# Gearing and The Force of Acceleration

Marc Haibeck

Improved acceleration is the goal of most modifications that are performed to increase the performance of an engine. Everyone understands that engine power upgrade and less vehicle weight will improve acceleration. Until recently, I under appreciated the roll of gearing. Acceleration is equal to the engine torque times the total gearing divided by the weight of the vehicle. From the formula, increasing the total gear ratio has the same effect as increasing engine torque. Chart 1 illustrates how a stock 405 hp ZR-1 is affected by a 4.10 axle ratio verses the OE 3.45 ratio.

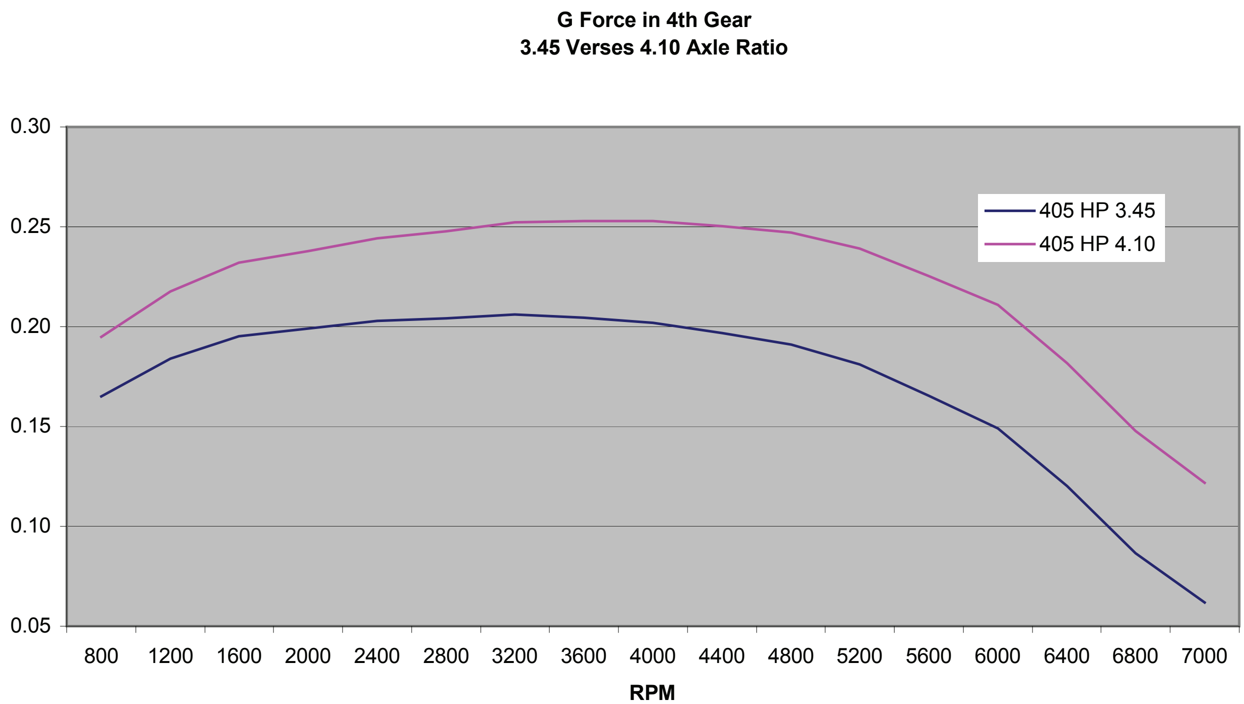


Chart 1

The chart shows that acceleration with the 4.10 gears is about .05 G greater at all engine speeds. This demonstrates that if the tires are not slipping, higher gearing is as important as higher engine torque.

Chart 2 shows the calculated acceleration in all gears for a stock 405 hp ZR-1 with 3.45 gears.

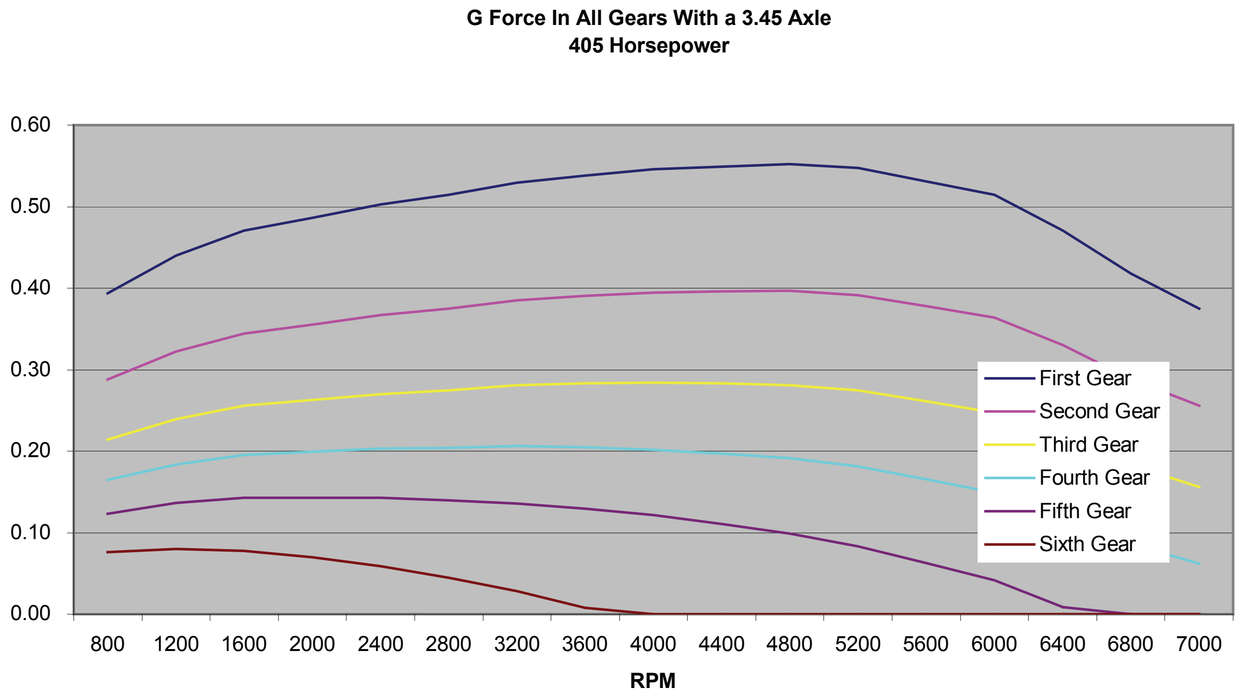


Chart 2

Chart 3 shows the calculated acceleration in all gears for a stock 405 hp ZR-1 with 4.10 gears.

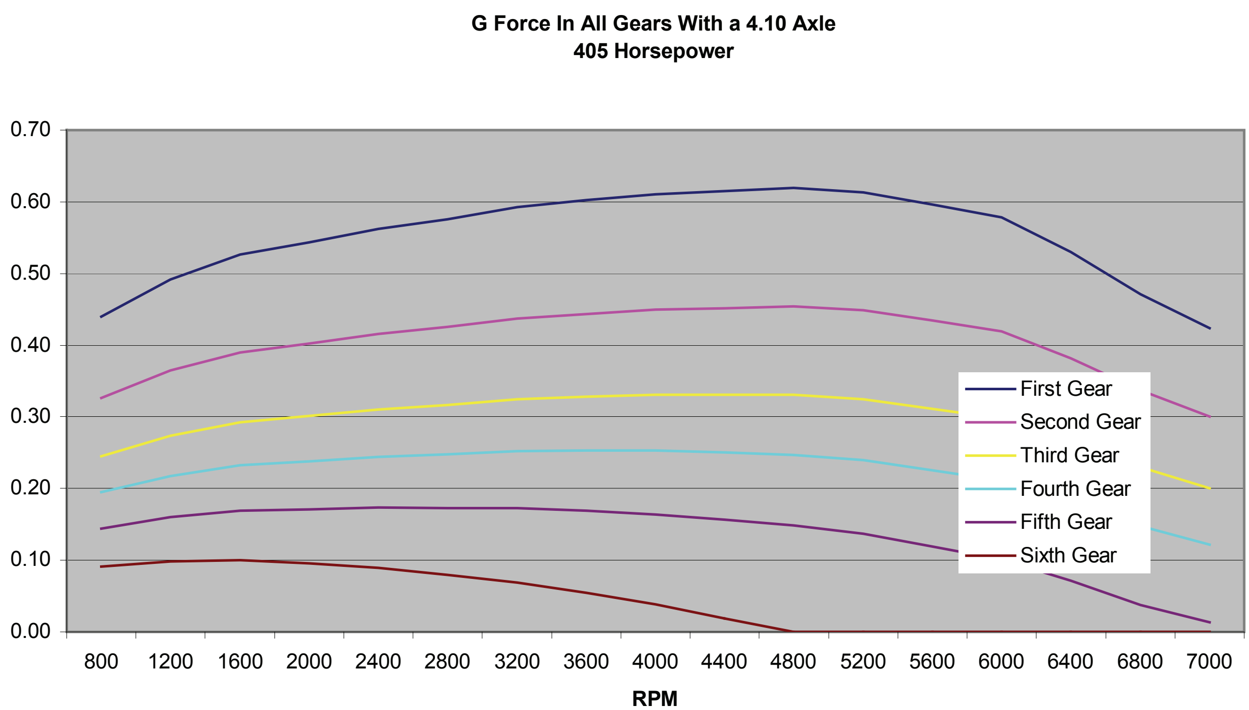


Chart 3

The 4.10 gearing provides .06 G more peak acceleration in first gear. It is important that the tires do not slip. When tires slip, it is like having a throttle limiter on the car. Tire slippage goes not have to be accepted with a high torque engine. As torque to the wheels is increased, the appropriate tire strategy can be utilized. Tires with a Z, W or Y speed rating are not optimal for straight-line traction. These tires are optimized for high-speed durability. In general, durability and coefficient of friction are at odds with each other. High-powered cars that are primarily used for straight-line acceleration need to have tires that are compounded for more grip. In general the drag radial tire will provide a significant increase in grip. I have found that the V speed rated Nitto NT 555R drag radial provides a significant increase in grip compared to all super high performance high speed rated tires. With Nitto NT 555R the car described in chart 5 does not slip the tires in first gear when the ambient temperature is 50 degrees or more. The high G force makes for thrilling acceleration.

Gearing as high as the highest ratio that is available for the Corvette Dana 44 gear case, 4.56, provides increasing acceleration performance.

Chart 4 shows acceleration in fourth gear for a 405 hp car with a 3.45 axle ratio, plotted with torque and horsepower.

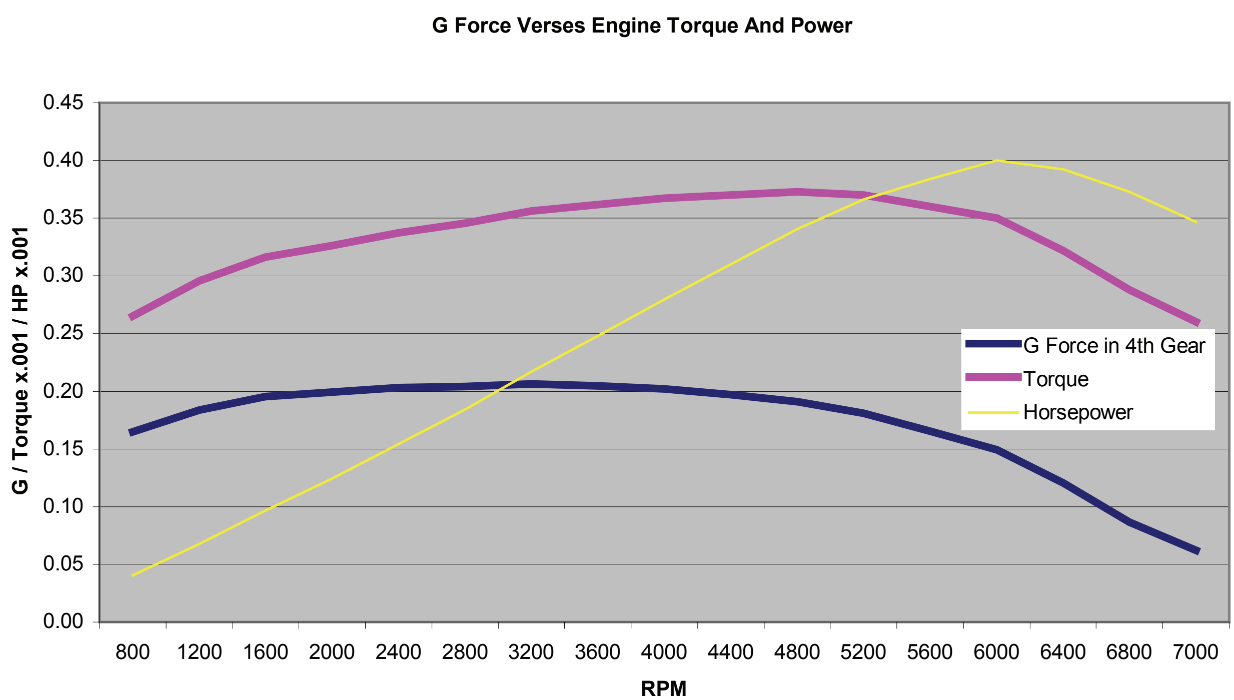


Chart 4

It is interesting to observe how the acceleration parallels the torque. This illustrates that for acceleration, torque is more important than horsepower. The acceleration profile is the same as the torque profile of the engine. Acceleration drops off after peak torque. Acceleration does not follow horsepower.

Chart 5 plots acceleration as measured by an accelerometer verses torque and horsepower. This verifies that the accelerations calculated in the charts are correct because they follow the torque curve just as the accelerometer does.


Chart 5

The combination of a 485 hp engine and 4.10 gears can produce a thrilling .67 G of acceleration at the torque peak at 5200 rpm. To achieve this, the tires must not slip. This is accomplished with the Nitto NT 555R drag radial.

Special thanks to Jim Ingle and his experience with the development of the Corvette at GM engineering. Jim provided valuable mechanical and aerodynamic loss factors that are necessary for accurate G force calculations.