













Automotive Electrical & Engine Performance 8/E










Chapter 6 Circuit Testers & Digital Meters




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 ASE Education (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 ASE Education (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.	<p>Explain the chapter learning objectives to the students.</p> <ol style="list-style-type: none"> 1. Discuss diode check, pulse width, and frequency. 2. Describe the prefixes used with electrical units and how to read digital meters. 3. Discuss how to safely set up and use a fused jumper wire, a test light, and a logic probe. 4. Explain how to safely and properly use a digital meter to read voltage, resistance, and current and compare to factory specifications. <p>This chapter will help you prepare for the ASE Electrical/Electronic Systems (A6) certification test content area "A" (General Electrical/Electronic System Diagnosis).</p>
Establish the Mood or Climate	Provide a <i>WELCOME</i> , 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 06 Chapter Images: From
http://www.jameshalderman.com/books_a8.html#anchor2

ICONS	Ch06 Circuit Testers & Digital Meters
	<p>1. SLIDE 1 CH6 CIRCUIT TESTERS & DIGITAL METERS</p>
	<p>Check for ADDITIONAL VIDEOS & ANIMATIONS @ http://www.jameshalderman.com/ WEB SITE IS CONSTANTLY UPDATED</p>
	<p><u>Videos</u></p>
	<p>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:</p>
	<p><u>HTTP://WWW.JAMESHALDERMAN.COM/BOOKS_A8.H TML#ANCHOR2</u> DOWNLOAD</p>
	<p>CROSSWORD PUZZLE (MICROSOFT WORD) (PDF) WORD SEARCH PUZZLE (MICROSOFT WORD) (PDF)</p>
	<p>2. SLIDE 2 EXPLAIN Figure 6-1 technician-made fused jumper lead equipped with a red 10 ampere fuse. Fused jumper wire uses terminals for testing circuits at a connector instead of alligator clips.</p>
	<p><u>DEMONSTRATION: SHOW STUDENTS HOW TO TEST A CIRCUIT WITH A FUSED JUMPER</u></p>
	<p><u>DISCUSSION: DISCUSS USES OF FUSED JUMPER WIRE. IF A DEVICE WORKS WHEN CONNECTED TO A FUSED JUMPER WIRE, WHAT IS DETERMINED?</u></p>
	<p>3. SLIDE 3 EXPLAIN Figure 6-2 12 volt test light is attached to a good ground while probing for power.</p>
	<p>4. SLIDE 4 EXPLAIN Figure 6-3 Test light can be used to locate an open in a circuit. Test light is grounded at a different location than the circuit itself.</p>
	<p><u>DEMONSTRATION: NON-POWERED TEST LIGHT WILL SHOW ONLY WHETHER CURRENT IS AVAILABLE. IT CANNOT DETERMINE HOW MUCH CURRENT OR EXACT VOLTAGE AVAILABLE. DEMONSTRATE A CONTINUITY TEST LIGHT FOR STUDENTS & DISCUSS WHEN IT SHOULD BE USED.</u></p>

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	<p>TEST LAMPS SHOULD NOT BE USED ON ANY CIRCUITS CONNECTED TO A PCM DUE TO VOLTAGES USED IN ELECTRONIC COMPONENTS</p>
	<p><u>Circuit Test, Test Light (View) (Download)</u></p>
	<p>5. SLIDE 5 EXPLAIN Figure 6-4 LED test light can be easily made using low cost components and an old ink pen. With the 470 ohm resistor in series with LED, this tester only draws 0.025 ampere (25 milliamperes) from circuit being tested. This low current draw helps assure technician that circuit or component being tested will not be damaged by excessive current flow.</p>
	<p><u>HANDS-ON TASK: HAVE STUDENTS USE FIGURE 8-5 TO CONSTRUCT AN LED TEST LAMP, AND THEN HAVE THEM USE IT TO TEST A CIRCUIT OR COMPONENT.</u></p>
	<p>6. SLIDE 6 EXPLAIN Figure 6-5 logic probe connected to vehicle battery. When tip probe is connected to circuit, it can check for power, ground, or a pulse</p>
	<p><u>DEMONSTRATION: SHOW LOGIC PROBE & PROPER WAY TO CONNECT IT TO A POWER AND GROUND SOURCE AND COMPONENT TO BE CHECKED.</u></p>
	<p>7. SLIDE 7 EXPLAIN Figure 6-6 Typical digital multimeter. Black meter lead always is placed in the COM terminal. Red meter test lead should be in the volt-ohm terminal except when measuring current in amperes</p>
	<p>8. SLIDE 8 EXPLAIN Figure 6-7 Typical digital multimeter (DMM) set to read DC volts.</p>
	<p><u>DISCUSS CHART 6-1 Common symbols and abbreviations used on digital meters.</u></p>
	<p>9. SLIDE 9 EXPLAIN Figure 6-8 (a) typical autoranging digital multimeter automatically selects proper scale to read voltage being tested. The scale selected is usually displayed on meter face. Note that display indicates “4,” meaning that this range can read up to 4 volts. (b) typical autoranging digital multimeter automatically selects proper scale to read voltage being tested. The scale selected is</p>

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	<p>usually displayed on meter face. The range is now set to the 40 volt scale, meaning that the meter can read up to 40 volts on the scale. Any reading above this level will cause the meter to reset to a higher scale. If not set on autoranging, the meter display would indicate OL if a reading exceeds limit of scale selected.</p> <p>10. SLIDE 10 EXPLAIN Figure 6-9 Using a digital multimeter set to read ohms (Ω) to test this light bulb. The meter reads the resistance of the filament.</p> <p>11. SLIDE 11 EXPLAIN Figure 6-10 Many digital multimeters can have the display indicate zero to compensate for test lead resistance. (1) Connect leads in the V Ω and COM meter terminals. (2) Select the Ω scale. (3) Touch the two meter leads together. (4) Push the “zero” or “relative” button on the meter. (5) The meter display will now indicate zero ohms of resistance.</p> <p>12. SLIDE 12 EXPLAIN Figure 6-11 Measuring the current flow required by a horn requires that the ammeter be connected to the circuit in series and the horn button be depressed by an assistant.</p>
	<p><u>Measure Battery Voltage Drop</u></p> <p><u>Meter Usage Battery Volt Check</u></p> <p><u>Meter Usage Check CAN Circuit</u></p> <p><u>Meter Usage Measure Amps</u></p> <p><u>Meter Usage Measure Frequency</u></p> <p><u>Meter Usage Measure Ohms</u></p> <p><u>Meter Usage Measure Volts</u></p> <p><u>Meter Usage Testing Diode</u></p>
	<p>DISCUSS FREQUENTLY ASKED QUESTION: HOW MUCH VOLTAGE DOES AN OHMMETER APPLY?</p> <p>1. Most digital meters set to measure ohms (resistance) apply 0.3 to 1 volts. Voltage comes from meter itself to measure resistance. 2 things are important to remember: component or circuit must be disconnected from any electrical circuit while the resistance is being measured.</p>

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2. Because meter itself applies voltage (even though it is low), a meter set to measure ohms can damage electronic circuits. Computer chips can be easily damaged if subjected to only a few milliamperes of current, similar to amount an ohmmeter applies when a resistance measurement is being performed.





EXPLAIN TECH TIP: Fuse Your Meter Leads!

Most digital meters include an ammeter capability. When reading amperes, leads of meter must be changed from volts or ohms (V or) to amperes (A), milliamperes (mA), or microamperes (ma). A common problem may occur the next time voltage is measured. Although technician may switch selector to read volts, often leads are not switched back to volt or ohm position. Because the ammeter lead position results in zero ohms of resistance to current flow through meter, the meter or fuse inside meter is destroyed if meter is connected to a battery. Many meter fuses are expensive and difficult to find. To avoid this problem, simply solder an inline 10-ampere blade-fuse holder into one meter lead. • SEE FIGURE 6-12. Do not think that this technique is for beginners only. Experienced technicians often get in a hurry and forget to switch lead. A blade fuse is faster, easier, and less expensive to replace than a meter fuse, or meter itself. Also, if soldering is done properly, addition of an inline fuse holder and fuse does not increase the resistance of the meter leads.

WARNING Do not use a meter equipped with an external add-on fuse when testing a high-voltage circuit to prevent possible shock hazard.



13. SLIDE 13 **EXPLAIN FIGURE 6-12** Note blade-type fuse holder soldered in series with one of meter leads. 10 ampere fuse helps protect internal meter fuse (if equipped) & meter itself from damage that may result from excessive current flow if used incorrectly

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	<p>DISCUSS FREQUENTLY ASKED QUESTION: WHAT DOES “CE” MEAN ON MANY METERS? THE “CE” MEANS THAT METER MEETS NEWEST EUROPEAN STANDARDS AND CE MARK STANDS FOR CONFORMITÉ EUROPEENNE, WHICH IS FRENCH FOR “EUROPEAN CONFORMITY.”</p>
	<ol style="list-style-type: none"> 14. SLIDE 14 EXPLAIN Figure 6-13 inductive ammeter clamp is used with all starting and charging testers to measure the current flow through battery cables. 15. SLIDE 15 EXPLAIN Figure 6-14 Typical mini clamp-on-type digital multimeter. This meter is capable of measuring alternating current (AC) & direct current (DC) without requiring that circuit be disconnected to install meter in series. Jaws are simply placed over wire and current flow through the circuit is displayed.
	<p><u>DEMONSTRATE</u> PROPER WAY TO CONNECT TEST LEADS TO DMM. POINT OUT INPUT TERMINALS ON DMM & FUNCTIONS. TELL STUDENTS THAT READING ON WRONG INPUT COULD DESTROY METER</p>
	<p><u>EXPLAIN TECH TIP:</u> <i>Over-Limit Display Does Not Mean the Meter Is Reading “Nothing”</i></p> <p>The meaning of the over-limit display on a digital meter often confuses beginning technicians. When asked what the meter is reading when an over limit (OL) is displayed on the meter face, the response is often, “Nothing.” Many meters indicate over limit or over load, which simply means that the reading is over the maximum that can be displayed for selected range. For example, meter displays OL if 12 volts are being measured, but the meter has been set to read a maximum of 4 volts. Autoranging meters adjust the range to match what is being measured. Here OL means a value higher than the meter can read (unlikely on the voltage scale for automobile usage), or infinity when measuring resistance (ohms). Therefore, OL means infinity when measuring resistance or an open circuit is being indicated. The meter reads 00.0 if the</p>

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resistance is zero, so “nothing” in this case indicates continuity (zero resistance), whereas OL indicates infinite resistance. Therefore, when talking with another technician about a meter reading, make sure you know exactly what the reading on the face of the meter means. Also be sure that you are connecting the meter leads correctly. • **SEE FIGURE 6-15.**

16. SLIDE 16 **EXPLAIN** Over Limit Display Does Not Mean the Meter Is Reading “Nothing” **FIGURE 6-15** Typical digital multimeter showing OL (over limit) on the readout with the ohms (Ω) unit selected. This usually means that the unit being measured is open (infinite resistance) and has no continuity

17. SLIDE 17 **EXPLAIN** Figure 6-16 Always look at meter display when a measurement is being made, especially if using an autoranging meter

DISCUSSION: HAVE STUDENTS DISCUSS VARIOUS SCALES AND SETTINGS ON A DMM. WHAT IS REASON THAT TEST RESULTS USING A DMM ARE MORE ACCURATE? DISCUSS THE AUTORANGE FEATURES

EXPLAIN TECH TIP: *Think of Money*

Digital meter displays can often be confusing. The display for a battery measured as 12 1/2 volts would be 12.50 V, just as \$12.50 is 12 dollars and 50 cents. A 1/2-volt reading on a digital meter will be displayed as 0.50 V, just as \$0.50 is half of a dollar. It is more confusing when low values are displayed. For example, if a voltage reading is 0.063 volt, an autoranging meter will display 63 millivolts (63 mV), or 63/1,000 of a volt, or \$63 of \$1,000. (It takes 1,000 mV to equal 1 volt.) Think of millivolts as one-tenth of a cent, with 1 volt being \$1.00. Therefore, 630 millivolts are equal to \$0.63 of \$1.00 (630 tenths of a cent, or 63 cents). To avoid confusion, try to manually range meter to read base units (whole volts). If meter is ranged to base unit volts, 63 millivolts would be displayed as

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0.063 or maybe just 0.06, depending on display capabilities of meter.

EXPLAIN TECH TIP: *Purchase a Digital Meter That Will Work for Automotive Use.* Try to purchase a digital meter that is capable of reading following:

- DC volts
- AC volts
- DC amperes (up to 10 A or more is helpful)
- Ohms up to 40 M Ω (40 million ohms)
- Diode check

Additional features include:

- Frequency (hertz, abbreviated Hz)
- Temperature probe ($^{\circ}$ F and/or $^{\circ}$ C)
- Pulse width (millisecond, abbreviated ms)
- Duty cycle



18. SLIDE 18 **EXPLAIN** Figure 6-17 When reading AC voltage signals, a true RMS meter (such as a Fluke 87) provides different reading than an average responding meter (such as Fluke 88). Only place this difference is important is when a reading is to be compared with a specification.

DISCUSS CHART 6-2 CONVERSION CHART SHOWING DECIMAL POINT LOCATION FOR PREFIXES.

DISCUSS CHART 6-3 SAMPLE METER READINGS, USING MANUALLY SET AND AUTORANGING SELECTION ON METER CONTROL.

19. SLIDE 19 **EXPLAIN** Figure 6-18 This meter display shows 052.2 AC volts. Notice that the zero beside the 5 indicates that the meter can read over 100 volts AC with a resolution of 0.1 volt.











SAFETY METER USAGE ON HYBRID-ELECTRIC VEHICLES

MANY HYBRID-ELECTRIC VEHICLES USE SYSTEM VOLTAGE AS HIGH AS 650 VOLTS DC. BE SURE TO FOLLOW ALL OEM TESTING PROCEDURES. IF A VOLTAGE MEASUREMENT IS NEEDED BE SURE TO USE A METER AND TEST LEADS THAT ARE DESIGNED TO INSULATE AGAINST HIGH VOLTAGES.



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	<p>THE <u>INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC)</u> HAS SEVERAL CATEGORIES OF VOLTAGE STANDARDS FOR METER AND METER LEADS. THESE CATEGORIES ARE RATINGS FOR OVERVOLTAGE PROTECTION AND ARE RATED CAT I, CAT II, CAT III, AND CAT IV. HIGHER CATEGORY RATING, GREATER PROTECTION AGAINST VOLTAGE SPIKES CAUSED BY HIGH-ENERGY CIRCUITS. UNDER EACH CATEGORY, THERE ARE VARIOUS ENERGY AND VOLTAGE RATINGS.</p> <p>CAT I METER IS USED FOR LOW-ENERGY VOLTAGE MEASUREMENTS, SUCH AS AT WALL OUTLETS IN THE HOME. METERS WITH A CAT I RATING ARE USUALLY RATED AT 300 TO 800 VOLTS.</p> <p>CAT II THIS HIGHER RATED METER IS TYPICALLY USED FOR CHECKING HIGHER ENERGY LEVEL VOLTAGES AT THE FUSE PANEL IN THE HOME. METERS WITH A CAT II RATING ARE USUALLY RATED AT 300 TO 600 VOLTS.</p> <p>CAT III THIS MINIMUM-RATED METER SHOULD BE USED FOR HYBRID VEHICLES. THE CAT III CATEGORY IS DESIGNED FOR HIGH-ENERGY LEVELS AND VOLTAGE MEASUREMENTS AT THE SERVICE POLE AT THE TRANSFORMER. METERS WITH THIS RATING ARE USUALLY RATED AT 600 TO 1,000 VOLTS.</p> <p>CAT IV CAT IV METERS ARE FOR CLAMP-ON METERS ONLY. IF A CLAMP-ON METER ALSO HAS METER LEADS FOR VOLTAGE MEASUREMENTS, THAT PART OF THE METER IS RATED AS CAT III.</p> <p>NOTE: ALWAYS USE THE HIGHEST CAT RATING METER, ESPECIALLY WHEN WORKING WITH HYBRID VEHICLES. A CAT III, 600-VOLT METER IS SAFER THAN A CAT II, 1,000-VOLT METER BECAUSE OF THE ENERGY LEVEL OF THE CAT RATINGS. THEREFORE, FOR BEST PERSONAL PROTECTION, USE ONLY METERS AND METER LEADS THAT ARE CAT III-OR CAT IV-RATED WHEN MEASURING VOLTAGE ON A HYBRID VEHICLE. • SEE FIGURES 42-19 AND 42-20.</p>

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	<p>20. SLIDE 20 EXPLAIN Figure 6-19 Be sure to only use a meter that is CAT III rated when taking electrical voltage measurements on a hybrid vehicle &</p> <p>21. SLIDE 21 EXPLAIN FIGURE 6-20 Always use meter leads that are CAT III rated on a meter that is also CAT III rated, to maintain the protection needed when working on hybrid vehicles</p>
 <p> Education Foundation</p>	<p>22. SLIDES 22-44 SLIDE SHOW ON DMM USE ASE EDUCATION TASK SHEET A5. DEMONSTRATE PROPER USE OF A TEST LIGHT ON AN ELECTRICAL CIRCUIT.</p>
 <p> Education Foundation</p>	<p>ASE EDUCATION TASK SHEET A6. USE FUSED JUMPER WIRES TO CHECK OPERATION OF ELECTRICAL CIRCUITS.</p>
 <p> Education Foundation</p>	<p>ASE EDUCATION TASK SHEET A3. DEMONSTRATE PROPER USE OF A DIGITAL MULTIMETER (DMM) WHEN MEASURING SOURCE VOLTAGE, VOLTAGE DROP (INCLUDING GROUNDS), CURRENT FLOW AND RESISTANCE.</p>
	<p>HOMework 2: HAVE STUDENTS USE INTERNET TO RESEARCH DIGITAL MULTIMETERS USED IN THE AUTOMOTIVE REPAIR FIELD. ASK THEM TO LIST FOUR TO FIVE METERS, THEIR MAIN FEATURES, AND THE COST OF EACH METER. HAVE STUDENTS DETERMINE WHICH METER THEY THINK WOULD BE THE BEST PURCHASE AND EXPLAIN THEIR CHOICE AND REASONING TO THE CLASS.</p>