Automotive Technology 6th Edition

Chapter 18 Gasoline Engine Operation, Parts, & Specifications

Opening Your Class

KEY ELEMENT	EXAMPLES
Introduce Content	This Automotive Technology 6th text provides complete coverage of automotive components, operation, design, and troubleshooting. It correlates material to task lists specified by ASE and ASEEducation (NATEF) and emphasizes a problem-solving approach. Chapter features include Tech Tips, Frequently Asked Questions, Case Studies, Videos, Animations, and ASEEducation (NATEF) Task Sheets.
Motivate Learners	Explain how the knowledge of how something works translates into the ability to use that knowledge to figure why the engine does not work correctly and how this saves diagnosis time, which translates into more money.
State the learning objectives for the chapter or course you are about to cover and explain this is what they should be able to do as a result of attending this session or class.	Explain the chapter learning objectives to the students as listed: 1. Discuss engine construction and energy and power of an engine. 2. Explain engine parts and systems. 3. Explain four-stroke cycle operation. 4. Discuss engine classification and construction. 5. Explain engine bore and stroke measurements. 6. Discuss compression ratio, torque, and horsepower.
Establish the Mood or Climate	Provide a ***WELCOME,*** Avoid put downs and bad jokes.
Complete Essentials	Restrooms, breaks, registration, tests, etc.
Clarify and Establish Knowledge Base	Do a round robin of the class by going around the room and having each student give their backgrounds, years of experience, family, hobbies, career goals, or anything they want to share.

NOTE: This lesson plan is based on the 6th Edition Chapter Images found on Jim's web site @ www.jameshalderman.com

DOWNLOAD Chapter 18 Chapter Images: From http://www.jameshalderman.com/automotive_principles.html NOTE: You can use Chapter Images or possibly Power Point files:

ICONS	CH18 GASOLINE ENGINE OPERATION
	1. SLIDE 1 CH18 GASOLINE ENGINE OPERATION, PARTS, & SPECIFICATIONS
	Check for ADDITIONAL VIDEOS & ANIMATIONS @ http://www.jameshalderman.com/ WEB SITE IS CONSTANTLY UPDATED
	http://www.jameshalderman.com/automotive_principles.html DOWNLOAD Crossword Puzzle (Microsoft Word) (PDF) Word Search Puzzle (Microsoft Word) (PDF
	Gasoline Engine Videos
	2. SLIDE 2 EXPLAIN **FIGURE 18-1** SHOWS rotating assembly for a V-8 engine that has eight pistons and connecting rods and one crankshaft 3. SLIDE 3 EXPLAIN **FIGURE 18-2** head with 4 valves per cylinder, 2 intake valves (larger) & 2 exhaust valves (smaller).

ICONS	CH18 GASOLINE ENGINE OPERATION

DISCUSS FREQUENTLY ASKED QUESTION: What Is a Flat-Head Engine?

A flat-head engine is an older type engine design that has the valves in the block. The valves are located next to the cylinders and the air-fuel mixture, and exhaust flows through the block to the intake and exhaust manifolds. Because the valves are in the block, the heads are flat and, therefore, are called flat-head engines. The most commonly known was the Ford flat-head V-8 produced from 1932 until 1953. Typical flat-head engines included:

- **Inline 4-cylinder engines (many manufacturers)**
- **Inline 6-cylinder engines (many manufacturers)**
- **Inline 8-cylinder engines (many manufacturers)**
- **V-8s (Cadillac and Ford)**
- **V-12s (Cadillac and Lincoln)**

4. **SLIDE 4 EXPLAIN FIGURE 18-3 C**oolant temperature is controlled by thermostat, which opens & allows coolant to flow to radiator when temperature reaches rating temperature of the thermostat.
5. **SLIDE 5 EXPLAIN FIGURE 18-4** typical lubrication system, showing the oil pan, oil pump, oil filter, and oil passages.

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	6. **SLIDE 6 EXPLAIN FIGURE 18-5** downward movement of piston draws air-fuel mixture into cylinder through the intake valve on intake stroke. On compression stroke, mixture is compressed by upward movement of piston with both valves closed. Ignition occurs at beginning of power stroke, and combustion drives piston downward to produce power. On exhaust stroke, upward-moving piston forces burned gases out open exhaust valve.
	Show 4-STROKE CYCLE ANIMATION: **4-Stroke Cycle (View) (Download)**
	7. **SLIDE 7 EXPLAIN Figure 18-6** Cutaway of an engine showing cylinder, piston, connecting rod, and crankshaft
QUESTION	**DISCUSSION 4-STROKE CYCLE: Ask students to explain the four-stroke cycle operation**
	Many newer engines are using GASOLINE direct injection due to its approximately 10% efficiency increase

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 **INTAKE STROKE**	**INTAKE STROKE:** starts with piston at top dead center (TDC). Lobe on camshaft opens intake valve Piston moves down in bore due to crankshaft rotation. As piston moves down, it pulls outside air through air cleaner and into the intake manifold past open intake valve and into cylinder. Downward movement of piston creates a low-pressure area above piston (volume increases, pressure decreases). Air rushes in to fill space left by PISTON downward movement, because atmospheric pressure is greater than pressure in cylinder. Piston tries to inhale a volume equal to its own displacement. Fuel-air mixture is homogeneous. During intake stroke, an air-fuel ratio is inducted. Throttle controls air mass that enters cylinder. Energy needed to move piston from TDC downward comes from either flywheel or overlapping power strokes. As piston nears BDC it slows down nearly to a stop. When piston reaches BDC, intake valve closes sealing cylinder & compression stroke begins.
 **COMPRESSION STROKE** The internal energy of gas is increased as heat is added to gas. Near end of compression stroke, a spark plug will ignite the mixture	**COMPRESSION STROKE:** Turning crankshaft now forces piston upward. Both valves are closed; there is no way (except past rings) for air to get out. Volume is decreasing as piston rises, so air-fuel gas mixture is compressed. Pressure is inversely proportional to volume according to Boyle's law. In compression of a gas, volume decreases & pressure and temperature rise as external work is done on gas. Compression ratio is ratio of volume at BDC to volume at TDC (clearance volume). Higher compression ratio means higher thermal efficiency or that portion of heat supplied to engine that is turned into work. As compression ratio increases, expansion ratio also increases; thus, thermal efficiency increases.
VOLUME BDC **VOLUME TDC**	**COMPRESSION RATIO**

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POWER STROKE	**COMBUSTION (POWER STROKE):** The power stroke begins shortly after fuel-air gas mixture is ignited by spark plug. The high pressures in cylinder push down on the piston. This pressure forces the piston down in the bore, which causes crankshaft to rotate (translation to rotation). Pressure falls as volume increases. Temperature falls, as gas does external work. Arc ignites air-fuel mixture in combustion chamber & fuel (reactant) burns supported by Oxygen. Nitrogen expands and pushes piston down during power stroke. As piston continues downward, these gases in cylinder expand and cool as they give up their energy. Power stroke is only stroke in which energy is used from fuel & cylinder pressure is highest.
EXHAUST STROKE	**EXHAUST STROKE:** As piston nears bottom of its travel, exhaust valve begins to open. Piston begins to rise in cylinder, beginning exhaust stroke. Upward movement of piston forces spent gases past exhaust valve & out of cylinder. As piston nears top of its movement, camshaft lobe again opens intake valve & cycle repeats itself. Exhaust valve is allowed to close, by spring pressure, shortly after piston begins-its downward movement. This is a stroke that produces no work but expends a quantity of energy to push exhaust gases from cylinder. In a spark-ignited gasoline-fueled engine, we have flame speed, which is nearly proportional or increases when engine speed increases. Therefore, number of crank angles occupied by combustion process is nearly independent of RPM.

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	7. **SLIDE 7 EXPLAIN FIGURE 18-7** Automotive engine cylinder arrangements. 8. **SLIDE 8 EXPLAIN FIGURE 18-8** horizontally opposed engine design helps to lower vehicle's center of gravity. 9. **SLIDE 9 EXPLAIN FIGURE 18-9** longitudinally mounted engine drives the rear wheels through a transmission, driveshaft, and differential assembly. 10. **SLIDE 10 EXPLAIN FIGURE 18-10** Two types of front-engine, front-wheel drive mountings.
	**DISCUSSION: Ask the students to discuss why an 8-cylinder engine will operate more smoothly than a 4-cylinder engine.**
	**DEMONSTRATION: Show students the difference between a longitudinal & transverse engine.**
	**DISCUSSION: Ask the students what is drawn into the cylinder in a typical non-direct fuel injection engine. (Answer: Fuel and air.)**
	**DISCUSSION: Ask the students to discuss the difference between a naturally aspirated (NA) engine and a supercharged or turbocharged engine.**
	**Most internal combustion engines achieve only about 20% efficiency.**
	**Most manufacturers do not allow fuels with methanol to be used in their vehicles. Some OEMS allow a small percentage (no more than 5%).**

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	11. **SLIDE 11** EXPLAIN **FIGURE 18-11** Cutaway of an overhead valve (OHV) V-8 engine showing the lifters, pushrods, roller rocker arms, and valves 12. **SLIDE 12** EXPLAIN **FIGURE 18-12** SOHC engines usually require additional components, such as a rocker arm, to operate all of the valves. DOHC engines often operate the valves directly.
	13. **SLIDE 13** EXPLAIN **FIGURE 18-13** DOHC engine uses a camshaft for the intake valve and a separate camshaft for the exhaust valves in each cylinder head
	DISCUSS FREQUENTLY ASKED QUESTION: What Is a Rotary Engine? A successful alternative engine design is the rotary engine, also called the Wankel engine after its inventor, Felix Heinrich Wankel (1902–1988), a German inventor. The Mazda RX-7 and RX-8 represent the only long-term use of the rotary engine. The rotating combustion chamber engine runs very smoothly, and produces high power for its size and weight. **The basic rotating combustion chamber engine has a triangular-shaped rotor turning in a housing. The housing is in the shape of a geometric figure called a two lobed epitrochoid. A seal on each corner, or apex, of the rotor is in constant contact with the housing, so the rotor must turn with an eccentric motion. This means that center of the rotor moves around the center of the engine. The eccentric motion can be seen in FIGURE 18–17.**
	14. **SLIDE 14** EXPLAIN **FIGURE 18-14** A rotary engine operates on the four-stroke cycle but uses a rotor instead of a piston and crankshaft to achieve intake, compression, power, and exhaust stroke

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	Show ROTARY ENGINE OP ANIMATION **Rotary Engine (View) (Download)**
	15. **SLIDE 15 EXPLAIN FIGURE 18–15** Inline 4-cylinder engine showing principal and non-principal ends. Normal direction of rotation is clockwise (CW) as viewed from the front or accessory belt (non-principal) end. 16. **SLIDE 16 EXPLAIN FIGURE 18-16** The bore and stroke of pistons are used to calculate an engine's displacement 17. **SLIDE 17 EXPLAIN FIGURE 18-17** distance between the centerline of the main bearing journal and the centerline of the connecting rod journal determines the stroke of the engine. This photo is a little unusual because it shows a V-6 with a splayed crankshaft used to even out the impulses on a 90-degree, V-6 engine design.
DEMO	**DEMONSTRATION: Show the students how to determine bore & stroke of an engine using service information.**
	HANDS-ON TASK: Have students look up engine displacement using service information for SEVERAL LAB vehicles. Since all specs are now metric, have the students calculate equivalent size in cubic inches.
DEMO	**DEMONSTRATION CID: Show the students how to calculate the cubic inch displacement of an engine given bore & stroke.**

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	DISCUSS FREQUENTLY ASKED QUESTION: What Is the Atkinson Cycle? In 1882, James Atkinson, a British engineer, invented an engine that achieved a higher efficiency than Otto cycle, but produced lower power at low engine speeds. Atkinson cycle engine was produced in limited numbers until 1890, when sales dropped, and company went out of business in 1893. However, the one key feature of the Atkinson cycle that remains in use today is that the intake valve is held open longer than normal to allow a reverse flow into the intake manifold. This reduces the effective compression ratio and engine displacement, and allows expansion to exceed the compression ratio, while Retaining a normal compression pressure. This is desirable for good fuel economy because the compression ratio in a spark ignition engine is limited by the octane rating of the fuel used. A high expansion delivers a longer power stroke and reduces the heat wasted in the exhaust. This increases efficiency of the engine because more work is being achieved. The Atkinson cycle engine design is commonly used in hybrid electric vehicles

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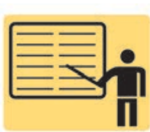
	**EXPLAIN TECH TIP:** **How Fast Can an Engine Rotate? Most passenger vehicle engines are designed to rotate at low speed for following reasons:** • **Maximum efficiency is achieved at low engine speed. A diesel engine used in a large ship, for example, will rotate at about 50 RPM for maximum efficiency.** • **Piston ring friction is the highest point of friction in the engine. The slower the engine speed, the less loss to friction from the piston rings.** **However, horsepower is what is needed to get a vehicle down the road quickly. Horsepower is torque times engine speed divided by 5,252. Therefore, a high engine speed usually indicates a high horsepower. For example, a Formula 1 race car is limited to 1.6 liter V-6, but uses a 1.6 inch (40 mm) stroke. This extremely short stroke means that the engine can easily achieve the upper limit allowed by the rules of 18000 RPM while producing over 700 horsepower. The larger the engine, the more power the engine is capable of producing. Several sayings are often quoted about engine size:** **“There is no substitute for cubic inches.”** **“There is no replacement for displacement.”** **Although a large engine generally uses more fuel, making an engine larger is often the easiest way to increase power.**
	18. **SLIDE 18 EXPLAIN FIGURE 18-18** Compression ratio is the ratio of the total cylinder volume (when the piston is at the bottom of its stroke) to the clearance volume (when the piston is at the top of its stroke).
	**DISCUSS CHARTS 18-1 AND 18-2**

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DISCUSSION: Ask the students how a build-up of carbon on top of the pistons would affect compression ratio. (Answer: It would increase compression ratio.)

Modern gasoline engines have a compression ratio of 8 to 10:1, diesel engines have a compression ratio of 20 to 22:1.

19. **SLIDE 19 EXPLAIN FIGURE 18–19** Combustion chamber volume is the volume above the piston when the piston is at top dead center.
20. **SLIDE 20 EXPLAIN FIGURE 18-20** Torque is a twisting force equal to the distance from the pivot point times the force applied expressed in units called pound-feet (lb-ft) or Newton-meters (N-m).

DEMONSTRATION: Show the students examples of various torque wrenches and demonstrate their proper use.

DISCUSS FREQUENTLY ASKED QUESTION: What's with these Kilowatts?

A watt is the electrical unit for power, the capacity to do work. It is named after a Scottish inventor, James Watt (1736–1819). The symbol for power is P. Electrical power is calculated as amperes times volts:

- P (power) = I (amperes) # E (volts)

Engine power is commonly rated in watts or kilowatts (1,000 watts equal 1 kilowatt), because 1 horsepower is equal to 746 watts. For example, a 200 horsepower engine can be rated in the metric system, as having the power equal to 149,200 watts or 149.2 kilowatts (kW).

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	HANDS-ON TASK: Have the students look up the torque specs for various engine fasteners.
ASE Education Foundation	**ON-VEHICLE ASEEDUCATION TASK:** Gasoline Engine Identification General Engine Specifications
	HANDS-ON TASK: SEARCH INTERNET to find out difference between a four-stroke engine and two-stroke engine.