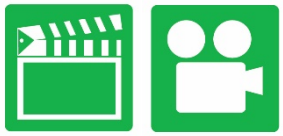
Automotive Electrical & Engine Performance 8/E
Chapter 28 GASOLINE, ALTERNATIVE FUELS, & DIESEL FUELS
Opening Your Class

KEY ELEMENT	EXAMPLES
Introduce Content	This Automotive Electrical & Engine Performance 8th edition provides complete coverage of automotive areas pertaining vehicle electrical systems and engine performance. 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, and Animations that are listed in this Lesson Plan. This Lesson Plan also references ASEEducation (NATEF) Task Sheets available from Jim's web site.
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. 1. Discuss the characteristics of gasoline, refining of gasoline, and volatility of gasoline. 2. Explain air-fuel ratios, normal and abnormal combustion, and octane rating. 3. Discuss gasoline additives, gasoline blending, and testing gasoline for alcohol content. 4. Discuss general gasoline recommendations. 5. Explain alternative fuel vehicles, and discuss the safety procedures when working with alternative fuels. 6. Discuss E85, methanol, and propane fuel. 7. Discuss compressed natural gas, liquefied natural gas, and P-series fuels. 8. Discuss synthetic fuels. 9. Compare diesel fuel, biodiesel, and E-diesel fuel.
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 Automotive Electrical & Engine Performance 8th Edition Chapter Images found on Jim's web site @ www.jameshalderman.com

DOWNLOAD Chapter 28 Chapter Images: From http://www.jameshalderman.com/books_a8.html#anchor2

ICONS	Ch28 Gasoline, Alternative & Diesel Fuels
	**1. SLIDE 1 CH28 GASOLINE, ALTERNATIVE FUELS, & DIESEL FUELS**
	**Check for ADDITIONAL VIDEOS & ANIMATIONS @ http://www.jameshalderman.com/** **WEB SITE IS CONSTANTLY UPDATED**
	**Videos**
	**Videos** **At the beginning of this class, you can download the crossword puzzle & Word Search from Jim's web site to familiarize your class with terms in this chapter & then discuss them, see below:** **HTTP://WWW.JAMESHALDERMAN.COM/BOOKS_A8.HTML#ANCHOR2** **DOWNLOAD** **CROSSWORD PUZZLE (MICROSOFT WORD) (PDF)** **WORD SEARCH PUZZLE (MICROSOFT WORD) (PDF**
	
	**DISCUSSION: Have the students talk about chemical composition of gasoline. How many carbon atoms do the hydrocarbons in gasoline have?**
	**DISCUSSION: Have the students talk about the dangers of hydrocarbons. Is a hydrocarbon harmful as a liquid? Is it harmful as a gas? What safety precautions should be taken when handling hydrocarbons?**
	**2. SLIDE 2 EXPLAIN Figure 28-1** crude oil refining process showing most of the major steps and processes
	**Having different grades of gasoline, different blends, and varying freshness on hand as you discuss gasoline will offer students a variety of fuels to observe & test.**
	**HANDS-ON TASK: Have the students complete an SDS review of hydrocarbons to determine whether they understand hazards of hydrocarbons**

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	**DISCUSSION:** Have the students talk about **Distillation** process. In addition to fuel, what other products are produced through distillation process?
	**DEMONSTRATION:** Locate a **video** that **demonstrates distillation process**. Have students watch it & discuss process. National Geographic Channel or Discovery Channel are possible video sources. **LRC** may have this video
	**DISCUSSION:** Have the students discuss cracking process. What is difference between thermal cracking, catalytic cracking, & hydrocracking?
	**FIGURE 28-1** 3. **SLIDE 3 EXPLAIN FIGURE 28–2** A pig is a plug-like device that is placed in a pipeline to separate two types or grades of fuel. 4. **SLIDE 4 EXPLAIN Figure 28-3** A gasoline testing kit, including an insulated container where water at 100° F is used to heat a container holding a small sample of gasoline. The reading on the pressure gauge is the Reid vapor pressure (RVP).
	**DEMONSTRATION:** Show the students how to test gasoline, emphasizing RVP reading as a classification for usage. **FIGURE 28-2**
	**DISCUSSION:** Have students discuss cold start problems that are related to fuel issues. Why is it important for fuel to have a specific **RVP** reading?
	**Fuel Blending In-Line (View) (Download)** **Fuel Blending Sequential (View) (Download)** **Fuel Blending Splash (View) (Download)** **Fuel Mileage, Gas (View) (Download)** **Fuel Mileage, Hybrid (View) (Download)**
	**DISCUSS FREQUENTLY ASKED QUESTION:** ***Why Do I Get Lower Gas Mileage in Winter?*** **Several factors cause the engine to use more fuel in winter than in summer, including:** • **Gasoline that is blended for use in cold climates is designed for ease of starting**

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	and contains fewer heavy molecules, which contribute to fuel economy. The heat content of winter gasoline is lower than summer blended gasoline. • In cold temperatures, all lubricants are stiff, causing more resistance. These lubricants include the engine oil, as well as transmission and differential gear lubricants. • Heat from the engine is radiated into the outside air more rapidly when the temperature is cold, resulting in longer run time until the engine has reached normal operating temperature. • • Road conditions, such as ice and snow, can cause tire slippage or additional drag on the vehicle.
	5. **SLIDE 5 EXPLAIN Figure 28-4** An engine will not run if the air-fuel mixture is either too rich or too lean. 6. **SLIDE 6 EXPLAIN Figure 28-5** With a three-way catalytic converter, emission control is most efficient with an air-fuel ratio between 14.65 to 1 and 14.75 to 1.
	**HANDS ON-TASK: Check fuel RVP BASED ON DEMO**
	**DISCUSSION: Have the students talk about how air-fuel ratios are stated. Why is the ratio usually measured by weight and not volume?**
	**DEMONSTRATION: Show how fuel injector sprays fuel into combustion chamber by creating an external fuel system in which students can view an injector spraying fuel into visible container. For safety reasons, you can perform this demonstration with water instead of fuel, keeping in mind that injectors and pump sustain damage from water after long-term use.**

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	**DISCUSSION:** Have the students discuss air-fuel ratios. What makes an air-fuel mixture too rich or too lean?
	**DISCUSSION:** Have the students talk about the gasoline combustion process. Will a contaminated atmosphere have an effect on combustion process?
	**DISCUSSION:** Have the students refer to **FIGURE 28–5** and discuss what happens to NO_x, CO, and HC in three-way catalytic converter. Why does **stoichiometric ratio** work best to control these mixtures? ANS: **STOICHIOMETRIC** IS concerned with, involving, or having the exact proportions for a particular chemical reaction.
	7. **SLIDE 7 EXPLAIN Figure 28-6** Normal combustion is a smooth, controlled burning of the air-fuel mixture. 8. **SLIDE 8 EXPLAIN Figure 28-7** Detonation is a secondary ignition of the air-fuel mixture. It is also called spark knock or pinging.
	**DEMONSTRATION:** Have students listen to a vehicle making knocking sound due to detonation. Ask them to describe what this sounds like to them. This can be done on an older vehicle by advancing timing or disconnecting EGR: **FIGURE 28-7**
	**HANDS-ON TASK:** Have students use a **5-gas analyzer on a vehicle**. Ask them to record readings and interpret their findings. Grade them on their understanding of by-products of combustion process and their awareness of what is required to reduce harmful emissions.
	9. **SLIDE 9 EXPLAIN Figure 28-8** A pump showing regular with a pump octane of 87, plus rated at 89, and premium rated at 93. These ratings can vary with brand as well as in different parts of the country.
	**DISCUSSION:** Have the students talk about grades of gasoline. Is it always better to use premium gas? Point out the problems of hard start and rough idle using **premium-grade gasoline** during cold weather conditions.

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	**DISCUSSION:** Have the students talk about injector flow rate. What is the relation of injector flow rate to horsepower?
	**DISCUSSION:** Have the students talk about octane rating. How is isooctane used in octane rating? What are the methods used to rate gasoline for antiknock properties?
	**HANDS-ON TASK:** Have the students locate a **Knock Sensor** on a vehicle. Ask them to review OEM information about sensor. Have students use a **scan tool** to compare it to live data from Sensor. Is knock sensor accurate?
	**DISCUSSION:** Have students discuss **high-altitude** octane requirements. What happens to air when atmospheric pressure drops? How does lowered atmospheric pressure affect octane rating?
	**DISCUSS FREQUENTLY ASKED QUESTION:** ***What Grade of Gasoline Does the EPA Use When Testing Engines?*** **Due to the various grades and additives used in commercial fuel, government (EPA) uses a liquid called indolene. Indolene has a research octane number of 96.5 and a motor method octane rating of 88, which results in an (R + M) , 2 rating of 92.25.**
	**EXPLAIN TECH TIP:** ***Horsepower and Fuel Flow*** **To produce 1 hp, the engine must be supplied with 0.50 pounds of fuel per hour (lb/hr). Fuel injectors are rated in pounds per hour. For example, a volt-8 engine equipped with 25 lb/hr fuel injectors could produce 50 hp per cylinder (per injector) or 400 hp. Even if the cylinder head or block is modified to produce more horsepower, limiting factor may be the injector flow rate. The following are flow rates and resulting horsepower for a V-8 engine:** • **30 lb/hr: 60 hp per cylinder or 480 hp** • **35 lb/hr: 70 hp per cylinder or 560 hp** • **40 lb/hr: 80 hp per cylinder or 640 hp** **Of course, injector flow rate is only one of many variables that affect power output. Installing larger**

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   	**injectors without other major engine modifications could decrease engine output and drastically increase exhaust emissions.** **DISCUSS CHART 68-1 Typical octane ratings for gasoline in most parts of the country.** 10. **SLIDE 10 EXPLAIN Figure 28-9** The posted octane rating in most high-altitude areas shows regular at 85 instead of the usual 87. **DISCUSSION: Have students discuss gasoline additives. What problems can be caused by additives?** **DISCUSS FREQUENTLY ASKED QUESTION:** ***Can Regular-Grade Gasoline Be Used If Premium Is Recommended Grade?*** ***Maybe.* It is possible to use regular-grade or midgrade (plus) gasoline in most new vehicles without danger of damage to the engine. Most vehicles built since 1990s are equipped with at least one knock sensor. If a lower-octane gasoline than specified is used, the engine ignition timing setting usually causes the engine to spark knock, also called detonation or ping. This spark knock is detected by knock sensor(s), which sends a signal to computer. Computer then retards ignition timing until spark knock stops.** **NOTE: Some scan tools show the "estimated Octane rating" of the fuel being used, which is based on knock sensor activity. As a result of this spark timing retardation, the engine torque is reduced. While this reduction in power is seldom noticed, it reduces fuel economy, often by four to five miles per gallon. If premium gasoline is then used, the PCM gradually permits the engine to operate at more advanced ignition timing setting. Therefore, it**

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	may take several tanks of premium gasoline to restore normal fuel economy. For best overall performance, use the grade of gasoline recommended by the OEM
	11. **SLIDE 11 EXPLAIN Figure 28-10** This refueling pump indicates that the gasoline is blended with 10% ethanol (ethyl alcohol) and can be used in any gasoline vehicle. E85 contains 85% ethanol and can be used only in vehicles specifically designed to use it. 12. **SLIDE 12 EXPLAIN Figure 28-11** A container with gasoline containing alcohol. Notice the separation line where the alcohol–water mixture separated from the gasoline and sank to the bottom.
	**DEMONSTRATION: Place some gas and water in a clear container for viewing. Have students talk about phase separation. Discuss what happens when an engine combusts a little water. What will happen to cylinder temperature if this happens?**
	**DISCUSSION: Have the students talk about adding ethanol to base gasoline. Why are there different methods for adding additives to create an E10 fuel mixture?**
	**DISCUSSION: Have students talk about reformulated gasoline. Will reformulated gas work well in cold weather conditions? Have students discuss changes made to reformulate gasoline. What has been result in areas where reformulated gas is being used?**
	13. **SLIDE 13 EXPLAIN Figure 28-12** In-line blending is the most accurate method for blending ethanol with gasoline because computers are used to calculate the correct ratio. 14. **SLIDE 14 EXPLAIN Figure 28-13** Sequential blending uses a computer to calculate correct ratio as well as the prescribed order in which the products are loaded. 15. **SLIDE 15 EXPLAIN Figure 28-14** Splash blending occurs when ethanol is added to a tanker with gasoline and is mixed as truck travels to retail outlet.
	**DISCUSS FREQUENTLY ASKED QUESTION:** ***What Is Meant by "Phase Separation"?***

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     	**All alcohols absorb water, and the alcohol-water mixture can separate from gasoline and sink to bottom of fuel tank. This process is called phase separation. To help avoid engine performance problems, try to keep at least a quarter tank of fuel at all times, especially during seasons when there is a wide temperature span between daytime highs and nighttime lows. These conditions can cause moisture to accumulate in fuel tank as a result of condensation of moisture in air.** **DISCUSSION: Have the students talk about oxygenated fuel additives. Under what conditions can additives be used to improve driveability?** **DEMONSTRATION: Show how to check for alcohol content in gas. Remind them of safety precautions to take when testing gasoline.** **WARNING: Do not smoke or run FUEL tests around sources of ignition!** 16. **SLIDE 16 EXPLAIN Figure 28-15** Checking gasoline for alcohol involves using a graduated cylinder and adding water to check if the alcohol absorbs the water. **DISCUSS FREQUENTLY ASKED QUESTION: *Is Water Heavier than Gasoline? Yes.* Water weighs about 8 pounds per gallon, whereas gasoline weighs about 6 pounds per gallon. The density as measured by specific gravity includes: Water = 1.000 (the baseline for specific gravity) Gasoline = 0.730 to 0.760 This means that any water that gets into the fuel tank sinks to bottom.**

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    	**ON-VEHICLE ASEEDUCATION TASK** Check fuel for contaminants and quality; determine necessary action. **DISCUSSION:** Remind students of importance of testing fuel for alcohol & water. How can *not* testing fuel for alcohol and water affect repair of driveability problems associated with fuel mixture? DISCUSS FREQUENTLY ASKED QUESTION: ***How Does Alcohol Content in the Gasoline Affect Engine Operation?*** In most cases, use of gasoline containing 10% or less of ethanol (ethyl alcohol) has little or no effect on engine operation. However, because addition of 10% ethanol raises volatility of fuel slightly, occasional rough idle or stalling may be noticed, especially during warm weather. The rough idle and stalling may also be noticeable after engine is started, driven, then stopped for a short time. Engine heat can vaporize alcohol enhanced fuel causing bubbles to form in the fuel system. These bubbles in the fuel prevent the proper operation of fuel injection system and result in a hesitation during acceleration, rough idle, or, in severe cases, repeated stalling until all the bubbles have been forced through fuel system, replaced by cooler fuel from the fuel tank. DISCUSS FREQUENTLY ASKED QUESTION: What Is “Top-Tier” Gasoline? Top-tier gasoline is gasoline that has specific standards for quality, including enough detergent to keep all intake valves clean. Four automobile manufacturers—BMW, General Motors, Honda, and Toyota—developed standards. Top-tier gasoline exceeds quality standards developed by World Wide Fuel Charter (WWFC) that was

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	established in 2002 by vehicle and engine manufacturers. The gasoline companies that agreed to make fuel that matches or exceeds standards as a top-tier fuel include ChevronTexaco, Shell, and ConocoPhillips. For additional information and a list of all stations that are top tier gas stations, visit www.toptiergas.com. • SEE FIGURE 28–16.
	**17. SLIDE 17 EXPLAIN FIGURE 28–16** Not all top-tier gas stations mention that they are top-tier like this station. For more information and the list of top-tier gasoline stations, visit www.toptiergas.com.
	**18. SLIDE 18 EXPLAIN Figure 28-17** Many gasoline service stations have signs posted warning customers to place plastic fuel containers on the ground while filling. If placed in a trunk or pickup truck bed equipped with a plastic liner, static electricity could build up during fueling and discharge from the container to the metal nozzle, creating a spark and possible explosion. Some service stations have warning signs not to use cell phones while fueling to help avoid the possibility of an accidental spark creating a fire hazard.
	19. SLIDE 19 EXPLAIN FIGURE 28–18 The ethanol molecule showing two carbon atoms, six hydrogen atoms, and one oxygen atom.
	20. SLIDE 20 EXPLAIN FIGURE 28–19 E85 has 85% ethanol mixed with 15% gasoline.
	**DEMONSTRATION: Demonstrate a sniff test on stale gasoline. Talk about what gasoline stabilizer is, when to use it, and where to find it.**
	**EXPLAIN TECH TIP: *The Sniff Test:* Problems can occur with stale gasoline from which the lighter parts of the gasoline have evaporated. Stale gasoline usually results in a no-start situation. If stale gasoline is suspected, sniff it. If it smells rancid, replace it with fresh gasoline.**
	NOTE: If storing a vehicle, boat, or lawnmower over the winter, put some gasoline stabilizer into the gasoline to reduce the evaporation and separation that can occur during storage. Gasoline stabilizer is

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	**frequently available at lawnmower repair shops or marinas.** **DISCUSSION: discuss keeping fuel level above ¼ tank. Why should fuel level be kept above that level?** **DISCUSS FREQUENTLY ASKED QUESTION: *Why Should I Keep the Fuel Gauge Above One-Quarter Tank?* Fuel pickup inside fuel tank can help keep water from being drawn into fuel system unless water is all that is left at bottom of tank. Over time, moisture in air inside fuel tank can condense, causing liquid water to drop to bottom of fuel tank (water is heavier than gasoline—about 8 lb per gallon for water and about 6 lb per gallon for). If alcohol blended gasoline is used, alcohol can absorb water and alcohol-water combination can be burned inside engine. However, when water combines with alcohol, a separation layer occurs between the gasoline at top of tank and alcohol-water combination at bottom. When the fuel level is low, fuel pump draws from this concentrated level of alcohol and water. Because alcohol and water do not burn as well as pure gasoline, severe driveability problems can occur, such as stalling, rough idle, hard starting, and missing.**
	**When a rich mixture is detected & fuel gauge reads full, remind the students to check charcoal canister outlet to the engine. Verify to see whether liquid gas is being sucked into the engine. Temporary blockage of line and repeated checking of O_2 sensor readings could verify condition.**

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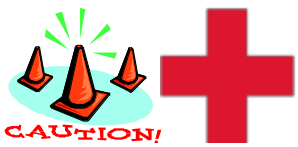
	**SAFETY** Discuss importance of having a fire extinguisher available when working with fuel, and of wearing PPE including safety glasses, a respirator, and gloves.
	**DISCUSSION:** Have the students talk about using a fuel composition tester to test for alcohol content in gasoline. What is the first step to using tester?
	**SLIDE SHOW ON GASOLINE TESTING** **EXPLAIN TECH TIP:** ***Do Not Overfill the Fuel Tank*** Gasoline fuel tanks have an expansion volume area at the top. The volume of this expansion area is equal to 10% to 15% of volume of tank. This area is normally not filled with gasoline, but rather is designed to provide a place for the gasoline to expand into, if vehicle is parked in hot sun and gasoline expands. This prevents raw gasoline from escaping from fuel system. A small restriction is usually present to control amount of air and vapors that can escape tank and flow to charcoal canister. This volume area could be filled with gasoline if fuel is slowly pumped into tank. Since it can hold an extra 10% (2 gallons in a 20-gallon tank), some people deliberately try to fill tank completely. When this expansion volume is filled, liquid fuel (rather than vapors) can be drawn into charcoal canister. When purge valve opens, liquid fuel can be drawn into engine, causing an excessively rich air–fuel mixture. Not only can this liquid fuel harm vapor recovery parts, but overfilling gas tank could also cause vehicle to fail an exhaust emission test, particularly during an enhanced test when tank could be purged while on the rollers.
	**DISCUSSION:** Have the students discuss ethanol and how it is produced. Since ethanol produced for fuel is the same as that found in alcoholic drinks, can drink manufacturers produce fuel for vehicles?
	**SAFETY** Review the meaning of **denatured**. Remind the students that when fuel becomes denatured, it is unfit for human consumption.

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  	**DISCUSSION:** Have the students talk about cellulose biomass? How are the greenhouse effects of combustion of biomass offset? **DISCUSS FREQUENTLY ASKED QUESTION:** ***Does Ethanol Production Harm Environment?*** The production of ethanol is considered carbon neutral because amount of CO2 released during production is equal to amount of CO2 that is released if the corn or other products were left to decay. **DISCUSS FREQUENTLY ASKED QUESTION:** ***What Is Switchgrass?*** Switchgrass (Panicum virgatum) can be used to make ethanol and is a summer perennial grass that is native to North America. It is a natural component of tall-grass prairie, which covered most of Great Plains, but was also found on the prairie soils in Black Belt of Alabama and Mississippi. Switchgrass is resistant to many pests and plant diseases, and is capable of producing high yields with very low applications of fertilizer. This means that the need for agricultural chemicals to grow switchgrass is relatively low. Switchgrass is also very tolerant of poor soils, flooding, and drought, which are widespread agricultural problems in the southeast. There are two main types of switchgrass: • Upland types—usually grow five to six feet tall • Lowland types—grow up to 12 feet tall and are typically found on heavy soils in bottomland sites Better energy efficiency is gained because less energy is used to produce ethanol from switchgrass.

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	**DISCUSSION:** Have students talk about **E85** and its effects on fuel economy. Is it worth using **E85** since you have to purchase more **E85** than regular gas for the same mileage? What is price difference between regular gas & **E85**? **FIGURE 69-2**
	21. **SLIDE 21 EXPLAIN Figure 28-20** location of sensor can vary, depending on make & model of vehicle, but it is always in fuel line between tank & injectors. 22. **SLIDE 22 EXPLAIN Figure 28-21** cutaway view of a typical variable fuel sensor.
	**DEMONSTRATION:** Show students location of variable fuel sensor. Review its function with the students:
	**DISCUSSION:** discuss fuel compensation. Compare use of **fuel compensation sensor** and oxygen sensor for a flex-fuel system. Why should a technician avoid resetting fuel compensation?
	23. **SLIDE 23 EXPLAIN FIGURE 28–22** flex-fuel vehicle often has a yellow gas cap, which is labeled E85/gasoline.
	**DISCUSSION:** Have the students discuss **E85** fuel system requirements. What additional hardware is on **E85** vehicles?
	24. **SLIDE 24 EXPLAIN Figure 28-23** This flexible fuel vehicle (FFV) vehicle emission control information (VECI) sticker located under the hood indicates that it can operate on either gasoline or ethanol.
	**DISCUSSION:** Have the students talk about enhanced fuel system **components** & **materials** used for flex-fuel vehicles. Can ethanol damage common fuel pumps? What will happen to O-rings that are not alcohol-resistant?
	**DEMONSTRATION:** Use a **Flex-Fuel Vehicle** to show students identifiers that place it in **E85** class. Talk about emissions produced by ethanol fueled vehicles.

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 • 	**HANDS-ON TASK:** Have students locate **VECI** on **Flex-Fuel Vehicles** you have in your shop. Have students share locations & information found: Have students identify special features on E85 vehicle & explain why vehicle is identified as flex-fuel. **EXPLAIN TECH TIP:** ***Purchase a Flex-Fuel Vehicle*** If purchasing a new or used vehicle, try to find a flex-fuel vehicle. Even though you may not want to use E85, a flex-fuel vehicle has a more robust fuel system than a conventional fuel system designed for gasoline or E10. The enhanced fuel system components and materials usually include: • Stainless steel fuel rail • Graphite commutator bars instead of copper in fuel pump motor (ethanol can oxidize into acetic acid, which can corrode copper) • Diamond-like carbon (DLC) corrosion-resistant fuel injectors • Alcohol-resistant O-rings and hoses • Cost of a flex-fuel vehicle compared with same vehicle designed to operate on gasoline is a no-cost or a low-cost option.
	**DISCUSS FREQUENTLY ASKED QUESTION:** ***How Does a Sensorless Flex-Fuel System Work?*** Many flex-fuel vehicles do not use a fuel compensation sensor and instead use the oxygen sensor to detect the presence of lean mixture and the extra oxygen in the fuel. Powertrain Control Module (PCM) then adjusts injector pulse-width and the ignition timing to optimize engine operation to the use of E85. This type of vehicle is called a virtual flexible fuel vehicle (V-FFV). The virtual flexible fuel vehicle can operate on pure gasoline or blends up to 85% ethanol.
	**DISCUSS FREQUENTLY ASKED QUESTION:** ***How Long Can Oxygenated Fuel Be Stored Before All of the Oxygen Escapes?*** The oxygen

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  •     	**in oxygenated fuels, such as E10 and E85, is not in a gaseous state like the CO2 in soft drinks. The oxygen is part of the molecule of ethanol or other oxygenates and does not bubble out of the fuel. *Oxygenated fuels, just like any fuel, have a shelf life of about 90 days.*** **25. SLIDE 25 EXPLAIN FIGURE 28–24** The molecular structure of methanol showing the one carbon atom, four hydrogen atoms, and one oxygen atom. **HANDS-ON TASK: Have students diagnose a vehicle with an O_2 code present. Help them use a SCAN TOOL, DMM, & 5-Gas analyzer, as needed, for their diagnoses.** **26. SLIDE 26 EXPLAIN FIGURE 28–25** Sign on methanol pump shows that methyl alcohol is a poison and can cause skin irritation and other personal injury. Methanol is used in industry, as well as being a fuel. **27. SLIDE 27 EXPLAIN FIGURE 28–26** Propane fuel storage tank in the trunk of a Ford taxi. **SAFETY Review with students PPE that should be used when handling methanol. Talk about ventilation procedures when working with methanol vehicles, including where exhaust fans should be placed, opening bay doors, monitoring running vehicles in shop, etc. FIGURE 69-9** **DISCUSSION: Have the students talk about methanol and its production. What is biggest source of methanol in United States? What is M85?** **28. SLIDE 28 EXPLAIN FIGURE 28–27** The blue sticker on the rear of this vehicle indicates that it is designed to use compressed natural gas. This Ford truck also has a sticker that allows it to be driven in high occupancy vehicle (HOV) lane, even if there is just driver, because it is a CNG vehicle. **DISCUSSION: Have the students talk about propane. How does propane's use compare to that of other fuels? Why is propane less economical to use than other fuels?**

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	**29. SLIDE 29 EXPLAIN Figure 28-28** A CNG storage tank from a Honda Civic GX shown with the fixture used to support it while it is being removed or installed in the vehicle. Honda specifies that three technicians be used to remove or install the tank through the rear door of the vehicle due to the size and weight of the tank.
	**DISCUSSION: Have students talk about compressed natural gas. Why is natural gas odorized during production?**
	**30. SLIDE 30 EXPLAIN Figure 28-29** fuel injectors used on this Honda Civic GX CNG engine are designed to flow gaseous fuel instead of liquid fuel and cannot be interchanged with any other type of injector.
	**DISCUSSION: Have the students discuss differences between using gasoline and CNG in vehicles. What design differences are required for a CNG engine?**
	**31. SLIDE 31 EXPLAIN FIGURE 28–30** This CNG pump is capable of supplying compressed natural gas at either 3,000 PSI or 3,600 PSI. The price per gallon is higher for the higher pressure.
	**DISCUSS FREQUENTLY ASKED QUESTION: *What Is the Amount of CNG Equal to in Gasoline?* To achieve amount of energy of one gallon of gasoline, 122 cubic feet of compressed natural gas (CNG) is needed. While octane rating of CNG is much higher than gasoline (130 octane), using CNG instead of gasoline in same engine results in a reduction 10% to 20% of power due to lower heat energy that is released when CNG is burned in engine.**
	**DISCUSS CHART 28-1 characteristics of alternative fuels compared to regular unleaded gasoline shows that all have advantages and disadvantages**
	**DISCUSSION: Have the students discuss CNG fuel systems. What is importance of having lock-off valves in CNG vehicles?**

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	**DISCUSSION:** Discuss refueling of CNG vehicles. Why is it important to fill a CNG vehicle's tank slowly?
	**DISCUSSION:** Have the students talk about liquefied natural gas. What are practicalities of using LNG in vehicles?
	**DISCUSSION:** Have the students talk about tri-fuel vehicles. Which fuels are tri-fuel vehicles capable of using?
	**DISCUSS FREQUENTLY ASKED QUESTION:** ***What Is a Tri-Fuel Vehicle?*** **In Brazil, most vehicles are designed to operate on ethanol or gasoline, or any combination of the two. In this South American country, ethanol is made from sugarcane, is commonly available, and is lower in price than gasoline. Compressed natural gas (CNG) is also being made available so many vehicle manufacturers in Brazil, such as General Motors and Ford, are equipping vehicles to be capable of using gasoline, ethanol, or CNG. These vehicles are called tri-fuel vehicles.**
	**DISCUSSION:** Have students use Chart 28–2 to review the advantages & disadvantages of alternative fuels. Which have fossil fuel sources?
	**32. SLIDE 32 EXPLAIN FIGURE 28–31** A Fischer-Tropsch processing plant is able to produce a variety of fuels from coal.
	**DISCUSSION:** discuss Fischer-Tropsch method. What is biggest drawback to Fischer-Tropsch fuels?
	**DISCUSSION:** Have the students discuss future of synthetic fuels. How is rising cost of crude oil

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        	affecting the cost effectiveness of alternative methods of producing fuels? **SAFETY** When working on fuel systems, equipment that can create a spark/flame should be removed from area. Students review their shop area & address which items should be removed for working on fuel systems. **WARNING: Do not smoke or have an open flame in the area when working around or refueling any vehicle.** **Fuel Mileage, Electric (View) (Download)** **Fuel Mileage, EREV (View) (Download)** **ASEEDUCATION TASK Alternative Fuel** Meets **ASEEDUCATION** Task: Not specified by **ASEEDUCATION** 33. **SLIDE 33 EXPLAIN Figure 28-32 (a)** Regular diesel fuel on the left has a clear or greenish tint, whereas fuel for off-road use is tinted red for identification. **(b)** A fuel pump in a farming area that clearly states the red diesel fuel is for off-road use only. **DISCUSSION: HAVE THE STUDENTS TALK ABOUT FEATURES & REQUIREMENTS OF DIESEL FUEL. REVIEW WHAT AMBIENT TEMPERATURE IS. WHAT IS MEANT BY DIESEL FUEL'S "POUR POINT"?** **DISCUSSION: DISCUSS CLOUD POINT. HOW DOES CLOUD POINT AFFECT FILTERS? HOW DO DIESEL FUEL SUPPLIERS ACCOMMODATE POUR POINT AND CLOUD POINT?** **DISCUSSION: TALK ABOUT CETANE # FOR DIESEL FUEL. REVIEW WHY OCTANE RATING FOR DIESEL IS LOWER THAN THE OCTANE RATING FOR GAS. DOES COMBUSTION PRESSURE AFFECT DIESEL FUEL'S CETANE NUMBER?**

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	**HANDS-ON TASK: HAVE STUDENTS EXPLAIN WHAT A CETANE RATING MEANS & WHAT EFFECTS IF ANY IT HAS ON DRIVABILITY.**
	**CETANE # is a measure of ignition quality of fuel relative to a reference fuel mixture composed of Cetane and alpha-methylnaphthalene, the %, by volume, of Cetane in mixture being Cetane #. CCI stands for calculated Cetane index. High Cetane numbers indicate good ignition quality resulting in a short delay period and low Cetane numbers indicate poor ignition quality that results in long delay period. Low Cetane numbers can cause a long ignition delay, which can cause a hard starting with white smoke & misfiring.**
	**CETANE # FOR DIESEL FUELS IS NOT TO BE INTERPRETED IN THE SAME MANNER AS THE OCTANE NUMBER FOR GASOLINE. OCTANE # REQUIREMENT DEPENDS ON THE FULL-LOAD PERFORMANCE, WHILE THE CETANE # DEPENDS ON THE REQUIREMENTS FOR GOOD IGNITION AT LIGHT LOADS AND LOW TEMPERATURES**
	**DEMONSTRATION: OBTAIN REGULAR DIESEL AND OFF-ROAD DIESEL TO SHOW TO THE STUDENTS. HAVE THEM VISUALLY NOTE DIFFERENCE IN THE TWO FUELS.**
	**DISCUSSION: DISCUSS GRADES OF DIESEL FUEL. IN WHICH APPLICATIONS IS GRADE #1 USED? WHY? IN WHICH APPLICATIONS IS GRADE #2 USED? WHY?**
	**34. SLIDE 34 EXPLAIN Figure 28-33** Testing API viscosity of a diesel fuel sample using a hydrometer.

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	**DEMONSTRATION: USE A HYDROMETER TO SHOW THE STUDENTS HOW TO TEST API GRAVITY OF DIESEL FUEL:**
	**HANDS-ON TASK:HAVE STUDENTS SAMPLE DIESEL FUEL AND TAKE AN API GRAVITY READING.**
	**SAFETY REVIEW WITH STUDENTS THE SAFETY PRECAUTIONS THAT SHOULD BE TAKEN WHEN WORKING WITH AND TESTING, DIESEL FUEL.**
	DISCUSS FREQUENTLY ASKED QUESTION: ***WHAT ARE THE PUMP NOZZLE SIZES?*** **Unleaded gasoline nozzles are smaller than those used for diesel fuel to help prevent fueling errors. However, it is still possible to fuel a diesel vehicle with gasoline. • SEE CHART 28–4 for the sizes and colors used for fuel pump nozzles.**
	**DISCUSS CHART 28-4: fuel pump nozzle size is standardized except for use by over-the-road truck stops where high fuel volumes and speedy Refills require larger nozzle sizes compared to passenger Vehicle filling station nozzles.**
	35. **SLIDE 35 EXPLAIN FIGURE 28–34** A biodiesel pump decal indicating that diesel fuel is ultra-low-sulfur diesel (ULSD) and must be used in 2007 and newer diesel vehicles.
	**DEMONSTRATION: SHOW LOCATION OF FUEL HEATER & FUEL FILTER ON A DIESEL VEHICLE:**
	**DISCUSSION: HAVE THE STUDENTS TALK ABOUT WHY SULFUR DIOXIDE IS HARMFUL TO ENVIRONMENT. WHAT IS DIFFERENCE IN APPEARANCE OF ULSD?**

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	**DISCUSS FREQUENTLY ASKED QUESTION: *I THOUGHT BIODIESEL WAS VEGETABLE OIL?*** **Biodiesel is vegetable oil with the glycerin component removed by means of reacting vegetable oil with a catalyst. Resulting hydrocarbon esters are 16 to 18 carbon atoms in length, almost identical to petroleum diesel fuel atoms. This allows use of biodiesel fuel in a diesel engine with no modifications needed. Biodiesel-powered vehicles do not need a second fuel tank, whereas vegetable-oil-powered vehicles do. *3 main types of fuel used in diesel engines.* These are:** • **Petroleum diesel, a fossil hydrocarbon with a carbon chain length of about 16 carbon atoms.** • **Biodiesel, a hydrocarbon with a carbon chain length of 16 to 18 carbon atoms.** • **Vegetable oil is a triglyceride with a glycerin component joining three hydrocarbon chains of 16 to 18 carbon atoms each, called straight vegetable oil (SVO). Other terms used when describing vegetable oil include:** • **Pure plant oil (PPO)—a term most often used in Europe to describe SVO** • **Waste vegetable oil (WVO)—this oil could include animal or fish oils from cooking** • **Used cooking oil (UCO)—a term used when the oil may or may not be pure vegetable oil** **Vegetable oil is not liquid enough at common ambient temperatures for use in a diesel engine fuel delivery system designed for lower-viscosity petroleum diesel fuel. Vegetable oil needs to be heated to obtain a similar viscosity to biodiesel and petroleum diesel.**

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	This means that a heat source needs to be provided before the fuel can be used in a diesel engine. This is achieved by starting on petroleum diesel or biodiesel fuel until the engine heat can be used to sufficiently warm a tank containing the vegetable oil. It also requires purging the fuel system of vegetable oil with petroleum diesel or biodiesel fuel prior to stopping the engine to avoid the vegetable oil thickening and solidifying in the fuel system away from the heated tank. The use of vegetable oil in its natural state does, however, eliminate need to remove glycerin component. Many vehicle and diesel engine fuel system suppliers permit the use of biodiesel fuel that is certified as meeting testing standards. None permit the use of vegetable oil in its natural state.
	**DISCUSSION:** HAVE THE STUDENTS TALK ABOUT **BIODIESEL BLENDS**. CAN **B20** BE USED IN UNMODIFIED DIESEL ENGINES? SINCE BIODIESEL COSTS MORE THAN REGULAR DIESEL, WHAT ARE ITS BENEFITS?
	**DISCUSSION:** HAVE STUDENTS TALK ABOUT BIODIESEL IN RELATION TO VEGETABLE OIL. WHAT IS DIFFERENCE BETWEEN BIODIESEL POWERED VEHICLES & **VEGETABLE-OIL-POWERED** VEHICLES? ALSO DISCUSS **E-DIESEL FUEL**. WHAT IS A TYPICAL BLEND LEVEL FOR E-DIESEL?
	**DISCUSSION:** HAVE THE STUDENTS TALK ABOUT THE **CETANE RATING OF E-DIESEL**. IN WHAT APPLICATIONS IS E-DIESEL CURRENTLY USED?

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 	**ON-VEHICLE TASK BIODIESEL FUEL** **MEETS ASEEDUCATION TASK: NOT SPECIFIED BY ASEEDUCATION**