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Elapsed Time of Vehicle Acceleration

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Elapsed Time of Vehicle Acceleration

Abstract

Newton's Second Law states that force is equal to the mass of an object multiplied by its acceleration. More specifically, force is the mass times the instantaneous change in velocity over time of an object. By rearranging this equation, it can be determined that the time elapsed of the acceleration of an object is equal to the integral of the inverse value of the force relative to change in velocity (dv). In the context of real world application, this method can be used to calculate the time taken for a vehicle to accelerate from its minimum to maximum speed, given the values of torque output relative to engine rpms, transmission specifications, vehicle weight, and tire size. To demonstrate the viability of this method, the elapsed time of acceleration is calculated for a 2017 Ford GT with a torque-rpm curve containing 58 values. It is found that the resulting values are realistic when neglecting forces of friction and air resistance. The results obtained would be analogous to the values obtained through experimentation on a dynamometer, which allows the vehicle to be tested while stationary.

Keywords

vehicle's engine, force, speed, transmission, tire radius, torque-rpm curve, Ford GT, Riemann sum, approximate integration

Problem Statement

The purpose of this paper is to calculate the amount of time it takes for a specific vehicle to accelerate to its maximum speed using information obtained from the engine's torque-rpm curve and the specifications of the vehicle.

Motivation

The ability to calculate the time necessary for a vehicle to go from idle to maximum speed exemplifies the key relationship between engineering, physics, and calculus. From the perspective of the automotive industry, this problem is important because it shows the effects of a combination of a vehicle's engine, transmission, and tire radius on the performance at maximum output. By collecting data on a variety of engines and transmissions, this can then be used to choose the engine and transmission gear ratios best fit for the intended purpose of the vehicle.

Mathematical Description and Solution Approach

To calculate the elapsed time of the vehicle acceleration, the specific points of the torque-rpm, differential ratio, gear ratio, vehicle weight, and tire radius must be obtained. First, the force at the rear wheels and vehicle speed must be calculated at each point on the torque-rpm curve using equations (1) and (2):

$$Force_{RW}(lbf) = \frac{Torque_{engine}(lbft)\times Differential\ Ratio\times(Ratio\ for\ Specific\ Gear)}{Tire\ Radius(ft)}, \qquad (1)$$

$$Velocity(ft/s) = \frac{rpm_{engine}\left(\frac{rev}{min}\right)\times Tire\ Radius(ft)\times 2\pi\left(\frac{rad}{rev}\right)}{Differential\ Ratio\times(Ratio\ for\ Specific\ Gear)\times 60\frac{s}{min}}\ . \tag{2}$$

The force is calculated by multiplying the torque from the engine and the total ratio of the output of the wheels from the engine and dividing by the tire radius which cancels out the unit of feet and yields the force output at the wheels. The velocity is then calculated by multiplying the rpm by the radius of the tire and 2π. This is done to convert the value from revolutions per minute to radians per minute. Finally, this value is divided by the differential ratio times the ratio of the specific gear times 60 seconds per minute. The calculations result in the velocity of the vehicle over ground in feet per second.

Once the force output and velocity are calculated for each rpm listed, the force inverse must be calculated. Because the force is expressed in pounds force, the equation is simply 1 divided by the force multiplied by the weight over the acceleration due to gravity, g_c. Once the force inverse (3) is calculated for each point, a graph must be generated of the force inverse relative to velocity for each value of rpm:

$$Force\ Inverse = \frac{m(lb)}{g_c\frac{ft}{s^2}} \times \frac{1}{Force_{RW}}\ . \tag{3}$$

A solution to the problem is reached on the basis that force is equal to the mass of the object times the acceleration, treated as the derivative of the velocity:

$$Force(lbf) = \frac{m}{g_c} \times \frac{dV}{dt}\ . \tag{4}$$

By rearranging equation (4) and integrating it we obtain formula (5):

$$Elapsed\ Time = \int dt = \int \frac{m}{g_c} \times \frac{1}{Force} \times dV. \tag{5}$$

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Taking the integral of the graph of the force inverse relative to velocity will result in the elapsed time of the acceleration of the vehicle. Because the curve obtained is not defined by a specific function, a method of estimation must be used to determine the value of the integral. Based on the curve, a right-Riemann sum will yield an overestimate while a left-Riemann sum will yield an underestimate since the overall slope is positive (see Appendix I and [1, Section 6.5]).

DISCUSSION

The vehicle selected for this paper is a 2017 Ford GT. The GT is a high-performance car with a 3.5L V6 with a maximum of 647hp and a 7-speed transmission. The total weight of the vehicle is 3,170lb and has a wheel radius of about 1.667ft. A torque-rpm/horsepower curve containing 58 data points is obtained from *Automobile Catalog* and used as the basis of all calculations (see [2, 3] and Appendix II). Below is the torque-rpm and horsepower curve:

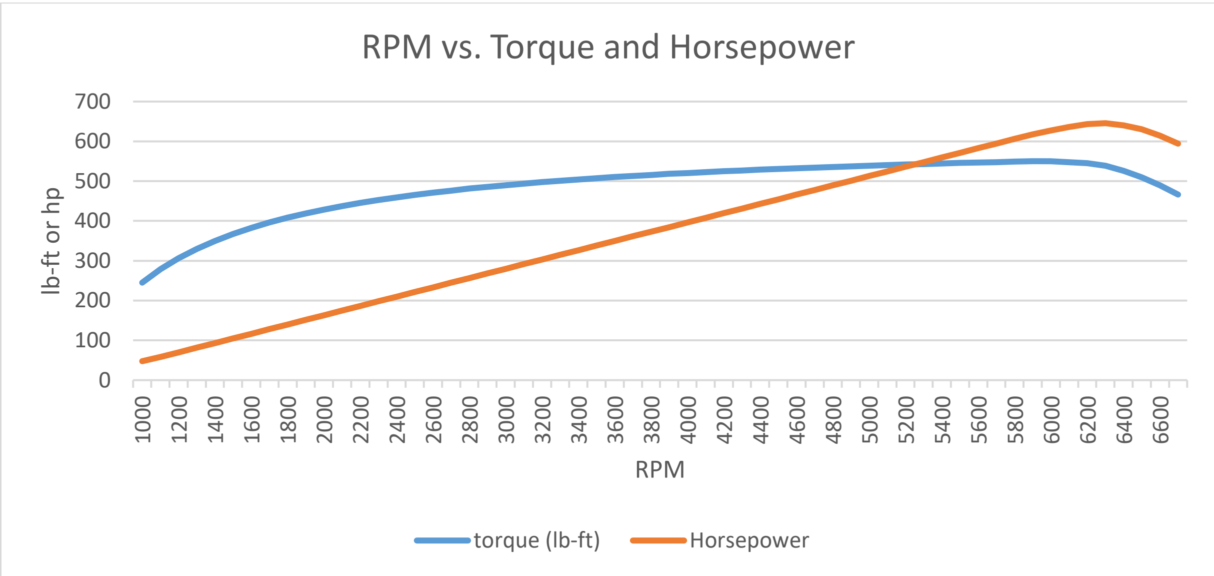

Figure 1

The force output at the rearwheels and vehicle speed are then calculated relative to rpms and set on a graph of force relative to speed. For a better visual understanding, the calculations are made for each gear and expressed on the graph for each gear.

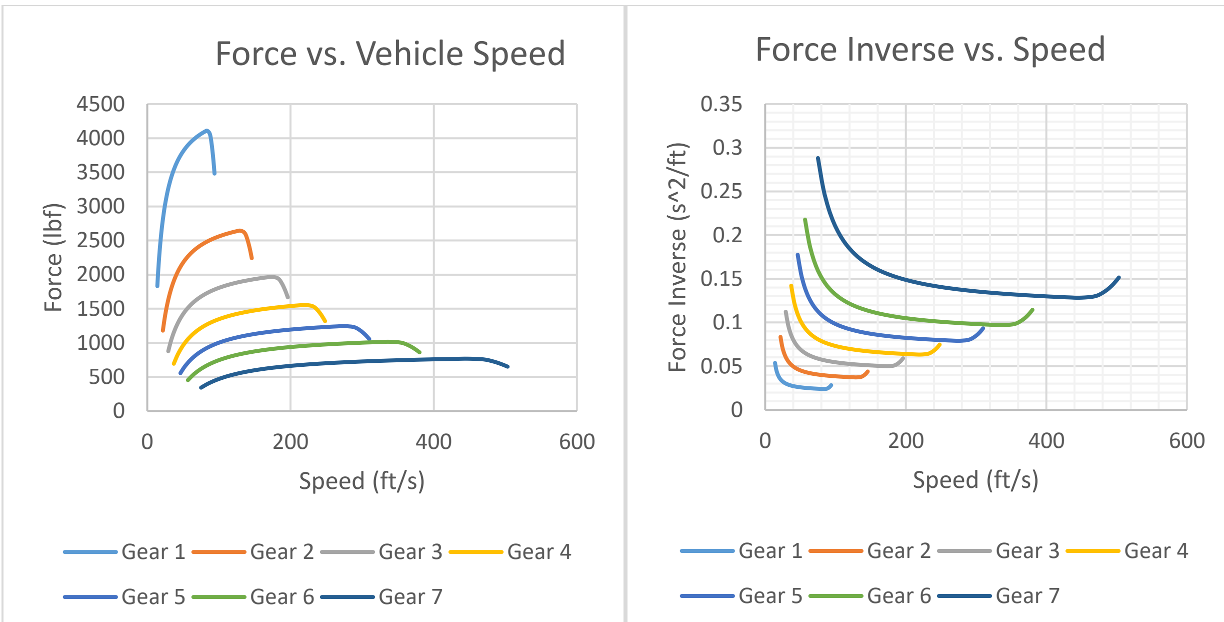

Figure 2 (left) and Figure 3 (right)

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A graph of the force inverse relative to speed is also produced. Finally, the left and right Riemann sums are taken using all of the data points obtained. The time elapsed calculated is 21.37s for a right Riemann sum and 19.01s for a left Riemann sum. It should be noted that when taking the area under the curve, since there are 7 different curves which have overlapping areas, the sum is calculated by taking the points on the curves in which there are not any other values of the other curves beneath. An additional graph of only the points used for the estimated area under the curve can better illustrate this.

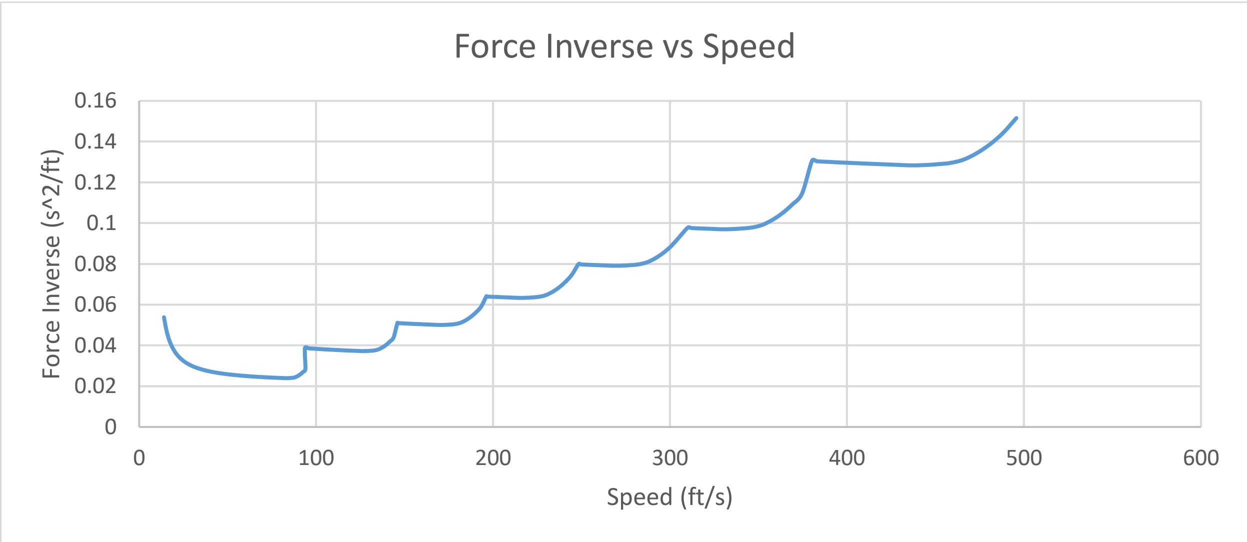

Figure 4

The results obtained are rather realistic taken into consideration internal and external factors such as friction and air resistance. The results demonstrate the pattern in which a vehicle accelerates based on its engine specifications and transmission gear ratios as well as the difference in how each gear ratio affects the acceleration of the vehicle. As portrayed in Figure 2 and Figure 3, the curve for each gear is very similar. However, each successive gear has a lower overall force output and can reach a higher magnitude of velocity. This demonstrates how each transmission gear ratio is selected to be used within a specific range of velocity to achieve a very high maximum speed while accelerating as much as possible.

It should be noted that the values in Figure 4 are not plotted starting from 0 for velocity. This is because under the minimum speed, the clutch on the vehicle is not fully engaged. Therefore, a portion of the torque produced from the engine is not being delivered to the rear wheels. The maximum speed of the vehicle is also unrealistically high in magnitude because the calculations negate air resistance, external forces of friction (friction between the tires and the road), and internal forces of friction (friction between moving parts within the vehicle).

Conclusions and Recommendations

The data concludes that the method of calculating the elapsed time of the acceleration of a vehicle by isolating the change in time (dt) in Newton's Second Law is viable. In a situation where a vehicle's performance is measured while it is stationary, the results of the time elapsed would most likely be very similar to the true values recorded experimentally with a dynamometer. This method could be valuable for optimizing the transmission gear ratio to

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provide maximum vehicle acceleration while being able to reach the highest speed possible, specifically in vehicles built for high performance.

When using this method, in order to reduce a potential error, it would be beneficial to use a form of integral estimation that is more accurate than a left or right Riemann sum. Ideally, a better form of estimation would be to use Simpson's Rule. This form of estimation is not used because the number of values obtained would not follow the formula needed. In such a case, Simpson's Rule could be combined with a trapezoidal Riemann sum. Estimating in this matter would decrease the error in the resulting elapsed time. Only using a trapezoidal Riemann sum would also reduce the error but this is not the most accurate method (see Appendix I and [1, Section 6.5]).

NOMENCLATURE

Symbol	Value	Units
lbf	Pounds Force	$\frac{lb \times ft}{s^2}$
g_c	Acceleration Due to Gravity	$32.2\frac{ft}{s^2}$
rpm	Revolutions per Minute	revs
m	Weight (Pounds)	lb

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2. Automobile Catalogue. 2017 Ford GT engine Horsepower / Torque Curve. http://www.automobile-catalog.com/bigcurve/2017/2563970/ford_gt.html .
3. Automobile Catalogue. Ford GT (d-cl. 7) (2017) full detailed specifications listing and photo gallery. http://www.automobile-catalog.com/auta_details1.php .

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APPENDIX I

[1, Section 6.5]

Any definite integral $\int_a^b f(x)dx$ can be approximated by the corresponding Riemann sums. If we divide the interval $[a, b]$ into n subintervals of equal length $\Delta x = (b - a)/n$, then we have:

$$\int_a^b f(x)dx \approx \sum_{k=1}^{n} f(c_k)\Delta x,$$

where c_k is any point in the *k-th* subinterval $[x_{k-1}, x_k]$. If c_k is chosen to be the left end-point of the interval, then $c_k = x_{k-1}$ and we have the left endpoint approximation:

$$\int_a^b f(x)dx \approx \sum_{k=1}^{n} f(x_{k-1})\Delta x.$$

If we choose c_k to be the right end-point, then $c_k = x_k$ and we have the right endpoint approximation:

$$\int_a^b f(x)dx \approx \sum_{k=1}^{n} f(x_k)\Delta x.$$

The Trapezoidal approximation results from averaging the left and right endpoint approximations:

$$\int_a^b f(x)dx \approx \frac{\Delta x}{2} \times \sum_{k=1}^{n} [f(x_{k-1}) + f(x_k)].$$

Simpson's rule for approximate integration:

$$\int_a^b f(x)dx$$

$$\approx \frac{\Delta x}{3} \times \sum_{k=1}^{n} [f(x_0) + 4f(x_1) + 2f(x_2) + 4f(x_3) + \cdots + 2f(x_{n-2}) + 4f(x_{n-1}) + f(x_n)]$$

results from using parabolas to approximate a curve $y = f(x)$.

APPENDIX II

Table 1. (Engine rpm vs. Torque and Horsepower)

rpm	torque (lb-ft)	Horsepower
1000	245	47.6
1100	278.4	58.3
1200	306.2	69.9
1300	329.8	81.6
1400	349.9	93.2
1500	367.5	104.9
1600	382.7	116.5
1700	396.3	128.2
1800	408.3	139.8
1900	419	151.5
2000	428.7	163.1
2100	437.5	174.8
2200	445.4	186.5
2300	452.7	198.1
2400	459.3	209.8
2500	465.4	221.4
2600	471.1	233.1
2700	476.3	244.7
2800	481.2	256.4
2900	485.7	268
3000	490	279.7
3100	493.9	291.3
3200	497.6	303
3300	501.1	314.7
3400	504.4	326.3
3500	507.4	338
3600	510.3	349.6
3700	513.1	361.3
3800	515.7	372.9
3900	518.2	384.6
4000	520.6	396.2
4100	522.8	407.9
4200	524.9	419.5
4300	527	431.2
4400	528.9	442.8
4500	530.8	454.5
4600	532.5	466.1
4700	534.2	477.8
4800	535.8	489.4
4900	537.5	501.1
5000	538.9	512.8
5100	540.4	524.4
5200	541.7	536
5300	543.1	547.7
5400	544.4	559.4
5500	545.6	571.1
5600	546.8	582.7
5700	547.9	594.3
5800	549	606
5900	550.1	617.6
6000	549.6	627.5
6100	547.9	636
6200	545.2	643.2
6300	538.6	645.6
6400	525.9	640.4
6500	509.4	630.1
6600	489.4	614.6
6700	465.9	593.9

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Table 2. (Torque (lb-ft) vs. Force (lbf) per gear)

torque (lb-ft)	1	2	3	4	5	6	7
245	1830.284	1177.804	876.0794	692.3506	554.4193	452.0484	341.5955
278.4	2079.8	1338.37	995.5123	786.7364	630.0013	513.6746	388.1641
306.2	2287.482	1472.015	1094.921	865.297	692.9109	564.9682	426.9247
329.8	2463.786	1585.469	1179.31	931.9887	746.3162	608.5125	459.8294
349.9	2613.944	1682.097	1251.184	988.7897	791.8012	645.5989	487.8542
367.5	2745.426	1766.706	1314.119	1038.526	831.6289	678.0726	512.3933
382.7	2858.978	1839.778	1368.472	1081.48	866.0255	706.118	533.5862
396.3	2960.578	1905.158	1417.103	1119.912	896.8015	731.2113	552.5482
408.3	3050.224	1962.847	1460.013	1153.823	923.9567	753.3524	569.2794
419	3130.159	2014.286	1498.275	1184.061	948.1701	773.095	584.1981
428.7	3202.624	2060.917	1532.96	1211.472	970.1206	790.9924	597.7225
437.5	3268.364	2103.222	1564.428	1236.34	990.0344	807.2292	609.9921
445.4	3327.382	2141.2	1592.677	1258.665	1007.912	821.8055	621.0068
452.7	3381.917	2176.294	1618.78	1279.294	1024.431	835.2747	631.1849
459.3	3431.222	2208.022	1642.381	1297.945	1039.366	847.4523	640.3871
465.4	3476.793	2237.347	1664.193	1315.184	1053.17	858.7074	648.8921
471.1	3519.375	2264.749	1684.576	1331.291	1066.069	869.2244	656.8394
476.3	3558.222	2289.748	1703.17	1345.986	1077.836	878.8189	664.0896
481.2	3594.827	2313.304	1720.692	1359.833	1088.925	887.8599	670.9215
485.7	3628.445	2334.937	1736.783	1372.55	1099.108	896.1628	677.1957
490	3660.568	2355.608	1752.159	1384.701	1108.839	904.0967	683.1911
493.9	3689.703	2374.357	1766.105	1395.722	1117.664	911.2926	688.6287
497.6	3717.344	2392.144	1779.335	1406.178	1126.037	918.1195	693.7875
501.1	3743.491	2408.97	1791.851	1416.069	1133.957	924.5773	698.6675
504.4	3768.144	2424.834	1803.651	1425.394	1141.425	930.6661	703.2686
507.4	3790.556	2439.257	1814.378	1433.872	1148.214	936.2014	707.4514
510.3	3812.22	2453.198	1824.748	1442.067	1154.776	941.5522	711.4947
513.1	3833.138	2466.659	1834.761	1449.98	1161.112	946.7184	715.3987
515.7	3852.561	2479.158	1844.058	1457.327	1166.996	951.5157	719.0238
518.2	3871.238	2491.176	1852.997	1464.392	1172.653	956.1284	722.5094
520.6	3889.167	2502.714	1861.579	1471.174	1178.084	960.5567	725.8557
522.8	3905.602	2513.29	1869.446	1477.391	1183.063	964.6159	728.9231
524.9	3921.29	2523.385	1876.955	1483.326	1187.815	968.4906	731.851
527	3936.978	2533.481	1884.465	1489.26	1192.567	972.3653	734.779
528.9	3951.172	2542.615	1891.259	1494.63	1196.867	975.8709	737.4281
530.8	3965.366	2551.749	1898.053	1499.999	1201.166	979.3766	740.0772
532.5	3978.066	2559.921	1904.132	1504.803	1205.013	982.5133	742.4475
534.2	3990.766	2568.094	1910.211	1509.607	1208.86	985.65	744.8177
535.8	4002.719	2575.786	1915.932	1514.128	1212.481	988.6021	747.0486
537.5	4015.419	2583.958	1922.011	1518.932	1216.328	991.7388	749.4188
538.9	4025.878	2590.689	1927.017	1522.889	1219.496	994.3219	751.3708
540.4	4037.084	2597.9	1932.381	1527.128	1222.891	997.0895	753.4622
541.7	4046.795	2604.149	1937.03	1530.801	1225.832	999.4882	755.2747
543.1	4057.254	2610.879	1942.036	1534.758	1229	1002.071	757.2267
544.4	4066.966	2617.129	1946.684	1538.431	1231.942	1004.47	759.0393
545.6	4075.93	2622.898	1950.975	1541.822	1234.658	1006.684	760.7124
546.8	4084.895	2628.667	1955.266	1545.214	1237.373	1008.898	762.3855
547.9	4093.113	2633.955	1959.2	1548.322	1239.863	1010.928	763.9192
549	4101.33	2639.243	1963.133	1551.431	1242.352	1012.957	765.4529
550.1	4109.548	2644.531	1967.067	1554.539	1244.841	1014.987	766.9866
549.6	4105.813	2642.127	1965.279	1553.126	1243.71	1014.064	766.2894
547.9	4093.113	2633.955	1959.2	1548.322	1239.863	1010.928	763.9192
545.2	4072.942	2620.975	1949.545	1540.692	1233.753	1005.946	760.1547
538.6	4023.637	2589.246	1925.944	1522.041	1218.817	993.7684	750.9525
525.9	3928.761	2528.193	1880.531	1486.152	1190.078	970.3357	733.2453
509.4	3805.497	2448.871	1821.53	1439.524	1152.74	939.8916	710.2399
489.4	3656.086	2352.724	1750.013	1383.006	1107.481	902.9897	682.3545
465.9	3480.528	2239.751	1665.981	1316.597	1054.302	859.6299	649.5892

Table 3. (rpm vs. Vehicle Speed per Gear (ft/s))

rpm	1	2	3	4	5	6	7
1000	14.01767	21.78318	29.28538	37.05683	46.27602	56.75569	75.1073
1100	15.41944	23.9615	32.21392	40.76251	50.90362	62.43126	82.61803
1200	16.8212	26.13981	35.14245	44.4682	55.53123	68.10683	90.12876
1300	18.22297	28.31813	38.07099	48.17388	60.15883	73.7824	97.63949
1400	19.62474	30.49645	40.99953	51.87956	64.78643	79.45797	105.1502
1500	21.02651	32.67477	43.92807	55.58524	69.41403	85.13354	112.6609
1600	22.42827	34.85308	46.85661	59.29093	74.04163	90.80911	120.1717
1700	23.83004	37.0314	49.78514	62.99661	78.66924	96.48468	127.6824
1800	25.23181	39.20972	52.71368	66.70229	83.29684	102.1602	135.1931
1900	26.63357	41.38804	55.64222	70.40798	87.92444	107.8358	142.7039
2000	28.03534	43.56636	58.57076	74.11366	92.55204	113.5114	150.2146
2100	29.43711	45.74467	61.4993	77.81934	97.17965	119.187	157.7253
2200	30.83887	47.92299	64.42783	81.52503	101.8072	124.8625	165.2361
2300	32.24064	50.10131	67.35637	85.23071	106.4348	130.5381	172.7468
2400	33.64241	52.27963	70.28491	88.93639	111.0625	136.2137	180.2575
2500	35.04418	54.45794	73.21345	92.64207	115.6901	141.8892	187.7682
2600	36.44594	56.63626	76.14199	96.34776	120.3177	147.5648	195.279
2700	37.84771	58.81458	79.07052	100.0534	124.9453	153.2404	202.7897
2800	39.24948	60.9929	81.99906	103.7591	129.5729	158.9159	210.3004
2900	40.65124	63.17122	84.9276	107.4648	134.2005	164.5915	217.8112
3000	42.05301	65.34953	87.85614	111.1705	138.8281	170.2671	225.3219
3100	43.45478	67.52785	90.78467	114.8762	143.4557	175.9426	232.8326
3200	44.85655	69.70617	93.71321	118.5819	148.0833	181.6182	240.3434
3300	46.25831	71.88449	96.64175	122.2875	152.7109	187.2938	247.8541
3400	47.66008	74.0628	99.57029	125.9932	157.3385	192.9694	255.3648
3500	49.06185	76.24112	102.4988	129.6989	161.9661	198.6449	262.8755
3600	50.46361	78.41944	105.4274	133.4046	166.5937	204.3205	270.3863
3700	51.86538	80.59776	108.3559	137.1103	171.2213	209.9961	277.897
3800	53.26715	82.77607	111.2844	140.816	175.8489	215.6716	285.4077
3900	54.66891	84.95439	114.213	144.5216	180.4765	221.3472	292.9185
4000	56.07068	87.13271	117.1415	148.2273	185.1041	227.0228	300.4292
4100	57.47245	89.31103	120.0701	151.933	189.7317	232.6983	307.9399
4200	58.87422	91.48935	122.9986	155.6387	194.3593	238.3739	315.4506
4300	60.27598	93.66766	125.9271	159.3444	198.9869	244.0495	322.9614
4400	61.67775	95.84598	128.8557	163.0501	203.6145	249.725	330.4721
4500	63.07952	98.0243	131.7842	166.7557	208.2421	255.4006	337.9828
4600	64.48128	100.2026	134.7127	170.4614	212.8697	261.0762	345.4936
4700	65.88305	102.3809	137.6413	174.1671	217.4973	266.7518	353.0043
4800	67.28482	104.5593	140.5698	177.8728	222.1249	272.4273	360.515
4900	68.68658	106.7376	143.4984	181.5785	226.7525	278.1029	368.0258
5000	70.08835	108.9159	146.4269	185.2841	231.3801	283.7785	375.5365
5100	71.49012	111.0942	149.3554	188.9898	236.0077	289.454	383.0472
5200	72.89189	113.2725	152.284	192.6955	240.6353	295.1296	390.5579
5300	74.29365	115.4508	155.2125	196.4012	245.2629	300.8052	398.0687
5400	75.69542	117.6292	158.141	200.1069	249.8905	306.4807	405.5794
5500	77.09719	119.8075	161.0696	203.8126	254.5181	312.1563	413.0901
5600	78.49895	121.9858	163.9981	207.5182	259.1457	317.8319	420.6009
5700	79.90072	124.1641	166.9267	211.2239	263.7733	323.5074	428.1116
5800	81.30249	126.3424	169.8552	214.9296	268.4009	329.183	435.6223
5900	82.70426	128.5207	172.7837	218.6353	273.0285	334.8586	443.1331
6000	84.10602	130.6991	175.7123	222.341	277.6561	340.5342	450.6438
6100	85.50779	132.8774	178.6408	226.0467	282.2837	346.2097	458.1545
6200	86.90956	135.0557	181.5693	229.7523	286.9113	351.8853	465.6652
6300	88.31132	137.234	184.4979	233.458	291.5389	357.5609	473.176
6400	89.71309	139.4123	187.4264	237.1637	296.1665	363.2364	480.6867
6500	91.11486	141.5907	190.355	240.8694	300.7941	368.912	488.1974
6600	92.51662	143.769	193.2835	244.5751	305.4217	374.5876	495.7082
6700	93.91839	145.9473	196.212	248.2808	310.0493	380.2631	503.2189

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Table 4. (Torque vs. Force Inverse (s^2/ft) per Gear)

torque (lb-ft)	1	2	3	4	5	6	7
245	0.053788	0.083585	0.112372	0.142193	0.177568	0.21778	0.288198
278.4	0.047335	0.073558	0.098891	0.125134	0.156265	0.191653	0.253623
306.2	0.043037	0.066879	0.089913	0.113773	0.142078	0.174253	0.230596
329.8	0.039958	0.062093	0.083479	0.105631	0.131911	0.161783	0.214095
349.9	0.037662	0.058526	0.078683	0.099563	0.124333	0.15249	0.201796
367.5	0.035859	0.055724	0.074915	0.094795	0.118379	0.145187	0.192132
382.7	0.034434	0.05351	0.07194	0.09103	0.113677	0.13942	0.184501
396.3	0.033253	0.051674	0.069471	0.087906	0.109776	0.134636	0.178169
408.3	0.032275	0.050155	0.067429	0.085323	0.10655	0.130679	0.172933
419	0.031451	0.048875	0.065707	0.083144	0.103829	0.127342	0.168517
428.7	0.03074	0.047769	0.06422	0.081262	0.101479	0.12446	0.164704
437.5	0.030121	0.046808	0.062929	0.079628	0.099438	0.121957	0.161391
445.4	0.029587	0.045978	0.061812	0.078216	0.097674	0.119794	0.158528
452.7	0.02911	0.045236	0.060816	0.076954	0.096099	0.117862	0.155972
459.3	0.028692	0.044586	0.059942	0.075848	0.094718	0.116168	0.153731
465.4	0.028316	0.044002	0.059156	0.074854	0.093477	0.114646	0.151716
471.1	0.027973	0.043469	0.05844	0.073949	0.092346	0.113259	0.14988
476.3	0.027668	0.042995	0.057802	0.073141	0.091338	0.112022	0.148244
481.2	0.027386	0.042557	0.057214	0.072397	0.090408	0.110881	0.146734
485.7	0.027132	0.042163	0.056684	0.071726	0.08957	0.109854	0.145375
490	0.026894	0.041793	0.056186	0.071096	0.088784	0.10889	0.144099
493.9	0.026682	0.041463	0.055743	0.070535	0.088083	0.10803	0.142961
497.6	0.026483	0.041154	0.055328	0.07001	0.087428	0.107227	0.141898
501.1	0.026298	0.040867	0.054942	0.069521	0.086817	0.106478	0.140907
504.4	0.026126	0.0406	0.054582	0.069067	0.086249	0.105781	0.139985
507.4	0.025972	0.04036	0.054259	0.068658	0.085739	0.105156	0.139158
510.3	0.025824	0.04013	0.053951	0.068268	0.085252	0.104558	0.138367
513.1	0.025683	0.039911	0.053657	0.067896	0.084787	0.103988	0.137612
515.7	0.025554	0.03971	0.053386	0.067553	0.08436	0.103464	0.136918
518.2	0.02543	0.039518	0.053129	0.067227	0.083953	0.102964	0.136257
520.6	0.025313	0.039336	0.052884	0.066917	0.083565	0.10249	0.135629
522.8	0.025207	0.039171	0.052661	0.066636	0.083214	0.102058	0.135058
524.9	0.025106	0.039014	0.05245	0.066369	0.082881	0.10165	0.134518
527	0.025006	0.038858	0.052241	0.066105	0.082551	0.101245	0.133982
528.9	0.024916	0.038719	0.052054	0.065867	0.082254	0.100881	0.133501
530.8	0.024827	0.03858	0.051867	0.065632	0.08196	0.10052	0.133023
532.5	0.024748	0.038457	0.051702	0.065422	0.081698	0.100199	0.132598
534.2	0.024669	0.038335	0.051537	0.065214	0.081438	0.09988	0.132176
535.8	0.024595	0.03822	0.051383	0.065019	0.081195	0.099582	0.131782
537.5	0.024517	0.038099	0.051221	0.064813	0.080938	0.099267	0.131365
538.9	0.024454	0.038	0.051088	0.064645	0.080728	0.099009	0.131023
540.4	0.024386	0.037895	0.050946	0.064466	0.080504	0.098735	0.13066
541.7	0.024327	0.037804	0.050824	0.064311	0.08031	0.098498	0.130346
543.1	0.024264	0.037707	0.050693	0.064145	0.080103	0.098244	0.13001
544.4	0.024207	0.037616	0.050572	0.063992	0.079912	0.098009	0.1297
545.6	0.024153	0.037534	0.050461	0.063851	0.079736	0.097794	0.129414
546.8	0.0241	0.037451	0.05035	0.063711	0.079561	0.097579	0.12913
547.9	0.024052	0.037376	0.050249	0.063583	0.079402	0.097383	0.128871
549	0.024004	0.037301	0.050148	0.063456	0.079243	0.097188	0.128613
550.1	0.023956	0.037227	0.050048	0.063329	0.079084	0.096994	0.128356
549.6	0.023978	0.037261	0.050093	0.063386	0.079156	0.097082	0.128473
547.9	0.024052	0.037376	0.050249	0.063583	0.079402	0.097383	0.128871
545.2	0.024171	0.037561	0.050498	0.063898	0.079795	0.097865	0.129509
538.6	0.024467	0.038022	0.051116	0.064681	0.080773	0.099065	0.131096
525.9	0.025058	0.03894	0.052351	0.066243	0.082723	0.101457	0.134262
509.4	0.02587	0.040201	0.054046	0.068389	0.085403	0.104743	0.138611
489.4	0.026927	0.041844	0.056255	0.071184	0.088893	0.109024	0.144276
465.9	0.028285	0.043955	0.059093	0.074774	0.093377	0.114523	0.151553

Table 5. (Transmission Specifications and Tire Radius)

Differential Ratio	Gear	Ratio	Tire Radius (ft)
3.666	1	3.397	1.667
	2	2.186	
	3	1.626	
	4	1.285	
	5	1.029	
	6	0.839	
	7	0.634	

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