U. S. DEPARTMENT OF COMMERCE

NATIONAL BUREAU OF STANDARDS

WASHINGTON

NBS Letter Circular LC517

MOTORISTS' MANUAL OF WEIGHTS AND MEASURES

(Issued March 14, 1938)

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The tables given herein have been prepared primarily for the convenience of American motorists traveling in Canada, Mexico, or elsewhere where the units of weights and measures in customary use in trade or commerce are those of the British (Imperial) or of the metric system of measurement. The tables may, of course, be found useful by others who have occasion to make conversions between U. S. customary, British (Imperial), and metric units.

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I. INTRODUCTION

In these days of extensive motor travel it is not unusual for American motorists to visit Canada, Mexico, the British Isles, or the Continent of Europe. In such cases a working knowledge of the weights and measures units customarily used in the countries visited is essential or at least very convenient.

In the United States the motorist is in the habit of thinking, with reference to his car, in terms of U. S. gallons, U. S. quarts, miles, miles per gallon, miles per hour, cents per gallon, cents per quart, etc., having in mind our customary system of weights, measures, and money. Similarly with reference to commodities purchased he is in the habit of thinking in terms of our customary units.

While it is impracticable, because of the variable rates of exchange, to make up useful comparison tables of equivalent prices in terms of the various monetary units, it is entirely practicable to prepare such comparison tables for the various units of volume, distance, speed, etc., and for certain combinations of these units.

The following tables are believed to include those most likely to be found useful to the American motorist and others traveling in foreign countries.

For the sake of simplicity and convenience the tables of equivalents given herein are carried only to a sufficient number of decimal places to meet practical requirements. The equivalents are in all cases correct to the number of decimal places given. If more exact values are required reference should be made to more complete tables published elsewhere, for example, to Miscellaneous Publication M121 of the National Bureau of Standards.

Tables 10, 21, and 22 are included in the present manual to emphasize certain facts that should be kept in mind by every motorist, but which are all too often ignored.

From Table 10 it is seen that an automobile, in common with all other moving objects when traveling at high speed, moves an incredibly long distance in one second of time. Eternal vigilance on the part of the driver is, therefore, not only the price of liberty but of life.

From Table 21 it is seen that even under the best of conditions a very considerable distance is required for bringing a fast moving motor vehicle to a safe stop. The optimistic individual who boasts that he can stop his car in its own length, from a speed of 30 or 40 miles per hour, would do well to go out and try it, on a clear road, before he is faced with the necessity of doing it in an emergency.

Table 22 shows the distance required to pass another car going in the same direction. This table should cause the driver to think twice before attempting to pass unless there is ample time and clear space ahead. The driver who "takes a chance" will sooner or later guess wrong. In this event he is not likely to have a second guess.

II. CONVERSION FACTORS

The tables published herein are based on the following conversion factors:

1 U. S. gallon	= 0.83267	Imperial gallon
	= 3.78533	liters
1 Imperial gallon	= 1.20095	U. S. gallons
	= 4.54596	liters
1 liter	= 0.26418	U. S. gallon
	= 0.21998	Imperial gallon
1 U. S. liquid quart	= 0.83267	Imperial quart
	= 0.94633	liter
	= 32	U. S. fluid ounces
1 Imperial quart	= 1.20095	U. S. liquid quarts
	= 1.13649	liters
	= 40	Imperial fluid ounces
1 liter	= 1.05671	U. S. liquid quarts
	= 0.87989	Imperial quart
	= 33.8147	U. S. fluid ounces
	= 35.1956	Imperial fluid ounces

1 U. S. fluid ounce	= 1.0408	Imperial fluid ounce
	= 29.573	milliliters or "cc"
1 Imperial fluid ounce	= 0.9608	U. S. fluid ounce
	= 28.412	milliliters or "cc"
1 pound (avoirdupois)	= 0.453592	kilogram
1 kilogram	= 2.204622	pounds (avoir.)
1 ounce (avoirdupois)	= 28.34953	grams
1 gram	= 0.03527	ounce (avoir.)
1 inch	= 2.54	centimeters
	= 25.4	millimeters
1 yard	= 0.91440	meter
1 meter	= 1.09361	yard
	= 3.28083	feet
	= 39.37000	inches
1 mile	= 5280	feet
	= 1760	yards
	= 1609.34722	meters
	= 1.60935	kilometers
1 kilometer	= 3280.83	feet
	= 1093.61	yards
	= 0.62137	mile

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III. TABLES

Table 1. U. S. Gallons to Imperial Gallons and to Liters

U. S. Gallons	Imperial Gallons	Liters
1	0.83	3.79
2	1.67	7.57
3	2.50	11.36
4	3.33	15.14
5	4.16	18.93
6	5.00	22.71
7	5.83	26.50
8	6.66	30.28
9	7.49	34.07
10	8.33	37.85
11	9.16	41.64
12	9.99	45.42
13	10.82	49.21
14	11.66	53.00
15	12.49	56.78
16	13.32	60.57
17	14.16	64.35
18	14.99	68.14
19	15.82	71.92
20	16.65	75.71
21	17.49	79.49
22	18.32	83.28
23	19.15	87.06
24	19.98	90.85
25	20.82	94.63

Example: If you are in the habit of buying gasoline in 10-gallon lots, it is seen that the equivalent amount is 8.33 Imperial gallons, or 37.85 liters. Possibly you will find it convenient to empty your tank to a somewhat lower point before refilling, in order that you may add 10 Imperial gallons, or 45 or 50 liters; assuming that your gasoline tank is of sufficient capacity to permit this.

Table 2. Imperial Gallons to U. S. Gallons and to Liters

Imperial Gallons	U. S. Gallons	Liters
1	1.20	4.55
2	2.40	9.09
3	3.60	13.64
4	4.80	18.18
5	6.00	22.73
6	7.21	27.28
7	8.41	31.82
8	9.61	36.37
9	10.81	40.91
10	12.01	45.46
11	13.21	50.01
12	14.41	54.55
13	15.61	59.10
14	16.81	63.64
15	18.01	68.19
16	19.22	72.74
17	20.42	77.28
18	21.62	81.83
19	22.82	86.37
20	24.02	90.92
21	25.22	95.47
22	26.42	100.01
23	27.62	104.56
24	28.82	109.10
25	30.02	113.65

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Table 3. Liters to U. S. Gallons and to Imperial Gallons

Liters	U. S. Gallons	Imperial Gallons
1	0.26	0.22
2	0.53	.44
3	0.79	.66
4	1.06	.88
5	1.32	1.10
6	1.59	1.32
7	1.85	1.54
8	2.11	1.76
9	2.38	1.98
10	2.64	2.20
15	3.96	3.30
20	5.28	4.40
25	6.60	5.50
30	7.93	6.60
35	9.25	7.70
40	10.57	8.80
45	11.89	9.90
50	13.21	11.00
55	14.53	12.10
60	15.85	13.20
65	17.17	14.30
70	18.49	15.40
75	19.81	16.50
80	21.13	17.60
85	22.46	18.70
90	23.78	19.80
95	25.10	20.90
100	26.42	22.00

Table 2. Imperial Gallons to U. S. Gallons and to Liters

Imperial Gallons	U. S. Gallons	Liters
1	1.20	4.55
2	2.40	9.09
3	3.60	13.64
4	4.80	18.18
5	6.00	22.73
6	7.21	27.28
7	8.41	31.82
8	9.61	36.37
9	10.81	40.91
10	12.01	45.46
11	13.21	50.01
12	14.41	54.55
13	15.61	59.10
14	16.81	63.64
15	18.01	68.19
16	19.22	72.74
17	20.42	77.28
18	21.62	81.83
19	22.82	86.37
20	24.02	90.92
21	25.22	95.47
22	26.42	100.01
23	27.62	104.56
24	28.82	109.10
25	30.02	113.65

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2	0.53	.44
3	0.79	.66
4	1.06	.88
5	1.32	1.10
6	1.59	1.32
7	1.85	1.54
8	2.11	1.76
9	2.38	1.98
10	2.64	2.20
15	3.96	3.30
20	5.28	4.40
25	6.60	5.50
30	7.93	6.60
35	9.25	7.70
40	10.57	8.80
45	11.89	9.90
50	13.21	11.00
55	14.53	12.10
60	15.85	13.20
65	17.17	14.30
70	18.49	15.40
75	19.81	16.50
80	21.13	17.60
85	22.46	18.70
90	23.78	19.80
95	25.10	20.90
100	26.42	22.00

Table 6. Liters to U. S. Liquid Quarts and to Imperial Quarts

Liters	U. S. Quarts	Imperial Quarts
1	1.06	0.88
2	2.11	1.76
3	3.17	2.64
4	4.23	3.52
5	5.28	4.40
6	6.34	5.28
7	7.40	6.16
8	8.45	7.04
9	9.51	7.92
10	10.57	8.80
11	11.62	9.68
12	12.68	10.56
13	13.74	11.44
14	14.79	12.32
15	15.85	13.20
16	16.91	14.08
17	17.96	14.96
18	19.02	15.84
19	20.08	16.72
20	21.13	17.60

Table 7. Miles per U. S. Gallon to Miles per Imperial Gallon, to Miles per Liter and to Kilometers per Liter

Miles per U. S. Gallon	Miles per Imperial Gallon	Miles per Liter	Kilometers per Liter
1	1.20	0.26	0.43
2	2.40	0.53	0.85
3	3.60	0.79	1.28
4	4.80	1.06	1.70
5	6.00	1.36	2.13
6	7.21	1.59	2.55
7	8.41	1.85	2.98
8	9.61	2.11	3.40
9	10.81	2.38	3.83
10	12.01	2.64	4.25
11	13.21	2.91	4.68
12	14.41	3.17	5.10
13	15.61	3.43	5.53
14	16.81	3.70	5.95
15	18.01	3.96	6.38
16	19.22	4.23	6.80
17	20.42	4.49	7.23
18	21.62	4.76	7.65
19	22.82	5.02	8.08
20	24.02	5.28	8.50
21	25.22	5.55	8.93
22	26.42	5.81	9.35
23	27.62	6.08	9.78
24	28.82	6.34	10.20
25	30.02	6.60	10.63

Table 7 (Cont'd)

Miles per U. S. Gallon	Miles per Imperial Gallon	Miles per Liter	Kilometers per Liter
26	31.22	6.87	11.05
27	32.43	7.13	11.48
28	33.63	7.40	11.90
29	34.83	7.66	12.33
30	36.03	7.93	12.75
31	37.23	8.19	13.18
32	38.43	8.45	13.60
33	39.63	8.72	14.03
34	40.83	8.98	14.46
35	42.03	9.25	14.88
36	43.23	9.51	15.31
37	44.44	9.77	15.73
38	45.64	10.04	16.16
39	46.84	10.30	16.58
40	48.04	10.57	17.01

Example: If your car runs 15 miles to the U. S. gallon of gasoline, it should run about 18 miles to the Imperial gallon, 4 miles to the liter, or 6.4 kilometers to the liter.

Table 8. Miles per Imperial Gallon to Miles per U. S. Gallon and to Kilometers per Liter

Miles per Imperial Gallon	Miles per U. S. Gallon	Kilometers per Liter
1	0.83	0.35
2	1.67	0.71
3	2.50	1.06
4	3.33	1.42
5	4.16	1.77
6	5.00	2.12
7	5.83	2.48
8	6.66	2.83
9	7.49	3.19
10	8.33	3.54
11	9.16	3.89
12	9.99	4.25
13	10.82	4.60
14	11.66	4.96
15	12.49	5.31
16	13.32	5.66
17	14.16	6.02
18	14.99	6.37
19	15.82	6.73
20	16.65	7.08
21	17.49	7.43
22	18.32	7.79
23	19.15	8.14
24	19.98	8.50
25	20.82	8.85

Table 8 (Cont'd)

Miles per Imperial Gallon	Miles per U.S. Gallon	Kilometers per Liter
26	21.65	9.20
27	22.48	9.56
28	23.31	9.91
29	24.15	10.27
30	24.98	10.62
31	25.81	10.97
32	26.65	11.33
33	27.48	11.68
34	28.31	12.04
35	29.14	12.39
36	29.98	12.74
37	30.81	13.10
38	31.64	13.45
39	32.47	13.81
40	33.31	14.16
41	34.14	14.51
42	34.97	14.87
43	35.80	15.22
44	36.64	15.58
45	37.47	15.93

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Table 9. Kilometers per Liter to Miles per Liter to Miles per U. S. Gallon and to Miles per Imperial Gallon

Kilometers per Liter	Miles per Liter	Miles per U. S. Gallon	Miles per Imperial Gallon
1	0.62	2.35	2.82
2	1.24	4.70	5.65
3	1.86	7.06	8.47
4	2.49	9.41	11.30
5	3.11	11.76	14.12
6	3.73	14.11	16.95
7	4.35	16.46	19.77
8	4.97	18.82	22.60
9	5.59	21.17	25.42
10	6.21	23.52	28.25
11	6.84	25.87	31.07
12	7.46	28.23	33.90
13	8.08	30.58	36.72
14	8.70	32.93	39.55
15	9.32	35.28	42.37

Table 10. Miles per Hour to Kilometers per Hour, Feet per Second, and Meters per Second

Miles per Hour	Kilometers per Hour	Feet per Second	Meters per Second
5	8.05	7.33	2.24
10	16.09	14.67	4.47
15	24.14	22.00	6.71
20	32.19	29.33	8.94
25	40.23	36.67	11.18
30	48.28	44.00	13.41
35	56.33	51.33	15.65
40	64.37	58.67	17.88
45	72.42	66.00	20.12
50	80.47	73.33	22.35
55	88.51	80.67	24.59
60	96.56	88.00	26.82
65	104.61	95.33	29.06
70	112.65	102.67	31.29
75	120.70	110.00	33.53
80	128.75	117.33	35.76
85	136.79	124.67	38.00
90	144.84	132.00	40.23
95	152.89	139.33	42.47
100	160.93	146.67	44.70

Note: Inclusion in this table of speeds in excess of legal driving speeds is not to be interpreted as approval of those speeds. It is, rather, a means of emphasizing the danger of excessive speeds, by indicating the distance traveled in one second, at various speeds.

If a driver who sets for himself a top driving speed of 60 miles per hour is driving a car of which the speedometer indicates speed in kilometers per hour he should see to it that his indicated speed is kept below 100.

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Table 11. Kilometers per Hour to Miles per Hour, Meters per Second, and Feet per Second

Kilometers per Hour	Miles per Hour	Meters per Second	Feet per Second
10	6.21	2.78	9.11
20	12.43	5.56	18.23
30	18.64	8.33	27.34
40	24.85	11.11	36.45
50	31.07	13.89	45.57
60	37.28	16.67	54.68
70	43.50	19.44	63.79
80	49.71	22.22	72.91
90	55.92	25.00	82.02
100	62.14	27.78	91.13
110	68.35	30.56	100.25
120	74.56	33.33	109.36
130	80.78	36.11	118.47
140	86.99	38.89	127.59
150	93.21	41.67	136.70
160	99.42	44.44	145.81

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Table 12. U. S. Fluid Ounces to Imperial Fluid Ounces and to Milliliters; Imperial Fluid Ounces to U. S. Fluid Ounces and to Milliliters; Milliliters to U. S. Fluid Ounces and to Imperial Fluid Ounces

U.S. Fl.Oz.	Imp. Fl.Oz.	Milli- liters	Imp. Fl.Oz.	U.S. Fl.Oz.	Milli- liters	Milli- liters	U.S. Fl.Oz.	Imp. Fl.Oz.
½	1.04	29.6	1	0.96	28.4	25	0.85	0.88
2	2.08	59.1	2	1.92	56.8	50	1.69	1.76
3	3.12	88.7	3	2.88	85.2	75	2.54	2.64
4	4.16	118.3	4	3.84	113.6	100	3.38	3.52
5	5.20	147.9	5	4.80	142.1			
						125	4.23	4.40
6	6.24	177.4	6	5.76	170.5	150	5.07	5.28
7	7.29	207.0	7	6.73	198.9	175	5.92	6.16
8	8.33	236.6	8	7.69	227.3	200	6.76	7.04
9	9.37	266.2	9	8.65	255.7			
10	10.41	295.7	10	9.61	284.1	225	7.61	7.92
						250	8.45	8.80
11	11.45	325.3	11	10.57	312.5	275	9.30	9.68
12	12.49	354.9	12	11.53	340.9	300	10.14	10.56
13	13.53	384.4	13	12.49	369.4			
14	14.57	414.0	14	13.45	397.8	325	10.99	11.44
15	15.61	443.6	15	14.41	426.2	350	11.84	12.32
						375	12.68	13.20
16	16.65	473.2	16	15.37	454.6	400	13.53	14.08
17	17.69	502.7	17	16.33	483.0			
18	18.73	532.3	18	17.29	511.4	425	14.37	14.96
19	19.78	561.9	19	18.26	539.8	450	15.22	15.84
20	20.82	591.5	20	19.22	568.2	475	16.06	16.72
						500	16.91	17.60
21	21.86	621.0	21	20.18	596.7	525	17.75	18.48
22	22.90	650.6	22	21.14	625.1	550	18.60	19.36
23	23.94	680.2	23	22.10	653.5	575	19.44	20.24
24	24.98	709.7	24	23.06	681.9	600	20.29	21.12
25	26.02	739.3	25	24.02	710.3			
						625	21.13	22.00
26	27.06	768.9	26	24.98	738.7	650	21.98	22.88
27	28.10	798.5	27	25.94	767.1	675	22.82	23.76
28	29.14	828.0	28	26.90	795.5	700	23.67	24.64
29	30.18	857.6	29	27.86	824.0			
30	31.22	887.2	30	28.82	852.4	725	24.52	25.52
						750	25.36	26.40
31	32.26	916.8	31	29.78	880.8	775	26.21	27.28
32	33.31	946.3	32	30.75	909.2	800	27.05	28.16
			33	31.71	937.6			
			34	32.67	966.0	825	27.90	29.04
			35	33.63	994.4	850	28.74	29.92
						875	29.59	30.80
			36	34.59	1022.8	900	30.43	31.68
			37	35.55	1051.3			
			38	36.51	1079.7	925	31.28	32.56
			39	37.47	1108.1	950	32.12	33.44
			40	38.43	1136.5	975	32.97	34.32
						1000	33.81	35.20

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Table 13. Pounds (avoirdupois) to Kilograms and Kilograms to Pounds (avoirdupois)

Pounds (avoir.)	Kilograms	Kilograms	Pounds (avoir.)
1	0.45	1	2.20
2	0.91	2	4.41
3	1.36	3	6.61
4	1.81	4	8.82
5	2.27	5	11.02
6	2.72	6	13.23
7	3.18	7	15.43
8	3.63	8	17.64
9	4.08	9	19.84
10	4.54	10	22.05
11	4.99	11	24.25
12	5.44	12	26.46
13	5.90	13	28.66
14	6.35	14	30.86
15	6.80	15	33.07
16	7.26		
17	7.71		
18	8.16		
19	8.62		
20	9.07		
21	9.53		
22	9.98		
23	10.43		
24	10.89		
25	11.34		

Table 14. Ounces (avoirdupois) to Grams and Grams to Ounces (avoirdupois)

Ounces (avoir.)	Grams	Grams	Ounces (avoir.)
1	28.35	25	0.88
2	56.70	50	1.76
3	85.05	75	2.65
4	113.40	100	3.53
5	141.75	125	4.41
6	170.10	150	5.29
7	198.45	175	6.17
8	226.80	200	7.05
9	255.15	225	7.94
10	283.50	250	8.82
11	311.84	275	9.70
12	340.19	300	10.58
13	368.54	325	11.46
14	396.89	350	12.35
15	425.24	375	13.23
16	453.59	400	14.11
		425	14.99
		450	15.87
		475	16.76
		500	17.64

Table 15. Yards to Meters and Meters to Yards

Yards	Meters	Meters	Yards
1	0.91	1	1.09
2	1.83	2	2.19
3	2.74	3	3.28
4	3.66	4	4.37
5	4.57	5	5.47
6	5.49	6	6.56
7	6.40	7	7.66
8	7.32	8	8.75
9	8.23	9	9.84
10	9.14	10	10.94

Table 16. Inches to Centimeters and Centimeters to Inches

Inches	Centimeters	Inches	Centimeters
1	2.5	1	0.4
2	5.1	2	0.8
3	7.6	3	1.2
4	10.2	4	1.6
		5	2.0
5	12.7		
6	15.2	6	2.4
7	17.8	7	2.8
8	20.3	8	3.1
		9	3.5
9	22.9	10	3.9
10	25.4		
11	27.9	15	5.9
12	30.5	20	7.9
		25	9.8
13	33.0	30	11.8
14	35.6	35	13.8
15	38.1		
16	40.6	40	15.7
		45	17.7
17	43.2	50	19.7
18	45.7	55	21.7
19	48.3	60	23.6
20	50.8		
		65	25.6
21	53.3	70	27.6
22	55.9	75	29.5
23	58.4	80	31.5
24	61.0	85	33.5
25	63.5	90	35.4
26	66.0	95	37.4
27	68.6	100	39.4
28	71.1		
29	73.7		
30	76.2		
31	78.7		
32	81.3		
33	83.8		
34	86.4		
35	88.9		
36	91.4		

If it is desired to convert centimeters to millimeters, move the decimal point 1 place to the right. Example, 2.54 centimeters = 25.4 millimeters.

To convert centimeters to decimeters move the decimal point 1 place to the left. Example, 2.54 centimeters = 0.254 decimeter.

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Table 17. Miles to Kilometers and Kilometers to Miles

Miles	Kilometers	Kilometers	Miles
1	1.6	1	0.6
2	3.2	2	1.2
3	4.8	3	1.9
4	6.4	4	2.5
5	8.0	5	3.1
6	9.7	6	3.7
7	11.3	7	4.3
8	12.9	8	5.0
9	14.5	9	5.6
10	16.1	10	6.2
20	32.2	20	12.4
30	48.3	30	18.6
40	64.4	40	24.9
50	80.5	50	31.1
60	96.6	60	37.3
70	112.7	70	43.5
80	128.7	80	49.7
90	144.8	90	55.9
100	160.9	100	62.1
200	321.9	200	124.3
300	482.8	300	186.4
400	643.7	400	248.5
500	804.7	500	310.7
600	965.6	600	372.8
700	1126.5	700	435.0
800	1287.5	800	497.1
900	1448.4	900	559.2
1000	1609.3	1000	621.4

Use of Tables

In using the tables, in those cases in which the desired equivalent is not given directly in the table, it will be found convenient to break the given value down into hundreds, tens, and units, find their equivalents separately from the table and add the results. For example, to find the equivalent, in miles, of 857 kilometers, proceed as follows:

800	kilometers	=	497.1	miles
50	"	=	31.1	"
7	"	=	4.3	"
857	"	=	532.5	"

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Table 18. Price per U. S. Gallon to Equivalent Price per Imperial Gallon and per Liter (All prices in U. S. money)

Price per U. S. Gallon	Price per Imperial Gallon	Price per Liter
$0.01	$0.01	$0.003
.02	.02	.005
.03	.04	.008
.04	.05	.011
.05	.06	.013
.06	.07	.016
.07	.08	.018
.08	.10	.021
.09	.11	.024
.10	.12	.026
.11	.13	.029
.12	.14	.032
.13	.16	.034
.14	.17	.037
.15	.18	.040
.16	.19	.042
.17	.20	.045
.18	.22	.048
.19	.23	.050
.20	.24	.053
.21	.25	.055
.22	.26	.058
.23	.28	.061
.24	.29	.063
.25	.30	.066
.26	.31	.069
.27	.32	.071
.28	.34	.074
.29	.35	.077
.30	.36	.079
.31	.37	.082
.32	.38	.085
.33	.40	.087
.34	.41	.090
.35	.42	.092
.36	.43	.095
.37	.44	.098
.38	.46	.100
.39	.47	.103
.40	.48	.106

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Table 19. Price per Imperial Gallon to Equivalent Price per U. S. Gallon and per Liter (All prices in U. S. money)

Price per Imperial Gallon	Price per U. S. Gallon	Price per Liter
$0.01	$0.01	$0.002
.02	.02	.004
.03	.02	.007
.04	.03	.009
.05	.04	.011
.06	.05	.013
.07	.06	.015
.08	.07	.018
.09	.07	.020
.10	.08	.022
.11	.09	.024
.12	.10	.026
.13	.11	.029
.14	.12	.031
.15	.12	.033
.16	.13	.035
.17	.14	.037
.18	.15	.040
.19	.16	.042
.20	.17	.044
.21	.17	.046
.22	.18	.048
.23	.19	.051
.24	.20	.053
.25	.21	.055

Table 19 (Cont'd)

Price per Imperial Gallon	Price per U. S. Gallon	Price per Liter
$0.26	$0.22	$0.057
.27	.22	.059
.28	.23	.062
.29	.24	.064
.30	.25	.066
.31	.26	.068
.32	.27	.070
.33	.27	.073
.34	.28	.075
.35	.29	.077
.36	.30	.079
.37	.31	.081
.38	.32	.084
.39	.32	.086
.40	.33	.088
.41	.34	.090
.42	.35	.092
.43	.36	.095
.44	.37	.097
.45	.37	.099
.46	.38	.101
.47	.39	.103
.48	.40	.106
.49	.41	.108
.50	.42	.110

Table 20. Price per Liter to Equivalent Price per U. S. Gallon and per Imperial Gallon

Price per Liter	Price per U. S. Gallon	Price per Imperial Gallon
$0.01	$0.04	$0.05
.02	.08	.09
.03	.11	.14
.04	.15	.18
.05	.19	.23
.06	.23	.27
.07	.26	.32
.08	.30	.36
.09	.34	.41
.10	.38	.45

Letter Circular LC 517 - 29

Performance of Automobile Brakes

The National Bureau of Standards has done no recent work on the performance of automobile brakes and its only official publication on this subject is Miscellaneous Publication M107 (Safety Code for Brakes and Brake Testing), copies of which can be obtained from the Superintendent of Documents, Government Printing Office, Washington, D. C., for 5 cents each. The maximum stopping distances proposed in this code are now excessive as they were based on conditions in 1923-25 before 4-wheel brakes came into general use.

Available data indicate that today the average automobile with 4-wheel brakes in good adjustment will stop in about 20 feet, after the brake is applied, from a speed of 20 mph on a straight, level, hard-surfaced highway.

A figure now coming to be generally adopted as a legal requirement is that an automobile with four-wheel brakes must be able to stop from a speed of 20 miles per hour in a distance of 30 feet on a straight level hard-surfaced road free from loose material.

Given S, the braking distance in feet from a speed of 20 mph, the braking distance (S_1) from any other speed (V_1) can be computed by the relation $S_1 = V_1^2 S/400$. Thus, if S = 20 feet, S_1 will be 5 feet from 10 mph, 45 feet from 30 mph, 80 feet from 40 mph, 125 feet from 50 mph, and 180 feet from 60 mph.

The term "braking distance" as used above refers to the distance that the car will travel after the brake pedal is depressed. It should be noted that the average driver requires about one-half second, from the time he receives a signal or warning to stop, before he can put the brakes in action. During this interval the car will travel approximately the distances indicated in column 3, Table 21, e.g., 7 feet at 10 mph, 15 feet at 20 mph, 22 feet at 30 mph, 29 feet at 40 mph, 37 feet at 50 mph, and 44 feet at 60 mph. The reaction times of different drivers differ considerably so that the one-half second here assumed can be taken only as a general average.

In the accompanying table (Table 21) the minimum braking distance and minimum stopping distance, from various speeds, under the most favorable conditions are shown in columns 4 and 6; the braking distance and stopping distance, from various speeds, that may be regarded as reasonable maximum distances allowed under motor vehicle regulations are shown in columns 5 and 7.

Inclusion in the accompanying table of car speeds in excess of legal driving speeds should not be interpreted as approval of those speeds, but rather as a means of emphasizing the danger of such speeds, by calling attention to the distances travelled in 1 second, and to the excessive stopping distances required by a car traveling at high speed.

Table 21.- Speeds and Stopping Distances

Car Speed		Reaction	Braking Distance		Stopping Distance	
miles/hr	ft/sec	Distance*	Practical minimum	Reasonable maximum**	Practical minimum	Reasonable maximum
		ft.	ft.	ft.	ft.	ft.
10	14.7	7.3	5.0	7.5	12	15
15	22.0	11.0	11.2	16.9	22	28
20	29.3	14.7	20.0	30.0	35	45
25	36.7	18.3	31.2	46.9	50	65
30	44.0	22.0	45.0	67.5	67	89
35	51.3	25.7	61.2	91.9	87	118
40	58.7	29.3	80.0	120.0	109	149
45	66.0	33.0	101.2	151.9	134	185
50	73.3	36.7	125.0	187.5	162	224
55	80.7	40.3	151.2	226.9	192	267
60	88.0	44.0	180.0	270.0	224	314
65	95.3	47.7	211.2	316.9	259	365
70	102.7	51.3	245.0	367.5	296	419
75	110.0	55.0	281.2	421.9	336	477
80	117.3	58.7	320.0	480.0	379	539
85	124.7	62.3	361.2	541.9	424	604
90	132.0	66.0	405.0	607.5	471	674
95	139.3	69.7	451.2	676.9	521	747
100	146.7	73.3	500.0	750.0	573	823

* Based on a reaction time of one-half second.

Three-quarters second is sometimes used, but experiments have shown that one-half second more nearly represents the average reaction time of experienced drivers.

** For a car that will pass reasonable motor vehicle inspection regulations.

Caution: When stopping from high speeds, brakes should be applied with extreme care, even under most favorable conditions.

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Minimum Passing Distance

When one driver overtakes another on the road and wishes to pass he must find a clear space in opposing traffic so that he can pass in safety. The clear space needed will depend on the relative speed of the two cars. If the passing driver is traveling at much higher speed than the one ahead and if the road is clear he can pass in a correspondingly shorter distance. But if roads are congested and one must follow the car ahead, waiting for a chance to pass, the speeds of the two cars will be nearly the same. Under these conditions, which are the most common ones, the time required to speed up and pass the car ahead and get back on the right side of the road is found to be very nearly 6 seconds whether the cars are traveling at 5 miles per hour or at 60, or anywhere between these speeds.

However, it is found that even the most expert drivers must allow more time than this. They find that it is not safe to pass unless there is 8 seconds of time available before meeting another car. This provides a "safety factor" of only 2 seconds, which certainly is as little as any driver should allow.

The following table gives the minimum distance which must be clear of approaching traffic in order that passing may be done with safety at different speeds.

Table 22. Minimum Passing Distance for Cars Going in the Same Direction and Traveling at Various Speeds.

Driving Speed (Before Speeding up to Pass)	Speed of Approaching Car (miles per hour)					
	10	20	30	40	50	60
	Minimum Clear Distance to Pass					
5	235 ft	350 ft	470 ft	585 ft	705 ft	820 ft
10	295	410	530	645	765	880
15	350	470	585	705	820	940
20	410	530	645	765	880	1000
25	470	585	705	820	940	1060
30	530	645	765	880	1000	1115
35	585	705	820	940	1060	1175
40	645	765	880	1000	1115	1230
45	705	820	940	1060	1175	1290
50	765	880	1000	1115	1230	1350
55	820	940	1060	1175	1290	1410
60	880	1000	1115	1230	1350	1470

Some Rules for Safe Driving

1. Keep on your own side of the road and in your own traffic lane.
2. Never exceed a speed from which you can stop safely within the clear distance you can see ahead. At night this distance is limited to the field clearly illuminated by your headlights. Don't out-drive your lights.
3. Don't pass another vehicle anywhere unless you are sure the road is clear far enough ahead to make passing safe.
4. At night when you meet a car that is standing still with its headlights on, slow down and keep well away from the standing car. You can see practically nothing beyond these headlights, and almost anything may be there. If your own car is standing still, dim your lights.
5. Be on your guard for unexpected actions of pedestrians, children, bicycle riders, inexperienced drivers, and stray animals. Don't expect them to get out of your way. The full responsibility is yours not to hit them.
6. Avoid doing the unexpected. Do not pull out from the curb, cross from one traffic lane to another, turn, or stop without making sure that the way is clear.
7. At railroad crossings look both ways before crossing, and if there are two or more tracks look out for moving trains temporarily hidden by standing cars or other trains. The fact that one train has just passed is no guarantee that there will not be another.

8. Don't hold up normal traffic by slow driving on a busy highway. If many cars are passing you, without exceeding the legal speed, you are driving too slowly; speed up.
9. Train yourself not to try to get back on the pavement at once if for any reason your right front wheel runs off the shoulder of the roadway. Slow down until you can get back safely. The natural impulse to get back on the pavement suddenly has been responsible for many serious accidents. Even a slight shoulder may cause your car to dart to the left, into the stream of oncoming traffic.
10. Look ahead and avoid trouble by anticipating it. The safe driver keeps out of trouble instead of showing how skillful he is in getting out of it.