



# Modern Automotive Technology Chapter 16

## Engine Size and Performance Measurements

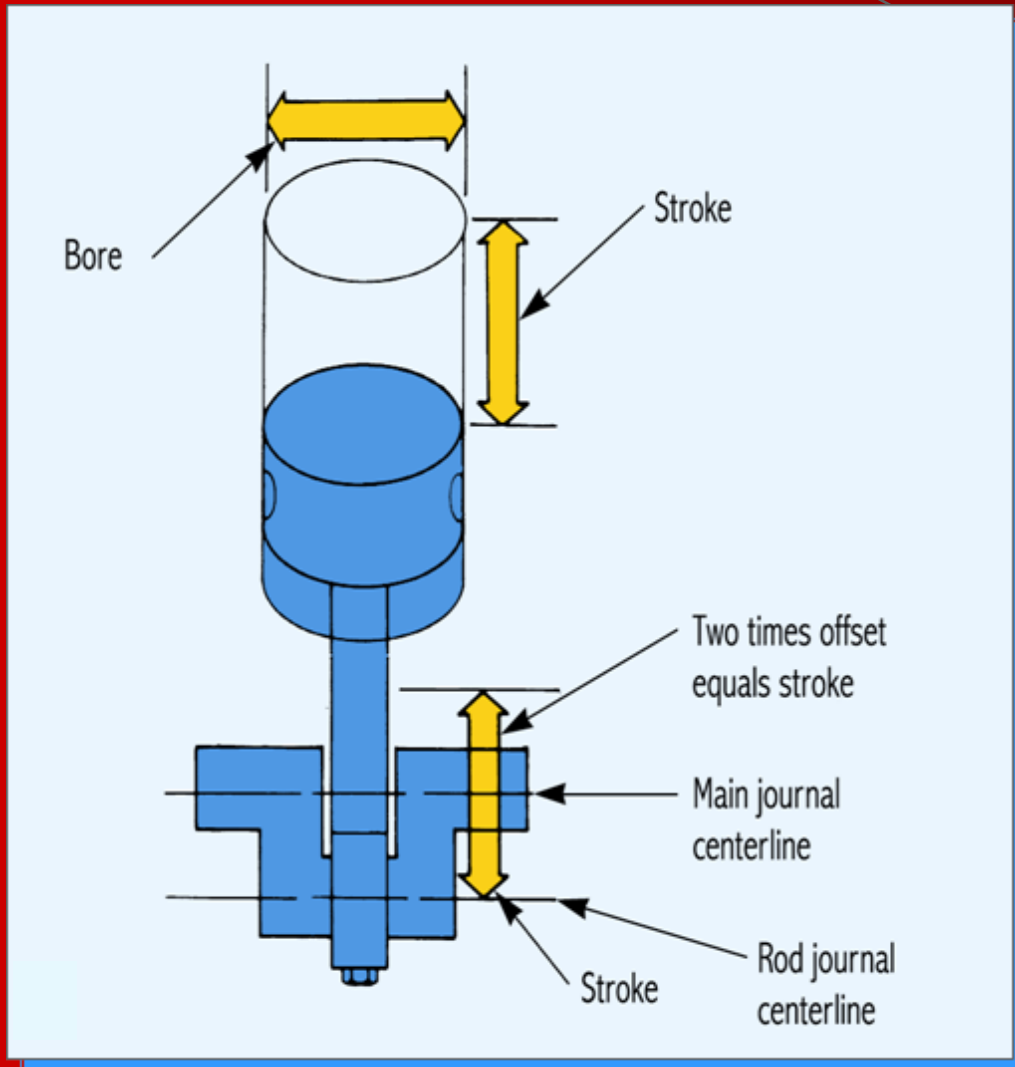
# Learning Objectives

- 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**)

# Piston Displacement

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

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

# 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?

$$25 \text{ cu. in.} \times 4 = 100 \text{ cu. in.}$$

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

$$\begin{aligned} 500 \text{ cc} \times 6 &= 3000 \text{ cc} \\ &= 3.0 \text{ L} \end{aligned}$$

1. **COMPRESSION RATIO** compares cylinder volumes with the piston at TDC and to the cylinder volume with the piston at BDC.
2. **THERMAL EFFICIENCY** is found by comparing the amount of fuel burned to horsepower output.
3. **MECHANICAL EFFICIENCY** compares brake horsepower and indicated horsepower.
4. **ENGINE TORQUE** 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?

$$\begin{aligned}\text{work} &= 3' \times 400 \text{ lb} \\ &= 1200 \text{ foot pounds (ft lb)}\end{aligned}$$

# 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:  
**power = distance x force**  
**time**

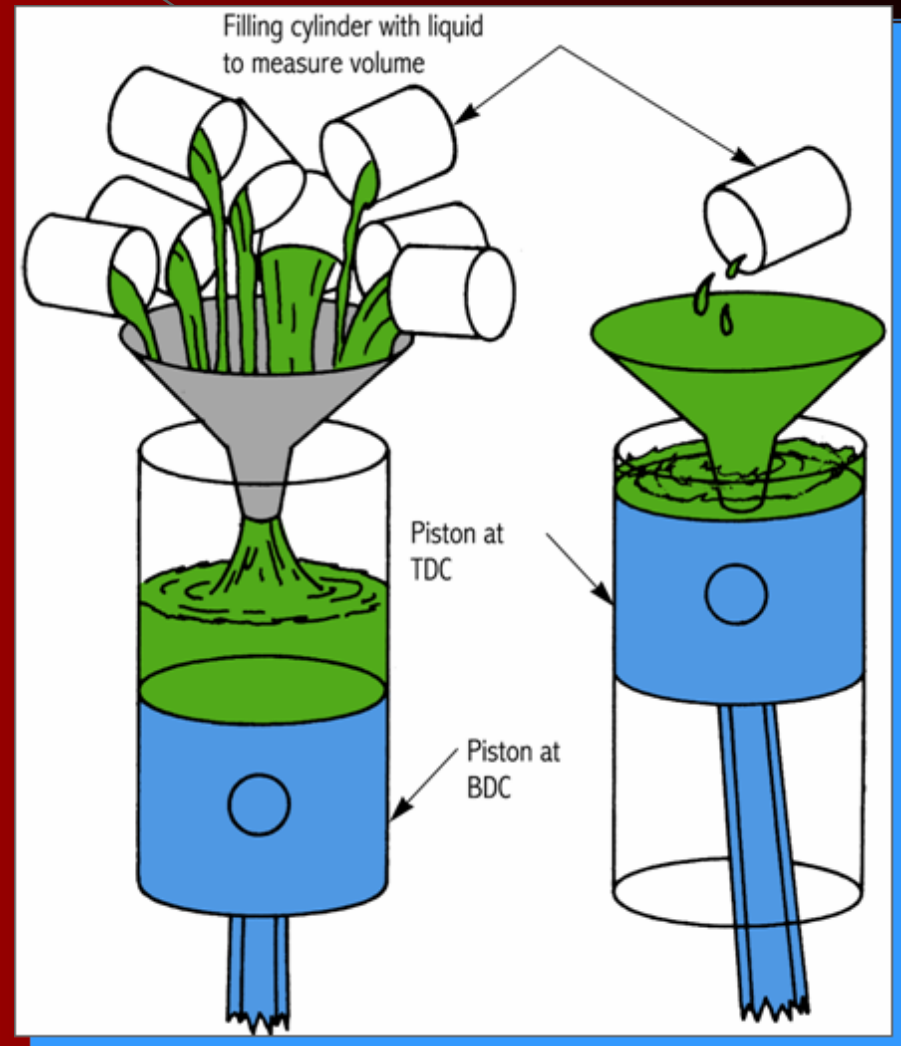
# Power

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

$$\begin{aligned}\text{power} &= \frac{1000 \text{ lb} \times 3000'}{1 \text{ minute}} \\ &= \frac{3,000,000 \text{ ft lb}}{\text{min.}}\end{aligned}$$

# Compression Ratio

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



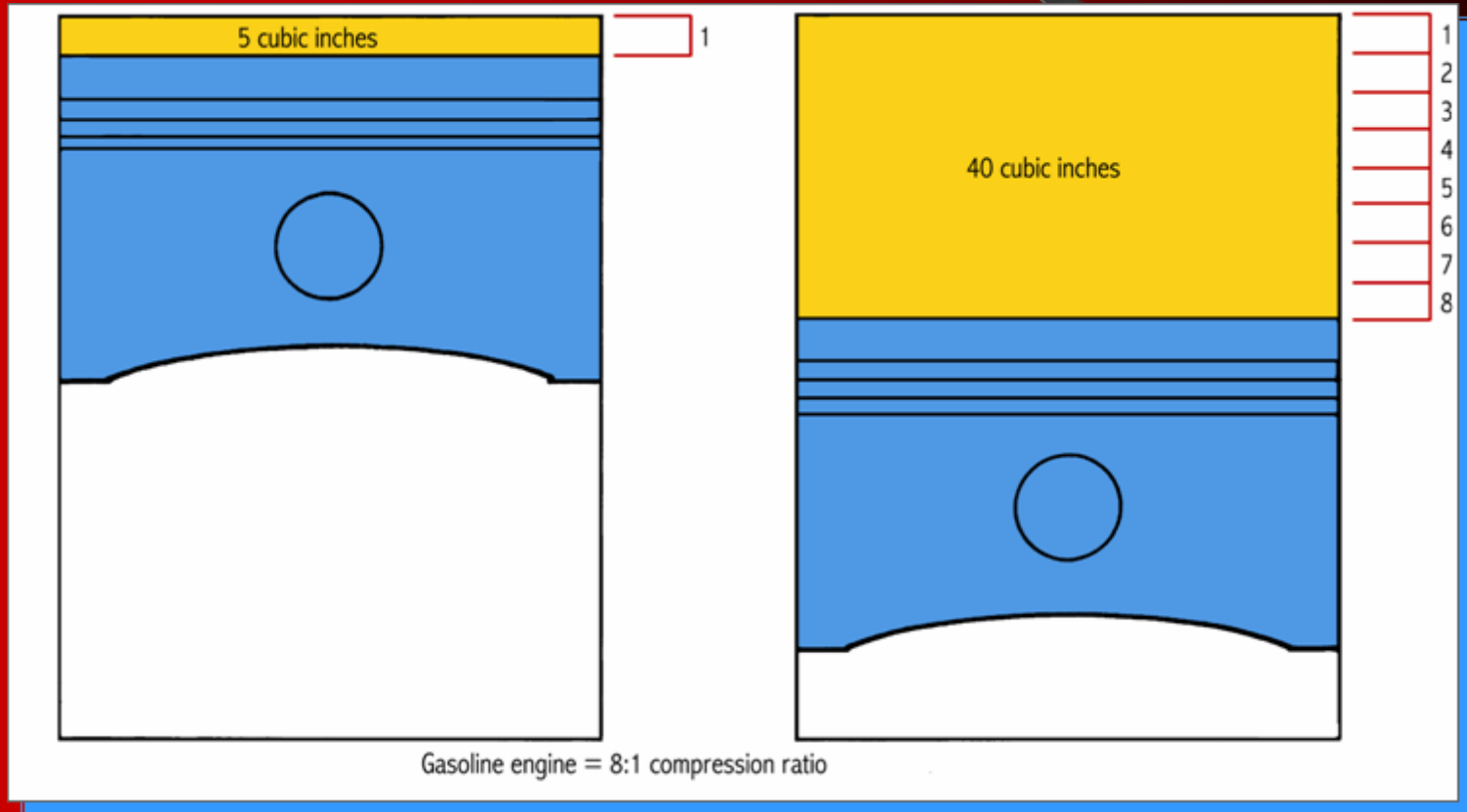
# Compression Ratio

- Formula for compression ratio:

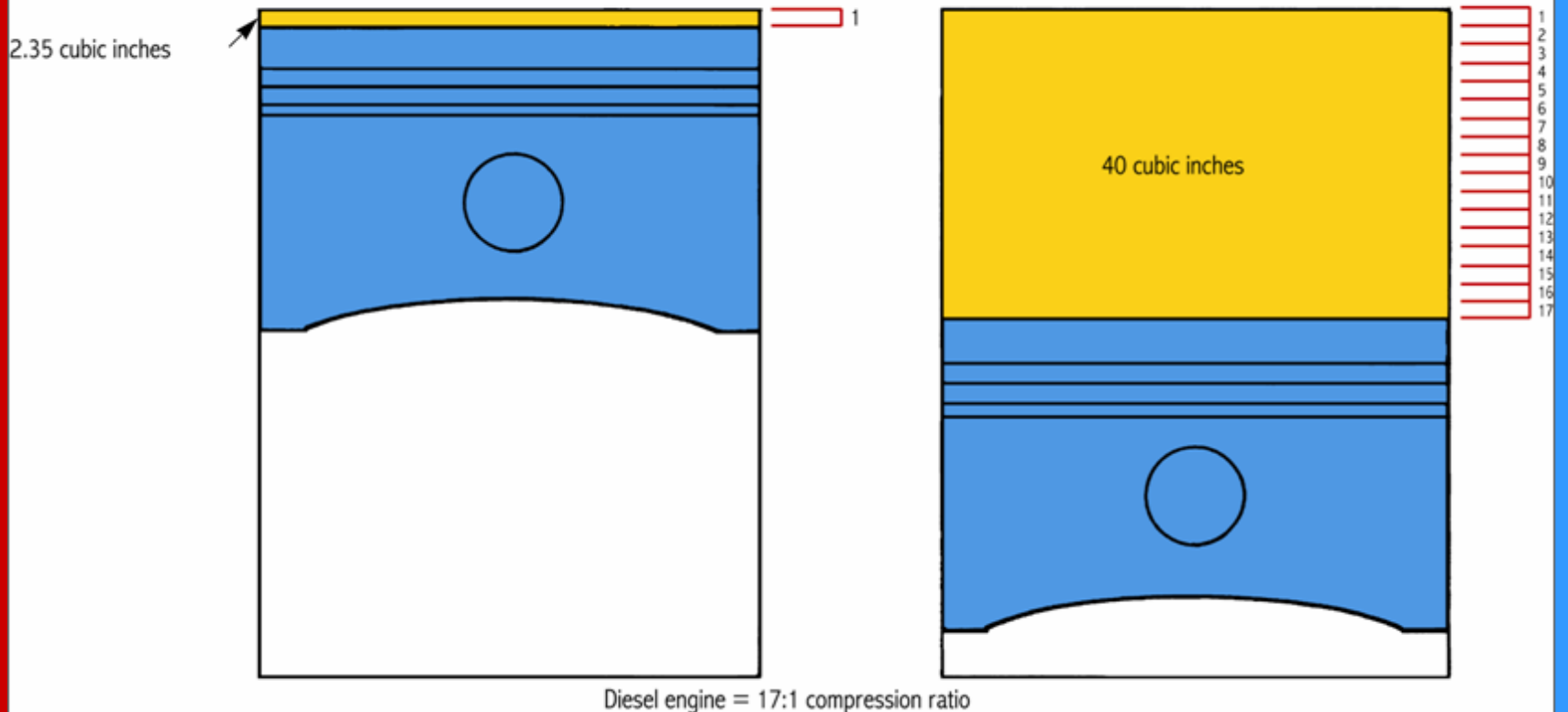
$$\text{compression ratio} = \frac{\text{cylinder volume at BDC}}{\text{cylinder volume at TDC}}$$

- Use of high compression ratio:
  - increases engine fuel efficiency and power
  - increases exhaust emissions ( $\text{NO}_x$ )
  - increases risk of detonation (ping)

# Compression Ratio (Gasoline Engine)



# Compression Ratio (Diesel Engine)





# Compression Gauge

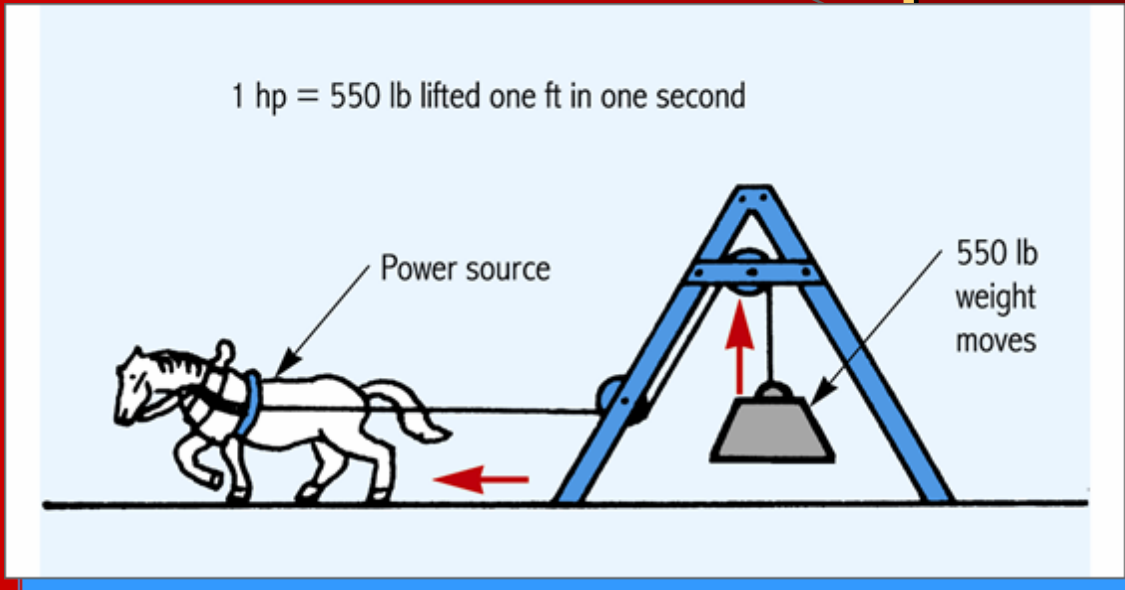
- Used to measure compression pressure
- Using a compression gauge:
  - gauge is screwed into the spark plug, injector, or glow plug hole
  - engine is cranked over
  - gauge measures compression pressure
- Gauge readings are a good indicator of engine mechanical condition

5. An **ENGINE DYNOMOMETER** is used to measure the brake horsepower of modern car engines.
6. The **CYLINDER BORE** is the diameter of the engine cylinder.
7. **CYLINDER DISPLACEMENT** 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

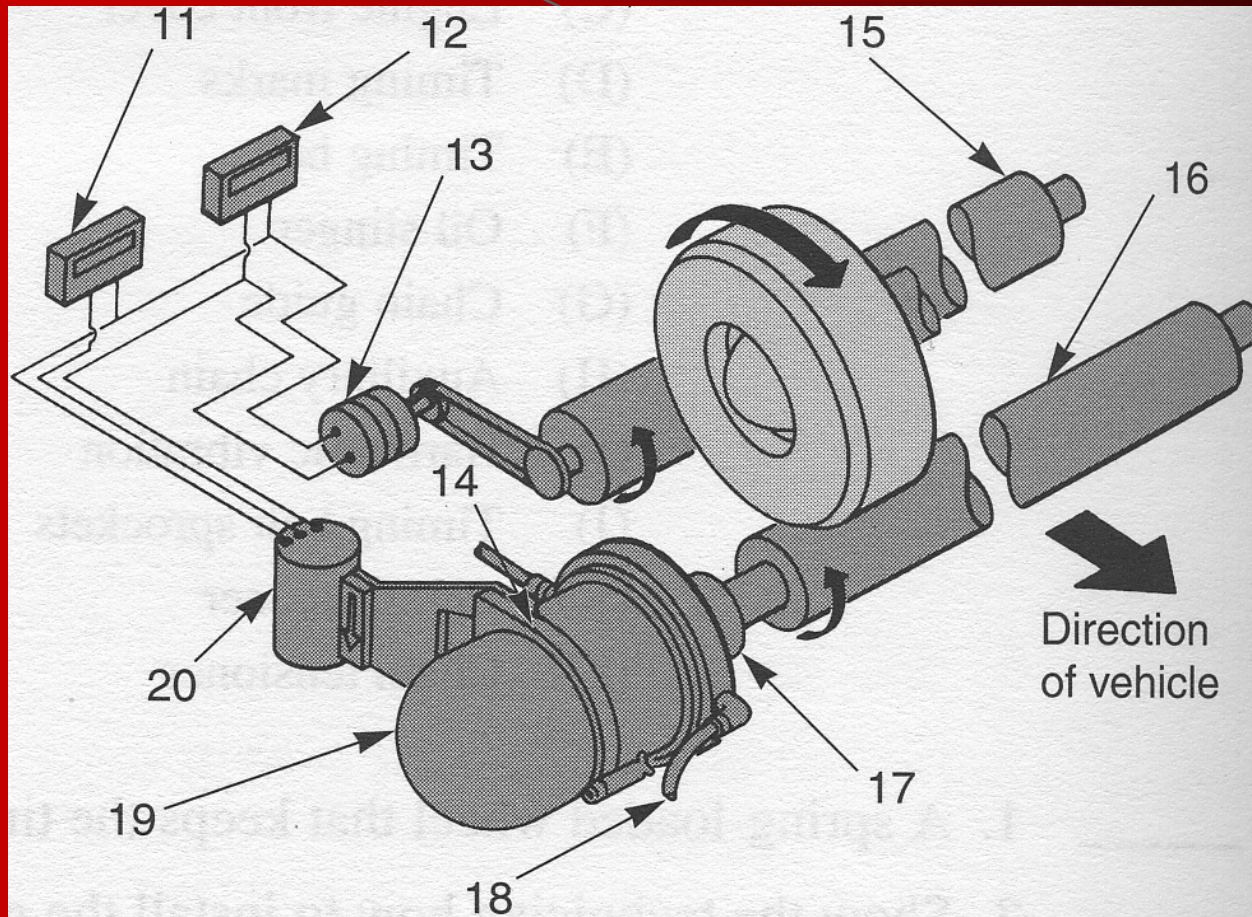
- Given in a shop manual
- Automobile makers rate engine power at a specific engine speed
- Horsepower example:
  - 300 hp @ 5000 rpm

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

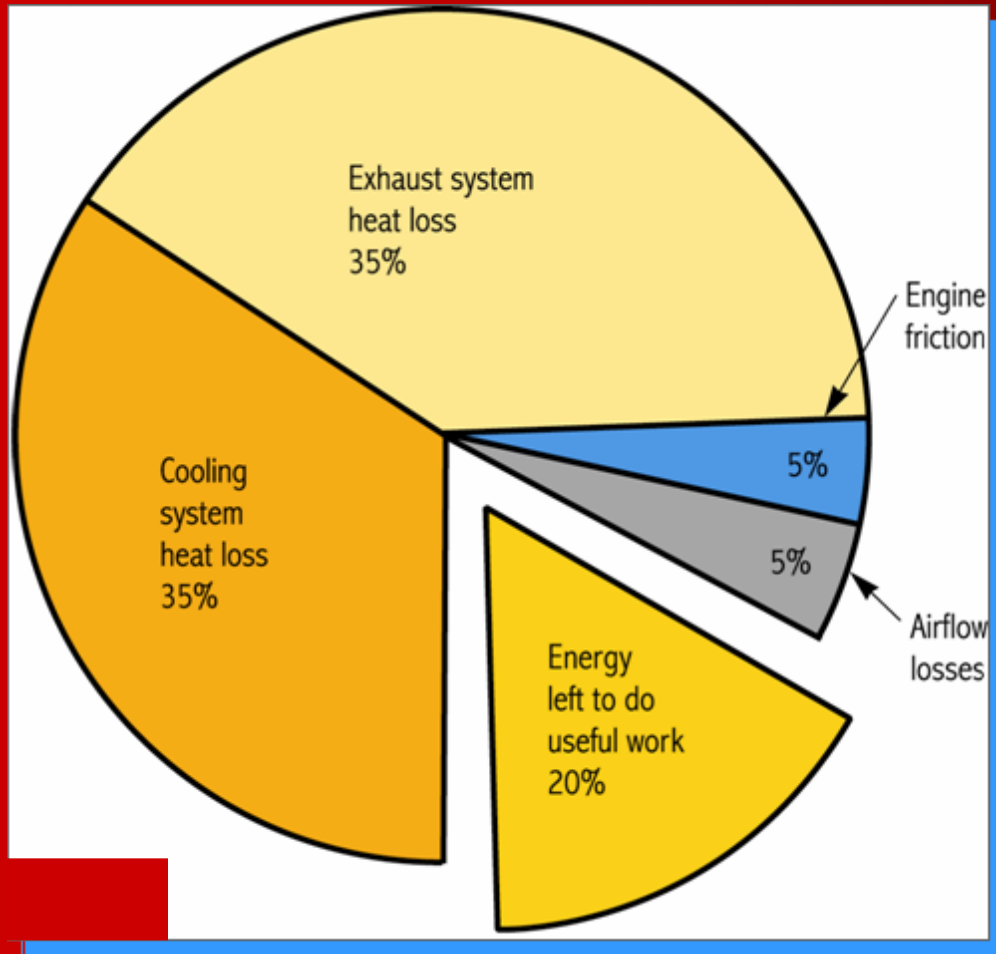
# Chassis Dynamometer



- 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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