	3.8730	2.4662	0.06667	12.2474	0.25820	0.08165
16	256	4096	4.0000	2.5198	0.06250	12.6491	0.25000	0.07906
17	289	4913	4.1231	2.5713	0.05882	13.0384	0.24253	0.07670
18	324	5832	4.2426	2.6207	0.05556	13.4164	0.23570	0.07454
19	361	6859	4.3589	2.6684	0.05263	13.7840	0.22942	0.07255
20	400	8000	4.4721	2.7144	0.05000	14.1421	0.22361	0.07071
21	441	9261	4.5826	2.7589	0.04762	14.4914	0.21822	0.06901
22	484	10648	4.6904	2.8020	0.04545	14.8324	0.21329	0.06742
23	529	12167	4.7958	2.8439	0.04348	15.1658	0.20851	0.06594
24	576	13824	4.8990	2.8845	0.04167	15.4919	0.20412	0.06455
25	625	15625	5.0000	2.9240	0.04000	15.8114	0.20000	0.06325
26	676	17576	5.0990	2.9625	0.03846	16.1245	0.19612	0.06202
27	729	19683	5.1962	3.0000	0.03704	16.4317	0.19245	0.06086
28	784	21952	5.2915	3.0366	0.03571	16.7332	0.18898	0.05976
29	841	24389	5.3852	3.0723	0.03448	17.0294	0.18570	0.05872
30	900	27000	5.4772	3.1072	0.03333	17.3206	0.18257	0.05774
31	961	29791	5.5678	3.1414	0.03226	17.6068	0.17961	0.05680
32	1024	32768	5.6569	3.1748	0.03125	17.8885	0.17678	0.05590
33	1089	35937	5.7448	3.2075	0.03030	18.1659	0.17408	0.05505
34	1156	39304	5.8310	3.2396	0.02941	18.4391	0.17150	0.05423
35	1225	42875	5.9161	3.2711	0.02857	18.7083	0.16903	0.05345
36	1296	46656	6.0000	3.3019	0.02778	18.9737	0.16667	0.05270
37	1369	50653	6.0828	3.3322	0.02703	19.2354	0.16440	0.05199
38	1444	54872	6.1644	3.3620	0.02632	19.4936	0.16222	0.05130
39	1521	59319	6.2450	3.3912	0.02564	19.7484	0.16013	0.05064
40	1600	64000	6.3245	3.4200	0.02500	20.0000	0.15811	0.05000
41	1681	68921	6.4031	3.4482	0.02439	20.2485	0.15617	0.04939
42	1764	74088	6.4807	3.4760	0.02381	20.4939	0.15430	0.04880
43	1849	79507	6.5574	3.5034	0.02328	20.7364	0.15250	0.04822
44	1936	85184	6.6332	3.5303	0.02273	20.9762	0.15076	0.04767
45	2025	91125	6.7082	3.5569	0.02222	21.2132	0.14907	0.04714
46	2116	97336	6.7823	3.5830	0.02174	21.4476	0.14744	0.04663
47	2209	103823	6.8557	3.6088	0.02128	21.6795	0.14587	0.04613
48	2304	110592	6.9284	3.6342	0.02083	21.9089	0.14434	0.04564
49	2401	117649	7.0000	3.6593	0.02041	22.1359	0.14286	0.04518
50	2500	125000	7.0711	3.6840	0.02000	22.3607	0.14142	0.04472

RECIPROCAL OF FOUR-FIGURE NUMBERS 29

	0	1	2	3	4	5	6	7	8	9	Mean Differences (Subtract.)								
											1	2	3	4	5	6	7	8	9
5.5	-1818	1815	1812	1808	1805	1802	1799	1795	1792	1789	0	1	1	1	2	2	2	3	3
5.6	-1786	1783	1779	1776	1773	1770	1767	1764	1761	1757	0	1	1	1	2	2	2	3	3
5.7	-1754	1751	1748	1745	1742	1739	1736	1733	1730	1727	0	1	1	1	1	2	2	3	3
5.8	-1724	1721	1718	1715	1712	1709	1706	1704	1701	1698	0	1	1	1	1	2	2	3	3
5.9	-1695	1692	1689	1686	1684	1681	1678	1675	1672	1669	0	1	1	1	1	2	2	3	3
6.0	-1667	1664	1661	1658	1656	1653	1650	1647	1645	1642	0	1	1	1	1	2	2	3	3
6.1	-1639	1637	1634	1631	1629	1626	1623	1621	1618	1616	0	1	1	1	1	2	2	3	2
6.2	-1613	1610	1608	1605	1603	1600	1597	1595	1592	1590	0	1	1	1	1	2	2	2	2
6.3	-1587	1585	1582	1580	1577	1575	1572	1570	1567	1565	0	0	1	1	1	1	2	2	2
6.4	-1562	1560	1558	1555	1553	1550	1548	1546	1543	1541	0	0	1	1	1	1	2	2	2
6.5	-1538	1536	1534	1531	1529	1527	1524	1522	1520	1517	0	0	1	1	1	1	2	2	2
6.6	-1515	1513	1511	1508	1506	1504	1502	1499	1497	1495	0	0	1	1	1	1	2	2	2
6.7	-1493	1490	1488	1486	1484	1481	1479	1477	1475	1473	0	0	1	1	1	1	2	2	2
6.8	-1471	1468	1466	1464	1462	1460	1458	1456	1453	1451	0	0	1	1	1	1	2	2	2
6.9	-1449	1447	1445	1443	1441	1439	1437	1435	1433	1431	0	0	1	1	1	1	2	2	2
7.0	-1420	1427	1425	1422	1420	1418	1416	1414	1412	1410	0	0	1	1	1	1	1	2	2
7.1	-1408	1406	1404	1403	1401	1399	1397	1395	1393	1391	0	0	1	1	1	1	1	2	2
7.2	-1389	1387	1385	1383	1381	1379	1377	1376	1374	1372	0	0	1	1	1	1	1	2	2
7.3	-1370	1368	1366	1364	1362	1361	1359	1357	1355	1353	0	0	1	1	1	1	1	2	2
7.4	-1351	1350	1348	1346	1344	1342	1340	1339	1337	1335	0	0	1	1	1	1	1	1	2
7.5	-1333	1332	1330	1328	1326	1325	1323	1321	1319	1318	0	0	1	1	1	1	1	1	2
7.6	-1316	1314	1312	1311	1309	1307	1305	1304	1302	1300	0	0	1	1	1	1	1	1	2
7.7	-1299	1297	1295	1294	1292	1290	1289	1287	1285	1284	0	0	0	1	1	1	1	1	1
7.8	-1282	1280	1279	1277	1276	1274	1272	1271	1269	1267	0	0	0	1	1	1	1	1	1
7.9	-1266	1264	1263	1261	1259	1258	1256	1255	1253	1252	0	0	0	1	1	1	1	1	1
8.0	-1250	1248	1247	1245	1244	1242	1241	1239	1238	1236	0	0	0	1	1	1	1	1	1
8.1	-1235	1233	1232	1230	1229	1227	1225	1224	1222	1221	0	0	0	1	1	1	1	1	1
8.2	-1220	1218	1217	1215	1214	1212	1211	1209	1208	1206	0	0	0	1	1	1	1	1	1
8.3	-1205	1203	1202	1200	1199	1198	1196	1195	1193	1192	0	0	0	1	1	1	1	1	1
8.4	-1190	1189	1188	1186	1185	1183	1182	1181	1179	1178	0	0	0	1	1	1	1	1	1
8.5	-1176	1175	1174	1172	1171	1170	1168	1167	1166	1164	0	0	0	1	1	1	1	1	1
8.6	-1163	1161	1160	1159	1157	1156	1155	1153	1152	1151	0	0	0	1	1	1	1	1	1
8.7	-1149	1148	1147	1145	1144	1143	1142	1140	1139	1138	0	0	0	1	1	1	1	1	1
8.8	-1136	1135	1134	1133	1131	1130	1129	1127	1126	1125	0	0	0	1	1	1	1	1	1
8.9	-1124	1122	1121	1120	1119	1117	1116	1115	1114	1112	0	0	0	1	1	1	1	1	1
9.0	-1111	1110	1109	1107	1106	1105	1104	1103	1101	1100	0	0	0	1	1	1	1	1	1
9.1	-1099	1098	1096	1095	1094	1093	1092	1090	1089	1088	0	0	0	0	1	1	1	1	1
9.2	-1087	1086	1085	1083	1082	1081	1080	1079	1078	1076	0	0	0	0	1	1	1	1	1
9.3	-1075	1074	1073	1072	1071	1070	1068	1067	1066	1065	0	0	0	0	1	1	1	1	1
9.4	-1064	1063	1062	1060	1059	1058	1057	1056	1055	1054	0	0	0	0	1	1	1	1	1
9.5	-1053	1052	1050	1049	1048	1047	1046	1045	1044	1043	0	0	0	0	1	1	1	1	1
9.6	-1042	1041	1039	1038	1037	1036	1035	1034	1033	1032	0	0	0	0	1	1	1	1	1
9.7	-1031	1030	1029	1028	1027	1026	1025	1024	1022	1021	0	0	0	0	1	1	1	1	1
9.8	-1020	1019	1018	1017	1016	1015	1014	1013	1012	1011	0	0	0	0	1	1	1	1	1
9.9	-1010	1009	1008	1007	1006	1005	1004	1003	1002	1001	0	0	0	0	0	1	1	1	1

28 RECIPROCAL OF FOUR-FIGURE NUMBERS

	0	1	2	3	4	5	6	7	8	9	Mean Differences (Subtract.)								
											1 2 3			4 5 6			7 8 9		
											1	2	3	4	5	6	7	8	9
1-0	1-000	9001	8004	9709	0615	9524	9434	9346	9259	9174	9	18	28	37	46	55	64	74	83
1-1	·9091	9009	8929	8850	8772	8696	8621	8547	8475	8403	8	15	23	31	38	46	53	61	69
1-2	·8333	8264	8197	8130	8065	8000	7937	7874	7813	7752	7	13	20	26	33	39	46	52	59
1-3	·7692	7634	7576	7519	7463	7407	7353	7299	7246	7194	6	11	17	22	28	33	39	44	50
1-4	·7143	7092	7042	6993	6944	6897	6849	6803	6757	6711	5	10	14	19	24	29	33	38	43
1-5	·6667	6623	6579	6536	6494	6452	6410	6369	6329	6289	4	8	13	17	21	25	29	33	38
1-6	·6250	6211	6173	6135	6098	6061	6024	5988	5952	5917	4	7	11	15	18	22	26	29	33
1-7	·5882	5848	5814	5780	5747	5714	5682	5650	5618	5587	3	7	10	13	16	20	23	26	29
1-8	·5556	5525	5495	5464	5435	5405	5376	5348	5319	5291	3	6	9	12	15	19	22	25	29
1-9	·5263	5236	5208	5181	5155	5128	5102	5076	5051	5025	3	5	8	11	13	17	18	21	24
2-0	·5000	4975	4950	4926	4902	4878	4854	4831	4808	4785	2	5	7	10	12	14	17	19	21
2-1	·4762	4739	4717	4695	4673	4651	4630	4608	4587	4566	2	4	7	9	11	13	15	17	19
2-2	·4545	4525	4505	4484	4464	4444	4425	4405	4386	4367	2	4	6	8	10	12	14	16	18
2-3	·4348	4329	4310	4292	4274	4255	4237	4219	4202	4184	2	4	5	7	9	11	13	14	16
2-4	·4167	4149	4132	4115	4098	4082	4065	4049	4032	4016	2	3	5	7	8	10	12	13	15
2-5	·4000	3984	3968	3953	3937	3922	3906	3891	3876	3861	2	3	5	6	8	9	11	12	14
2-6	·3846	3831	3817	3802	3788	3774	3759	3745	3731	3717	1	3	4	6	7	9	10	11	13
2-7	·3704	3690	3676	3663	3650	3636	3623	3610	3597	3584	1	3	4	5	7	8	9	11	12
2-8	·3571	3559	3546	3534	3521	3509	3497	3484	3472	3460	1	2	4	5	6	7	9	10	11
2-9	·3448	3436	3425	3413	3401	3390	3378	3367	3356	3344	1	2	3	5	6	7	8	9	10
3-0	·3333	3322	3311	3300	3290	3279	3268	3257	3247	3236	1	2	3	4	5	6	8	9	10
3-1	·3228	3215	3205	3195	3185	3175	3165	3155	3145	3135	1	2	3	4	5	6	7	8	9
3-2	·3125	3115	3106	3096	3086	3077	3067	3058	3049	3040	1	2	3	4	5	6	7	8	9
3-3	·3030	3021	3012	3003	2994	2985	2976	2967	2959	2950	1	2	3	4	4	5	6	7	8
3-4	·2941	2933	2924	2915	2907	2899	2890	2882	2874	2865	1	2	3	3	4	5	6	7	8
3-5	·2857	2849	2841	2833	2825	2817	2809	2801	2793	2786	1	2	2	3	4	5	6	6	7
3-6	·2778	2770	2762	2755	2747	2740	2732	2725	2717	2710	1	2	2	3	4	5	5	6	7
3-7	·2703	2695	2688	2681	2674	2667	2660	2653	2646	2639	1	1	2	3	4	4	5	6	6
3-8	·2632	2625	2618	2611	2604	2597	2591	2584	2577	2571	1	1	2	3	3	4	5	5	6
3-9	·2564	2558	2551	2545	2538	2532	2525	2519	2513	2506	1	1	2	3	3	4	4	5	6
4-0	·2500	2494	2488	2481	2475	2469	2463	2457	2451	2445	1	1	2	2	3	3	4	5	5
4-1	·2439	2433	2427	2421	2415	2410	2404	2398	2392	2387	1	1	2	2	3	3	4	5	5
4-2	·2381	2375	2370	2364	2358	2353	2347	2342	2336	2331	1	1	2	2	3	3	4	4	5
4-3	·2326	2320	2315	2309	2304	2299	2294	2288	2283	2278	1	1	2	2	3	3	4	4	5
4-4	·2273	2268	2262	2257	2252	2247	2242	2237	2232	2227	1	1	2	2	3	3	4	4	5
4-5	·2222	2217	2212	2208	2203	2198	2193	2188	2183	2179	0	1	1	2	2	3	3	4	4
4-6	·2174	2169	2165	2160	2155	2151	2146	2141	2137	2132	0	1	1	2	2	3	3	4	4
4-7	·2128	2123	2119	2114	2110	2105	2101	2096	2092	2088	0	1	1	2	2	3	3	4	4
4-8	·2083	2079	2075	2070	2066	2062	2058	2053	2049	2045	0	1	1	2	2	3	3	4	4
4-9	·2041	2037	2033	2028	2024	2020	2016	2012	2008	2004	0	1	1	2	2	2	3	3	4
5-0	·2000	1996	1992	1988	1984	1980	1976	1972	1969	1965	0	1	1	2	2	2	3	3	4
5-1	·1961	1957	1953	1949	1946	1942	1938	1934	1931	1927	0	1	1	2	2	2	3	3	3
5-2	·1923	1919	1916	1912	1908	1905	1901	1898	1894	1890	0	1	1	2	2	2	3	3	3
5-3	·1887	1883	1880	1876	1873	1869	1866	1862	1859	1855	0	1	1	1	2	2	2	3	3
5-4	·1852	1848	1845	1842	1838	1835	1832	1828	1825	1821	0	1	1	1	2	2	2	3	3

E.g. $\frac{1}{3.7} = .2703$, $\frac{1}{3.74} = .2674$, $\frac{1}{3.748} = .2668$, $\frac{1}{3.748} = .002668$, $\frac{1}{.0003748} = 2668$.

	0	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9
5.5	1.7047	7066	7084	7102	7120	7138	7156	7174	7192	7210	2	4	5	7	9	11	13	14	16
5.6	1.7228	7246	7263	7281	7299	7317	7334	7352	7370	7387	2	4	5	7	9	11	12	14	16
5.7	1.7405	7422	7440	7457	7475	7492	7509	7527	7544	7561	2	3	5	7	9	10	12	14	16
5.8	1.7579	7596	7613	7630	7647	7664	7681	7699	7716	7733	2	3	5	7	9	10	12	14	15
5.9	1.7750	7766	7783	7800	7817	7834	7851	7867	7884	7901	2	3	5	7	8	10	12	13	15
6.0	1.7918	7934	7951	7967	7984	8001	8017	8034	8050	8066	2	3	5	7	8	10	12	13	15
6.1	1.8083	8099	8116	8132	8148	8165	8181	8197	8213	8229	2	3	5	6	8	10	11	13	15
6.2	1.8245	8262	8278	8294	8310	8326	8342	8358	8374	8390	2	3	5	6	8	10	11	13	14
6.3	1.8405	8421	8437	8453	8469	8485	8500	8516	8532	8547	2	3	5	6	8	9	11	13	14
6.4	1.8563	8579	8594	8610	8625	8641	8656	8672	8687	8703	2	3	5	6	8	9	11	12	14
6.5	1.8718	8733	8749	8764	8779	8795	8810	8825	8840	8855	2	3	5	6	8	9	11	12	14
6.6	1.8871	8886	8901	8916	8931	8946	8961	8976	8991	9006	2	3	5	6	8	9	11	12	14
6.7	1.9021	9036	9051	9066	9081	9095	9110	9125	9140	9155	1	3	4	6	7	9	10	12	13
6.8	1.9169	9184	9199	9213	9228	9242	9257	9272	9286	9301	1	3	4	6	7	9	10	12	13
6.9	1.9315	9330	9344	9359	9373	9387	9402	9416	9430	9445	1	3	4	6	7	9	10	12	13
7.0	1.9459	9473	9488	9502	9516	9530	9544	9559	9573	9587	1	3	4	6	7	9	10	11	13
7.1	1.9601	9615	9629	9643	9657	9671	9685	9699	9713	9727	1	3	4	6	7	8	10	11	13
7.2	1.9741	9755	9769	9782	9796	9810	9824	9838	9851	9865	1	3	4	6	7	8	10	11	12
7.3	1.9879	9892	9906	9920	9933	9947	9961	9974	9988	0001	1	3	4	5	7	8	10	11	12
7.4	2.0015	0028	0042	0055	0069	0082	0096	0109	0122	0136	1	3	4	5	7	8	9	11	12
7.5	2.0149	0162	0176	0189	0202	0215	0229	0242	0255	0268	1	3	4	5	7	8	9	11	12
7.6	2.0281	0295	0308	0321	0334	0347	0360	0373	0386	0399	1	3	4	5	7	8	9	10	12
7.7	2.0412	0425	0438	0451	0464	0477	0490	0503	0516	0528	1	3	4	5	6	8	9	10	12
7.8	2.0541	0554	0567	0580	0592	0605	0618	0631	0643	0656	1	3	4	5	6	8	9	10	11
7.9	2.0669	0681	0694	0707	0719	0732	0744	0757	0769	0782	1	3	4	5	6	8	9	10	11
8.0	2.0794	0807	0819	0832	0844	0857	0869	0882	0894	0906	1	3	4	5	6	7	9	10	11
8.1	2.0919	0931	0943	0956	0968	0980	0992	1005	1017	1029	1	2	4	5	6	7	9	10	11
8.2	2.1041	1054	1066	1078	1090	1102	1114	1126	1138	1150	1	2	4	5	6	7	9	10	11
8.3	2.1163	1175	1187	1199	1211	1223	1235	1247	1258	1270	1	2	4	5	6	7	8	10	11
8.4	2.1282	1294	1306	1318	1330	1342	1353	1365	1377	1389	1	2	4	5	6	7	8	10	11
8.5	2.1401	1412	1424	1436	1448	1459	1471	1483	1494	1506	1	2	4	5	6	7	8	9	11
8.6	2.1518	1529	1541	1552	1564	1576	1587	1599	1610	1622	1	2	3	5	6	7	8	9	10
8.7	2.1633	1645	1656	1668	1679	1691	1702	1713	1725	1736	1	2	3	5	6	7	8	9	10
8.8	2.1748	1759	1770	1782	1793	1804	1815	1827	1838	1849	1	2	3	5	6	7	8	9	10
8.9	2.1861	1872	1883	1894	1905	1917	1928	1939	1950	1961	1	2	3	4	6	7	8	9	10
9.0	2.1972	1983	1994	2006	2017	2028	2039	2050	2061	2072	1	2	3	4	6	7	8	9	10
9.1	2.2083	2094	2105	2116	2127	2138	2148	2159	2170	2181	1	2	3	4	5	7	8	9	10
9.2	2.2192	2203	2214	2225	2235	2246	2257	2268	2279	2289	1	2	3	4	5	6	8	9	10
9.3	2.2300	2311	2322	2332	2343	2354	2364	2375	2386	2396	1	2	3	4	5	6	7	9	10
9.4	2.2407	2418	2428	2439	2450	2460	2471	2481	2492	2502	1	2	3	4	5	6	7	8	10
9.5	2.2513	2523	2534	2544	2555	2565	2576	2586	2597	2607	1	2	3	4	5	6	7	8	9
9.6	2.2618	2628	2638	2649	2659	2670	2680	2690	2701	2711	1	2	3	4	5	6	7	8	9
9.7	2.2721	2732	2742	2752	2762	2773	2783	2793	2803	2814	1	2	3	4	5	6	7	8	9
9.8	2.2824	2834	2844	2854	2865	2875	2885	2895	2905	2915	1	2	3	4	5	6	7	8	9
9.9	2.2925	2935	2946	2956	2966	2976	2986	2996	3006	3016	1	2	3	4	5	6	7	8	9

NATURAL LOGARITHMS OF 10¹¹

n	1	2	3	4	5	6	7	8	9
log _e 10 ¹¹	3.6974	5.3948	7.0922	10.7897	12.4871	14.1845	17.8819	19.5793	21.2767

E.g. log_e 0.005847 = log_e (5.847 × 10⁻³) = 1.7659 + 7.0922 = 8.8581

	0	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9
1.0	0.0000	0100	0198	0296	0392	0488	0583	0677	0770	0862	10	19	29	38	48	57	67	76	86
1.1	0.0953	1044	1133	1222	1310	1398	1484	1570	1655	1740	9	17	26	35	44	52	61	70	78
1.2	0.1823	1908	1989	2070	2151	2231	2311	2390	2469	2546	8	16	24	32	40	48	56	64	72
1.3	0.2624	2700	2782	2865	2927	3001	3075	3148	3221	3293	7	15	22	30	37	44	52	59	67
1.4	0.3365	3436	3507	3577	3646	3716	3784	3853	3920	3988	6	14	21	28	35	41	48	55	62
1.5	0.4055	4121	4187	4253	4318	4383	4447	4511	4574	4637	5	13	19	26	32	39	45	52	58
1.6	0.4700	4762	4824	4886	4947	5008	5068	5128	5188	5247	4	12	18	24	30	36	42	48	55
1.7	0.5306	5365	5423	5481	5539	5596	5653	5710	5766	5822	3	11	17	23	29	34	40	46	51
1.8	0.5878	5933	5988	6043	6098	6152	6206	6259	6313	6366	2	11	16	22	27	32	38	43	49
1.9	0.6419	6471	6523	6575	6627	6678	6729	6780	6831	6881	1	10	15	20	26	31	36	41	46
2.0	0.6931	6981	7031	7080	7129	7178	7227	7275	7324	7372	5	10	15	20	24	29	34	39	44
2.1	0.7419	7467	7514	7561	7608	7655	7701	7747	7793	7839	5	9	14	19	23	28	33	37	42
2.2	0.7885	7930	7975	8020	8065	8109	8154	8198	8242	8286	4	9	13	18	22	27	31	36	40
2.3	0.8329	8372	8416	8459	8502	8544	8587	8629	8671	8713	4	9	13	17	21	26	30	34	38
2.4	0.8755	8796	8838	8879	8920	8961	9002	9042	9083	9123	4	8	12	16	20	24	29	33	37
2.5	0.9163	9203	9243	9282	9322	9361	9400	9439	9478	9517	4	8	12	16	20	24	27	31	35
2.6	0.9555	9594	9632	9670	9708	9746	9783	9821	9858	9895	4	8	11	15	19	23	26	30	34
2.7	0.9933	9969	10006	10043	10080	10116	10152	10188	10225	10260	4	7	11	15	18	22	25	29	33
2.8	1.0296	10332	10367	10403	10438	10473	10508	10543	10578	10613	4	7	11	14	18	21	25	28	32
2.9	1.0647	10682	10716	10750	10784	10818	10852	10886	10919	10953	3	7	10	14	17	20	24	27	31
3.0	1.0986	1019	1053	1086	1119	1151	1184	1217	1249	1282	3	7	10	13	16	20	23	26	30
3.1	1.1314	1346	1378	1410	1442	1474	1506	1537	1569	1600	3	6	10	13	16	19	22	25	29
3.2	1.1632	1663	1694	1725	1756	1787	1817	1848	1878	1909	3	6	9	12	15	18	22	25	28
3.3	1.1939	1969	2000	2030	2060	2090	2119	2149	2179	2208	3	6	9	12	15	18	21	24	27
3.4	1.2238	2267	2296	2326	2355	2384	2413	2442	2470	2499	3	6	9	12	15	17	20	23	26
3.5	1.2528	2556	2585	2613	2641	2669	2698	2726	2754	2782	3	6	8	11	14	17	20	23	25
3.6	1.2809	2837	2865	2892	2920	2947	2975	3002	3029	3056	3	5	8	11	14	17	19	22	25
3.7	1.3083	3110	3137	3164	3191	3218	3244	3271	3297	3324	3	5	8	11	13	16	19	21	24
3.8	1.3350	3378	3403	3429	3455	3481	3507	3533	3558	3584	3	5	8	10	13	16	18	21	23
3.9	1.3610	3635	3661	3686	3712	3737	3762	3788	3813	3838	3	5	8	10	13	15	18	20	23
4.0	1.3863	3888	3913	3938	3962	3987	4012	4036	4061	4085	2	5	7	10	12	15	17	20	22
4.1	1.4110	4134	4159	4183	4207	4231	4255	4279	4303	4327	2	5	7	10	12	14	17	19	22
4.2	1.4351	4375	4398	4422	4446	4469	4493	4516	4540	4563	2	5	7	9	12	14	16	19	21
4.3	1.4586	4609	4633	4656	4679	4702	4725	4748	4770	4793	2	5	7	9	12	14	16	18	21
4.4	1.4816	4839	4861	4884	4907	4929	4953	4974	4996	5019	2	5	7	9	11	14	16	18	20
4.5	1.5041	5063	5085	5107	5129	5151	5173	5195	5217	5239	2	4	7	9	11	13	15	18	20
4.6	1.5261	5282	5304	5326	5347	5369	5390	5412	5433	5454	2	4	6	9	11	13	15	17	19
4.7	1.5476	5497	5518	5539	5560	5581	5602	5623	5644	5665	2	4	6	8	11	13	15	17	19
4.8	1.5686	5707	5728	5748	5769	5790	5810	5831	5851	5872	2	4	6	8	10	12	14	16	19
4.9	1.5892	5913	5933	5953	5974	5994	6014	6034	6054	6074	2	4	6	8	10	12	14	16	18
5.0	1.6094	6114	6134	6154	6174	6194	6214	6233	6253	6273	2	4	6	8	10	12	14	16	18
5.1	1.6292	6312	6332	6351	6371	6390	6409	6429	6448	6467	2	4	6	8	10	12	14	16	18
5.2	1.6487	6506	6525	6544	6563	6582	6601	6620	6639	6658	2	4	6	8	10	11	13	15	17
5.3	1.6677	6696	6715	6734	6752	6771	6790	6808	6827	6846	2	4	6	7	9	11	13	15	17
5.4	1.6864	6882	6901	6919	6938	6956	6974	6993	7011	7029	2	4	5	7	9	11	13	15	17

NATURAL LOGARITHMS OF 10ⁿ

n	1	2	3	4	5	6	7	8	9
log _e 10 ⁿ	2.3026	4.6052	6.9078	9.2103	11.5129	13.8155	16.1181	18.4207	20.7233

$$E.g. \log_e 584.7 = \log_e(5.847 \times 10^2) = 1.7659 + 4.6052 = 6.3711.$$

PHYSICAL TABLES

32 EXPONENTIAL AND HYPERBOLIC FUNCTIONS

x	e^x	e^{-x}	θ° (gd x)	$\cosh x$ (sec θ)	$\sinh x$ (tan θ)	$\tanh x$ (sin θ)	log $\cosh x$	log $\sinh x$
-1	1.1052	.9048	5.720	1.0050	-1.002	-.0907	-.0022	I-.0007
-2	1.2214	.8187	11.384	1.0201	-2.013	-.1974	-.0086	I-.3039
-3	1.3499	.7408	16.937	1.0453	-3.045	-.2913	-.0163	I-.8336
-4	1.4918	.6703	22.331	1.0811	-4.108	-.3799	-.0339	I-1.6136
-5	1.6487	.6065	27.524	1.1278	-5.211	-.4621	-.0522	I-2.7169
-6	1.8221	.5488	32.483	1.1855	-6.367	-.5370	-.0739	I-4.0993
-7	2.0138	.4960	37.183	1.2552	-7.580	-.6044	-.0987	I-5.8800
-8	2.2255	.4493	41.608	1.3374	-8.881	-.6640	-.1263	I-8.0485
-9	2.4590	.4066	45.750	1.4331	-1.0265	-.7163	-.1563	I-0.0114
-10	2.7183	.3679	49.605	1.5431	-1.1752	-.7616	-.1884	0-0701
1.1	3.0042	.3329	53.178	1.6685	1.3356	-.8005	-.2223	0-1257
1.2	3.3201	.3012	56.476	1.8107	1.5085	-.8337	-.2578	0-1738
1.3	3.6693	.2725	59.511	1.9709	1.6984	-.8617	-.2947	0-2300
1.4	4.0552	.2466	62.295	2.1509	1.9043	-.8854	-.3326	0-2797
1.5	4.4817	.2231	64.843	2.3524	2.1293	-.9051	-.3715	0-3282
1.6	4.9530	.2019	67.171	2.5775	2.3756	-.9217	-.4112	0-3758
1.7	5.4730	.1827	69.294	2.8283	2.6456	-.9354	-.4515	0-4225
1.8	6.0490	.1653	71.228	3.1075	2.9422	-.9468	-.4924	0-4687
1.9	6.6859	.1496	72.987	3.4177	3.2682	-.9562	-.5337	0-5143
2.0	7.3891	.1353	74.584	3.7622	3.6269	-.9640	-.5754	0-5595
2.1	8.1662	.1225	76.037	4.1443	4.0219	-.9705	-.6175	0-6044
2.2	9.0250	.1108	77.354	4.5679	4.4571	-.9757	-.6597	0-6491
2.3	9.9742	.1003	78.549	5.0372	4.9370	-.9801	-.7022	0-6935
2.4	11.023	.0907	79.633	5.5509	5.4662	-.9837	-.7448	0-7377
2.5	12.183	.0821	80.615	6.1323	6.0502	-.9866	-.7876	0-7818
2.6	13.464	.0743	81.513	6.7690	6.6947	-.9890	-.8305	0-8257
2.7	14.890	.0672	82.310	7.4735	7.4003	-.9910	-.8735	0-8696
2.8	16.445	.0608	83.040	8.2527	8.1619	-.9926	-.9166	0-9134
2.9	18.174	.0550	83.707	9.1146	9.0596	-.9940	-.9597	0-9571
3.0	20.086	.0498	84.301	10.068	10.018	-.9951	1.0029	1.0008
3.1	22.198	.0450	84.841	11.121	11.076	-.9959	1.0462	1.0444
3.2	24.533	.0408	85.336	12.287	12.246	-.9967	1.0894	1.0880
3.3	27.113	.0369	85.775	13.575	13.538	-.9973	1.1327	1.1316
3.4	29.904	.0334	86.177	14.999	14.965	-.9978	1.1761	1.1751
3.5	33.115	.0302	86.541	16.573	16.543	-.9982	1.2194	1.2180
3.6	36.598	.0273	86.870	18.313	18.285	-.9985	1.2629	1.2621
3.7	40.447	.0247	87.168	20.236	20.211	-.9988	1.3061	1.3056
3.8	44.701	.0224	87.437	22.362	22.339	-.9990	1.3495	1.3491
3.9	49.402	.0202	87.681	24.711	24.691	-.9992	1.3929	1.3925
4.0	54.598	.0183	87.903	27.308	27.290	-.9993	1.4363	1.4360
4.1	60.340	.0166	88.104	30.178	30.162	-.9995	1.4797	1.4795
4.2	66.686	.0150	88.281	33.351	33.336	-.9996	1.5231	1.5229
4.3	73.700	.0136	88.447	36.857	36.843	-.9996	1.5665	1.5664
4.4	81.451	.0123	88.591	40.732	40.719	-.9997	1.6099	1.6098
4.5	90.017	.0111	88.723	45.014	45.003	-.9997	1.6533	1.6532
4.6	99.484	.0101	88.840	49.747	49.737	-.9998	1.6968	1.6967
4.7	109.95	.0091	88.957	54.978	54.969	-.9998	1.7402	1.7401
4.8	121.51	.0082	89.065	60.759	60.751	-.9999	1.7836	1.7836
4.9	134.29	.0074	89.146	67.149	67.141	-.9999	1.8270	1.8270
5.0	148.41	.0067	89.227	74.210	74.203	-.9999	1.8705	1.8704

I. C.G.S. UNITS

FUNDAMENTAL UNITS

LENGTH (L)—The centimetre (cm.), 1/100 of the international metre which is the distance at 0° C. between two marks on a standard platinum-iridium bar kept in Paris.

$$\begin{aligned} N.B.—1 \text{ micron } (\mu) &= 10^{-4} \text{ cm.} \\ 1 \text{ millimicron } (m\mu) &= 10^{-7} \text{ cm.} \end{aligned}$$

MASS (M)—The gram (gm.), 1/1000 of the international kilogram which is a mass of platinum-iridium kept in Paris.

N.B.—The kilogram was originally intended to be the mass of a litre or cubic decimetre (1000 c.cm.) of pure water at 4° C. This is slightly in error, but the error is so very small, that for all practical purposes the gram may be defined as the mass of 1 cub. cm. of pure water at 4° C.

TIME (T)—The second (sec.), 1/86400 of the mean Solar Day, which is the average interval between two successive returns of the sun to the meridian.

DERIVED UNITS — GENERAL

AREA (L²)—The square centimetre (sq. cm.).

VOLUME (L³)—The cubic centimetre (c.cm.).

N.B.—1 litre = volume of 1 kgm. of pure water at 4° C.

$$1 \text{ millilitre (ml.)} = \frac{1}{1000} \text{ litre} = 1 \text{ c.cm.} = \text{vol. of 1 gm. water.}$$

By experiment it is found that a litre, as here defined = 1000.028 c.cm.

DENSITY (ML⁻³) = mass per unit volume. Unit, 1 gm. per c.cm.

VELOCITY (LT⁻¹)—1 cm. per sec.

ACCELERATION (LT⁻²)—1 cm. per sec. per sec.

ANGULAR VELOCITY (T⁻¹)—1 radian (57°·296) per sec.

ANGULAR ACCELERATION (T⁻²)—1 radian per sec. per sec.

MOMENTUM (LMT⁻¹)—Mass × Velocity. Unit, 1 gm. cm. per sec.

MOMENT OF MOMENTUM (L²MT⁻¹)—Momentum × distance from axis of reference. Unit, 1 gm. cm.² per sec.

FORCE (LMT⁻²)—Mass × acceleration. Unit, 1 dyne = force which, acting on a mass of 1 gm., produces an acceleration of 1 cm. per sec. per sec.

PRESSURE OR STRESS (L⁻¹MT⁻²)—Force per unit area. Unit, 1 dyne per sq. cm.

N.B.—1 bar = 10⁶ dynes per sq. cm., 1 millibar = 10³ dynes per sq. cm., 1 atmosphere = 760 mm. mercury at 0° C., lat. 45° and sea-level = 1.0132 bar.

ENERGY OR WORK (L²MT⁻²)—Force × distance through which pt. of application moves in direction of force. Unit, 1 erg = 1 dyne-cm. *N.B.*—1 joule = 10⁷ ergs.

POWER (L²MT⁻³)—Rate of doing work = work per unit time. Unit, 1 erg per sec.

N.B.—1 watt = 10⁷ ergs per sec. = 1 joule per sec. = 1 volt-ampere.

Board of Trade Unit of ENERGY is 1 kilowatt-hour = 3.6 × 10⁶ watt-secs. = 3.6 × 10⁹ joules = 1.34 H.P. for 1 hour.

DERIVED UNITS — ABSOLUTE ELECTRO-MAGNETIC UNITS (E.M.U.)

MAGNETIC POLE (m)—A magnetic pole has unit strength if, when placed in air at a distance of 1 cm. from an equal pole, the force between the poles is 1 dyne.

MAGNETIC FIELD STRENGTH (H)—A magnetic field has unit strength or intensity (1 gauss) at any point when it exerts a force of 1 dyne on a unit pole placed at that point.

N.B.—Strength of field at any point (i.e. no. of gauss) is represented, according to convention, by the number of lines of force passing normally through an area of 1 sq. cm. at that point.

From this convention it follows that 4 π lines of force leave (or enter) a unit magnetic pole.

MAGNETIC MOMENT OF A MAGNET (M) = pole strength × distance between poles.

INTENSITY OF MAGNETISATION (I) = magnetic moment per c.cm.

MAGNETIC SUSCEPTIBILITY ($k = \frac{I}{H}$) of any material, e.g. iron, is the ratio of the intensity of magnetisation to the strength of field producing it.

N.B.—For iron at ordinary temperatures k is about 200 but decreases as H increases.

MAGNETIC INDUCTION (B) in any material, e.g. iron, is measured by the number of lines of force (usually called lines of magnetisation or lines of induction when within the material) passing normally through 1 sq. cm.

MAGNETIC PERMEABILITY ($\mu = \frac{B}{H}$) of any material, e.g. iron, is the ratio of the magnetic induction to the strength of field producing it.

$$N.B. - B = 4\pi I + H \therefore \frac{B}{H} = 4\pi \frac{I}{H} + 1 \therefore \mu = 4\pi k + 1.$$

CURRENT (I)—Unit current is that which, flowing in an arc of length 1 cm. and radius 1 cm. produces unit magnetic field (1 gauss) at the centre of the arc.

QUANTITY (Q)—The unit (E.M.U.) is the quantity delivered by unit current per sec.

N.B.—The electrostatic unit (E.S.U.) of quantity is such that it repels an equal quantity placed in air at a distance of 1 cm. with a force of 1 dyne.

The ratio (V) of the E.M.U. to the E.S.U. of quantity = 3×10^{10} .

ELECTROMOTIVE FORCE (E.M.F.) OR POTENTIAL DIFFERENCE (P.D.)—Unit:—The P.D. which exists between two points when 1 erg is required to move unit quantity from one point to the other.

RESISTANCE (R)—Unit:—That resistance which allows unit E.M.F. or P.D. to produce unit current.

SELF INDUCTANCE and also **MUTUAL INDUCTANCE**—A conductor has unit inductance when unit E.M.F. is produced in it by unit change of current per sec.

RELATION BETWEEN C.G.S. AND F.P.S. UNITS

LENGTH—	RECIPROCAL	DENSITY—	RECIPROCAL
1 inch = 2.540 cm.	. . . . . 3937	1 lb. per cub. ft. = .01602 gm. per c.c.	62.43
1 yard = .914399 m.	. . . . . 1.093614	FORCE—	
1 mile = 1.609 km.	. . . . . 6214	1 poundal = 13825 dynes	7.233×10^{-8}
8 km. = 5 miles (approx.)		1 lb. wt. = 4.45×10^8 dynes	2.248×10^{-8}
AREA—		PRESSURE—	
1 sq. in. = 6.452 sq. cm.	. . . . . 1550	1 lb. per sq. in. = 68944 dynes	
1 sq. yd. = .8361 sq. m.	. . . . . 1.196	per sq. cm.	1.45×10^{-8}
VOLUME—		1 lb. per sq. in. = 70.31 gm.	
1 cub. in. = 16.39 c.cm.	. . . . . 0.06102	per sq. cm. . . . .	.01422
1 cub. ft. = 28.32 litres.	. . . . . 0.3531	ENERGY—	
1 gallon = 4.546 litres.	. . . . . 2200	1 foot pound = 1.356 joules . . . . .	.7373
MASS—		POWER—	
1 oz. (avoird.) = 28.35 gm.	. . . . . 0.3527	1 horse power = .746 k.watts.	1.34
1 lb. = .45359243 kg.	. . . . . 2.2046223		
1 ton = 1016 kg.	. . . . . 0.0009842		

MISCELLANEOUS

	RECIPROCAL
1 degree = .01745 radians	57.296
1 gram-calorie = 4.185 joules . . . . .	.2389
1 kilo-calorie = 3.968 lb.-degrees F. . . . .	.2520
1 lb. water at 62° F. = .4546 litres	2.200
1 lb. water at 62° F. = .1000 gallons	10.00
1 lb. water at 4° C. = .01602 cub. ft.	62.43
1 oz. per gallon = 6.236 gm. per litre . . . . .	.1603
1 atmosphere = 1.013×10^6 dynes per sq. cm.	9.873×10^{-7}
1 atmosphere = 14.70 lb. per sq. in. . . . .	.06803
1 mile per hour = 44.70 cm. per sec. . . . .	.02238
1 litre normal air = 1.293 gm. . . . .	.7734
1 knot = 1 nautical mile per hour = 6082.00 ft. per hour.	
1 Admiralty knot = 6080 ft. per hour.	
1 horse power (H.P.) = 550 ft.-lb. per sec.	

II. MATHEMATICAL CONSTANTS

$$e = \text{Base of natural logarithms} = 1 + \frac{1}{1!} + \frac{1}{2!} + \frac{1}{3!} + \dots = 2.71828, \frac{1}{e} = 0.36788$$

$$M = \text{Modulus of common logarithms} = \log_{10} e = 0.434294, \log_{10} 10 = 2.30259$$

$$\log_{10} N = \log_e N \times .4343, \quad \log_e N = \log_{10} N \times 2.3026, \quad 1 \text{ Radian} = 57^\circ.2958 = 57^\circ 17' 45''$$

	Number.	Logarithm.	Number.	Logarithm.
π	3.14159265	0.4971	9.8696	0.9943
$\frac{4\pi}{3}$	4.1888	0.6221	31.006	1.4914
$\frac{\pi}{180}$	0.01745	5.2419	0.31831	1.5029
			0.10132	1.00570
			$\sqrt{\pi}$	1.7725
			$\frac{3}{\sqrt{\pi}}$	1.4046
			$\frac{3\sqrt{3}}{\sqrt{\pi}}$	1.2407
				0.0937

Geometrical Form.	Perimeter.	Area or Surface.	Volume.
Rectangle (sides a, b)	$2a + 2b$	ab	...
Square (side a)	$4a$	a^2	...
Triangle (base a , altitude h)	...	$\frac{1}{2}ah$	...
Triangle (sides a, b, c)	$a + b + c = 2s$	$\sqrt{s(s-a)(s-b)(s-c)}$ or $\frac{1}{2}bc \sin A$	...
Circle (radius r)	$2\pi r$	πr^2	...
Ellipse (axes $2a, 2b$)	$2\pi \sqrt{\frac{a^2 + b^2}{2}}$ approx.	πab	...
Rectangular Solid, or Cuboid (edges a, b, c)	...	$2(ab + bc + ca)$	abc
Cylinder (radius r , height h)	...	$2\pi r(h + r)$	$\pi r^2 h$
Cone (radius r , height h , slant height l)	...	$\pi r(l + r)$	$\frac{1}{3} \pi r^2 h$
Sphere (radius r)	...	$4\pi r^2$	$\frac{4}{3} \pi r^3$
Anchor Ring (mean radius R , radius of circular section r)	...	$4\pi^2 r R$	$2\pi^2 r^2 R$

III. EARTH, SUN, AND MOON

	Mean Radius.	Density.	Mass.	Mass.	Mass.	Gravity at Equator.
	Cm.	(gm. per c cm.)	Gm.	Tons.	(Earth = 1).	(Earth = 1)
Earth	6368 × 10 ⁵	5.527	5.98 × 10 ²⁷	5.87 × 10 ²¹	1	1
Moon	1798 × 10 ³	3.34	7.3 × 10 ²³	7.2 × 10 ¹⁹	$\frac{1}{81.5}$	$\frac{1}{6}$
Sun	6.0 × 10 ¹⁰	1.41	2 × 10 ³³	1.9 × 10 ²⁷	3.3 × 10 ⁵	27.6

Distance of Earth from Sun = 1.497 × 10¹³ cm. = 0.300 × 10⁷ miles.
 Mean solar second = $\frac{1}{365.256}$ of mean solar day.
 Sidereal day = 86164.1 mean solar seconds.
 Mean synodical or lunar month = 29.531 mean solar days.
 Tropical and civil year = 365.242 mean solar days.
 N.B.—Century years are not leap years unless divisible by 400.

IV. GRAVITATION

- (A) Attraction of two masses, each 1 gram, concentrated at points 1 centimetre apart (G) 6.670 × 10⁻⁴ dynes.
 Mass which, concentrated 1 centimetre apart from equal mass, will give attraction of 1 dyne 3872 grams.
 Attraction of two masses, each 1 pound, concentrated at points 1 foot apart 1.069 × 10⁻⁷ poundals.

(B)	Weight of mass of 1 gram in dynes	London.	Edinburgh.	Dublin.
	981.2	981.0	981.4	981.4
	32.19	32.20 +	32.20 +	32.20 +

(C) ACCELERATION (g) DUE TO GRAVITY, AND LENGTH (l) OF SECONDS PENDULUM

	Latitude.	g in cm. per sec. per sec.	l in cm.	Latitude.	g in cm. per sec. per sec.	l in cm.
Equator	0° 0'	978.030	99.094	45° 30'	980.65	99.360
Madras	13° 4'	978.28	99.120	48° 50'	980.943	99.300
Jamaica	18° 25'	978.52	99.144	51° 28'	981.188	99.414
Calcutta	22° 33'	978.82	99.175	51° 31'	981.19	99.415
Sydney	33° 52' S.	979.68	99.262	52° 12'	981.26	99.422
Cape Town	33° 56' S.	979.68	99.262	52° 28'	981.28	99.424
Tokio	35° 43'	979.801	99.274	53° 21'	981.36	99.432
Melbourne	37° 50' S.	979.98	99.292	53° 24'	981.35	99.431
Washington	38° 53'	980.08	99.303	53° 28'	981.36	99.432
New York	40° 48'	980.27	99.322	55° 53'	981.50	99.452
Wellington (N.Z.)	41° 17' S.	980.29	99.324	55° 55'	981.58	99.454
Chicago	41° 47'	980.323	99.323	57° 9'	981.68	99.464
Toronto	43° 40'	980.43	99.334	59° 57'	981.93	99.490
....	45° 0'	980.610	99.357	90° 0'	983.22	99.620

N.B. $g = \pi^2/l$.

V. PROPERTIES OF THE ELEMENTS

Element.	Symbol.	Atomic Weight (O = 16).	Valency.	Electro-Chemical Equivalent (Gm. per Kilo-Coulomb).	Density (Gm. per c.c.) at 20° C.	Melting-Point (° C.) (Temp. above Pt. point may be uncertain by over 50°).	Boiling Point (° C.) at 760 mm.
Actinium	Ac	226.7	3	...	...	...	...
Aluminium	Al	26.97	3	...	2.70	660	1800 (?)
Antimony	Sb	121.76	3	...	6.6	630	1645
Argon	A	39.944	0	...	0.00178/0°	-189.3	-186
Arsenic	As	74.91	3	...	5.72	...	sublim. at 450
Barium	Ba	137.36	2	...	3.8	704	1140 (?)
Beryllium (Gluc- inum)	Be	9.02	2	...	1.83	1281	1500 (?)
Bismuth	Bi	209.00	3	...	9.8	269	1560
Boron	B	10.82	3	...	2.5 (?)	2000 to 2500	...
Bromine	Br	79.916	1	...	3.1/25°	-7.3	58.8
Cadmium	Cd	112.41	2	...	8.64	321	707
Caesium	Cs	132.91	1	...	1.87	28.4	670
Calcium	Ca	40.08	2	...	1.54	851	1175
Carbon	C	12.010	4	...	1.9-2.3	3500	3927
Cerium	Ce	140.13	3	...	6.9	815	1400 (?)
Chlorine	Cl	35.457	1	...	0.00322/0°	-103	-34
Chromium	Cr	52.01	3	...	7.1	1830	2260
Cobalt	Co	58.94	2	...	8.6	1490	3467
Columbium (Nio- bium)	Nb	92.91	5	...	8.5	1950	...
Copper	Cu	63.54	1	...	8.03	1083	2360
Dysprosium	Dy	162.46	3	...	...	...	...
Erbium	Er	167.2	3	...	4.8 (?)	...	...
Europium	Eu	152.0	3	...	...	...	...
Fluorine	F	19.00	1	...	0.00170/0°	-223	-188
Gadolinium	Gd	156.9	3	...	5.9	...	...
Gallium	Ga	69.72	3	...	5.95	29.8	2300
Germanium	Ge	72.60	4	...	5.47	958	...
Gold	An	197.2	1	...	19.3	1063	2360
Hafnium (Celtium)	Hf	178.6	3	...	...	2227	...
Helium	He	4.003	0	...	0.00179/0°	below -272	-268.98
Holmium	Ho	164.94	3	...	...	...	...
Hydrogen	H	1.0080	1	...	0.0008987/0°	-250	-252.8
Indium	In	114.76	3	...	7.3	156.4	>1400
Iodine	I	126.92	1	...	4.95	113.7	184.4
Iridium	Ir	193.1	4	...	22.4	2454	2550 (?)
Iron	Fe	55.85	2	...	7.87	1527	3235
Krypton	Kr	83.7	0	...	0.00371/0°	-156.6	-152.0
Lanthanum	La	138.92	3	...	6.12	812	...
Lead	Pb	207.21	2	...	11.34	327.4	1755
Lithium	Li	6.940	1	...	0.534	180	>1400
Lutecium (Cassio- peium)	Lu	174.99	3	...	...	...	...
Magnesium	Mg	24.32	2	...	1.74	659	1097
Manganesc	Mn	54.93	2	...	7.4	1242	1900
Mercury	Hg	200.61	1	...	13.596/0°	-38.86	356.7

N.B.—The Atomic Weights, etc., of the Elements Masurium and Illinium are not accurately known.

PROPERTIES OF THE ELEMENTS—continued

Element.	Symbol.	Atomic Weight (O = 16).	Valency.	Electro-Chemical Equivalent (gm. per Kilo-Coulomb).	Density (Gm. per c.c.) at 20° C.	Melting-Point (° C.) (Temp. above Pt. point may be uncertain by over 50°).	Boiling Point (° C.) at 760 mm.
Molybdenum	Mo	95.95	{ 4 6 }	{ .2487 .1658 }	10.0	2622	c. 3560
Neodymium	Nd	144.27	3	.4985	6.96	840	...
Neon	Ne	20.183	0	...	.000000/0°	-248.7	-210.3
Nickel	Ni	58.69	{ 2 3 }	{ .3040 .2027 }	8.8	1455	3075
Nitrogen	N	14.008	{ 3 5 }	{ .0484 .0290 }	.00125/0°	-210.02	-195.84
Osmium	Os	190.2	6	.3297	22.5	2700 (?)	...
Oxygen	O	16.0000	2	.0829	.00143/0°	-219	-182.97
Palladium	Pd	106.7	{ 2 4 }	{ .5528 .2764 }	11.4	1554	...
Phosphorus	P	30.98	{ 3 5 }	{ .1071 .0842 }	2.2 (red) 1.8 (yellow)	44.1	279
Platinum	Pt	195.23	{ 2 4 }	{ 1.0104 .5052 }	21.4	1773.5	4300 (?)
Polonium	Po	210.0	...	...	...	...	...
Potassium	K	39.096	1	.4052	0.86	63.6	758
Praseodymium	Pr	140.92	3	.4857	6.48	940	...
Proto-actinium	Pa	231	...	...	...	...	...
Radium	Ra	226.05	2	1.1731	...	960 (?)	...
Radon (Niton)	Rn	222	...	...	.00973/0°	-71	-02
Rhenium	Re	186.31	...	...	21.2	3167	...
Rhodium	Rh	102.91	3	.3554	12.44	1965	2500 (?)
Rubidium	Rb	85.48	1	.8855	1.53	39.0	696
Ruthenium	Ru	101.7	{ 6 8 }	{ .1757 .1317 }	12.3	1900 (?)	2520 (?)
Samarium	Sm	150.43	3	.5195	7.8	> 1350	...
Scandium	Sc	45.10	3	.1523	...	...	...
Selenium	Se	78.96	2	.4104	4.8	220	685
Silicon	Si	28.06	4	.0733	c. 2.3	1415	2302
Silver	Ag	107.880	1	1.1180	10.5	960.5	2152
Sodium	Na	22.997	1	.2384	0.97	97.6	878
Strontium	Sr	87.63	2	.4540	2.54	771	1366
Sulphur	S	32.066	{ 2 4 }	{ .1662 .0831 }	2.07 (rhombic)	113 to 120	444.6
Tantalum	Ta	180.88	5	.3751	16.6	2996	...
Tellurium	Te	127.61	2	.6606	6.25	452	1390
Terbium	Tb	159.2	3	.5490	...	...	...
Thallium	Tl	204.30	1	2.1141	11.9	302	1457
Thorium	Th	232.12	4	.6021	11.3	1680-1730	...
Thulium	Tm	169.4	3	.5821	...	...	...
Tin	Sn	118.70	{ 2 4 }	{ .6166 .3083 }	7.28	231.86	2270
Titanium	Ti	47.90	4	.1246	4.5	1800	...
Tungsten	W	183.92	6	.3178	19.3	3387	4830
Uranium	U	238.07	{ 4 6 }	{ .6179 .4119 }	18.7	1689	...
Vanadium	V	50.95	{ 3 5 }	{ .1762 .1057 }	6.0	1720	...
Xenon	Xe	131.3	0	...	.00585/0°	-111.8	-108.0
Ytterbium	Yb	173.04	3	.5976	5.5	...	...
Yttrium	Y	88.92	3	.3074	3.8 (?)	1490	...
Zinc	Zn	65.38	2	.3387	7.1	419.5	913
Zirconium	Zr	91.22	4	.2347	6.5	1857	...

N.B.—The quantity of Radon in equilibrium with 1 gm. of Radium is called a *Curie* and has a volume at N.T.P. of .66 c.c.m.

Four new elements, Neptunium (Np), Plutonium (Pu), Americium (Am) and Curium (Cm) have been recently detected. Their respective atomic numbers are 93, 94, 95, 96.

VI. PROPERTIES OF SOLIDS

Substance.	Density (Gm. per c.c.).	Specific Heat.	Melting Point (° C.).	Latent Heat of Lique- faction.	Coeff. of Lin. Expansion ($\times 10^{-6}$).	Thermal Conductivity. 18° C. 100° C.	Electrical Resistance (Microhms per cent. cube) at 18° C.	Temp. Coef. of Resistance.
Aluminium	2.7	.21	900	92.4	.255	.480	3.21	-.0038
Antimony	6.6	-.05	630	24.3	.115	.044	40.5	-.00398
Bismuth	9.8	-.0304	269	13	.134	.0194	119	-.0042
Brass	8.2 to 8.7	-.089	800 to 1000	...	.189	.28	6 to 9	.001 to .002
Carbon (Graphite)	2.3	.2	3500	...	.079	.0004	3000 to 7000	-.00056 to -.00088
Cobalt	8.6	-.103	1490	58	.123	...	9.7	-.0033
Constantan (Eureka)	8.9	-.098	1320	...	.17	.054	49.0	-.00002
Copper	8.93	-.091	1083	43	.167	.018	1.78	-.00425
Cork	.23 to .26	.49	...	...	...	.00012	...	-.00044
German Silver	8.3 to 8.5	-.095	c. 1050	...	.184	.070	20 to 30	...
Glass (Crown)	2.5 to 2.7	.16	1100	...	.090	.0025	> 10 ¹⁴	...
Glass (Flint)	2.9 to 4.5	.12	1063	15.9	.079	.002	2.42	-.0040
Gold	19.3	-.0303	0	79.67	.139	.700	3 \times 10 ¹⁴	...
Ice	.92	.502	...	...	.51	.005	8 \times 10 ⁹	...
India-rubber	.91 to .93	.27 to .48	1500	...	.704	.00045	75	-.042
Invar	8.0	.12	...	...	.009	...	74 to 98	...
Iron (Cast)	7.0 to 7.7	.119	c. 1100	Grey 23 White 38	.106	.114	...	...
Iron (Wrought)	7.8 to 7.9	.115	1500	...	.114	.144	13.9	-.0062
Lead	11.34	-.0302	327	6	.292	.083	20.8	-.0043
Magnesium	c. 2	.22	610	...	.24	...	...	...
Manganese	8.5	...	...	...	...	.053	44.5	-.00001
Marble	2.5 to 2.8	.21	...	...	.014-.044	.007	...	...
Naphthalene	1.15	.32	80	35.6	1.07	.00095	...	...
Nickel	8.8	-.106	1455	...	.128	.142	11.8	-.0027
Paraffin	8.7 to .93	.69	c. 54	35.1	1.10	.0006	5 to 10	...
Phosphor Bronze	8.7 to 8.9	...	c. 1000	...	.17	...	34.4	...
Platinoïd	c. 9	...	...	...	...	.060	5 \times 10 ¹⁸	-.00025
Platinum	21.4	-.0324	1773	27.2	.089	.166	10.9	-.0037
Quartz	2.64	.17	c. 1750	135 to 260	(Fibre) .017	.022	1 \times 10 ¹⁴	...
Silver	10.5	-.056	961	22	.192	1.006	1.63	-.0040
Sodium	.97	-.283	97.8	27.5	.75	.31	4.74	-.00439
Sulphur	2.07	.16 to .18	115	9.4	c. 7	.00063	4 \times 10 ¹⁶	...
Tin	7.3	-.054	232	14.6	.223	.155	11.3	-.0045
Zinc	7.1	-.092	419	26.6	.203	.265	6.1	-.0037

VII. PROPERTIES OF LIQUIDS

Substance.	(Density at 0° C. (gm. per c.c.))	Surface Tension (dyne per cm.) with air at 20° C.	Viscosity at 20° C. (dyne per sq. cm. per unit vel. grad.)	Specific Heat at 20° C.	Boiling Point (° C.)	Latent Heat of Vaporisation at B. Pt.	Freezing Point.	Coefficient of Expansion of Volume	Thermal Conductivity (from 8° to 15° C.)	Electrical Resistance (ohms per c.c.) at 18° C.	Index of Refraction at 15° C. for D line
Alcohol (Ethyl) (C ₂ H ₅ O)	.792	21.7	.0110	.60	78.3	206	-115	.00110	.000423	...	1.362
Benzene or Benzole (C ₆ H ₆)	.878 at 20°	29.3	.00649	.41	80.2	95	5.5	.00124	.000393	...	1.504
Bromine (Br)	3.1	44	.00993	.11	58.8	45.6	-7.3	.00117	...	...	{ 1.626 (12°) (A line.) }
Carbon Bisulphide (CS ₂)	1.292	35	.00367	.24	46.2	85	-110	.00121	.000343	...	1.632
Chloroform (CHCl ₃)	1.527	27.2	.00564	.23	61.2	58.5	-63	.00126	.000298	...	1.499
Ether (C ₄ H ₁₀ O)	.736	16	.00234	.56	34.6	83	-123	.00163	.000303	...	1.354
Glycerine (C ₃ H ₅ O ₃)	1.26	63.14	8.5	.58	290	...	17	.00053	.000637	...	1.473
Hydrochloric Acid (HCl) (20 per cent. sol.)	1.10	74	...	.70	110	...	-65	...	...	1.3	1.41 (Δ=1.17)
Mercury (Hg)	13.596	465	.0156	.033	356.7	68	-38.8	.00182	.0201	.0000958	1.73
Nitric Acid (HNO ₃) (20 per cent. sol.)	1.12	...	...	.82	104	...	-24	...	...	1.4	1.40 (Δ=1.36)
Nitro-benzene (C ₆ H ₅ NO ₂)	1.21	...	.0203	.36	211	79.2	5.67	.00086	.00038	...	1.553
Olive Oil	.92	32	.089(15°)	.47	6.300	...	...	.00070	.000405	...	1.46
Sulphuric Acid (H ₂ SO ₄) (20 per cent. sol.)	1.14	76	...	.84	105	...	-38	.00051	.00130	1.53	1.44 (Δ=1.81)
Turpentine (C ₁₀ H ₁₆)	.87	27.3	.0149	.42	159	70	-10	.00094	.000325	...	1.47
Water (H ₂ O)	.99987	73.5	.01006	1.0	100	539	0	.00015 (10°-20°)	.00131	9.1 × 10 ⁻⁶ (at 4° C.)	1.333
Water (Sea)	1.025	...	...	.94	104(?)	...	-9	...	...	...	1.343

* The temperature coefficient of resistance of electrolytes is negative, and varies from .5 per cent. to 2 per cent. per degree Centigrade

VIII. PROPERTIES OF

<i>N.B.</i> —Where not otherwise indicated, the various columns refer to gases at 0° C. and 760 mm. pressure.	Density in gm. per litre.	Mean Velocity of Molecules in cm. per sec. (Ω).	Mean Free Path of Molecules in cm. (L).	Number of Collisions per sec. (Ω/L).	Viscosity in dynes per sq. cm. per unit vel. grad. (η).	Critical Temp. (° C.). (θ_c).
Acetylene (C_2H_2) . . .	1.17	...	...	...	...	36.5
Air	1.293	44700	9.6×10^{-6}	4660×10^6	.000183	-140
Ammonia (NH_3) . . .	.771	57800	7.0×10^{-6}	8260×10^6	.0000957	130
Argon (A)	1.781	38000	10×10^{-6}	3800×10^6	.000210	-122
Carbon Dioxide (CO_2) .	1.977	36100	6.3×10^{-6}	5730×10^6	.000139	31.1
Carbon Monoxide (CO) .	1.250	45400	9.3×10^{-6}	4880×10^6	.000166	-139
Chlorine (Cl_2)	3.21	28200	4.6×10^{-6}	6130×10^6	.000129	146
Cyanogen (C_2N_2) . . .	2.337	33300	4.0×10^{-6}	8320×10^6	.0000948	128
Ethylene (C_2H_4) (Olefin-ant Gas) }	1.260	44900	5.5×10^{-6}	8160×10^6	.000097	10
Helium (He) . . . . .	.1785	120700	28×10^{-6}	4310×10^6	.000189	-268
Hydrogen (H_2) . . . . .	.0899	169300	18×10^{-6}	9410×10^6	.000086	-239.9
Hydrogen Chloride (HCl)	1.64	39600	6.9×10^{-6}	5740×10^6	.000138	52.3
Hydrogen Sulphide (H_2S)	1.538	40900	5.9×10^{-6}	6930×10^6	.000118	100
Methane (CH_4), (Marsh-Gas—Fire-Damp) }	.717	59700	7.8×10^{-6}	7650×10^6	.00012	-82
Nitric Oxide (NO) . . .	1.340	43800	9.1×10^{-6}	4810×10^6	.000165	-93.5
Nitrous Oxide (N_2O) (Laughing Gas) }	1.978	36100	6.1×10^{-6}	5920×10^6	.000135	38.8
Nitrogen (N_2) *	1.251	45400	9.4×10^{-6}	4830×10^6	.000167	-147
Oxygen (O_2)	1.429	42500	9.9×10^{-6}	4290×10^6	.000192	-118
Sulphur Dioxide (SO_2) .	2.927	29700	4.6×10^{-6}	6460×10^6	.000117	155.4
Steam at 100° C. . . . .	.581	...	...	...	.000120	374
Water Vapour (0°) . . .	...	65200	7.2×10^{-6}	9060×10^6	.000087	...

* One litre of "atmospheric nitrogen" consists of 988.14 c.c. of pure nitrogen and 11.86 c.c. of argon, and has a weight of 1.257 grams.

N.B.—The volume of 32 gm. of oxygen at N.T.P. is 22.415 litres, and this volume of any gas is called a gram-molecular volume, or gram-molecule, or mole, of the gas.

GASES AND VAPOURS

Critical Pressure in Atmos. (p_c).	Critical Volume. (v_c)*.	Boiling Point at Atmos. Press. ($^{\circ}$ C.).	Freezing Point ($^{\circ}$ C.).	Heat of Vaporisation.	Specific Heat (Constant Pressure). (C_p).	Ratio of Specific Heats i.e., $\frac{C_p}{C_v}$ (κ).	Thermal Conductivity at 0° C.	Index of Refraction for D line. $\lambda = 5893 \times 10^{-8}$ cm.
61.6	.0069	-83.6	...	...	.402	1.26	.000045	1.000606
39.0	.00468	-190	...	c. 50	.237	1.402	.0000577	1.000292
115	.00481	-33.5	-75.5	341	.520	1.336	.0000522	1.000375
48	.00404	-186	-189	...	.127	1.667	.0000389	1.000284
73	.0066	-78.2	-65	57	.201	1.306	.0000343	1.000450
35.9	.00505	-191	-199	51	.250	1.401	.0000558	1.000334
76	.00615	-34	-103	67	.114	1.34	.0000172	1.000768
59.6	.00924	-20.7	-35	...	...	...	...	1.000805
51.7	.00752	-102.7	-169	...	.364	1.264	.0000395	1.000674
2.26	.00299	-269	{ below } { -272 }	...	1.25	1.63	.000343	1.000035
12.8	.00264	-252.7	-259	123	3.42	1.41	.000318	1.000138
86.0	.0052	-85	-111	98	.194	1.40	...	1.000444
88.7	.00578	-59.4	-83.8	132	.245	1.34	.0000287	1.000610
46	.00488	-164	-164	...	.530	1.313	.0000647 (8° C.)	1.000441
71.2	.00347	-153	-160.0	...	.232	1.394	.0000460 (8° C.)	1.000297
77.5	.00436	-89.8	-102	67 (-20°)	.213	1.324	.0000361	1.000515
33.0	.00517	-195.8	-210	50	.235	1.41	.0000581	1.000297
50	.00426	-182.0	-219	58	.242	1.40	.0000583	1.000272
78.9	.00745	-10.8	-76	96.2	.154	1.26	.0000184	1.000660
218.5	.00248	100	...	539	.488	1.305	.0000519	...
...	...	...	...	...	..	...	...	1.000254

* v_c = vol. at θ_c and p_c which at N.T.P. would have unit volume.

N.B.—The coefficient of expansion at constant pressure for all ordinary gases may be taken as $\frac{1}{273}$, or .003662. For the perfect gas it is $\frac{1}{273.15} = .0036609$.

IX. ATMOSPHERE

PERCENTAGE (By volume, nitrogen 78.05, oxygen 21, argon .95) With traces of CO₂, Kr,
COMPOSITION (By weight, nitrogen 75.5, oxygen 23.2, argon 1.3) Xe, Ne, and He.

DENSITY AT 0° C. AND 76 cm. = .001293 gm. per c.c. = .0807 lb. per c. ft.

STANDARD PRESSURE = 760 mm. of mercury at 0° C., lat. 45°, and sea-level.
= 29.92 inches of mercury.
= 1033 gm. weight per sq. cm. = 14.7 lbs. weight per sq. in.
= 1.0132×10^6 dynes per sq. cm. = 1013.2 millibars.

STRUCTURE

TROPOSPHERE—region of weather—extending up to 12 km. (say 7½ miles) in the latitude of Britain, and to 18 km. (say 11½ miles) at the equator.—temp. falls by about 6° C. per km. (say 1° F. per 300 ft.) of ascent, and for first 1200 metres barometer falls by 8.5 mm. approx. per 100 metres (say .3 in. per 100 yds.)—upper boundary called Tropopause.

STRATOSPHERE—practically cloudless region lying above the troposphere—temperature nearly uniform (about 219° K.) up to at least 30 km. (say 19 miles)—from 30 to 60 km. (38 miles) temperature increases again in a region containing most of the ozone of the atmosphere and sometimes called the *Ozonsphere*—in the higher regions of the Stratosphere, sometimes called the *Ionosphere*, are ionized layers:—

(a) Kennelly-Heaviside or E layer, reflecting longer radio waves mainly—at about 100 km. (say 60 miles).

(b) Appleton or F layers (F₁ and F₂), reflecting shorter radio waves—at between 200 and 300 km. (say 125-185 miles).

Note.—Waves shorter than 8 to 10 m. usually pierce the ionosphere and pass into outer space.

RELATIVE HUMIDITIES FOR WET AND DRY BULB HYGROMETER
(VENTILATED) TYPE

De- pression of Wet Bulb in ° C.	Dry Bulb Temperature in ° C.								
	0°	5°	10°	15°	20°	25°	30°	35°	40°
1°	82%	86%	88%	90%	91%	92%	93%	93%	94%
2°	65	72	76	80	83	84	86	87	87
3°	47	58	65	71	74	77	79	81	81
4°	30	45	54	61	66	70	73	75	76
5°	...	32	44	52	59	63	67	69	71
6°	...	21	34	44	51	57	61	64	66
7°	...	...	24	35	44	51	56	58	61
8°	...	...	15	27	37	44	50	53	56
9°	...	...	...	20	30	39	44	48	51
10°	...	...	...	12	24	33	39	44	47

X. HEAT

THERMOMETERS—Centigrade 0°
Fahrenheit 32°
Réaumur 0°

F.P. 100°
32°
0°

B.P. 212°
80°

Hence—
= 4 Réaumur Scale Divisions
= 5 Centigrade " "
= 9 Fahrenheit " "

UNITS OF HEAT:—

Calorie = heat required to raise the temperature of 1 gram water 1° C.

British Thermal Unit (B.Th.U.) = heat required to raise 1 lb. water 1° F. = 252.0 cal.

Centigrade Heat Unit (C.H.U.) = heat required to raise 1 lb. water 1° C. = 453.6 cal.

Therm (used by gas engineers) = 100,000 B.Th.U.

MECHANICAL EQUIVALENT OF HEAT—Joule's Equivalent—J.

1 gram-calorie at 15° C. = 4.185×10^7 ergs = 4.185 joules = 427 metre-grams.

1 B.Th.U. = 778 foot-pounds = 1055 joules.

1 C.H.U. = 1400 foot-pounds = 1898 joules.

HEAT—continued

RADIATION—

Stefan-Boltzmann Law.—If a black body at absolute temperature T be placed in an enclosure exhausted of air, and the walls of the enclosure be maintained at absolute temperature t , the rate of radiation from the body is $E = \sigma(T^4 - t^4) = 5.75 \times 10^{-9}(T^4 - t^4)$ ergs per sq. cm. per sec. = $1.37 \times 10^{-12}(T^4 - t^4)$ calories per sq. cm. per sec.
 $\sigma = 5.75 \times 10^{-9}$ is known as Stefan's Constant.

Quantum Theory of Radiation.—The amount (δ) of energy in the quantum is proportional to the frequency (n) of the radiation, i.e. $\delta = hn$, where h is Planck's Constant.
 $h = 6.62 \times 10^{-27}$ erg sec.

Light quanta are frequently spoken of as *photons*.

DENSITY OF WATER

(Gm. per c.c.)

Temp.	0	2	4	6	8	10	12	14	16	18
0° C.	.99987	.99997	1.0000	.99997	.99987	.99973	.99953	.99927	.99897	.99862
20°	.99823	.99780	.99732	.99681	.99626	.99567	.99505	.99440	.99371	.99298
40°	.9922	.9915	.9907	.9898	.9890	.9881	.9872	.9862	.9853	.9843
60°	.9832	.9822	.9811	.9801	.9789	.9778	.9767	.9755	.9743	.9731
80°	.9718	.9706	.9693	.9680	.9667	.9653	.9640	.9626	.9612	.9598

Density at 100° = .9584 ; at 110° = .951 ; at 150° = .917 ; at 200° = .863.

Note.—The maximum density-point of water is 3.98° C.

PRESSURE OF SATURATED WATER VAPOUR IN MM. OF MERCURY

Temp. C.	Pressure mm.	Temp. C.	Pressure mm.	Temp. C.	Pressure mm.
-10°	2.16	11°	9.84	35°	42.02
-9°	2.32	12°	10.51	40°	55.13
-8°	2.51	13°	11.23	45°	71.64
-7°	2.71	14°	11.98	50°	92.30
-6°	2.93	15°	12.78	55°	117.9
-5°	3.17	16°	13.62	60°	149.2
-4°	3.40	17°	14.52	65°	187.6
-3°	3.67	18°	15.46	70°	233.5
-2°	3.99	19°	16.46	75°	288.9
-1°	4.26	20°	17.51	80°	355.1
0°	4.58	21°	18.62	85°	433.4
1°	4.92	22°	19.79	90°	525.8
2°	5.29	23°	21.02	95°	633.9
3°	5.68	24°	22.32	99°	733.1
4°	6.10	25°	23.69	100°	760.00
5°	6.54	26°	25.13	101°	787.4
6°	7.01	27°	26.65	105°	905.7
7°	7.51	28°	28.25	110°	1074.5
8°	8.04	29°	29.94	150°	3569
9°	8.61	30°	31.71	200°	11647
10°	9.21				

N.B.—Near 100° C. the B.P. of water rises by about .37° C. per rise of 10 mm. atmospheric pressure.

SOLAR RADIATION—

The Sun radiates energy at the rate of 3.8×10^{33} ergs per sec. or 9.1×10^{26} cal. per sec., and therefore, in accordance with the Theory of Relativity, loses mass ($M = \frac{E}{C^2}$, where M = change of mass, E = change of energy, C = veloc. of light)

at the rate of 4.2×10^{12} grams (about 4 million tons) per sec.

SOLAR CONSTANT—the amount of Solar Energy incident at right angles at Earth's mean distance = 1.97 calories per sq. cm. per minute = .137 watts per sq. cm. = 7400 H.P. (approx.) per acre.

LIGHT—continued

Hence Metre-candle or Lux = 1 lumen per sq. metre.
Centimetre-candle or Phot = 1 lumen per sq. cm.
Foot-candle = 1 lumen per sq. ft.

Also 1 Phot = 10⁸ lux. 1 foot-candle = 10.76 lux.

The EFFICIENCY of the clear gas-filled tungsten lamp, taking into account the screening effect of the holder, runs from 1 to 1.25 watts per candle-power, i.e. rather less than 12 lumens per watt on the average. A good arc flame gives about 4 candles (say 50 lumens) per watt.

MECHANICAL EQUIVALENT OF LIGHT = .0016 watts per lumen approx. for the frequency of maximum luminosity, which is in the yellow-green, ($\lambda = 5560 \times 10^{-8}$ cm.), i.e. 625 lumens per watt.

The energy (heat and light) falling on 1 sq. cm. at 1 metre from a standard candle is about 4 ergs per second (Rayleigh).

REFRACTIVE INDICES (AGAINST AIR) FOR MEAN D LINE

($\lambda = 5893 \times 10^{-8}$ cm.)

Canada Balsam	1.53	Iceland Spar (ord.)	1.658
Crown Glass	1.48-1.61	" (ext.)	1.480
Diamond	2.417	Quartz (ord.)	1.544
Felspar	1.52	" (ext.)	1.553
Flint Glass	1.53-1.96	Rock Salt	1.544
Fluor Spar	1.434	Ruby	1.76
Ice	1.31	Sylvine (KCl)	1.490

WAVE-LENGTHS IN TENTH-METRES OF IMPORTANT SPECTRAL LINES
IN AIR AT 15° C. AND 760 MM.

(1 tenth-metre = 10⁻⁸ cm. = Ångström unit)

Line.	Wave-length in tenth-metres	Line.	Wave-length in tenth-metres
K red	7668	Mg green (b ₁)	5178
O red (A)	7594	" (b ₂)	5173
" (B)	6870	" (b ₃)	5168
Li red	6708	Cd green *	5085.82
H _α red (C)	6563	H _β blue-green (F)	4861
Cd red *	6438.47	Cd blue *	4799.91
Li orange	6104	Sr blue	4608
Na orange (D ₁)	5896	Li blue	4602
" (D ₂)	5890	H _γ blue (G')	4340
He yellow (D ₃)	5876	Fe and Ca blue (G)	4308
Tl green	5351	Ca blue (g)	4227
Fe and Ca green (E)	5270	K violet	4047

* Accepted standard lines.

Rydberg's Constant—Hydrogen, 109677.75; Helium, 109722.4.

ELECTRO-MAGNETIC SPECTRUM

Approximate wave-lengths in tenth-metres (10⁻⁸ cm.)₁₀

Hertzian Waves	10 ¹⁴	10 ¹⁶
Broadcasting and Television	2 × 10 ¹⁵	7 × 10 ¹⁶
Infra-red	3 × 10 ¹⁶	7.5 × 10 ¹⁶
Red	7.5 × 10 ¹⁶	0.5 × 10 ¹⁷
Orange	6.5 × 10 ¹⁶	5.0 × 10 ¹⁶
Yellow	5.0 × 10 ¹⁶	5.3 × 10 ¹⁶
Green	5.3 × 10 ¹⁶	4.0 × 10 ¹⁶
Blue	4.0 × 10 ¹⁶	4.2 × 10 ¹⁶
Violet	4.2 × 10 ¹⁶	3.0 × 10 ¹⁶
Ultra-Violet	3.0 × 10 ¹⁶	1.8 × 10 ¹⁶
X-rays :—		
Soft	2 × 10	1
Hard	1	10 ⁻¹
Gamma Rays	5 × 10 ⁻¹	5 × 10 ⁻²

HEAT—continued

SOME IMPORTANT TEMPERATURES

	Absolute Scale	Centigrade Scale
Absolute zero	0° K.	-273° C.
Boiling-point of liquid helium	4°·2	-268°·8
Melting-point of solid hydrogen	14°	-259°
Boiling-point of liquid hydrogen	20°·3	-252°·7
Boiling-point of liquid air	83°	-190°
Boiling-point of liquid oxygen. (Oxygen point)	90°·03	-182°·07*
Boiling-point of liquid carbonic acid	194°·8	-78°·2
Melting-point of ice (Ice point)	273°	0°
Healthy human body	309°·9	36°·9
Boiling-point of water (Steam point)	373°	100°
Melting-point of tin	505°	232°
Ignition-point of gunpowder	561°	288°
Melting-point of lead	600°	327°
Boiling-point of sulphur (Sulphur point)	717°·60	444°·60*
Melting-point of silver (Silver point)	1233°·5	960°·5*
Melting-point of gold (Gold point)	1336°	1063°*
Melting-point of copper	1356°	1083°
Melting-point of platinum	2040°	1773°
Low red heat	500° to 600° C.	
White heat	1500° to 1800° C.	
Oxy-hydrogen flame	2200° C.	
Bessemer furnace	2230° C.	
Electric arc	3300° to 3500° C.	
Estimated temperature of radiating layer of sun	about 6000° K.	
Estimated temperature of hottest stars	about 35,000° K.	

* Basic Fixed Points of the International Temperature Scale.

The Thermo-dynamic Temperature of the Ice-point may be taken as 273°·16 K.

XI. LIGHT

VELOCITY OF LIGHT = 2.998×10^{10} cm. per sec. = 186,300 miles per sec.

1 light-year = 5.878×10^{12} miles = 9.460×10^{12} km.

1 parsec = distance corresponding to a parallax of 1 second of arc = 19.18×10^{12} miles = 30.87×10^{12} km. = 3.263 light-years.

WAVE-LENGTH FOR MEAN D (SODIUM) LINE = 5893×10^{-8} cm.

The VISIBLE SPECTRUM is comprised between the wave-lengths 7500×10^{-8} cm. (red) and 3900×10^{-8} cm. (violet).

PHOTOMETRIC UNITS—These depend upon the INTERNATIONAL CANDLE, which has been adopted by Great Britain, France, and U.S.A., and which is defined as a source of light having a luminous intensity of $1/10$ of that of the Vernon-Harcourt pentane lamp. The German Hefner lamp = 0.9 international candle.

LUMINOUS FLUX is the time rate of flow of luminous energy. The unit of luminous flux is the LUMEN, which is the flux, or luminous energy per sec., emitted in unit solid angle (steradian) by a uniform point-source of one international candle.

Note—The unit solid angle, or steradian, is the solid angle subtended at the centre of a sphere by an area on the surface of the sphere equal to the square of the radius.

The total solid angle at a point is 4π steradians, and therefore the total luminous flux emitted by a point-source of one international candle is 4π lumens, i.e. 12.57 lumens approx.

The LUMINOUS INTENSITY of a point-source in any direction is the luminous flux (i.e. no. of lumens) emitted per steradian in that direction.

The ILLUMINATION at any point of a surface is the luminous flux falling normally on the surface per unit area.

The unit of illumination is the LUX or Metre-candle, which is defined as the illumination at any point on the surface of a sphere of one metre radius when a point-source of one international candle is at the centre of the sphere.

Since the total flux in this case = 4π lumens, and the area of the sphere = $4\pi r^2$ sq. metres,

$$\text{the illumination} = \frac{4\pi}{4\pi r^2} = \frac{1}{r^2} = 1 \text{ lumen per sq. metre.}$$

MAGNETISM AND ELECTRICITY—continued

RESISTANCE

OHM = 10⁹ C.G.S. units = 1/9 × 10⁻¹¹ E.S.U. = resistance at 0° C. of a column of mercury 106.3 cm. long, of uniform cross-section, and weighing 14.4521 grams. 1 microhm = 10⁻⁶ ohms. A conductor having a resistance of 1 ohm is said to have a CONDUCTANCE OF 1 MHO.

QUANTITY

COULOMB = 10⁻¹ C.G.S. units = quantity which passes any point in 1 second in the case of a conductor carrying a current of 1 ampere = 3 × 10⁹ electrostatic units.

FARADAY = 96,494 coulombs (i.e. $\frac{107.88}{.0011180}$) = charge carried by one gram-equivalent of an ion, e.g. charge required to pass to liberate 107.88 gm. of silver.

CAPACITY

FARAD = 10⁻⁹ C.G.S. units = capacity of any condenser which requires a coulomb to raise its potential by 1 volt = 9 × 10¹¹ electrostatic units.

Capacity of 1 nautical mile of Atlantic cable = $\frac{1}{3} \times 10^{-6}$ farads = $\frac{1}{3}$ MICROFARAD.

INDUCTION

HENRY = 10⁹ C.G.S. units = induction produced in a circuit when the induced E.M.F. is 1 volt, and the inducing current varies at the rate of 1 ampere per second.

ENERGY OR WORK

JOULE = 10⁷ ergs = .2389 calories.

ACTIVITY OR POWER

WATT = 1 joule per second = rate at which work is done by a current of 1 ampere working through 1 volt. 746 watts = 1 horse-power. KILO-WATT-HOUR = Board of Trade unit of electric energy = energy supplied when product of amperes, volts, and hours is 1000 = 3.6 × 10⁶ joules = 1.34 horse-power for 1 hour.

APPROXIMATE E.M.F.'s OF VARIOUS CELLS

Cell	E.M.F. in Volts	Cell.	E.M.F. in Volts
Bichromate	2	Leclanche	1.5
Bunsen	1.8-1.9	Lessing	1.5
Daniell	1.07-1.08	Obach	1.5
Grove	1.8-1.9	Clark (Standard)	1.433 (at 15° C.)
Standard Cadmium (Weston) Cell			1.0186 (at 20° C.).
Secondary Cell			1.85 to 2.2 volts.

IMPERIAL STANDARD WIRE-GAUGE AND WIRE RESISTANCES (15° C.)

Gauge Number	Diameter (cm.)	Section (Sq. cm.)	Copper (ohms per metre)	Eureka or Constantan* (ohms per metre)	German Silver † (ohms per metre)	Manganin ‡ (ohms per metre)	Platinoid § (ohms per metre)
10	.3251	.08302	.0021	.057	.027	.051	.049
12	.2642	.05480	.0032	.086	.041	.077	.075
14	.2032	.03243	.0054	.146	.070	.131	.126
16	.1626	.02076	.0083	.228	.109	.204	.197
18	.1219	.01163	.0148	.405	.193	.361	.342
20	.09144	.006567	.0260	.722	.345	.645	.622
22	.07112	.003973	.0435	1.20	.57	1.07	1.03
24	.05588	.002452	.0705	1.93	.92	1.73	1.67
26	.04572	.001642	.105	2.89	1.38	2.58	2.50
28	.03759	.001110	.155	4.27	2.02	3.82	3.69
30	.03150	.0007701	.222	6.08	2.90	5.45	5.25
32	.02743	.0005910	.293	8.02	3.83	7.18	6.81
34	.02337	.0004289	.404	11.1	5.27	9.90	9.55
36	.01930	.0002927	.590	16.2	7.74	14.5	14.0
38	.01524	.0001824	.950	26.0	12.4	23.2	22.5
40	.01219	.0001167	1.48	40.6	19.4	36.3	35.1

* 60 Cu, 40 Ni.

‡ 84 Cu, 4 Ni, 12 Mn.

† c. 60 Cu, 15 Ni, 25 Zn.

§ German Silver with say 1 per cent. W.

XII. MAGNETISM AND ELECTRICITY

MAGNETIC ELEMENTS

Place	Year	Declination	Inclination	C.G.S. Units	
				Horiz. Intensity	Vertical Intensity
		°	°	(H)	(V)
Lerwick	1938	12 35.8 W.	72 54.4 N.	-14402	-46837
Eskdalemuir	1938	13 17.1 W.	69 50.7 N.	-16504	-44967
Meanook (Alberta)	1938	25 64.8 E.	77 52.7 N.	-12726	-59252
Valentia (Ireland)	1938	16 2.4 W.	67 58.3 N.	-17808	-44012
Abinger (Surrey)	1938	11 1.4 W.	66 43.2 N.	-18522	-43050
Agincourt (Ontario)	1938	7 35.1 W.	74 51.3 N.	-15310	-56564
Shanghai	1938	3 25.0 W.	45 31.7 N.	-33316	-33937
Helwan (Egypt)	1938	0 20.2 E.	42 3.0 N.	-30383	-27406
Hongkong	1938	0 38.7 W.	30 26.7 N.	-37673	-22143
Bombay	1938	0 20.1 W.	25 20.3 N.	-37727	-17865
Samoa	1938	10 45.3 E.	30 35.4 N.	-34894	-20631
Mauritius	1938	13 35.0 W.	53 0.6 S.	-22462	-20818
Cape Town	1938	24 24.4 W.	63 35.0 S.	-14585	-29361
Toolangi (Australia)	1938	8 45.0 E.	67 49.3 S.	-22909	-56198
Christchurch, N.Z.	1938	18 18.8 E.	68 2.0 S.	-22263	-55198

N.B.—The above values are *mean values for the year*. Over the British Islands generally, the western declination is at present decreasing at a rate of about 11' per annum, while the inclination, horizontal force, and vertical force are changing very slowly.

SPECIFIC INDUCTIVE CAPACITIES (K)

(for very long waves *i.e.* $\lambda = \infty$)

VACUUM = 1

Ebonite	2.7-2.9	Ethyl Alcohol (20° C.)	25.8	Air (0° C.)	1.000594
Glass	5-10	Benzene (18° C.)	2.29	Air (20° C.)	1.000528
Ice	2-3	Ether (18° C.)	4.37	Carbon Dioxide (0° C.)	1.000985
Mica	5.7-6.7	Glycerine (15° C.)	56	Carbon Monoxide (0° C.)	1.000695
Paraffin	2-2.3	Turpentine (20° C.)	2.23	Hydrogen (0° C.)	1.000265
Shellac	3-3.7	Vaseline	1.0	Helium (0° C.)	1.000074
Sulphur	3.6-4.8	Water (18° C.)	81	Sulphur Dioxide (14° C.)	1.00995

In general K increases with λ and decreases with rise of temperature.

THE NATURAL UNIT OF ELECTRICITY

The *electron* (*e*), or natural unit of electricity, is the negative charge carried by a cathode ray particle. It is equal to the charge carried by the hydrogen, or any other univalent, ion in the electrolysis of solutions. The mean of the latest determinations gives the charge of the electron to be equal to 4.805×10^{-10} electro-static units, or 1.602×10^{-19} coulombs. The inertia (mass) of an electron is somewhere about $\frac{1}{1838}$ of that of the hydrogen atom.

PRACTICAL ELECTRIC UNITS

CURRENT

AMPERE = 10^{-1} C.G.S. units = 3×10^9 E.S.U. — current which, when passed through a solution of nitrate of silver in water, deposits .001118 grams of silver per second. A 50 candle-power metallic-filament lamp working at 100 volts requires about .65 ampere

ELECTROMOTIVE FORCE

VOLT = 10^8 C.G.S. units = $1/300$ R.S.U.

SOUND—continued

MEASUREMENT OF LOUDNESS

The INTENSITY of a sound is a physical quantity which is measurable to a considerable degree of accuracy, and its physiological counterpart is LOUDNESS, which is capable only of relatively rough measurement.

When the intensity of a sound increases in geometrical progression the loudness increases—in accordance with the general law of sensation known as the Weber-Fechner law—only in arithmetical progression. For example, at threshold audibility, and increasing intensity by 5-fold steps:—

INTENSITY	1	5	25	125	625, etc.
LOUDNESS	0 (approx.)	1	2	3	4, etc.

Thus loudness is proportional to the logarithm of intensity.

Hence if L_0 = loudness at threshold, which is = 0 approx.

I_0 = corresponding intensity of sound

L = any greater degree of loudness

I = corresponding intensity

$$\text{then } L - L_0 = k(\log_{10} I - \log_{10} I_0) = k \log_{10} \frac{I}{I_0}$$

(taking, for convenience, 10 as logarithmic base).

If $I = 10 I_0$, then $L - L_0 = k$, and, if unit difference of loudness be defined as that which is due to one sound having 10 times the intensity of another, k becomes 1, and for any two degrees of intensity, A and B, of which A is the greater, $L_A - L_B = \log_{10} \frac{A}{B}$.

On the logarithmic scale of sound-intensity this ten-fold increase is called a "BEL," and its tenth part is the "DECIBEL" (db). Two sounds differ in intensity by 1 decibel if their intensities are in the ratio 1:1.26, ($\sqrt[10]{10} = 1.26$ approx.), and the corresponding difference in loudness is called one "PHON." An increase of 1 decibel represents, therefore, an increase of 26 per cent. in intensity and its equivalent increase in loudness, the phon, is, roughly, the minimum increase which the average ear can appreciate.

It must be noted, however, that the sound-intensity corresponding to the threshold of hearing is very different for sounds of different frequency, being considerably greater for very high and very low notes than for notes of medium frequency, and therefore a sound-energy meter cannot, in all cases, be used to measure loudness. The British phon is based on a frequency of 1000 cycles per second, the intensity corresponding to audibility threshold being taken as .0002 dyne per sq. cm.

The following table illustrates the application of the scale:—

Intensity in terms of threshold-intensity = .0002 dyne per sq. cm.	Intensity in decibels	Loudness in phons
1	0	0 Threshold of hearing
10	10 (1 bel)	10 Virtual silence
10 ²	20	20 Quiet room
10 ³	30	30 Watch ticking at 3 ft.
10 ⁴	40	40 Quiet street
10 ⁵	50	50 Quiet conversation
10 ⁶	60	60 Quiet motor at 3 ft.
10 ⁷	70	70 Loud conversation
10 ⁸	80	80 Door slamming
10 ⁹	90	90 Busy typing room
10 ¹⁰	100	100 Near loud motor horn
10 ¹¹	110	110 Pneumatic drill
10 ¹²	120	120 Near aeroplane engine
10 ¹³	130	130 Threshold of pain

XIII. SOUND

VELOCITY OF SOUND

Substance	Temperature	Metres per sec.	Feet per sec.
Air	0° C.	331.3	1087
Hydrogen	0°	1278	4193
Oxygen	0°	317	1041
Water	20°	1410	4629
Alcohol	12.5°	1241	4072
Copper	20°	3000	11810
Iron	20°	5000	16400
Oak (along Fibre)	10° to 20°	3850	12820
Glass	10° to 20°	5000-6000	16400-19700

N.B.—For moderate increases of temperature the velocity of sound in air may be taken as increasing by .6 metres per sec., or 2 ft. per sec., per 1° C. Thus for air at 15° C. the velocity of sound at sea-level is about 1120 ft. per sec. At a height of 30,000 ft. it is about 970 ft. per sec.

MUSICAL SCALES—VIBRATION RATIOS

	C	D	E	F	G	A	B	C
Basic * Scale	24 1.000	27 1.125	30 1.250	32 1.333	36 1.500	40 1.667	45 1.875	48 2.000
Intervals	...	$\frac{9}{8}$	$\frac{10}{9}$	$\frac{16}{15}$	$\frac{9}{8}$	$\frac{10}{9}$	$\frac{9}{8}$	$\frac{16}{15}$

The vibration-numbers in the Basic Scale must bear the given ratios to each other, but their absolute values are matter of convention. French Standard Pitch makes the "Middle C" 261; the Stuttgart Pitch (adopted by the Society of Arts) makes it 264; while Modern Concert Pitch makes it 273. In Physics, the "Middle C" is generally taken as 256.

The London International Conference of May 1939 agreed that the international standard of concert pitch should be based on 440 for the treble A, i.e. 264 for the "Middle C."

In the EQUALLY TEMPERED SCALE the octaves remain as before, but 11 notes are introduced between them, the intervals being made equal and each $\sqrt[12]{2}$, i.e. 1.0595, say 1.06 (approx.). The following is such an equally tempered chromatic scale based on 435 as the treble A:—

	Frequency		Frequency		Frequency
C'	258.7	F	345.3	A	435
C#	271.0	F#	365.8	A#	460.9
D	290.3	G	387.5	B	488.3
D#	307.6	G#	410.6	C'	517.3
E	325.9				

LIMITS OF AUDIBILITY—Between 30 and 30,000 vibrations per sec. (approx.).

* The Basic Scale is frequently referred to as the Natural or Diatonic Scale.

PHYSICAL TABLES

XIV. MISCELLANEOUS

REDUCTION OF GASEOUS VOLUMES TO N.T.P.

$$v_0 = \frac{v}{1 + 0.00367t} \times \frac{p}{760}$$

VALUES OF $1 + 0.00367t$

Temp. (<i>t</i>)	0.	1.	2.	3.	4.	5.	6.	7.	8.	9.
0° C.	1.0000	1.0037	1.0073	1.0110	1.0147	1.0183	1.0220	1.0257	1.0294	1.0330
10	·0367	·0404	·0440	·0477	·0514	·0550	·0587	·0624	·0661	·0697
20	·0734	·0771	·0807	·0844	·0881	·0917	·0954	·0991	·1028	·1064
30	·1101	·1138	·1174	·1211	·1248	·1284	·1321	·1358	·1395	·1431
40	·1468	·1505	·1541	·1578	·1615	·1651	·1688	·1725	·1762	·1798
50	·1835	·1872	·1908	·1945	·1982	·2018	·2055	·2092	·2129	·2165
60	·2202	·2239	·2275	·2312	·2349	·2385	·2422	·2459	·2496	·2532
70	·2569	·2606	·2642	·2679	·2716	·2752	·2789	·2826	·2863	·2899
80	·2936	·2973	·3009	·3046	·3083	·3119	·3156	·3193	·3230	·3266
90	·3303	·3340	·3376	·3413	·3450	·3486	·3523	·3560	·3597	·3633
100	·3670	·3707	·3743	·3780	·3817	·3853	·3890	·3927	·3964	·4000

VALUES OF $\frac{p}{760}$

Press. (<i>p</i>)	0.	1.	2.	3.	4.	5.	6.	7.	8.	9.
700mm.	·9211	·9224	·9237	·9250	·9263	·9276	·9289	·9303	·9316	·9329
710	·9342	·9355	·9368	·9382	·9395	·9408	·9421	·9434	·9447	·9461
720	·9474	·9487	·9500	·9513	·9526	·9539	·9552	·9566	·9579	·9592
730	·9605	·9618	·9632	·9645	·9658	·9671	·9684	·9697	·9711	·9724
740	·9737	·9750	·9763	·9776	·9789	·9803	·9816	·9829	·9842	·9855
750	·9868	·9882	·9895	·9908	·9921	·9934	·9947	·9961	·9974	·9987
760	1.0000	1.0013	1.0026	1.0039	1.0053	1.0066	1.0079	1.0092	1.0105	1.0118
770	1.0132	1.0145	1.0158	1.0171	1.0184	1.0197	1.0211	1.0224	1.0237	1.0250

SCALE OF HARDNESS

Substance.	Hardness (H).	Substance.	Hardness (H).	Substance.	Hardness (H).
Talc	1	Felspar	6	Bodies scratched by finger-nail	2.5 or less
Rock-salt	2	Quartz	7	Window glass	5 to 5.5.
Calcite	3	Topaz	8	Bodies scratched by penknife	approx. 6
Fluorite	4	Corundum (Emery)	9		
Apatite	5	Diamond	10		

MISCELLANEOUS—*continued*

TIME OF DAY REFERRED TO GREENWICH

When it is noon at Greenwich it is:—

Noon	France, Belgium, Spain, Portugal, Morocco, Gold Coast.
1 P.M.	Austria, Hungary, Scandinavia, Germany, Poland, Yugoslavia, Czechoslovakia, Switzerland, Nigeria.
2 P.M.	Greece, Soviet Russia (2 P.M. and 3 P.M.), Finland, Bulgaria, Turkey, Union S. Africa, Egypt, Palestine.
3 P.M.	Kenya, Tanganyika, Somaliland, Iraq.
5.30 P.M.	India, Ceylon.
7 P.M.	Malaya.
8 to 10 P.M.	Australia (different parts).
9 P.M.	Japan, Korea.
11.30 P.M.	New Zealand.
12 P.M.	Fiji.
11 A.M.	Iceland.
9 A.M. to 7 A.M.	Brazil (different parts).
8 A.M.	Argentina, Trinidad.
8 A.M. to 4 A.M.	U.S.A. and Canada (different parts).
7 A.M.	Jamaica, Chile, Cuba, Panama, Peru.

MISCELLANEOUS CONSTANTS (ATOMIC, MOLECULAR, ETC.)

Electron charge = $\frac{1}{3}$ charge on a particle	$e = 4.805 \times 10^{-10}$ E.S.U. $= 1.602 \times 10^{-19}$ coulombs.
Ratio of electron charge to mass	$\frac{e}{m} = 5.273 \times 10^{17}$ E.S.U. per gram.
Mass of an electron for small velocities	$m = \text{about } 9.113 \times 10^{-28}$ grams.
Ratio of electron mass to mass of hydrogen atom	$= \frac{1}{1837.7}$
Mass of a proton (atom of positive electricity)	$= 1.673 \times 10^{-24}$ grams.
Volume of one gram-molecule of any gas at N.T.P.	$V = 22.415$ litres.
Number of molecules per gram-molecule	} $N = 6.019 \times 10^{23}$.
(<i>Avogadro's Constant</i>)	
Number of gas molecules per c.c. (760 mm., 0° C.)	$n = 2.69 \times 10^{19}$.
Gas constant $R = \frac{pv}{T}$	$= 8.314 \times 10^7$ ergs per degree per gram-molecule.
Boltzmann's Constant ($k = \frac{R}{N}$)	$= 1.381 \times 10^{-16}$ ergs per degree.
Mass of hydrogen atom	$= 1.675 \times 10^{-24}$ grams.
Mass of α particle (helium atom)	$= 6.649 \times 10^{-24}$ grams.
Radius of an atom	$= \text{about } 10^{-8}$ cm.
Diameter of hydrogen molecule	$= 2.53 \times 10^{-8}$ cm.
Planck's Constant (h)	$= 6.62 \times 10^{-27}$ erg secs.
Mass of 1 gram	$= 9 \times 10^{20}$ ergs of energy.

XV. ATOMIC NUMBERS AND ISOTOPES OF THE ELEMENTS

N.B.—The *Atomic Number* of an Element is its number in the series of the Elements arranged in order of ascending atomic weights. On the Rutherford theory of the atom it represents the magnitude of the positive charge on the nucleus, and therefore also the number of "planetary" electrons.

Isotopes are chemically identical substances having the same positive charge on the atomic nucleus, but different atomic weights.

Atomic Number	Element	Symbol	Atomic Weight 0 = 16	Naturally occurring Isotopes (At. Wts.) in Order of Abundance— Under 1 per cent. bracketed
1	Hydrogen . . .	H	1.0080	1, (2 †)
2	Helium . . .	He	4.003	4, (3)
3	Lithium . . .	Li	6.940	7, 6
4	Beryllium . . .	Be	9.02	9
5	Boron . . .	B	10.82	11, 10
6	Carbon . . .	C	12.010	12, (13)
7	Nitrogen . . .	N	14.008	14, (15)
8	Oxygen . . .	O	16.0000	16, (18, 17)
9	Fluorine . . .	F	19.00	19
10	Neon . . .	Ne	20.183	20, 22, (21)
11	Sodium . . .	Na	22.997	23
12	Magnesium . . .	Mg	24.32	24, 25, 26
13	Aluminium . . .	Al	26.97	27
14	Silicon . . .	Si	28.06	28, 29, 30
15	Phosphorus . . .	P	30.98	31
16	Sulphur . . .	S	32.066	32, 34, 33, (36)
17	Chlorine . . .	Cl	35.457	35, 37
18	Argon . . .	A	39.944	40, (36, 38)
19	Potassium . . .	K	39.096	39, 41, (40 *)
20	Calcium . . .	Ca	40.08	40, 44, (42, 48, 43, 46)
21	Scandium . . .	Sc	45.10	45
22	Titanium . . .	Ti	47.90	48, 46, 47, 49, 50
23	Vanadium . . .	V	50.95	51
24	Chromium . . .	Cr	52.01	52, 53, 50, 54
25	Manganese . . .	Mn	54.93	55
26	Iron . . .	Fe	55.85	56, 54, 57, (58)
27	Cobalt . . .	Co	58.94	59
28	Nickel . . .	Ni	58.69	58, 60, 62, 61, (64)
29	Copper . . .	Cu	63.54	63, 65
30	Zinc . . .	Zn	65.38	64, 66, 68, 67, (70)
31	Gallium . . .	Ga	69.72	69, 71

* Radioactive isotopes are distinguished by an asterisk.

† This isotope—"Heavy hydrogen" or "Deuterium"—has an atomic weight of 2.0147. "Heavy Water" (D₂O) freezes at 3.8° C., boils at 101.42° C., and has maximum density (1.1059) at 11.6° C.

ATOMIC NUMBERS AND ISOTOPES OF THE ELEMENTS

—continued

Atomic Number	Element	Symbol	Atomic Weight 0 = 16	Naturally occurring Isotopes (At. Wts.) in Order of Abundance— Under 1 per cent. bracketed
32	Germanium . . .	Ge	72.60	74, 72, 70, 73, 76
33	Arsenic	As	74.91	75
34	Selenium	Se	78.96	80, 78, 76, 82, 77, (74)
35	Bromine	Br	79.916	79, 81
36	Krypton	Kr	83.7	84, 86, 82, 83, 80, (78)
37	Rubidium	Rb	85.48	85, 87 *
38	Strontium	Sr	87.63	88, 86, 87, (84)
39	Yttrium	Y	88.92	89
40	Zirconium	Zr	91.22	90, 92, 94, 91, 96
41	Columbium (Niobium)	Nb	92.91	93
42	Molybdenum	Mo	95.95	98, 96, 95, 92, 97, 94, 100
43	Masurium	Ma	...	...
44	Ruthenium	Ru	101.7	102, 104, 101, 99, 100, 96, 98
45	Rhodium	Rh	102.91	103, (101) ?
46	Palladium	Pd	106.7	106, 108, 105, 110, 104, (102)
47	Silver	Ag	107.880	107, 109
48	Cadmium	Cd	112.41	114, 112, 111, 110, 113, 116, 106, 108
49	Indium	In	114.76	115, 113
50	Tin	Sn	118.70	120, 118, 116, 119, 117, 124, 122, 112, (114), (115)
51	Antimony	Sb	121.76	121, 123
52	Tellurium	Te	127.61	130, 128, 126, 125, 124, 122, 123, 120
53	Iodine	I	126.92	127
54	Xenon	Xe	131.3	132, 129, 131, 134, 136, 130, 128, (124), (126)
55	Caesium	Cs	132.91	133
56	Barium	Ba	137.36	138, 137, 136, 135, 134, (130), (132)
57	Lanthanum	La	138.92	139
58	Cerium	Ce	140.13	140, 142, (136), (138)
59	Praseodymium	Pr	140.92	141
60	Neodymium	Nd	144.27	142, 144, 146, 143, 145, 148, 150
61	Illinium	Il	...	...
62	Samarium	Sm	150.43	152, 154, 147, 149, 148*, 150, 144
63	Europium	Eu	152.0	153, 151

* Radioactive isotopes are distinguished by an asterisk.

ATOMIC NUMBERS AND ISOTOPES OF THE ELEMENTS

—continued

Atomic Number	Element	Symbol	Atomic Weight 0 = 16	Naturally occurring Isotopes (At. Wts.) in Order of Abundance— Under 1 per cent. bracketed
64	Gadolinium . . .	Gd	156.9	158, 160, 156, 157, 155, (154), (152)
65	Terbium . . .	Tb	159.2	159
66	Dysprosium . . .	Dy	162.46	164, 162, 163, 161, (160), (158)
67	Holmium . . .	Ho	164.94	165
68	Erbium . . .	Er	167.2	166, 168, 167, 170, (164), (162)
69	Thulium . . .	Tm	169.4	169
70	Ytterbium . . .	Yb	173.04	174, 172, 173, 171, 176, (170), (168)
71	Lutecium . . .	Lu	175.0	175, (176*), (177) ?
72*	Hafnium . . .	Hf	178.6	180, 178, 177, 179, 176, (174)
73	Tantalum . . .	Ta	180.88	181
74	Tungsten . . .	W	183.92	184, 186, 182, 183, (180)
75	Rhenium . . .	Re	186.31	187, 185
76	Osmium . . .	Os	190.2	192, 190, 189, 188, 187, 186, (184)
77	Iridium . . .	Ir	193.1	193, 191
78	Platinum . . .	Pt	195.23	195, 194, 196, 198, (192)
79	Gold . . .	Au	197.2	197
80	Mercury . . .	Hg	200.61	202, 200, 199, 201, 198, 204, (196)
81	Thallium . . .	Tl	204.39	205, 203, (207*), (208*), (210*)
82	Lead . . .	Pb	207.21	208, 206, 207, 204, (210*), (211*), (212*), (214*)
83	Bismuth . . .	Bi	209.00	209, (210*), (212*), (214*), (211*)
84	Polonium . . .	Po	210	210*, (218*), (216*), (211*), (215*), (214*), (212*)
85	<i>Undiscovered.</i>	...	...	...
86	Radon (Niton) .	Rn	222	222*, (220*), (219*)
87	<i>Undiscovered.</i>	...	...	223*
88	Radium . . .	Ra	226.05	226*, (228*), (223*), (224*)
89	Actinium . . .	Ac	c. 226.7	227*, (228*)
90	Thorium . . .	Th	232	...
91	Proto-Actinium	Pa	231	(231*)
92	Uranium . . .	U	238.07	(238*), (235*), (234*)
93	Neptunium . . .	Np	...	...
94	Plutonium . . .	Pu	...	...
95	Americium . . .	Am	...	...
96	Curium . . .	Cm	...	...

* Radioactive isotopes are distinguished by an asterisk.

XVI. MOMENTS OF INERTIA (I)

M = mass of body.

Body.	Axis of Oscillation.	Moment of Inertia.
Uniform thin rod (length = l).	At end, perpendicular to length.	$M \frac{l^2}{3}$
Uniform thin rod (length = l).	At middle, perpendicular to length.	$M \frac{l^2}{12}$
Rectangular lamina (sides a and b).	Through centre of gravity, parallel to side b .	$M \frac{a^2}{12}$
Rectangular lamina (sides a and b).	Through centre of gravity, perpendicular to plane.	$M \frac{a^2 + b^2}{12}$
Rectangular solid (edges a , b , and c).	Through centre of gravity, perpendicular to face ab .	$M \frac{a^2 + b^2}{12}$
Circular lamina (radius = r).	Any diameter.	$M \frac{r^2}{4}$
Circular lamina (radius = r).	Through centre, perpendicular to plane.	$M \frac{r^2}{2}$
Right cylinder (radius = r).	Axis of figure.	$M \frac{r^2}{2}$
Hollow cylinder (external and internal radii R and r).	Axis of figure.	$M \frac{R^2 + r^2}{2}$
Right cylinder (length = l , radius = r).	Through centre, perpendicular to axis of figure.	$M \left(\frac{l^2}{12} + \frac{r^2}{4} \right)$
Sphere (radius = r).	Any diameter.	$M \frac{2r^2}{5}$

XVII. ELASTIC MODULI

Substance.	Young's Modulus (E) in units of 10^{11} dynes per sq. cm.	Rigidity or Torsion Modulus (n) in units of 10^{11} dynes per sq. cm.	Volume Elasticity (k) in units of 10^{11} dynes per sq. cm.	Poisson's Ratio (σ).	Tenacity $\div 10^8$ (dynes per sq. cm.) (Wires.)
Aluminium.	7.05	2.67	7.46	.34	17 to 20
Brass	9.7 to 10.2	c. 3.5	10.7	.3 to .4	31 to 39
Constantan	16.3	6.1	15.5	.325	...
Copper	12.3 to 12.9	3.9 to 4.6	13 to 14.3	.26 to .34	28 to 46
German Silver	11.6	4.3 to 4.7	...	.37	46
Gold	8.0	2.8	16.6	.422	26
Iron (cast)	10 to 13	3.5 to 5.3	9.6	.23 to .31	...
Iron (wrought)	19 to 20	7.7 to 8.3	14.6	c. .27	46 to 62
Lead (cast)	1.62	.56	5.0	.446	2.1
Manganin	12.4	4.7	12.1	.329	...
Phosphor Bronze	12.0	4.4	...	.38	69 to 108
Platinoid	13.6	3.6	...	.37	...
Platinum	10.8	6.1	24.7	.387	33
Silver	7.00	2.9	10.9	.379	29
Steel	19 to 21	7.9 to 8.9	16.4 to 18.1	.25 to .33	110 to 230
Tin (cast)	5.43	2.0	5.3	.33	2.5
Zinc	8.7 to 12.5	3.8	6.0	.2 to .3	13
Glass (Crown)	0.5 to 7.8	2.6 to 3.2	4.0 to 5.9	.20 to .27	...
India Rubber (vulcanized)	.0003 to .0006	.00015 to .0002	...	.46 to .49	...

N.B.—The above quantities vary greatly for different specimens. For an isotropic material $E = \frac{9nk}{3k+n} = 2n(\sigma+1)$. It is usual to calculate k (which is also called the Bulk-modulus, and is the reciprocal of the Compressibility) by aid of above equation from data in first two columns. The values given for k above are, however, in several cases "observed."

4

EARTH	OCEAN.
Volume	Volume
Radius { Equatorial	Mass
{ Polar	Area
Mass	Mean depth
Land Area	Greatest depth (off Mindanao)
Mean height of land	Distance of sea-horizon for eye
Greatest height (Mt. Everest)	x ft. above sea-level
	sea-miles
	(Actually, because of refraction, = 1.15√x sea-miles)

B. THE SOLAR SYSTEM

	Distance in 10 ⁶ miles.	Orbital or Sidereal Period.	Axial Period.	Mass (Earth = 1).	Mean Density (Water = 1).	"G" (Earth = 1).	Inclination of Orbit to Ecliptic.
Sun . . . . .	...	...	25 days (at solar equator)	3.8 × 10 ³⁰	1.41	27.61	0° ...
Mercury	36	88 days	88 ½ days	0.04	3.73	0.28	7 0
Venus	67.2	225 days	225 ½ days	0.81	5.21	0.91	3 24
Earth	93	365.26 days	h. m. s.	1.00	5.527	1.00	0 0
Mars	141.6	1.88 years	23 56 4	0.106	3.94	0.38	1 51
Jun	483.3	11.86 years	24 37 23	314.5	1.34	2.57	1 18
Sat	886.2	29.46 years	9 56 ±	94.07	0.69	1.01	2 29
Ura	742.6	84.02 years	10 45 ±	14.40	.30	0.95	0 40
Ne		64.8 years	15 40	16.72	??	0.97	1 47
Plu		106 ½ years	...	...	??	...	17 9

DISTANCES IN LIGHT-YEARS
 1 ly = 5.8 × 10¹² miles

<i>Sir</i>	<i>Orion</i>	<i>Antares</i>	<i>Arcturus</i>	<i>Sirius</i>	<i>Polaris</i>	<i>Aldebaran</i>	<i>Rigel</i>	<i>Procyon</i>	<i>Altair</i>	<i>Vega</i>	<i>Spica</i>	<i>Castor</i>	<i>Regulus</i>	<i>Proxima Centauri</i>
α Cen	β Ori	α Ori	α Boo	α CMa	α UMi	α Tau	β Ori	α CMa	α Lyr	α Lyr	α Vir	α Gem	α Leo	α Cen
9 × 10 ¹³	135 × 10 ¹³	135 × 10 ¹³	250 × 10 ¹³	8 × 10 ¹³	4.2 × 10 ¹³	39 × 10 ¹³	700 × 10 ¹³	3.5 × 10 ¹³	16 × 10 ¹³	25 × 10 ¹³	22 × 10 ¹³	13 × 10 ¹³	12.5 × 10 ¹³	4.2 × 10 ¹³
Andromeda	Orion	Antares	Arcturus	Sirius	Polaris	Aldebaran	Rigel	Procyon	Altair	Vega	Spica	Castor	Regulus	Proxima Centauri

XIX. RADIO-ACTIVE CONSTANTS

	At. No.	Rays Emitted	Half-Life Period (T)	Range of α -rays in cm., (15° C.)
<i>Uranium-radium Series—</i>				
Uranium I	92	α	4.6×10^8 yrs.	2.69
Uranium X ₁	90	β	24.5 days	...
Uranium X ₂	91	β	68 secs.	3.24
Uranium X ₃	92	α	3×10^5 yrs.	...
Uranium X ₄	90	α	8.5×10^4 yrs.	3.16
Uranium X ₅	88	α	1500 yrs.	3.26
Uranium X ₆	86	α	3.82 days	4.01
Uranium X ₇	84	α	3.05 mins.	4.62
Uranium X ₈	82	β	26.8 mins.	...
Uranium X ₉	83	β, α	19.7 mins.	4.04
Uranium X ₁₀	84	α	10^{-6} secs.	6.87
Uranium X ₁₁	81	β	1.32 mins.	...
Uranium X ₁₂	82	β	22.3 yrs.	...
Radium A	83	β	5 days	...
Radium F (Polonium)	84	α	139 days	3.81
Radium G (Uranium Lead = Pb 206)	82	...	...	...
<i>Actinium Series—</i>				
Actino-Uranium	92	α	7×10^8 yrs.	...
Actino-Uranium Y ₁	90	β	24.6 hrs.	...
Actino-Uranium Y ₂	91	α	3.2×10^4 yrs.	3.63
Actinium X	89	β	13.5 yrs.	...
Actinium Y	90	α	18.0 days	4.7
Actinium Z	88	α	11.2 days	4.28
Actinium Z'	86	α	3.92 secs.	5.65
Actinium Z''	84	α	.002 secs.	6.6
Actinium Z'''	82	β	36 mins.	...
Actinium Z''''	83	α, β	2.16 mins.	5.39
Actinium Z'''''	84	α	.001 secs.	6.52
Actinium Z''''''	81	β	4.76 mins.	...
Actinium Z'''''''	82	...	...	...
Actinium Z''''''''	90	α	1.4×10^{10} yrs.	2.57
Actinium Z'''''''''	88	β	6.7 yrs.	...
Actinium Z''''''''''	89	β	6.13 hrs.	...
Actinium Z'''''''''''	90	α	1.9 yrs.	3.40
Actinium Z''''''''''''	88	α	3.64 days	4.24
Actinium Z'''''''''''''	86	α	54.5 secs.	4.91
Actinium Z''''''''''''''	84	α	0.14 secs.	5.60
Actinium Z'''''''''''''''	82	β	10.5 hrs.	...
Actinium Z''''''''''''''''	83	α, β	60.5 mins.	4.68
Actinium Z'''''''''''''''''	84	α	10^{-10} secs.	8.53
Actinium Z''''''''''''''''''	81	β	2.1 mins.	...
Actinium Z'''''''''''''''''''	82	...	...	...

Fraction of radio-active substance present which decays

$$\frac{dI}{I} = -\lambda dt$$

half-life period = $\frac{T}{\lambda}$

E.g. λ (for radium) = 4.36×10^{-4} per annum.

= 1.38×10^{-11} per sec.

ONE GRAM OF RADIUM, in equilibrium with its products and emits about 15.3

XX. TERMINOLOGY OF ATOMIC PHYSICS

ELECTRON OR NEGATRON (*e*)

Very light particle of mass 9.11×10^{-31} gm. carrying charge of 4.80×10^{-10} E.S.U. Is the β -particle of radio-activity and also cathode-ray particle. May also be obtained by heating metals or by exposing them to ultra-violet or to X-rays.

POSITRON OR POSITIVE ELECTRON

Discovered in 1932 by Anderson in connection with cosmic rays. Mass and charge equal to that of electron but charge of opposite sign. After very short life—say 10^{-8} secs.—combines with an electron to produce about 1.6×10^{-6} ergs of energy ($E = mc^2$) in form of γ -rays.

PROTON

Positive charge, or $+1y$ charged particle, forming nucleus of hydrogen atom. Charge equal to that of electron or positron, but mass = 1.673×10^{-24} gm. i.e. 1838 times that of electron.

NEUTRON

Discovered by Chadwick in 1932. Mass slightly greater than that of proton, and no charge. Possibly a proton associated with an electron. Nuclei of atoms now believed to consist of protons and neutrons, isotopes being accounted for by the varying number of neutrons.

α -PARTICLE

Nucleus of helium atom. Consists of two protons and two neutrons combined. Mass = 6.65×10^{-24} gm., charge = twice that of proton. Is the particle of α -rays.

NEUTRINO

An electron with no charge. No experimental evidence yet obtained, but existence suspected on theoretical grounds.

MESON OR MESOTRON

Component of cosmic rays. Charge positive or negative and equal to that of electron but mass about 150 times as great. Has short life, say, 10^{-8} sec.

PHOTONS OR QUANTA

Atoms of light, or, more generally, parcels of radiant energy. Amount of energy in a parcel determined by $E = h\nu$, where h = Planck's Constant and ν = frequency of radiation. E.g. photon of red light = $\frac{6.62 \times 10^{-27} \times 3 \times 10^{10}}{7 \times 10^{-5}} = 2.8 \times 10^{-12}$ ergs

ELECTRON-VOLT (E.V.)

Energy imparted to an electron when it has been accelerated by potential difference of 1 volt.

Since 1 electron = 4.8×10^{-10} E.S.U. of charge, and

$$1 \text{ volt} = \frac{1}{3 \times 10^9} \text{ E.S.U. of potential,}$$

$$\therefore 1 \text{ electron volt} = 4.8 \times 10^{-10} \times \frac{1}{3 \times 10^9} \text{ ergs} = 1.6 \times 10^{-12} \text{ ergs.}$$

* RADIO-ACTIVITY

α -rays = streams of α -particles.

β -rays = streams of electrons.

X_{γ} -rays = electro-magnetic waves of length $2 \times 10^{-7} - 10^{-9}$.

γ -rays = electro-magnetic waves of length $5 \times 10^{-9} - 5 \times 10^{-10}$.

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