AUTOMOTIVE Youth Educational Systems YES The Passport to a Rewarding Automotive Career

ASE CERTIFIED

Modern Automotive Technology Chapter 16

Engine Size and Performance Measurements

North Montco Technical Career Center

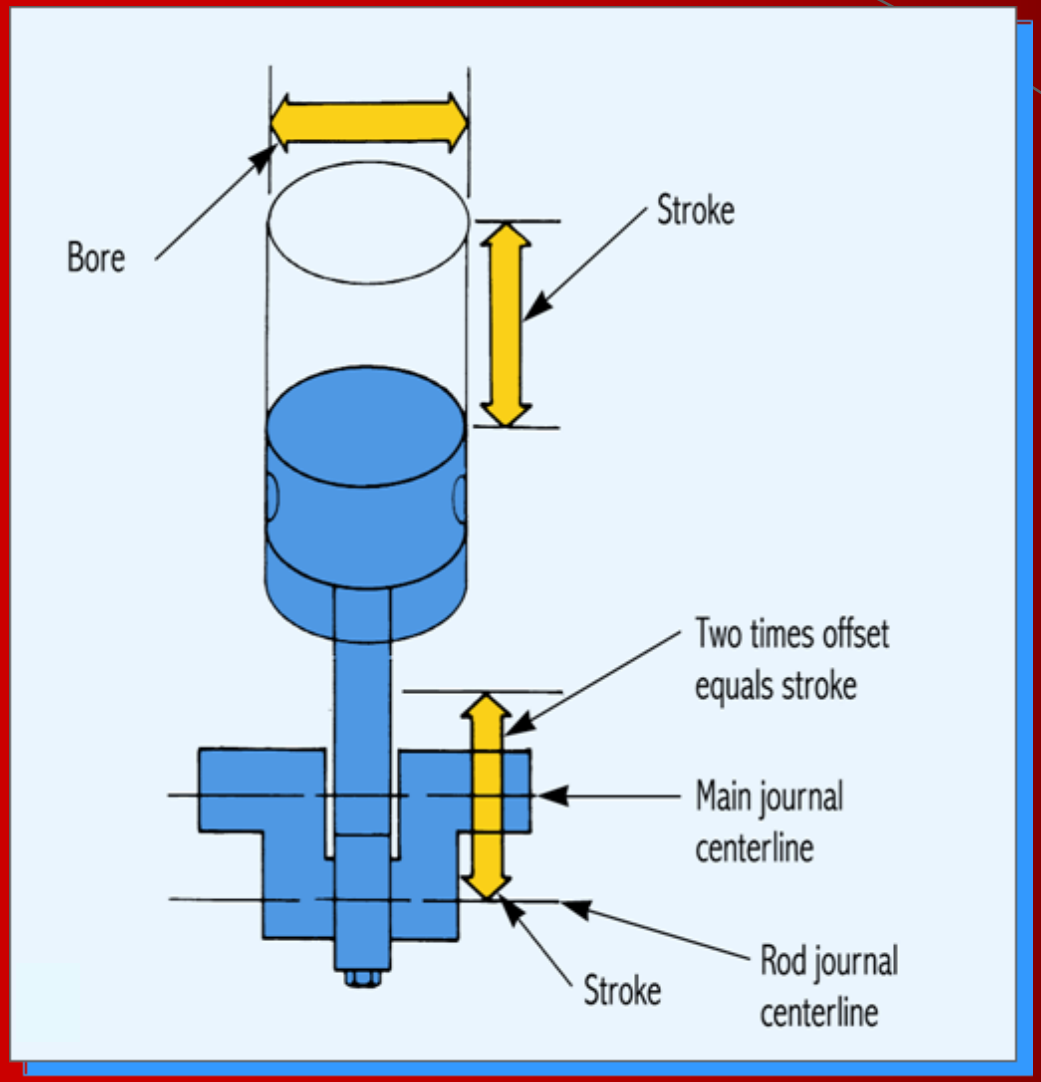
Learning Objectives

- Describe safety practices when making engine performance measurements
- Describe engine size measurements
- Explain engine compression ratio
- Explain engine torque and HP ratings
- Describe different methods used to measure engine performance
- Explain volumetric efficiency, thermal efficiency and mechanical efficiency

Engine Size Measurements

- Engine size is determined by the number of cylinders, the cylinder diameter, and the amount of piston travel per stroke
- Engine size information is used when ordering parts and when measuring wear during major repairs

Bore and Stroke



Bore

- Diameter of the engine cylinder
- Measured across the cylinder, parallel with the top of the block

Stroke

- Distance the piston moves from (TDC) to (BDC)

TDC = Top Dead Center BDC = Bottom Dead Center

Piston Displacement

- Volume the piston displaces as it travels from BDC to TDC
- Found by comparing cylinder diameter and piston stroke
- Piston displacement formula:

$$\text{piston displacement} = \frac{\text{bore squared x 3.14 x stroke}}{4}$$

Engine Displacement

- Volume displaced by all the pistons in an engine
  - piston displacement multiplied by the number of cylinders
- Units of engine displacement:
  - cubic inch displacement (CID)
  - liters (L)

Engine Displacement

If one piston displaces 25 cu. in. and the engine has four cylinders, what is the engine displacement?

25 cu. in. x 4 = 100 cu. in.

If one piston displaces 500 cc and the engine has six cylinders, what is the engine displacement?

500 cc x 6 = 3000 cc
= 3.0 L

1. COMPRESSION RATIO compares cylinder volumes with the piston at TDC and to the cylinder volume with the piston at BDC.
2. THERMAL EFFICIENTY is found by comparing the amount of fuel burned to horsepower output.
3. MECHANICAL EFFICIENTY compares brake horsepower and indicated horsepower.
4. ENGINE TORQURE is a rating of the turning force at the crankshaft.

Force

- Pushing or pulling action
- Measured in pounds or Newton
- When a spring is compressed, an outward movement and force is produced

Work

- Occurs when force causes movement
- Measured in foot-pounds or joules
- Formula for work:

work = distance moved x force applied

For example, if you use a hoist to lift a 400 pound engine 3 feet in the air, how much work has been done?

work = 3’ x 400 lb

= 1200 foot pounds (ft lb)

Power

- Rate, or speed, at which work is done
- Measured in foot-pounds per second or per minute
- Metric unit for power:
  - watt or kilowatt
- Formula for power:

$$\text{power} = \frac{\text{distance x force}}{\text{time}}$$

Power

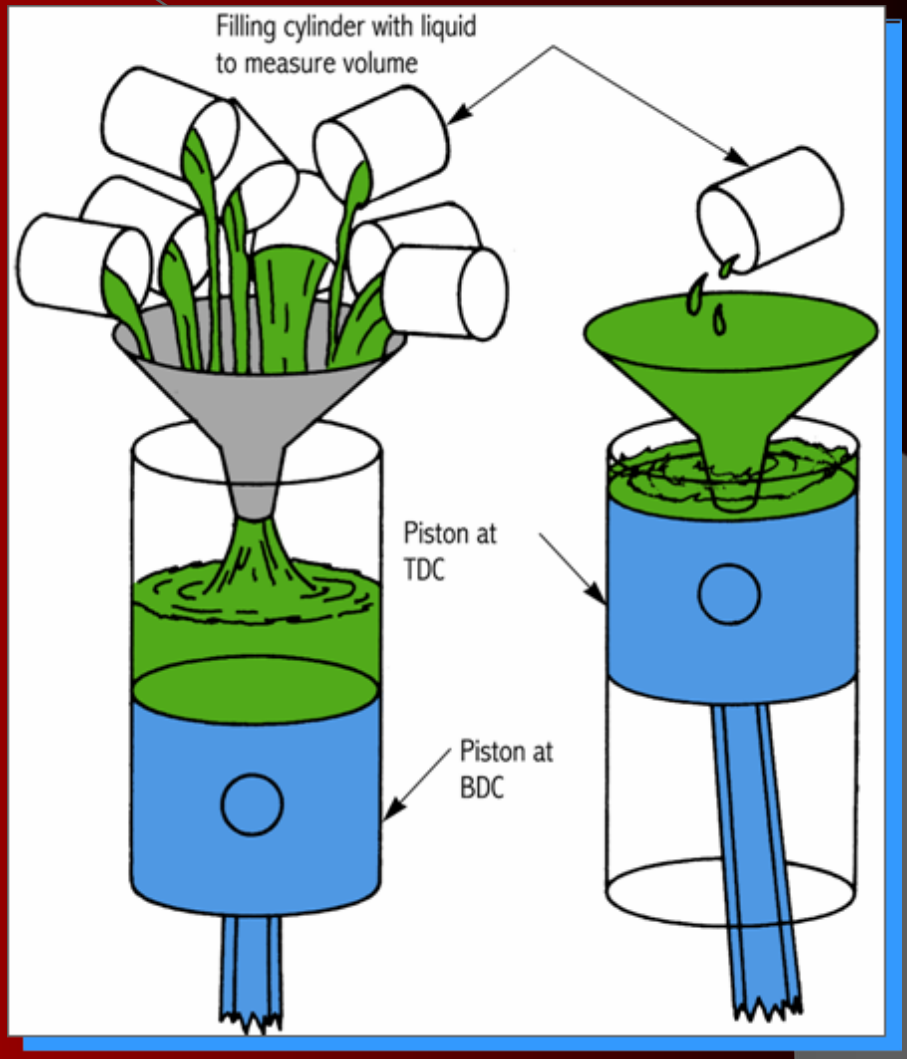
If an engine moves a 3000 pound car 1000 feet in one minute, how much power is needed?

$$\text{power} = \frac{1000 \text{ lb} \times 3000'}{1 \text{ minute}}$$

$$= \frac{3{,}000{,}000 \text{ ft lb}}{\text{min.}}$$

Compression Ratio

This engine has eight times the volume at BDC, producing an 8:1 compression ratio



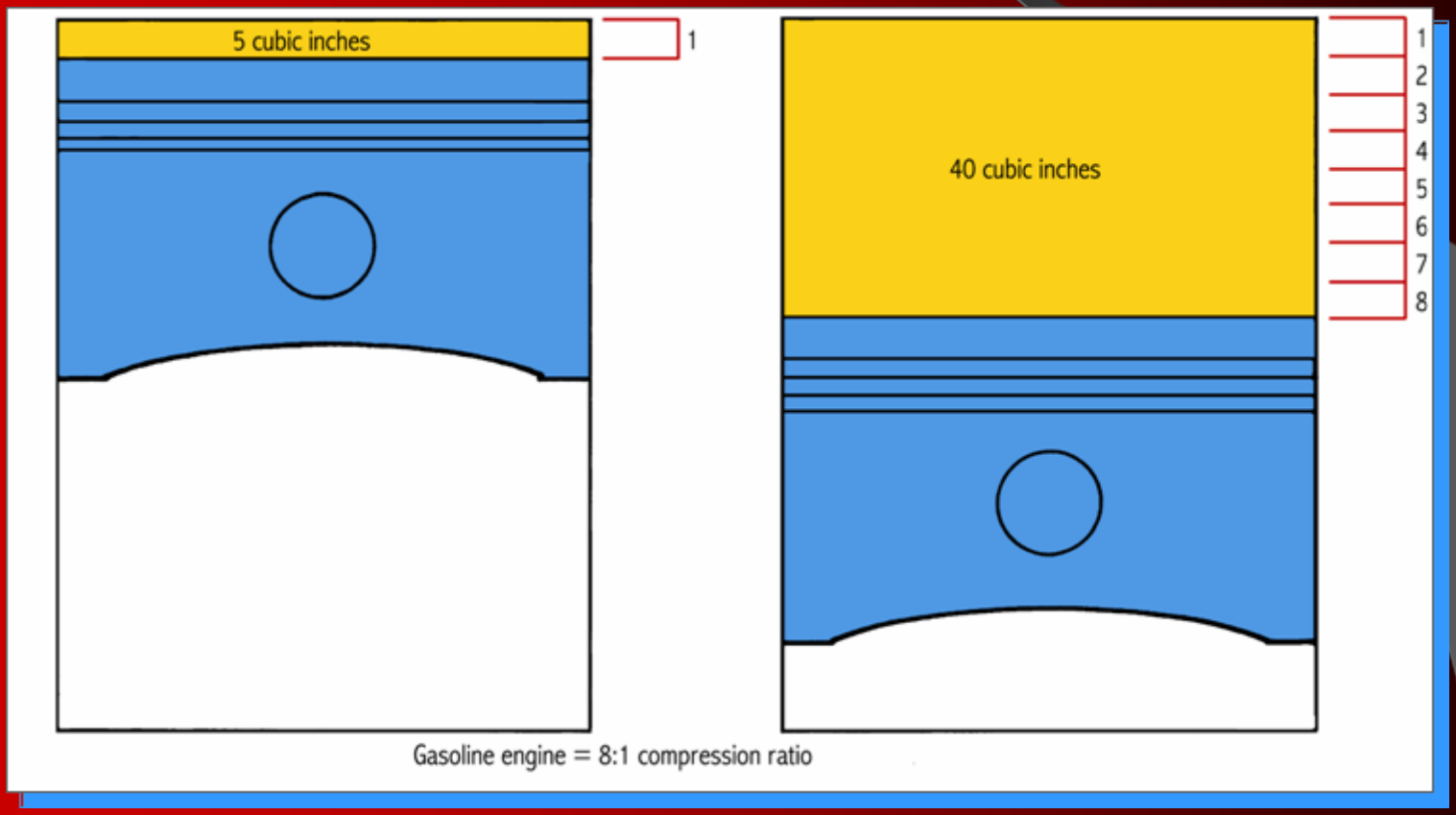
Compression Ratio

- Formula for compression ratio:

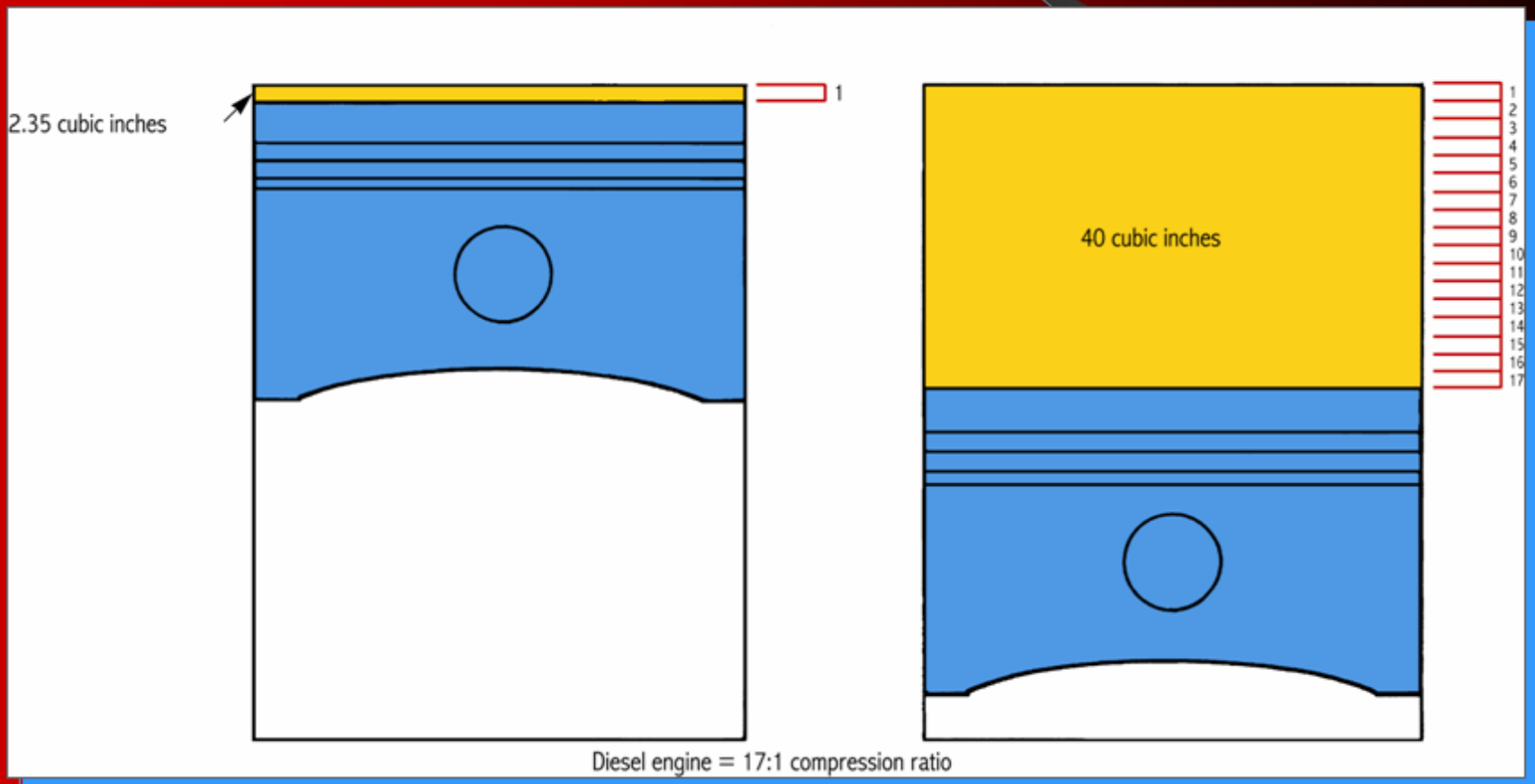
$$\text{compression ratio} = \frac{\text{cylinder volume at BDC}}{\text{cylinder volume at TDC}}$$

- Use of high compression ratio:
  - increases engine fuel efficiency and power
  - increases exhaust emissions (NO_x)
  - increases risk of detonation (ping)

Compression Ratio
(Gasoline Engine)



Compression Ratio
(Diesel Engine)



Compression Gauge

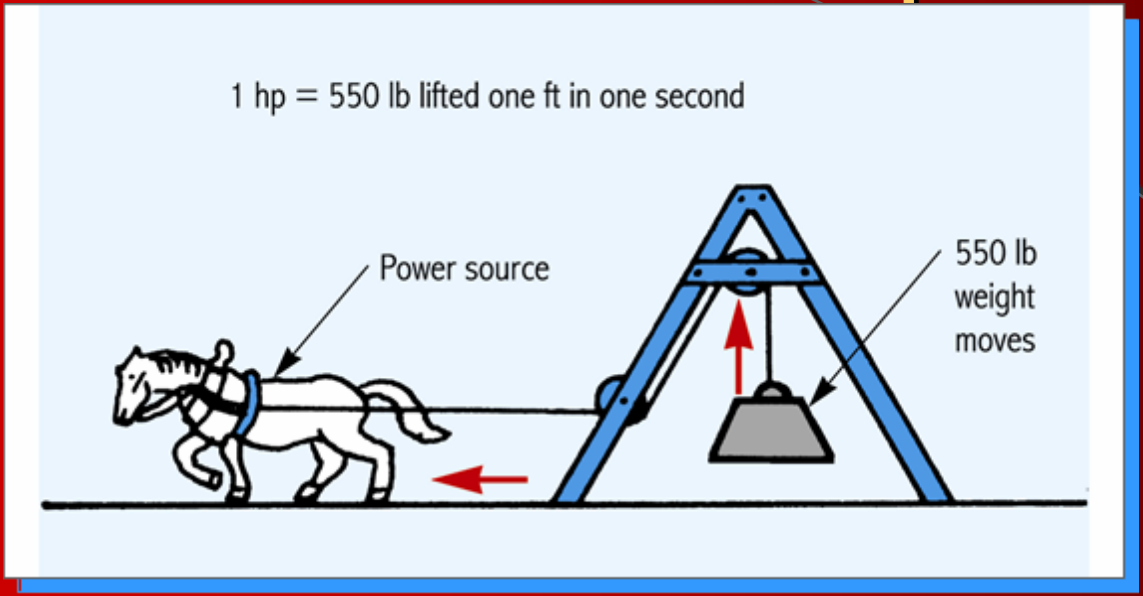
- Used to measure compression pressure
- Using a compression gauge:
  - gauge is screwed into the spark plug, injector, or glow plug hole
  - engine is cranked over
  - gauge measures compression pressure
- Gauge readings are a good indicator of engine mechanical condition

5. An ENGINE DYNOMOMETER is used to measure the brake horsepower of modem car engines.
6. The CYLINDER BORE is the diameter of the engine cylinder.
7. CYLINDER DISPLACMENT is the volume of displacement from BDC to TDC.

Engine Torque

- Rating of the turning force at the engine crankshaft
- When combustion pressure pushes the piston down, a strong rotating force is applied to the crankshaft

Horsepower



One horsepower equals 33,000 ft lb of work per minute

Measure of an engine's ability to perform work (power). At one time, one horsepower was the approximate strength of a horse

Factory Horsepower Ratings

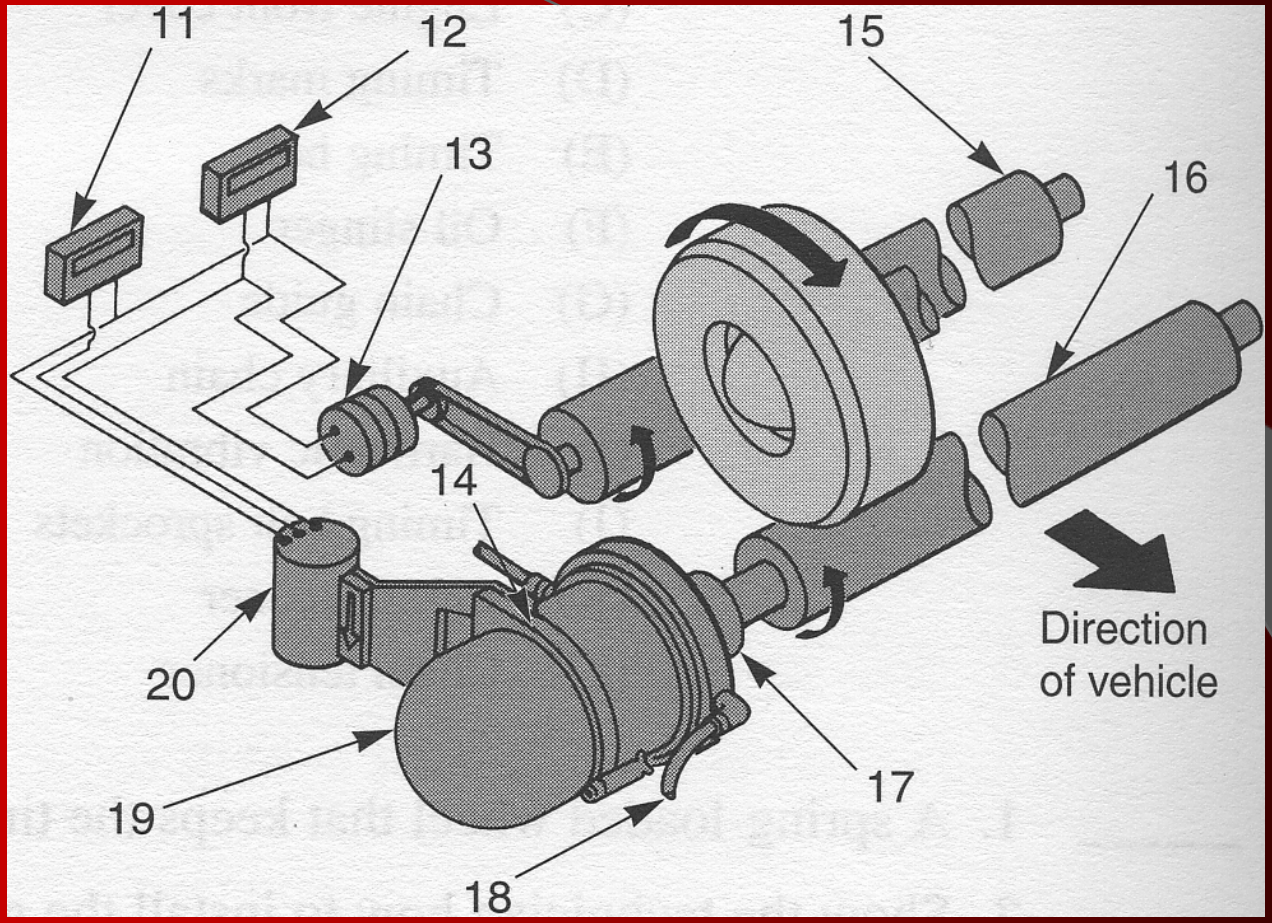
- Given in a shop manual
- Automobile makers rate engine power at a specific engine speed
- Horsepower example:
  - 300 hp @ 5000 rpm

8. HORSEPOWER is a measure of an engine's ability to perform work.
9. VOLUMETRIC EFFICIENCY is the ratio of actual air drawn into the cylinder and the maximum amount of air that could enter the cylinder.
10. The PISTON STROKE is the distance of piston movement from TDC to BDC.

Chassis Dynamometer

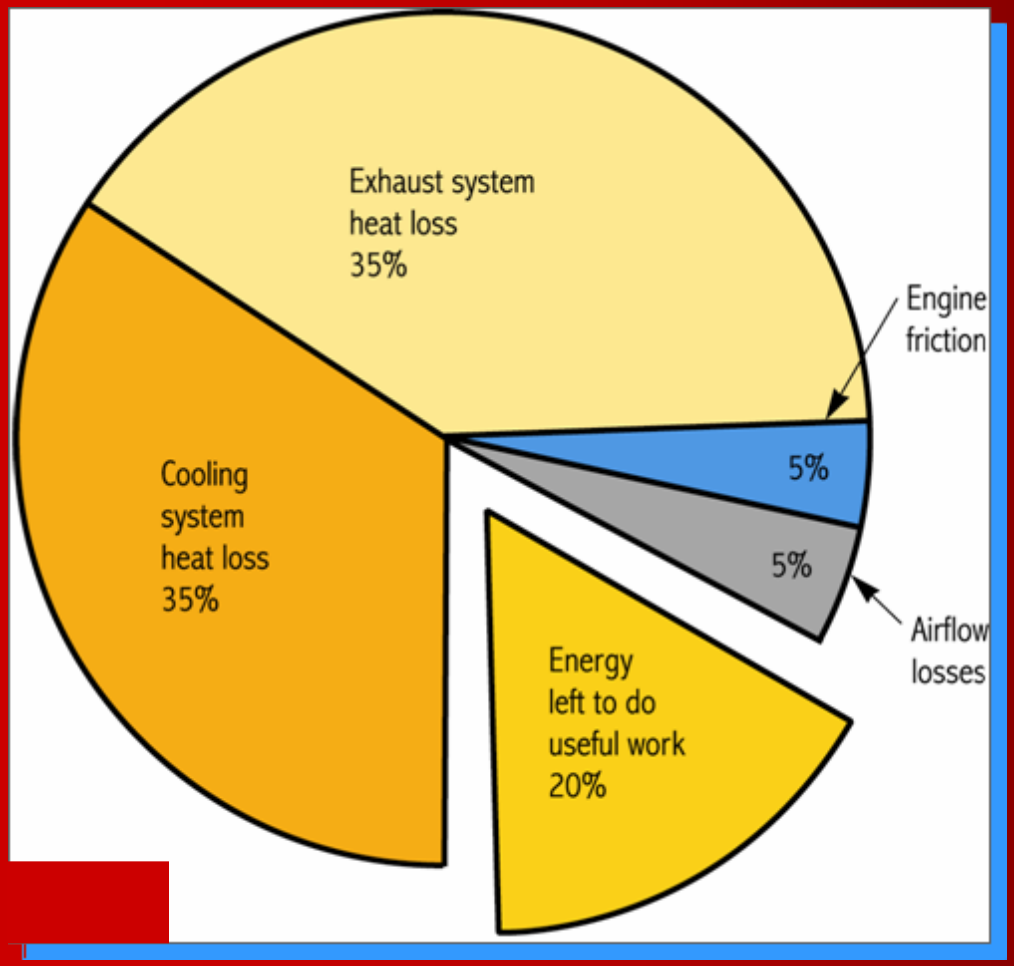
- Measures the horsepower delivered to the rear wheels
- Indicates the amount of horsepower available to propel the car
- Accounts for any power consumed by the drive train

Chassis Dynamometer



11. Power meter 12. Speed meter 13. Tachometer generator 14. Stator 15. Idler roller 16. Drive roller 17. Power absorption unit 18. Cooling water 19. Rotor 20. Torque bridge

Engine Efficiency



- Ratio of usable power at the crankshaft (brake horsepower) to the power supplied to the engine (heat content of fuel)
- By comparing consumption to engine power output, you can find engine efficiency
- Most engines are about 20% efficient

Volumetric Efficiency

- Ratio of air drawn into the cylinder and the maximum possible amount of air that could enter the cylinder
- Indicates how well an engine can “breathe” on its intake stroke

Mechanical Efficiency

- Compares brake horsepower and indicated horsepower
- Measurement of mechanical friction
- Mechanical efficiency of 70–80% is normal
- 20–30% of the engine's power is lost to friction (frictional hp loss)
- Engines are capable of only 80–90% volumetric efficiency
- Restrictions in the ports and around the valves limit airflow

Thermal Efficiency

- Found by comparing the horsepower output to the amount of fuel burned
- Indicates how well an engine uses the fuel's heat energy
- One U.S. gallon of gasoline has about 19,000 Btu (British thermal units) of heat energy
- One horsepower equals about 42.4 Btu of heat energy per minute

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