Automotive Technology 6th Edition

Chapter 45 Wiring Schematics & Circuit Testing

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. Interpret wiring schematics and explain the procedure to identify relay terminals. 2. Explain how to locate an open circuit, how to determine whether a system has common power or common ground, and discuss circuit troubleshooting procedure. 3. Explain how to locate an open circuit, how to determine whether a system has common power or common ground, and discuss circuit troubleshooting procedure.
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 6th Edition Chapter Images found on Jim's web site @
www.jameshalderman.com

DOWNLOAD Chapter 45 Chapter Images: From
http://www.jameshalderman.com/automotive_principles.html

NOTE: You can use Chapter Images or possibly Power Point files:

ICONS	Ch 45 Wiring Schematics
	**1. TITLE SLIDE 1: WIRING SCHEMATICS & CIRCUIT TESTING** **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** **Videos** **Bulb Test, Meter (View) (Download)** **Circuit Test, Amps, Meter (View) (Download)** **Circuit Test, Meter (View) (Download)** **DC Motor (View) (Download)** **Headlight Circuit, Parking Lights (View) (Download)** **Headlight Circuit, High Beam (View) (Download)** **Headlight Circuit, Low Beam (View) (Download)** **Map Sensor Ground Check (View) (Download)** **Map Sensor Reference Voltage Check (View) (Download)** **DISCUSSION: Have students talk about circuit information on a wiring diagram. How is a wiring diagram similar to a roadmap?** **2. SLIDE 2 EXPLAIN Figure 45-1** The center wire is a solid color wire, meaning that the wire has no other identifying tracer or stripe color. The two end wires could be labeled "BRN/WHT," indicating a brown wire with a white tracer or stripe. **DISCUSS CHART 45-1 Typical abbreviations used on schematics to show wire color. Some vehicle manufacturers use 2 letters to represent a wire color. Check service information for color abbreviations used.** **DEMONSTRATION: Procure a wiring harness to show students various colors of wires in harness**
	

ICONS	Ch 45 Wiring Schematics
	**DISCUSSION: Have the students talk about the various colors of the wires in a wiring harness. What is the significance of different colors?** 3. **SLIDE 3 EXPLAIN Figure 45-2** Typical section of a wiring diagram. Notice that 2 wire color changes at connection C210. 2 ".8" represents 2 metric wire size in square **millimeters**. 4. **SLIDE 4 EXPLAIN Figure 45-3** Electrical/electronic symbols used in automotive wiring & circuit diagrams. 5. **SLIDE 5 EXPLAIN FIGURE 45.4** In this typical connector, note that the positive terminal is usually a female connector. **DISCUSSION: Have students discuss the symbols used to indicate male and female connectors. Why is the battery side of the connector female & not male? Have the students study Chart 45–3 to become familiar with symbols used in wiring diagrams. What do the shorter and longer lines on the battery symbol mean? How is wiring shown?** **EXPLAIN TECH TIP: *Read the Arrows:* Wiring diagrams indicate connections by symbols that look like arrows. • SEE FIGURE 45–4. Do not read these "arrows" as pointers showing direction of current flow. Also observe that power side (positive side) of circuit is usually female end of connector. If a connector becomes disconnected, it is difficult for circuit to become shorted to ground or to another circuit because wire is recessed inside connector.** 6. **SLIDE 6 EXPLAIN Figure 45-5** symbol for a battery. The positive plate of a battery is represented by the longer line and the negative plate by the shorter line. The voltage of the battery is usually stated next to the symbol. 7. **SLIDE 7 EXPLAIN Figure 45-6** ground symbol on the left represents earth ground. The ground symbol on the right represents a chassis ground. 8. **SLIDE 8 EXPLAIN Figure 45-7** Starting at top, wire from ignition switch is attached to terminal B of connector C2, wire is 0.5 mm^2 (20 gauge AWG), and yellow. Circuit number is 5. Wire enters connector C202 at terminal B3. 9. **SLIDE 9 EXPLAIN Figure 45-8** electrical terminals are usually labeled with a letter or number. 10. **SLIDE 10 EXPLAIN Figure 45-9** Two wires that cross at the dot indicate that the two are electrically connected.

ICONS	Ch 45 Wiring Schematics

DEMONSTRATION: Procure a wiring harness with splices. Open it up to show splices in harness and explain the need for splices.

11. **SLIDE 11 EXPLAIN Figure 45-10** Wires that cross, but do not electrically contact each other, are shown with one wire bridging over the other.
12. **SLIDE 12 EXPLAIN Figure 45-11** Connectors (C), grounds (G), and splices (S) are followed by a number, generally indicating the location in the vehicle. For example, G209 is a ground connection located under dash.

DISCUSSION: Have students talk about numbers used to indicate general areas for connection locations. Why is there need to separate vehicle into different areas to simplify repairs? What is difference between even & odd numbered connectors?

13. **SLIDE 13 EXPLAIN Figure 45-12** ground for the battery is labeled G305 indicating the ground connector is located in the passenger compartment of the vehicle. The ground wire is black (BLK), the circuit number is 50, and the wire is 32 mm^2 (2 gauge AWG).
14. **SLIDE 14 EXPLAIN Figure 45-13** The symbol for light bulbs shows the filament inside a circle, which represents the glass ampoule of the bulb.
15. **SLIDE 15 EXPLAIN Figure 45-14** An electric motor symbol shows a circle with the letter M in the center and two black sections that represent the brushes of the motor. This symbol is used even though the motor is a brushless design.
16. **SLIDE 16 EXPLAIN Figure 45-15** Resistor symbols vary depending on the type of resistor.
17. **SLIDE 17 EXPLAIN Figure 45-16** rheostat uses only two wires—one is connected to a voltage source and the other is attached to the movable arm.
18. **SLIDE 18 EXPLAIN Figure 45-17** Symbols used to represent capacitors. If one of the lines is curved, this indicates that the capacitor being used has a polarity, while the one without a curved line can be installed in the circuit without concern about polarity.
19. **SLIDE 19 EXPLAIN Figure 45-18** grid like symbol represents an electrically heated element. Symbol represents a cigarette lighter or heated rear window

ICONS	Ch 45 Wiring Schematics

DISCUSSION: Talk about symbols used to represent capacitors on wiring diagrams. Why are 2 different symbols needed for capacitors?

20. **SLIDE 20 EXPLAIN Figure 45-19** Dashed outline represents a portion (part) of a component.
21. **SLIDE 21 EXPLAIN Figure 45-20** Solid box represents an entire component.
22. **SLIDE 22 EXPLAIN Figure 45-21** Symbol represents a component that is case grounded.

DEMONSTRATION: Show students how to use a copy of a wiring diagram and highlighter to trace circuits for testing or repair.

23. **SLIDE 23 EXPLAIN Figure 45-22a** symbol for a single-pole, single-throw (SPST) switch. This type of switch is normally open (N.O.) because nothing is connected to the terminal that the switch is contacting in its normal position.
24. **SLIDE 24 EXPLAIN Figure 45-22b** single-pole, double-throw (SPDT) switch has three terminals.
25. **SLIDE 25 EXPLAIN Figure 45-22c** A double-pole, single-throw (DPST) switch has two positions (off and on) and can control two separate circuits.
26. **SLIDE 26 EXPLAIN Figure 45-22d** double-pole, double-throw (DPDT) switch has six terminals—three for each pole. Note: Both (c) and (d) also show a dotted line between the two arms indicating that they are mechanically connected, called a "ganged switch."
27. **SLIDE 27 EXPLAIN Figure 45-23a** symbol for a normally open (N.O.) momentary switch.
28. **SLIDE 28 EXPLAIN Figure 45-23b** symbol for a normally closed (N.C.) momentary switch.

EXPLAIN TECH TIP: *Color-Coding Is Key to Understanding*

Whenever diagnosing an electrical problem, it is common practice to print out the schematic of the circuit and take it to the vehicle. A meter is then used to check for voltage at various parts of the circuit to help determine if there is a fault. The diagnosis can be made easier if the parts of the circuit are first color-coded using markers or color pencils. The colors represent voltage conditions in various parts of a circuit. Once the circuit has been color-coded, it can be tested using the factory wire colors as a

ICONS	Ch 45 Wiring Schematics

guide.• **SEE FIGURE 45–24.**

29. **SLIDE 29 EXPLAIN FIGURE 45-24** Color the parts of the circuit that have 12 volts, then take to the vehicle to see if power is available at each location marked
30. **SLIDE 30 EXPLAIN Figure 45-25** relay uses a movable arm to complete a circuit whenever there is a power at terminal 86 and a ground at terminal 85. A typical relay only requires about 1/10 ampere through the relay coil. The movable arm then closes the contacts (#30 to #87) and can relay 30 amperes or more.
31. **SLIDE 31 EXPLAIN Figure 45-26** cross-sectional view of a typical 4-terminal relay. Current flowing through coil (terminals 86 and 85) causes movable arm (called armature) to be drawn toward coil magnet. Contact points complete electrical circuit connected to terminals 30 & 87.
32. **SLIDE 32 EXPLAIN Figure 45-27** typical relay showing the schematic of the wiring in the relay.
33. **SLIDE 33 EXPLAIN Figure 45-28** All schematics are shown in their normal, non-energized position.

EXPLAIN TECH TIP: *Divide Circuit in Half:* When diagnosing any circuit that has a relay, start testing at relay and divide circuit in half.

- **High-current portion: Remove the relay and check that there are 12 volts at the terminal 30 socket. If there is, the power side is okay. Use an ohmmeter and check between terminal 87 socket and ground. If load circuit has continuity, there should be some resistance. If OL, the circuit is electrically open.**
- **Control circuit (low current): With relay removed from the socket, check that there are 12 volts to terminal 86 with ignition on and control switch on. If not, check service information to see if power should be applied to terminal 86, and continue troubleshooting switch power and related circuit.**
- **Check relay itself: Use an ohmmeter and measure for continuity and resistance between terminals 85 and 86 (coil), there should be 60 to 100 ohms. If not, replace the relay.**
- **Between terminals 30 and 87 (high-amperage switch controls), there should be continuity (low ohms) when there is power applied to terminal 85 and a ground applied to terminal 86 that operates the**

ICONS	Ch 45 Wiring Schematics

relay. If OL is displayed on the meter set to read ohms, the circuit is open, which requires that the relay be replaced.

- **Between terminals 30 and 87a (if equipped), with the relay turned off, there should be low resistance (less than 5 ohms).**

DISCUSSION: Have students talk about operation of normally open and normally closed relays. What are the applications for normally open relays? What are the applications for normally closed relays?

34. **SLIDE 34 EXPLAIN Figure 45-29** typical horn circuit. Note that relay contacts supply the heavy current to operate horn when horn switch simply completes a low-current circuit to ground, causing relay contacts to close.
35. **SLIDE 35 EXPLAIN Figure 45-30** When relay or solenoid coil current is turned off, the stored energy in coil flows through clamping diode and effectively reduces voltage spike.

DISCUSSION: Ask students to talk about controlling relay voltage spikes. How does diode used in a relay coil circuit eliminate voltage spikes?

36. **SLIDE 36 EXPLAIN Figure 45-31** resistor used in parallel with the coil windings is a common spike reduction method used in many relays.

An inoperative circuit involving a relay can be divided in ½ for testing. high-current and low-current sides can be tested separately to determine which side of circuit is inoperative.

LAB HANDS-ON TASK: Students complete the W3D1 Worksheet 1 on Highlighting Wiring Diagrams

Education Foundation

ASEEDUCATION Task Sheet Use wiring diagrams during diagnosis of electrical circuit problems

DISCUSS FREQUENTLY ASKED QUESTION: *What Is the Difference Between a Relay and a Solenoid?*
Often, these terms are used differently among OEMS, which can lead to some confusion.

ICONS	Ch 45 Wiring Schematics
	Relay: A relay is an electromagnetic switch that uses a movable arm. Because a relay uses a movable arm, it is generally limited to current flow not exceeding 30 amperes. **Solenoid: A solenoid is an electromagnetic switch that uses a movable core. Because of this type of design, a solenoid is capable of handling 200 amperes or more. It is used in the starter motor circuit and other high-amperage applications, such as in the glow plug circuit of diesel engines.** **37. SLIDE 37 EXPLAIN Figure 45-32** typical wiring diagram showing multiple switches & bulbs powered by one fuse.
	**EXPLAIN TECH TIP: *Do It Right—Install a Relay*** **Often the owners of vehicles, especially owners of pickup trucks and sport utility vehicles (SUVs), want to add additional electrical accessories or lighting. It is tempting in these cases to simply splice into an existing circuit. However, when another circuit or component is added, the current that flows through the newly added component is also added to the current for the original component. This additional current can easily overload the fuse and wiring. Do not simply install a larger amperage fuse; the wire gauge size was not engineered for the additional current and could overheat. The solution is to install a relay, which uses a small coil to create a magnetic field that causes a movable arm to switch on a higher current circuit. The typical relay coil has 50 to 150 ohms (usually 60 to 100 ohms) of resistance and requires just 0.24 to 0.08 ampere when connected to a 12-volt source. This small additional current is not enough to overload the existing circuit. • SEE FIGURE 45–33 for an example of how additional lighting can be added.** **38. SLIDE 38 EXPLAIN Figure 45-33** To add additional lighting, simply tap into an existing light wire & connect a relay. Whenever the existing light is turned on, the coil of the relay is energized. The arm of the relay then connects power from another circuit (fuse) to auxiliary lights without overloading the existing light circuit.

ICONS	Ch 45 Wiring Schematics
	**39. SLIDE 39 EXPLAIN Figure 45-34** Always check simple things first. Check fuse for circuit you are testing. Maybe a fault in another circuit controlled by same fuse could have caused fuse to blow. Use a test light to check that both sides of fuse have voltage. **DISCUSS CASE STUDY: *The Electric Mirror Fault Story*** **A customer noticed that electric mirrors stopped working. The service technician checked all electrical components in the vehicle and discovered that the interior lights were also not working. The interior lights were not mentioned by the customer as being a problem most likely because the driver only used the vehicle in daylight hours. The service technician found the interior light and power accessory fuse blown. Replacing the fuse restored proper operation of the electric outside mirror and interior lights. However, what caused the fuse to blow? Visual inspection of the dome light, next to the electric sunroof, showed an area where a wire was bare. Evidence showed bare wire had touched metal roof, which could cause the fuse to blow. The technician covered bare wire with a section of vacuum hose and then taped hose with electrical tape to complete the repair.** **Summary:** • **Complaint—Electric power mirrors stopped working.** • **Cause—Blown fuse due to a fault in wiring at dome light.** • **Correction—Repaired wiring at the dome light, which restored proper operation of electric mirrors that shared the same fuse as dome light.** **DEMONSTRATION: Use Trainer for an open circuit. Have students work through circuit troubleshooting procedure with you. Explain reason for testing simple things first. Try out this exercise before class to make sure it works properly for demonstrating to Students.** **DISCUSSION: Discuss circuit breaker method of testing for a short-to-ground circuit. Why is this A better alternative than fuse replacement method?**
	**DISCUSS FREQUENTLY ASKED QUESTION: *Where to Start?* The common question is, where does a technician start troubleshooting when using a wiring diagram (schematic)?**

ICONS	Ch 45 Wiring Schematics

HINT 1 circuit contains a relay, start your diagnosis at relay. Entire circuit can be tested at terminals of relay.

HINT 2 easiest first step is to locate unit on schematic that is not working or not working.

A. Trace where the unit gets its ground connection.

b. Trace where the unit gets its power connection.

Often a ground is used by more than one component. Therefore, ensure that everything else is working correctly. If not, the fault may lie at the common ground (or power) connection.

HINT 3 Divide the circuit in half by locating a connector or a part of the circuit that can be accessed easily. Then check for power and ground at this midpoint. This step could save you time.

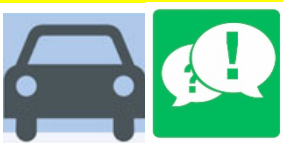
HINT 4 U e a fused jumper wire to substitute a ground or a power source to replace a suspected switch or section of wire.

40. **SLIDE 40 EXPLAIN Figure 45-35 (a)** After removing the blown fuse, a pulsing circuit breaker is connected to the terminals of fuse.
41. **SLIDE 41 EXPLAIN Figure 45-35 (b)** circuit breaker causes current to flow, then stop, then flow again, through circuit up to point of the short-to-ground. By observing the Gauss gauge, location of short is indicated near where the needle stops moving due to the magnetic field created by the flow of current through the wire.
42. **SLIDE 42 EXPLAIN Figure 45-36** Gauss gauge can be used to determine the location of a short circuit even behind a metal panel.

DEMONSTRATION: Show students how a gauss gauge works. Have them use gauss gauge to check for a shorted wire.

43. **SLIDE 43 EXPLAIN Figure 45-37** tone generator-type tester used to locate open circuits and circuits that are shorted-to-ground. Included with this tester is a transmitter (tone generator), receiver probe, and headphones for use in noisy shops.

ICONS	Ch 45 Wiring Schematics
	DISCUSSION: Have students discuss four methods of testing for a short-to-ground circuit. Which method would be the easiest, & which would be most difficult? Why?
	44. **SLIDE 44 EXPLAIN Figure 45-38** To check for a short-to-ground using a tone generator, connect black transmitter lead to a good chassis ground & red lead to load side of fuse terminal. Turn the transmitter on and check for tone signal with the receiver. Using a wiring diagram, follow strongest signal to short-to-ground. There will be no signal beyond the fault, either a short-to-ground as shown or an open circuit.
	**EXPLAIN TECH TIP: *Heat or Movement*: Electrical shorts are commonly caused either by movement, which causes insulation around the wiring to be worn away, or by heat melting the insulation. When checking for a short circuit, first check the wiring that is susceptible to heat, movement, and damage.** 1. **Heat. Wiring near heat sources, such as the exhaust system, cigarette lighter, or alternator** 2. **Wire movement. Wiring that moves, such as in areas near the doors, trunk, or hood** 3. **Damage. Wiring subject to mechanical injury, such as in the trunk, where heavy objects can move around and smash or damage wiring can also occur as a result of an accident or a previous repair**
	**EXPLAIN TECH TIP: *Wiggle Test:* Intermittent electrical problems are common, yet difficult to locate. To help locate these hard-to-find problems, try operating circuit and start wiggling the wires and connections that control the circuit. If in doubt where the wiring goes, try moving all the wiring starting at the battery. Pay particular attention to wiring running near the battery or the windshield washer container. Corrosion can cause wiring to fail, and battery acid fumes and alcohol-based windshield washer fluid can start or contribute to the problem. If you notice any change in the operation of the device being tested while wiggling wiring, look closer in the area you were wiggling until you locate and correct the actual problem.**

ICONS	Ch 45 Wiring Schematics
	**DISCUSS CASE STUDY: *Shocking Experience*** **A customer complained that after driving for a while, he got a static shock whenever he grabbed the door handle when exiting the vehicle. The customer thought that there must be an electrical fault and that the shock was coming from the vehicle itself. In a way, the shock was caused by the vehicle, but it was not a fault. The service technician sprayed the cloth seats with an antistatic spray and the problem did not reoccur. Obviously, a static charge was being created by the movement of the driver's clothing on the seats and then discharged when the driver touched the metal door handle. • SEE FIGURE 45–39.** **Summary:** **Complaint–Vehicle owner complained that he got shocked when the door handle was touched.** **Cause–Static electricity was found to be the cause, not a fault with the vehicle.** **Correction–The seats and carpet were sprayed with an anti-static spray and this corrected the concern.** **45. SLIDE 45 EXPLAIN FIGURE 45-39** Antistatic spray can be used by customers to prevent being shocked when they touch a metal object like the door handle. **DEMONSTRATION: Raise a vehicle on a lift. Have students inspect & locate areas where potential electrical OR electronic problems could occur from heat or movement of a wiring harness.** **ASEEDUCATION Task Sheet Locate shorts, grounds, opens, & resistance problems in electrical/electronic circuits; determine necessary action (P-1)**
Education Foundation	**ASEEDUCATION Task Sheet Identify and interpret electrical/electronic system concern; determine necessary action. (P-1)**
Education Foundation	