Horsepower and Torque

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Objectives

- Define horsepower
- Define torque
- Understand the relationship between horsepower, work, torque and RPM

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James Watt (1736 – 1819)

- Engineer
- Inventor of the steam engine
- Coined the term horsepower when comparing the power of a steam engine with the power of a draft horse

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Horsepower

- Horsepower is a measure of an engine's ability to do work per unit time
- Watt calculated that an average horse could lift a 550 pounds of coal a distance of one foot in one second
- He concluded that a horse could perform work at the rate of 33,000-foot pounds per minute
- The unit of time for measuring horsepower is foot-pounds per second

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Horsepower

Simply put: Horsepower is the amount of energy required to move 550 pounds, one foot, in one second.

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Defining work?

- Application of force over a distance
- You push on a car with 100 lbs. of force and move the car a distance of 30 feet
- How much work have you done?
- 100 ft. lbs. force X 30 feet = 3000 ft. lbs. of work

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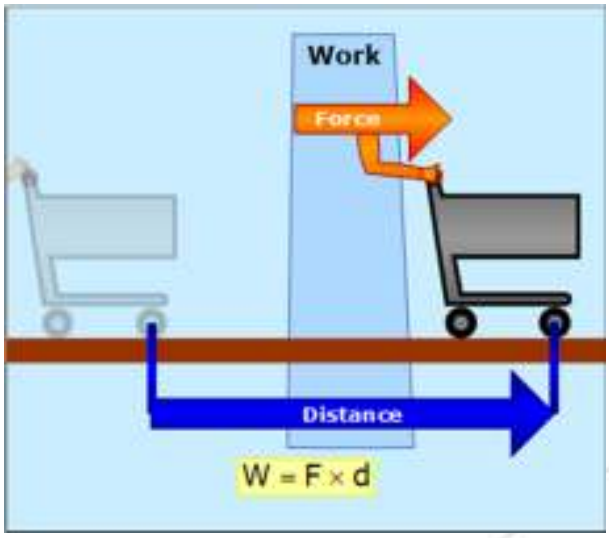
Work = Force x Distance



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What is Power?

- Amount of work an engine can perform within a specific time
- Watt calculated that one horse could do 33,000-ft pounds of work per minute
- 1 horsepower is the ability to perform 550 ft. lbs. of work per second

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Torque

- Its what gets things moving
- A twisting force applied to an object
- Measured in foot pounds or Newton meters
- Torque is what you feel when accelerating

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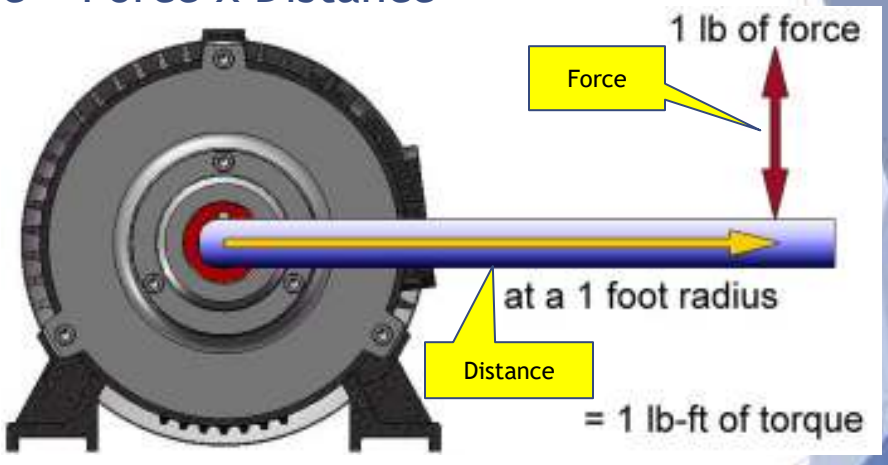
Torque = Force x Distance



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Torque

- Movement or motion is not required for torque to exist
- For example, loosening a tight bolt requires the application of torque
- A 130 lb. person standing on a lug wrench one foot long, yields 130 foot-pounds of torque applied
- No work occurs and no power is generated until the lug nut moves, but torque is applied.

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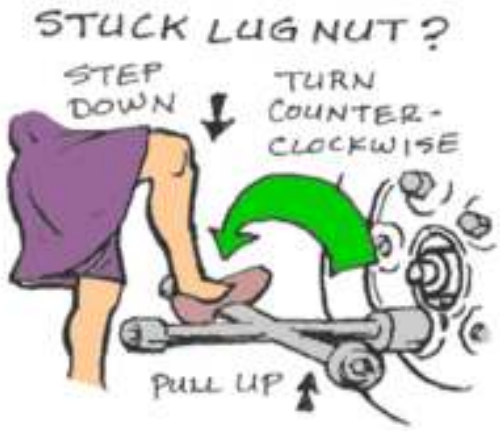

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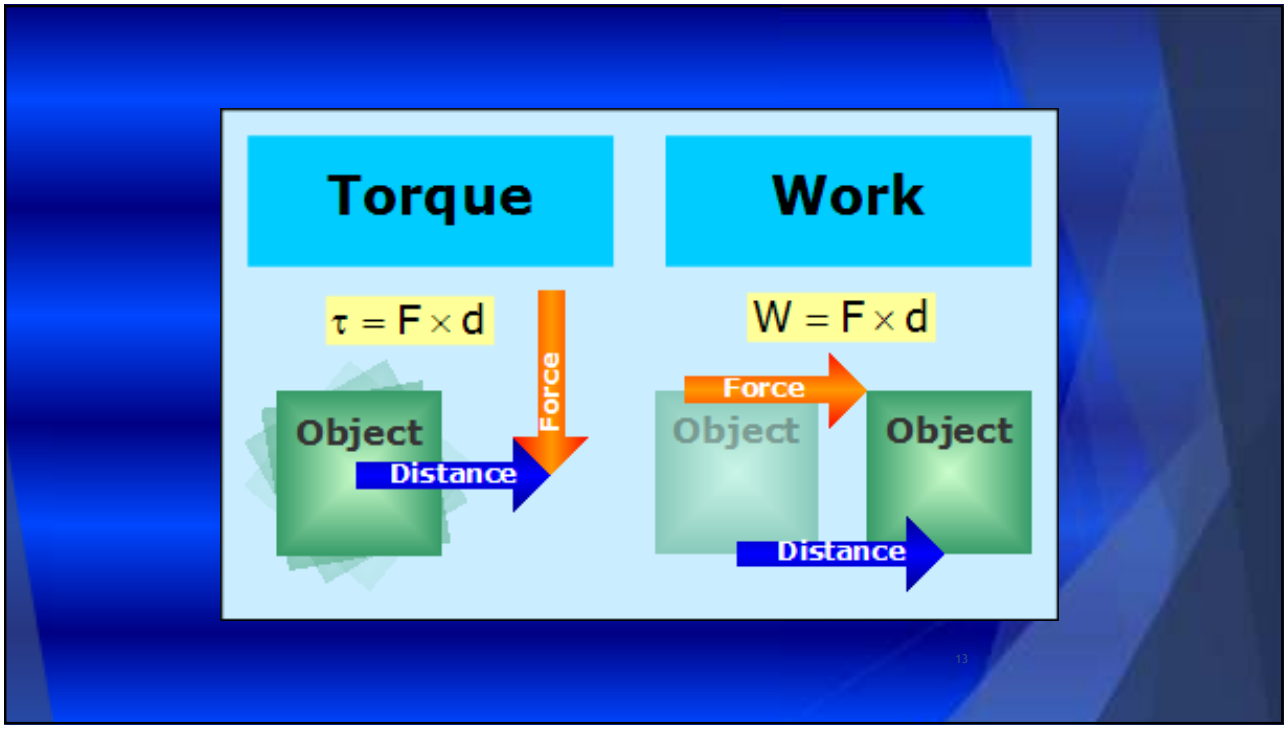

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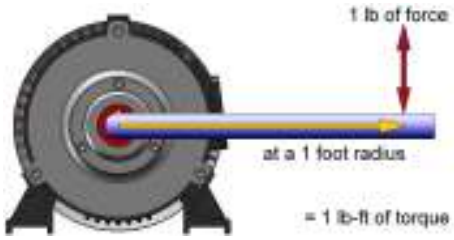

- Work = Force x Distance
- Rotating the lever one full revolution will move it a total circumference of 6.2832 feet
- *Circumference = π × diameter (3.1416 x 2= 6.2832)*
- To rotate the it a full turn would require 6.2832 foot pounds of work (Work = 1 x 6.2832)

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Torque

- The lug bolt loosens and starts to turn
- 87.5 pounds of force is needed to keep the wrench turning
- For every revolution of the wrench, she is applying 87.5-pounds of force over a distance of 6.28 feet

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Torque = Distance X Force

- A distance of 6.28 feet multiplied by a force of 87.5 ft lbs of force = 550 ft lbs of work
- If she can could turn the lug wrench one full revolution per-second she would be doing 550 ft-lb of work per-second
- That would be applying one horsepower to rotate the wrench

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Horsepower Torque Relationship

- Engine torque is created on the power stroke
- HP is directly proportional to torque and RPM
- Horsepower cannot be measured
- Horsepower can be calculated when you know the torque at a specific RPM

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Horsepower Torque Relationship

- There's not a machine in existence that measures horsepower
- It is a man-made number calculated from the torque and RPM of the engine
- The measure of an engine's performance is torque
- Horsepower is calculated by multiplying the torque by the RPMs and dividing by a constant of 5250

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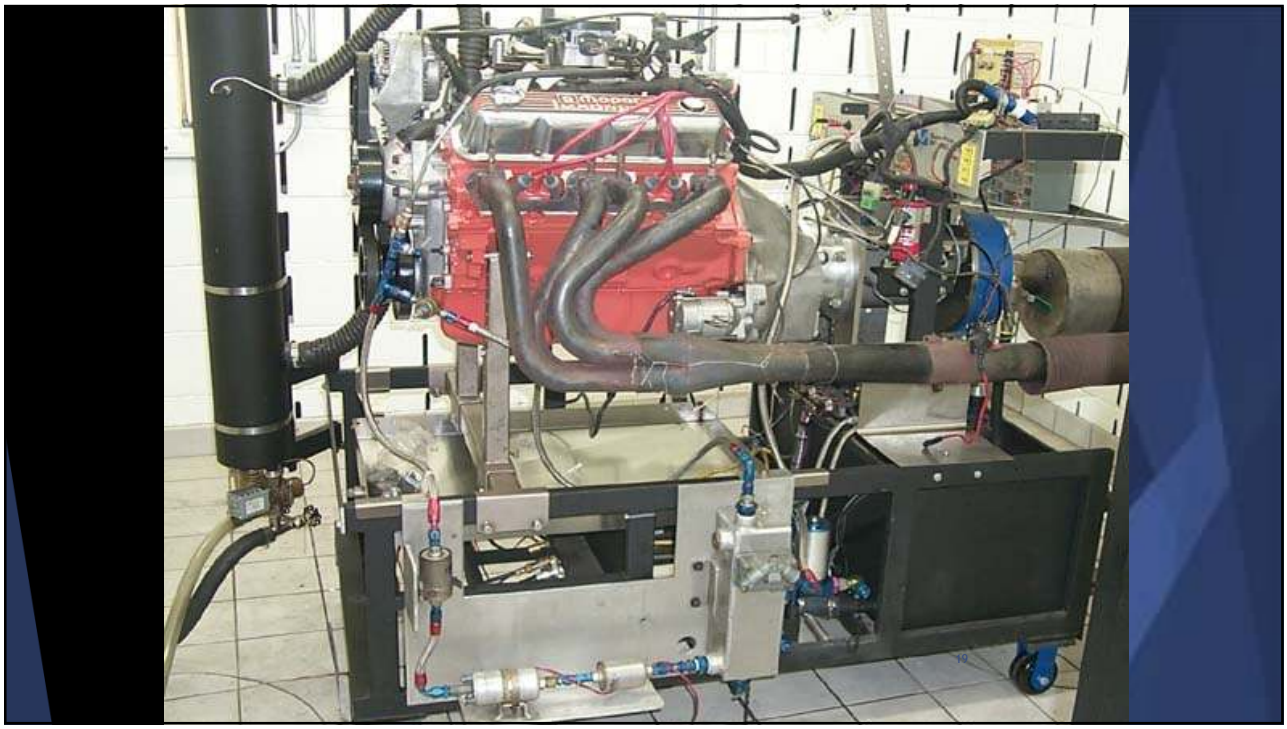

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Horsepower = Torque x RPM / 5252

- Horsepower is a measurement of Torque at a certain RPM
- 1 Horsepower = 33,000 ft. lbs. of work per minute
- To rotate a 1-foot lever, 1 revolution with 1 ft. lb. of force required 6.2832 ft. lbs. torque
- 33,000 / 6.2832 = 5252.11
- 1 ft. pound of torque, rotating at 5252 rpm = 1 horsepower
- 5252 is a constant

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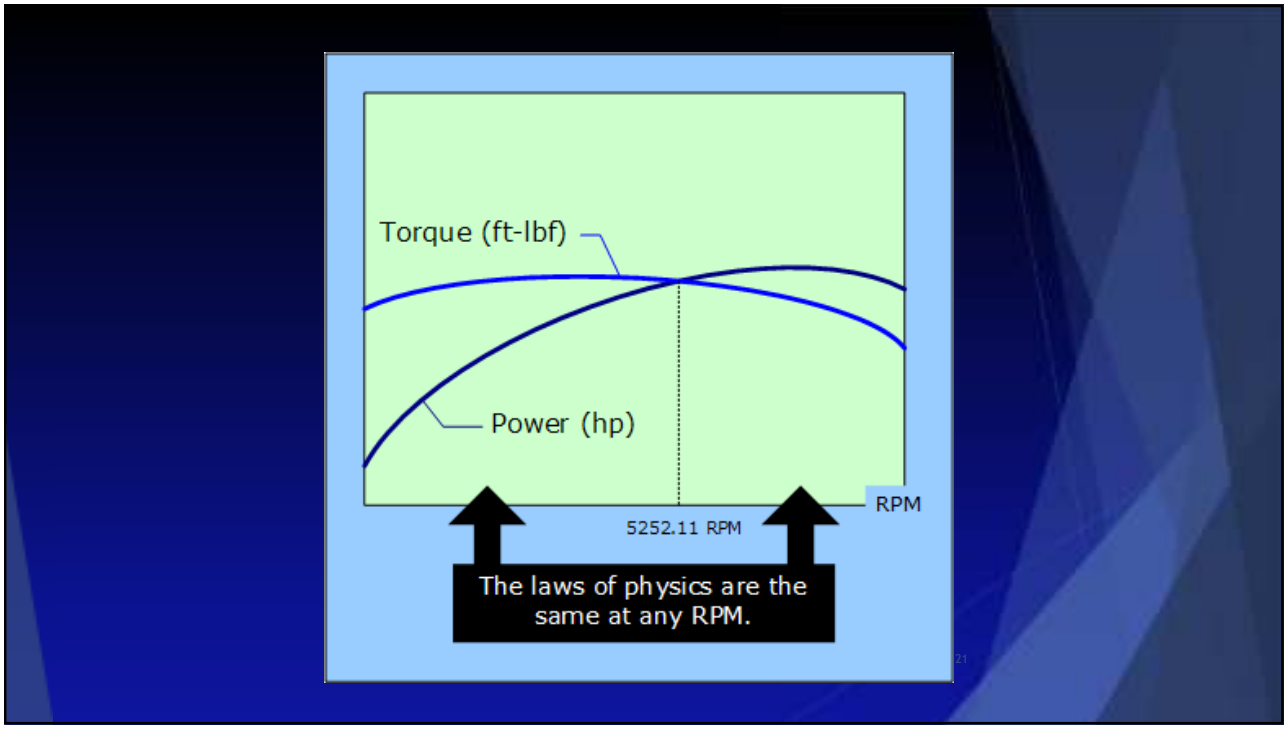

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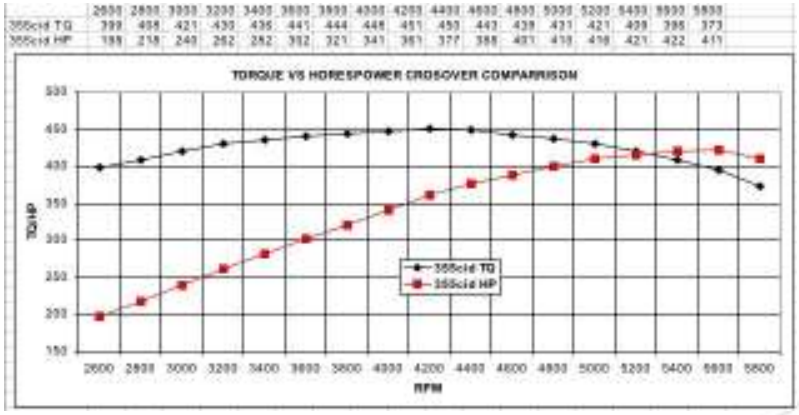
Torque = horsepower at 5252 rpm



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Horsepower Peak & Torque Peak

- Torque decreases at high RPM because the cylinders don't have enough time to completely fill air
- Peak torque is determined by the engine ability fill the cylinders with air at high RPM (Volumetric Efficiency)

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Horsepower Peak & Torque Peak

- When the torque peak starts to drop, it is not enough to offset the increasing RPM, so the horsepower continues to increase
- When the decrease in torque overcomes the increasing RPM, horsepower will start to decrease
- Horsepower peak will always occur after the torque peak because horsepower is what keeps things moving

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Horsepower Peak & Torque Peak

- Below 5252 RPMs an engine's torque will always be higher than its horsepower.
- Above 5252 RPMs an engine's horsepower will always be higher than its torque.
- At 5252 RPMs the horsepower and torque will be exactly the same.

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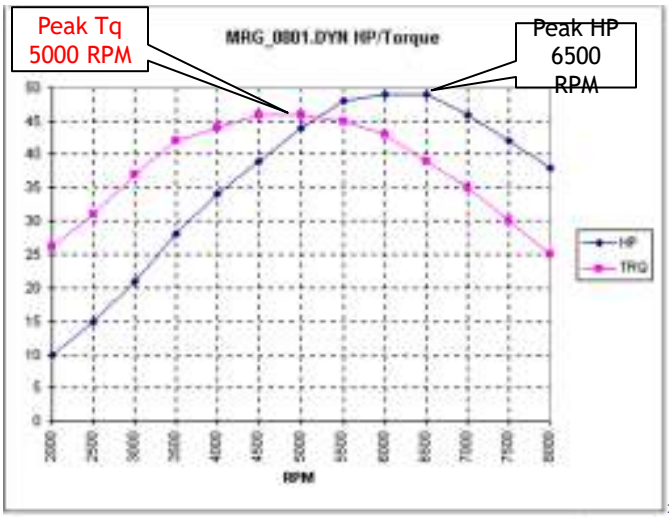
Where is the Shift Redline?



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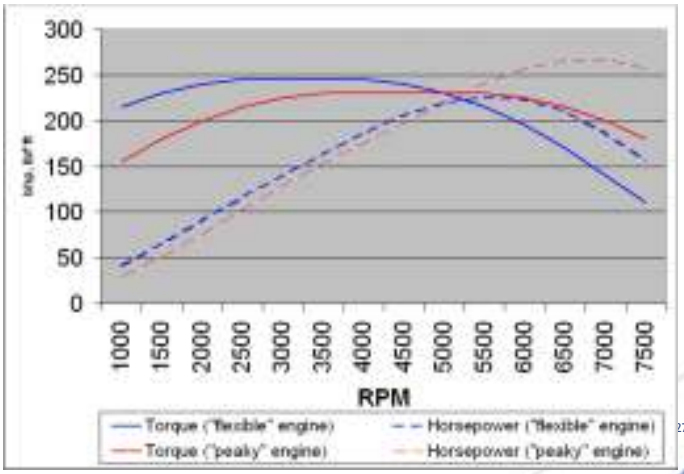
Engine's Powerband

- The range from peak torque to peak horsepower



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Gears

- Gearing is extremely important because it controls RPM and therefore horsepower.
- Gears magnify torque — hence quicker acceleration is available in first gear.

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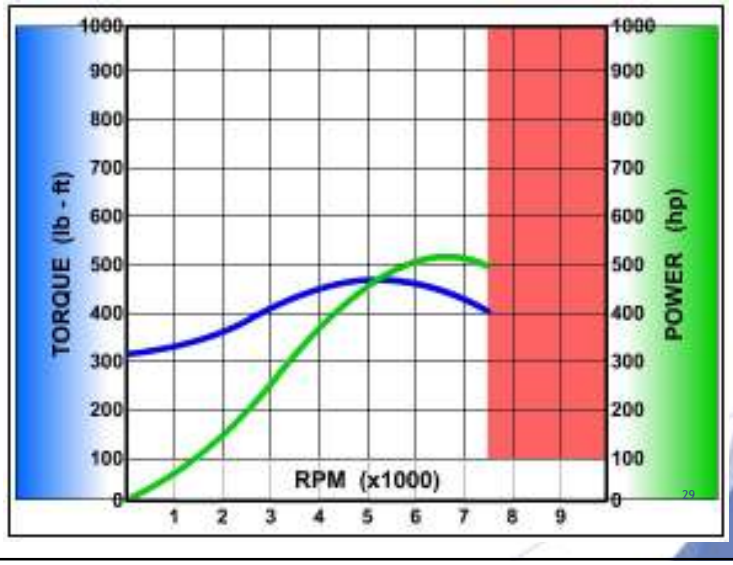
Redline is at Peak HP



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Horsepower Terms

- Brake or Net Horsepower (BHP) is measured at the crankshaft, before power losses
- Effective or wheel horsepower (WHP) is the actual power measured at the wheels.
- BHP is about 15% to 25% higher than WHP.
- Remember:
  - Horsepower is what your read about.
  - Torque is what you feel when accelerating.

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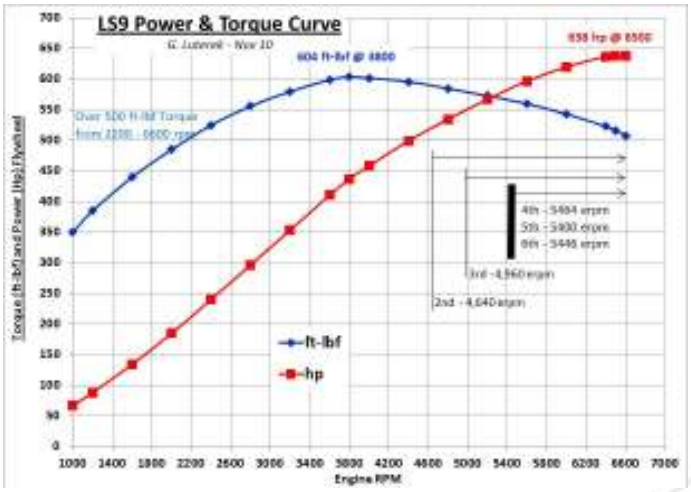
Corvette ZO6



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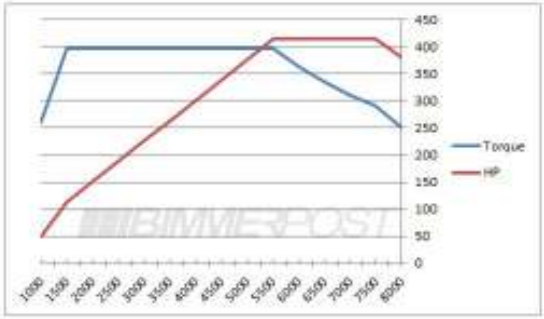
BMW M4

	Torque	HP
1000	260	50
1500	396	113
2000	396	151
2500	396	188
3000	396	226
3500	396	264
4000	396	302
4500	396	339
5000	396	377
5500	396	415
6000	363	415
6500	335	415
7000	311	415
7500	291	415
8000	250	381



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- Torque Video

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