Automotive Engines

Chapter 12 Gasoline, Alternative Fuels, & Diesel Fuels

Opening Your Class

KEY ELEMENT	EXAMPLES
Introduce Content	This engine systems course or class provides complete coverage of the components, operation, design, and troubleshooting. It correlates material to task lists specified by ASE and NATEF and emphasizes a problem-solving approach. Chapter features include Tech Tips, Frequently Asked Questions, Real World Fixes, Videos, Animations, and NATEF Task Sheet references.
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 learning objectives to students as listed on NEXT SLIDE. 1. Describe how the proper grade of gasoline affects engine performance. 2. List gasoline purchasing hints. 3. Discuss how volatility affects driveability. 4. Explain how oxygenated fuels can reduce CO exhaust emissions. 5. Discuss safety precautions when working with gasoline.
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.

ICONS	Ch12 Gasoline, Alternative Fuels, Diesel Fuels
	**1. SLIDE 1 Chapter 12 Chapter 12 Gasoline, Alternative Fuels, & Diesel Fuels** **2. SLIDES 2-4** EXPLAIN Objectives & KEY TERMS **5. SLIDE 5** EXPLAIN INTRODUCTION
	**Check for ADDITIONAL VIDEOS & ANIMATIONS @ http://www.jameshalderman.com/** **WEB SITE REGULARLY UPDATED**
	**Fuel and Air (133 Links)** **AVAILABLE VIDEOS**
	**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?**
	**6. SLIDE 6** EXPLAIN **Gasoline** **7. SLIDE 7** EXPLAIN **FIGURE 12-1** crude oil refining process showing most of the major steps and processes. **8. SLIDE 8** EXPLAIN **FIGURE 12–2** A pig is a plug like device that is placed in a pipeline to separate two types or grades of fuel
	**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 MSDS 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 66-1**
	9. **SLIDE 9** EXPLAIN Volatility & EXPLAIN **Figure 12-3** 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) 10. SLIDE 10 EXPLAIN FREQUENTLY ASKED QUESTION
	**DEMONSTRATION:** Show the students how to test gasoline, emphasizing RVP reading as a classification for usage. **FIGURE 12-3**
	**HANDS ON-TASK:** Check fuel RVP BASED ON DEMO
	**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?
	**DISCUSSION:** Have the students talk about the gasoline combustion process. Will a contaminated atmosphere have an effect on combustion process? **FIGURES 12-3 & 4**

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	**11. SLIDE 11** EXPLAIN air-fuel ratio is proportion by weight of air & gasoline that injection system mixes as needed for engine combustion & **FIGURE 12-4** engine will not run if air-fuel mixture is either too rich or too too lean. **12. SLIDE 12** EXPLAIN ideal mixture or ratio at which all of the fuel combines with all of the oxygen in the air and burns completely is called the Stoichiometric ratio, a chemically perfect combination **& FIGURE 12-5** 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
	**DISCUSSION: Have the students refer to FIGURE 12–5 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.**
	**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.**
	**DISCUSSION: Have the students discuss air-fuel ratios. What makes an air-fuel mixture too rich or too lean?**

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	**Show ANIMATION: TOO RICH/TOO LEAN MIXTURE (Ch66) www.myautomotivelab.com** http://media.pearsoncmg.com/ph/chet/chet_myautomotivelab_2/animations/A16_Animation/Chapter52_Fig_52_10/index.htm
	13. **SLIDE 13 EXPLAIN Normal and Abnormal Combustion & FIGURE 12-6** Normal combustion is a smooth, controlled burning of the air-fuel mixture
	14. **SLIDE 14 EXPLAIN FIGURE 12-7** 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 12-7**
	**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.**
	15. **SLIDE 15 EXPLAIN** Octane Rating & **EXPLAIN FIGURE 12-8** 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.
	16. **SLIDE 16 EXPLAIN CHART 12-1**
	**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? FIGURE 12-8**
	17. **SLIDE 17 EXPLAIN FREQUENTLY ASKED QUESTION**

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	**18. SLIDE 18** EXPLAIN TECH TIP
	**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.**
	**DISCUSSION: Have the students talk about injector flow rate. What is the relation of injector flow rate to horsepower?**
	**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?**
	**19. SLIDE 19** EXPLAIN **FIGURE 12-9** posted octane rating in most high-altitude areas shows regular at 85 instead of the usual 87.
	**DISCUSSION: Have students discuss high-altitude octane requirements. What happens to air when atmospheric pressure drops? How does lowered atmospheric pressure affect octane rating?**
	**20. SLIDE 20** EXPLAIN Gasoline Additives & EXPLAIN **FIGURE 12-10** 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
	**DISCUSSION: Have students discuss gasoline additives. What problems can be caused by additives?**
	**21. SLIDE 21** EXPLAIN FREQUENTLY ASKED QUESTION

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	**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? FIGURE 12-10**
	**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?**
	**DISCUSSION: Have the students talk about oxygenated fuel additives. Under what conditions can additives be used to improve driveability?**
	**22. SLIDE 22 EXPLAIN PHASE SEPARATION & FIGURE 12-11** 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?**
	**23. SLIDE 23 EXPLAIN Gasoline Blending & EXPLAIN FIGURE 12-12** In-line blending is the most accurate method for blending ethanol with gasoline because computers are used to calculate the correct ratio
	**24. SLIDE 24 EXPLAIN FIGURE 12-13** Sequential blending uses a computer to calculate correct ratio as well as the prescribed order in which the products are loaded.
	25. SLIDE 25 EXPLAIN FIGURE 12-14 Splash blending occurs when ethanol is added to a tanker with gasoline and is mixed as truck travels to retail outlet.
	**26. SLIDE 26 EXPLAIN FREQUENTLY ASKED QUESTION**

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	**27. SLIDE 27 EXPLAIN Testing Gasoline for Alcohol Content**
	**28. SLIDE 28 EXPLAIN WARNING**
	**29. SLIDE 29 EXPLAIN Figure 12-15** Checking gasoline for alcohol involves using a graduated cylinder and adding water to check if the alcohol absorbs the water.
	**DEMONSTRATION: Show the students how to check for alcohol content in gas. Remind them of safety precautions to take when testing gasoline. FIGURE 12-15**
	**31. SLIDE 31 EXPLAIN FREQUENTLY ASKED QUESTION**
	**ON-VEHICLE NATEF TASK (A8-D-2) Check fuel for contaminants and quality; determine necessary action. (P-2)**
	**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?**
	**30. SLIDES 30-31 EXPLAIN General Gasoline Recommendations**
	**32. SLIDE 32 EXPLAIN FREQUENTLY ASKED QUESTION**
	33. SLIDE 33 EXPLAIN FIGURE 12–16 The gas cap on a Ford vehicle notes that BP fuel is recommended
	**34. SLIDE 34 EXPLAIN Figure 12-17** 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

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	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.
	**35. SLIDE 35** EXPLAIN TECH TIP
	**DEMONSTRATION:** Demonstrate a **sniff test on stale gasoline**. Talk about what gasoline stabilizer is, when to use it, and where to find it.
	**DISCUSSION:** Have students discuss keeping the **fuel level above ¼ tank**. Why should fuel level be kept above that level?
	**36. SLIDE 36** EXPLAIN FREQUENTLY ASKED QUESTION
	37. SLIDE 37 EXPLAIN TECH TIP
	**38. SLIDE 38** EXPLAIN TECH TIP
	**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.**
	**SAFETY** Discuss importance of having a fire extinguisher available when working with fuel, and of wearing PPE including safety glasses, a respirator, and gloves.

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	**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**
	**39. SLIDE 39 EXPLAIN E85 & FIGURE 12–18** The ethanol molecule showing two carbon atoms, six hydrogen atoms, and one oxygen atom **40. SLIDE 40 EXPLAIN FIGURE 12–19** Some retail stations offer a variety of fuel choices, such as this station in Ohio where E10 and E85 are available **41. SLIDE 41 EXPLAIN E85**
	**42. SLIDE 42 EXPLAIN TECH TIP**
	**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?**
	**43. SLIDE 43 EXPLAIN** ALTERNATIVE FUEL VEHICLES **44. SLIDE 44 EXPLAIN FIGURE 12–20** The location of the variable fuel sensor can vary, depending on the make and model of vehicle, but it is always in the fuel line between the fuel tank and the fuel injectors
	**DEMONSTRATION: Show students location of variable fuel sensor. Review its function with the students: FIGURES 67-3 & 4**
	**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?**

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	45. **SLIDE 45 EXPLAIN FIGURE 12–21** cutaway view of a typical variable fuel sensor 46. **SLIDE 46 EXPLAIN ALTERNATIVE FUEL VEHICLES FIGURE 12–22** A flex fuel vehicle often has a yellow gas cap, which is labeled E85/gasoline 47. **SLIDE 47 EXPLAIN FIGURE 12–23** A vehicle emission control information (VECI) sticker on a flexible fuel vehicle indicating that it can use ethanol from 0% to 85%.
	**DISCUSSION: Have the students discuss E85 fuel system requirements. What additional hardware is on E85 vehicles?**
	**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.**
	48. **SLIDE 48 EXPLAIN FREQUENTLY ASKED QUESTION** 49. **SLIDE 49 EXPLAIN FREQUENTLY ASKED QUESTION**
	50. **SLIDE 50 EXPLAIN Methanol**, also known as methyl alcohol, wood alcohol, or methyl hydrate, is a chemical compound formula that includes one carbon atom, four hydrogen atoms, and one oxygen atom & **FIGURE 12–24** The molecular structure of methanol showing the one carbon atom, four hydrogen atoms, and one oxygen atom

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	**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.
	**51. SLIDE 51 EXPLAIN FIGURE 12–25** 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
	**DISCUSSION:** Have the students talk about **methanol** and its production. What is biggest source of methanol in United States? What is **M85**?
	**52. SLIDE 52 EXPLAIN Methanol**
	**53. SLIDE 53 EXPLAIN Propane** **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? **FIGURE 67-10**
	**54. SLIDE 54 EXPLAIN FIGURE 12–26** Propane fuel storage tank in the trunk of a Ford taxi
	**55. SLIDE 55 EXPLAIN CNG** **DISCUSSION:** Have students talk about compressed natural gas. Why is natural gas odorized during production?
	**56. SLIDE 56 EXPLAIN FIGURE 12–27** 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 the high occupancy vehicle (HOV) lane, even if there is just the driver, because it is a CNG vehicle

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	57. SLIDE 57 EXPLAIN FIGURE 12–28 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.
	**58. SLIDE 58 EXPLAIN FREQUENTLY ASKED QUESTION**
	**59. SLIDE 59 EXPLAIN FIGURE 12–29** The 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? FIGURE 12-29**
	**60. SLIDE 60 EXPLAIN FIGURE 12–30** 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
	61. SLIDE 61 EXPLAIN CHART 12-2
	**DISCUSSION: Have the students discuss CNG fuel systems. What is importance of having lock-off valves in CNG vehicles?**
	**DISCUSSION: Discuss refueling of CNG vehicles. Why is it important to fill a CNG vehicle's tank slowly?**
	**62. SLIDE 62 EXPLAIN** Liquefied Natural Gas
	**DISCUSSION: Have the students talk about liquefied natural gas. What are practicalities of using LNG in vehicles?**

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	**DISCUSSION:** Have the students talk about tri-fuel vehicles. Which fuels are **tri-fuel vehicles** capable of using?
	**63. SLIDE 63** EXPLAIN P-Series Fuels **64. SLIDE 64** EXPLAIN **CHART 12–3** **65. SLIDE 65** EXPLAIN Synthetic Fuels **66. SLIDE 66** EXPLAIN **Figure 12-31** 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? **FIGURE 12-31**
	**67. SLIDES 67-68** EXPLAIN Safety Procedures When Working With Alternative Fuels CLICK ON ICON & EXPLAIN
	**69. SLIDE 69** EXPLAIN WARNING
	**DISCUSSION:** Have the students discuss future of **synthetic fuels**. How is rising cost of crude oil 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.
	**ON-VEHICLE NATEF TASK Alternative Fuel** Meets NATEF Task:
	**70. SLIDE 70** EXPLAIN DIESEL FUEL

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	**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?**
	**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 IGNITON DELAY, which can cause a hard starting with white smoke & misfiring.**
	**71. SLIDE 71 EXPLAIN Figure 12-32 (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)** fuel pump in a farming area that clearly states the red diesel fuel is for off-road use only.

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	**DEMONSTRATION: Obtain regular diesel and off-road diesel to show to the students. Have them visually note difference in the two fuels**
	**72. SLIDE 72 EXPLAIN Figure 12-33** Testing API viscosity of a diesel fuel sample using a hydrometer
	**DEMONSTRATION: Use a hydrometer to show the students how to test API gravity of diesel fuel: FIGURE 12-33**
	**73. SLIDE 73 EXPLAIN FREQUENTLY ASKED QUESTION**
	**74. SLIDE 74 EXPLAIN** Biodiesel & **EXPLAIN Figure 12-34** pump decal indicating that the biodiesel fuel is ultra-low-sulfur diesel (ULSD) and must be used in 2007 and newer diesel vehicles.
	**DISCUSSION: Have the students talk about why sulfur dioxide is harmful to environment. What is difference in appearance of ULSD?**
	**75. SLIDES 75-76 EXPLAIN Biodiesel**
	**77. SLIDE 77 EXPLAIN FREQUENTLY ASKED QUESTION**
	**78. SLIDE 78 EXPLAIN FREQUENTLY ASKED QUESTION**
	**79. SLIDE 79 EXPLAIN FREQUENTLY ASKED QUESTION**
	**80. SLIDE 80 EXPLAIN FREQUENTLY ASKED QUESTION**
	**81. SLIDE 81 EXPLAIN FREQUENTLY ASKED QUESTION**

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	**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?
	**82. SLIDE 82** EXPLAIN E-Diesel Fuel
	**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?
	**ON-VEHICLE NATEF TASK Biodiesel Fuel** **Meets NATEF Task: Not specified by NATEF**
	**83. SLIDE 83** EXPLAIN FREQUENTLY ASKED QUESTION
	**84. SLIDE 84** EXPLAIN CHART 12-4
	**Talk through SUMMARY and questions**
	**HOMEWORK:** complete Ch12 crossword puzzle: http://www.jameshalderman.com/links/book_engine_theory_serv_7/cw/crossword_ch_12.pdf