

# AUTO-1510: AUTOMOTIVE ELECTRICAL SYSTEMS

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## Cuyahoga Community College

**Viewing: AUTO-1510 : Automotive Electrical Systems**

**Board of Trustees:**

January 2022

**Academic Term:**

Fall 2022

**Subject Code**

AUTO - Automotive Technology

**Course Number:**

1510

**Title:**

Automotive Electrical Systems

**Catalog Description:**

Integrates operational principles and diagnostic skills needed to repair various vehicle electrical systems utilizing electrical concepts and schematics. Charging and starting systems, including security systems, supplemental restraint (SRS), instrumentation, and body computers and related accessories are explained and analyzed. Laboratory practice provides student applied knowledge for troubleshooting these systems.

**Credit Hour(s):**

3

**Lecture Hour(s):**

2

**Lab Hour(s):**

3

## Requisites

**Prerequisite and Corequisite**

AUTO-1502 Automotive Electrical Fundamentals; or departmental approval.

## Outcomes

**Course Outcome(s):**

Diagnose, repair, and maintain electronic brake, traction and stability control systems

**Essential Learning Outcome Mapping:**

Critical/Creative Thinking: Analyze, evaluate, and synthesize information in order to consider problems/ideas and transform them in innovative or imaginative ways.

**Objective(s):**

1. Inspect, test, and/or replace components of brake warning light system.
2. Identify components of brake warning light system.
3. Check electric parking brake operation and parking brake indicator light system operation; determine necessary action.
4. Identify and inspect electronic brake control system components; determine necessary action.
5. Identify traction control/vehicle stability control system components.
6. Test, diagnose, and service electronic brake control system speed sensors (digital and analog), toothed ring (tone wheel), and circuits using a graphing multimeter (GMM)/digital storage oscilloscope (DSO) (includes output signal, resistance, shorts to voltage/ground, and frequency data).

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**Course Outcome(s):**

Prepare vehicle for customer.

**Objective(s):**

1. Ensure vehicle is prepared to return to customer per school/company policy (floor mats, steering wheel cover, etc.).
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**Course Outcome(s):**

Perform General Electrical System Diagnosis and Identify a Logical Electrical Circuit Testing Order

**Essential Learning Outcome Mapping:**

Critical/Creative Thinking: Analyze, evaluate, and synthesize information in order to consider problems/ideas and transform them in innovative or imaginative ways.

**Objective(s):**

1. Check operation of electrical circuits with a test light.
  2. Check operation of electrical circuits with fused jumper wires.
  3. Replace electrical connectors and terminal ends.
  4. Repair data bus wiring harness.
  5. Check electrical/electronic circuit waveforms; interpret readings and determine needed repairs.
  6. Disable and enable supplemental restraint system (SRS); verify indicator lamp operation.
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**Course Outcome(s):**

Diagnose, repair, and maintain the vehicles starting system

**Essential Learning Outcome Mapping:**

Critical/Creative Thinking: Analyze, evaluate, and synthesize information in order to consider problems/ideas and transform them in innovative or imaginative ways.

**Objective(s):**

1. Perform starter current draw tests; determine necessary action.
  2. Perform starter circuit voltage drop tests; determine necessary action.
  3. Inspect and test starter relays and solenoids; determine necessary action.
  4. Remove and install starter in a vehicle.
  5. Inspect and test switches, connectors, and wires of starter control circuits; determine necessary action.
  6. Differentiate between electrical and engine mechanical problems that cause a slow-crank or a no-crank condition.
  7. Demonstrate knowledge of an automatic idle-stop/start-stop system.
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**Course Outcome(s):**

Diagnose, repair, and maintain the vehicles charging system.

**Essential Learning Outcome Mapping:**

Critical/Creative Thinking: Analyze, evaluate, and synthesize information in order to consider problems/ideas and transform them in innovative or imaginative ways.

**Objective(s):**

1. Perform charging system output test; determine necessary action.
  2. Diagnose charging system for causes of undercharge, no-charge, or overcharge conditions.
  3. Remove, inspect, and/or replace generator (alternator).
  4. Remove, inspect, and re-install generator (alternator).
  5. Perform charging circuit voltage drop tests; determine necessary action.
  6. Confirm proper battery capacity for vehicle application; perform battery capacity and load test; determine needed action.
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**Course Outcome(s):**

Diagnose and repair the vehicles gauges, warning devices, and driver information systems

**Essential Learning Outcome Mapping:**

Critical/Creative Thinking: Analyze, evaluate, and synthesize information in order to consider problems/ideas and transform them in innovative or imaginative ways.

**Objective(s):**

1. Verify operation of the instrument panel engine warning indicators.
2. Inspect, test, and replace oil temperature and pressure switches and sensors.
3. Inspect and test gauges and gauge sending units for causes of abnormal gauge readings; determine necessary action.
4. Diagnose the causes of incorrect operation of warning devices and other driver information systems; determine necessary action.

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**Course Outcome(s):**

Diagnose, repair, and maintain vehicles accessory systems.

**Essential Learning Outcome Mapping:**

Critical/Creative Thinking: Analyze, evaluate, and synthesize information in order to consider problems/ideas and transform them in innovative or imaginative ways.

**Objective(s):**

1. Diagnose incorrect operation of motor-driven accessory circuits; determine necessary action.
2. Diagnose incorrect electric lock operation (including remote keyless entry); determine necessary action.
3. Diagnose incorrect operation of cruise control systems; determine necessary action.
4. Diagnose (troubleshoot) supplemental restraint system (SRS) problems; determine necessary action.
5. Disable and enable an airbag system for vehicle service; verify indicator lamp operation.
6. Remove and reinstall door panel.
7. Describe the operation of keyless entry/remote-start systems.
8. Reset maintenance indicators as required.
9. Diagnose (troubleshoot) body electronic system circuits using a scan tool; determine necessary action.
10. Diagnose the cause(s) of false, intermittent, or no operation of anti-theft systems.

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**Course Outcome(s):**

Comply with appropriate shop safety procedures, concerning personal protective items, including those specifically required while working with electrical circuits.

**Objective(s):**

1. Identify general shop safety rules and procedures.
2. Utilize safe procedures for handling of tools and equipment.
3. Identify and use proper placement of floor jacks and jack stands.
4. Identify and use proper procedures for safe lift operation.
5. Utilize proper ventilation procedures for working within the lab/shop area.
6. Identify marked safety areas.
7. Identify the location and the types of fire extinguishers and other fire safety equipment; demonstrate knowledge of the procedures for using fire extinguishers and other fire safety equipment.
8. Identify the location and use of eye wash stations.
9. Identify the location of the posted evacuation routes.
10. Comply with the required use of safety glasses, ear protection, gloves, and shoes during lab/shop activities.
11. Identify and wear appropriate clothing for lab/shop activities.
12. Secure hair and jewelry for lab/shop activities.
13. Demonstrate awareness of the safety aspects of supplemental restraint systems (SRS), electronic brake control systems, and hybrid vehicle high voltage circuits.
14. Demonstrate awareness of the safety aspects of high voltage circuits (such as high intensity discharge (HID) lamps, ignition systems, injection systems, etc.).
15. Locate and demonstrate knowledge of material safety data sheets (MSDS).

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**Course Outcome(s):**

Apply the principles and fundamentals of electrical circuits and use the correct tools, equipment and service information to evaluate and maintain vehicle electrical systems, taking into account safety, work ethics and behaviors, proper repair techniques, and customer needs.

**Essential Learning Outcome Mapping:**

Critical/Creative Thinking: Analyze, evaluate, and synthesize information in order to consider problems/ideas and transform them in innovative or imaginative ways.

**Objective(s):**

1. Identify tools and their usage in automotive applications.
2. Identify standard and metric designation.
3. Demonstrate safe handling and use of appropriate tools.
4. Demonstrate proper cleaning, storage, and maintenance of tools and equipment.
5. Demonstrate proper use of precision measuring tools (i.e. micrometer, dial-indicator, dial-caliper).
6. Identify safety precautions for high voltage systems on electric, hybrid, hybrid-electric, and diesel vehicles.
7. Identify electrical/electronic modules, security systems, radios, and other accessories that require reinitialization or code entry after reconnecting vehicle battery.

**Course Outcome(s):**

Prepare vehicle for service.

**Objective(s):**

1. Identify information needed and the service requested on a repair order.
  2. Identify purpose and demonstrate proper use of fender covers, mats.
  3. Demonstrate use of the three C's (concern, cause, and correction).
  4. Review vehicle service history.
  5. Complete work order to include customer information, vehicle identifying information, customer concern, related service history, cause, and correction.
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**Course Outcome(s):**

Diagnose operation of comfort and convenience accessories and related circuits

**Objective(s):**

1. Diagnose operation of comfort and convenience accessories and related circuits (such as: power window, power seats, pedal height, power locks, truck locks, remote start, moon roof, sun roof, sun shade, remote keyless entry, voice activation, steering wheel controls, back-up camera, parking assist, cruise control, and auto dimming headlamps); determine needed repairs.
  2. Diagnose operation of security/anti-theft systems and related circuits (such as: theft deterrent, door locks, remote keyless entry, remote start, and starter/fuel disable); determine needed repairs.
  3. Diagnose operation of entertainment and related circuits (such as: radio, DVD, remote CD changer, navigation, amplifiers, speakers, antennas, and voice-activated accessories); determine needed repairs.
  4. Diagnose operation of safety systems and related circuits (such as: horn, airbags, seat belt pretensioners, occupancy classification, wipers, washers, speed control/collision avoidance, heads-up display, parking assist, and back-up camera); determine needed repairs.
  5. Diagnose body electronic systems circuits using a scan tool; check for module communication errors (data communication bus systems); determine needed action.
  6. Describe the process for software transfer, software updates, or reprogramming of electronic modules.
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**Methods of Evaluation:**

1. Participation and discussion
2. Observation
3. Written assignments
4. Exams
5. Quizzes
6. Lab tasks
7. Classroom recitations

**Course Content Outline:**

1. Batteries
  - a. Functions
    - i. operate electrical if engine is not running
    - ii. operate starter during cranking
    - iii. energy may be needed if insufficient charging
    - iv. voltage stabilizer
  - b. Electrochemical action and components
    - i. sponge lead
    - ii. positive plate - lead peroxide
    - iii. electrolyte - sulfuric acid and water
    - iv. affect on plates and electrolyte during discharge
    - v. cycling
  - c. Battery types
    - i. vent cap
    - ii. low-maintenance
    - iii. maintenance free
    - iv. absorbed glass mat (AGM)
  - d. Low-maintenance and maintenance free

- i. most common
    - ii. need little or no water
    - iii. use calcium alloy for plate grids and have larger electrolyte capacity
  - e. Battery electrolyte
    - i. definition of specific gravity
    - ii. chemical make up
    - iii. battery's state of charge checked with specific gravity
  - f. State of charge indicators
    - i. visual charge indicators
    - ii. Delco-Remy design
  - g. Battery charging voltage
    - i. means by which a battery is charged
    - ii. counterelectromotive force and internal resistance
  - h. Battery selection and rating methods
    - i. types of 12 volt batteries
      - 1. starting
      - 2. cycling
    - ii. battery ratings
      - 1. ampere hour
      - 2. cold cranking amps (CCA)
      - 3. reserve capacity
    - iii. group number
  - i. Battery installation
    - i. determinants of battery location
      - 1. battery cable length
      - 2. airflow cooling
      - 3. secure mounting
      - 4. accessibility for servicing
    - ii. mounting locations
      - 1. engine compartment
      - 2. trunk
      - 3. under seat
    - iii. two battery setup
    - iv. installation components
      - 1. styles of connectors
      - 2. carrier tray
      - 3. hold-down brackets
      - 4. heat shields
  - j. Battery life and performance factors
    - i. electrolyte level
    - ii. corrosion
    - iii. overcharging
    - iv. undercharging and sulfating
    - v. deep cycling
    - vi. temperature
    - vii. vibration
- 2. Charging systems and alternators
  - a. Charging system history
    - i. DC generator
    - ii. AC generator advantages
      - 1. lighter weight
      - 2. operate at higher speeds
      - 3. longer brush life
      - 4. current production not dependant on direction of rotation
  - b. Charging voltage
    - i. 14.5 volts output
  - c. Components
    - i. battery
    - ii. alternator

- iii. regulator
- iv. ammeter or voltmeter
- d. Circuits
  - i. field
  - ii. output
- e. Single phase current
  - i. means of voltage induction
  - ii. single phase voltage
  - iii. sine wave
  - iv. diode rectification
  - v. multiple phase voltage needed
  - vi. alternating current converted to direct current
  - vii. components used
- f. Alternator construction
  - i. rotor
    - 1. usually twelve poles
  - ii. pole pieces
  - iii. rotor windings
  - iv. stator consists of three conductors wound onto a cylindrical core
  - v. nonmagnetic housing
  - vi. slip ring end
  - vii. drive end
  - viii. housing grounded to engine
  - ix. slip rings and brushes conduct current to rotor
  - x. most alternators have two slip rings
  - xi. field current is 1.5 to 3 amperes
  - xii. alternators typically have three positive and three negative diodes
- g. Current production
  - i. excitation of field circuit
  - ii. current source with key-on, engine off
  - iii. current source once alternator produces current
  - iv. battery discharge prevented with key-off, engine-off
- h. Types of alternator field circuits
  - i. A-circuit
  - ii. B-circuit
  - iii. isolated-field circuit
- i. Voltage regulation
  - i. field current changes as sensed system voltage and rotor speed changes
- j. Solid-state regulators
  - i. advantages
    - 1. compact
    - 2. not seriously affected by temperature
    - 3. no moving parts
- k. Computer-controlled regulation
  - i. trouble codes
  - ii. components
    - 1. diodes
    - 2. transistors
    - 3. Zener diodes
    - 4. thermistors
    - 5. capacitor
- l. Indicators
  - i. ammeter
  - ii. voltmeter
  - iii. indicator lamps
- m. Charging system protection
  - i. dangers
  - ii. excessive heat
  - iii. excessive amperage

- iv. voltage surges
- v. fusible links
- 3. Starting system overview
  - a. Starting system operation
    - i. requires large cable due to high current flow
    - ii. circuits
    - iii. starter
    - iv. control
  - b. Starting system components
    - i. battery
    - ii. ignition switch
    - iii. starter safety switch
    - iv. relays or solenoids
    - v. starter motor
    - vi. heavy gauge cables
    - vii. ignition switch
      - 1. four or five positions
      - 2. panel mounted
      - 3. column mounted
    - viii. starting safety switch
    - ix. relays and solenoids
  - c. Starter motors
    - i. frame and field assembly
      - 1. frame
      - 2. iron cylindrical center
      - 3. brush end housing
      - 4. drive end housing
      - 5. creation of magnetic field
      - 6. iron pole shoes
      - 7. heavy copper ribbon field windings
      - 8. starter motor produces torque or rotary force
    - ii. motor types
      - 1. series
      - 2. shunt
      - 3. compound
    - iii. armature and commutator assembly
      - 1. armature has laminated core
      - 2. commutator wired to armature
      - 3. composition of commutator
      - 4. armature shaft
      - 5. armature winding
      - 6. commutator and brushes
    - iv. pinion gear
  - d. Starter motor and drive types
    - i. methods of engaging and disengaging the pinion with the flywheel
      - 1. solenoid actuated, direct drive
      - 2. solenoid actuated, gear reduction drive
      - 3. movable pole shoe drive
      - 4. permanent magnet
    - ii. overrunning clutch
    - iii. drive type application
    - iv. rollers
    - v. transmits motion in one direction
- 4. Semiconductors and solid-state electronics
  - a. Semiconductors
    - i. elements of four valence rings
    - ii. neither good conductors nor good insulators
    - iii. N-material

- iv. P-material
- v. hole flow
- b. Voltage and semiconductors
  - i. reaction to voltage
  - ii. diode allows current flow only in one direction
  - iii. biasing
    - 1. forward biased
    - 2. reverse biased
  - iv. Zener diode
    - 1. peak inverse voltage
- c. Light-emitting diodes (LED)
- d. Clamping diode
- e. Transistors
  - i. Negative-Positive-Negative (NPN) and Positive-Negative-Positive (PNP) types
  - ii. phototransistors
  - iii. three leads
    - 1. base
    - 2. emitter
    - 3. collector
  - iv. similar in function to a relay
- 5. Automotive computer systems
  - a. Elements of the computer
    - i. programs
    - ii. functions
      - 1. input
      - 2. processing
      - 3. storage
      - 4. output
  - b. Automotive on-board computers
  - c. Analog and digital systems
    - i. analog systems
    - ii. digital systems
    - iii. digital computers change analog input signals to digital bits
  - d. Computer programs
    - i. programs
    - ii. instruct the computer how to determine the vehicle's condition
    - iii. store fixed vehicle values
    - iv. store variable vehicle values
    - v. Electrically erasable programmable read-only memory (EEPROM)
  - e. Computer components
    - i. software and hardware
    - ii. central processing unit (CPU)
    - iii. read only memory (ROM)
    - iv. random access memory (RAM)
    - v. onboard computers can be one purpose or multipurpose units
  - f. Introduction to transducers
    - i. converts one form of energy into another
    - ii. functional characteristics
    - iii. most sensors operate with an input reference voltage
    - iv. computer reads the return signal voltage for changes
    - v. design characteristics
      - 1. repeatability
      - 2. accuracy
      - 3. operating range
      - 4. linearity
    - vi. types
      - 1. switches and timers
      - 2. potentiometers
      - 3. thermistors



- 4. piezoresistive devices
- 5. transformers
- 6. generators
- 7. actuators
- 8. solenoids
- 9. stepper motors
- vii. means of control
  - 1. pulse width modulation
  - 2. duty cycle
- 6. Electromagnetic interference (EMI)
  - a. Affects onboard computer systems
  - b. Transmission methods
    - i. conductive coupling
    - ii. capacitive coupling
    - iii. inductive coupling
    - iv. electromagnetic radiation
  - c. Reduction methods
    - i. resistance
    - ii. capacitors or choke coils
    - iii. metal or metalized plastic shielding
    - iv. ground straps
- 7. Theft deterrent systems
  - a. Function
    - i. scare away thieves
    - ii. attract attention to the vehicle
  - b. Operation
    - i. disable fuel, ignition or starter
    - ii. inform driver of tampering
  - c. Components
    - i. control module
    - ii. door switches
    - iii. trunk key cylinder switch
    - iv. hood switch
    - v. starter inhibit relay
    - vi. horn relay
    - vii. alarm
- 8. Supplemental inflatable restraint (SRS)
  - a. Passive restraint systems
  - b. Components
    - i. air bag module
    - ii. clock spring
    - iii. diagnostic module
    - iv. motion sensors
- 9. Lighting systems
  - a. Headlamp circuits
    - i. circuit types
      - 1. two lamp
      - 2. four lamp
    - ii. circuit diagrams
    - iii. switches and circuit breakers
    - iv. headlamps
      - 1. symmetrical
      - 2. asymmetrical
      - 3. conventional
      - 4. halogen
      - 5. composite
      - 6. high intensity discharge (HID)
      - 7. Light emitting diode (LED)
    - v. headlamp location and mounting

- vi. state and federal laws govern installation
- vii. flash-to-pass circuits
- viii. automatic headlamp systems
- b. Common automotive bulbs
- c. Taillamp, license plate lamp and parking lamp circuits
  - i. circuit diagram
  - ii. switches, fuses, and flashers
  - iii. bulbs
- d. Hazard warning lamp
  - i. circuit diagram
  - ii. switches, fuses and flasher
- e. Backup lamp circuits
  - i. circuit diagram
  - ii. switches and fuses
  - iii. bulbs
- f. Side marker and clearance lamp circuits
  - i. circuit diagrams
  - ii. switches and fuses
  - iii. bulbs
- g. Instrument panel and interior lamp circuits
  - i. instrument panel
  - ii. interior lamps
- 10. Battery service
  - a. Battery safety
    - i. acid burns
    - ii. arcing
    - iii. explosive hydrogen gas
  - b. Inspection, cleaning and replacement
    - i. tools
    - ii. battery inspection
      - 1. electrolyte level
      - 2. inspect case for dirt or grease
      - 3. corrosion
      - 4. cracks and loose terminals
      - 5. missing or damaged cell caps
      - 6. broken cables, corroded wires, or damaged insulation
      - 7. tightness of cable connections
      - 8. properly installed heat shields
    - iii. battery cleaning
    - iv. battery replacement
  - c. Battery testing
    - i. specific gravity test
    - ii. state-of-charge indicators
    - iii. open circuit voltage test
    - iv. capacity (load) test
    - v. three minute charge test
    - vi. battery drain (parasitic load) test
  - d. Battery charging
    - i. charge rate
    - ii. charging safety
    - iii. fast charging precautions
    - iv. maintenance-free charging precautions
  - e. Jump starting
    - i. problems push starting
      - 1. automatic transmission
      - 2. diesel vehicle
      - 3. catalytic converter
    - ii. jump start procedure
    - iii. jump starting dual battery vehicles

11. Charging system testing
  - a. Safety while conducting on-car testing
  - b. Charging system symptoms
    - i. ammeter, voltmeter or warning lamp
    - ii. low battery
    - iii. alternator noises
  - c. Inspection
    - i. battery's state of charge
    - ii. alternator drive belt
    - iii. wiring and connectors
    - iv. alternator and regulator mountings
  - d. Drive belts
    - i. checking belt tensions
    - ii. adjusting belt tensions
    - iii. installing drive belts
  - e. Alternator testing
    - i. positive side voltage drop
    - ii. negative side voltage drop
    - iii. circuit resistance testing
    - iv. current output testing
    - v. voltage output testing
      1. too high
      2. too low
      3. check under load at 2,000 rpm
    - vi. field current draw test
    - vii. full fielding
    - viii. voltage regulator testing
  - f. Alternator removal and installation
12. Starting system testing
  - a. System inspection
    - i. battery
    - ii. ignition switch
    - iii. starter motor
    - iv. starting safety switch
    - v. magnetic switches
  - b. On-car testing
    - i. equipment
      1. voltmeter
      2. ammeter
      3. variable resistance carbon pile
      4. jumper wires
      5. remote starter switch
    - ii. disable ignition system
    - iii. headlight quick test
      1. headlights go out
      2. headlights dim
      3. headlights stay at same brightness
    - iv. cranking voltage test
    - v. current draw test
    - vi. circuit resistance tests
  - c. Starting safety switch replacement and adjustment
  - d. Starter removal and installation
13. Organized troubleshooting
  - a. Opens, grounds, and shorts
  - b. Troubleshooting process
    - i. ask the driver/owner
    - ii. know the system
    - iii. operate the system
    - iv. list the possible causes

- v. isolate the problem circuit
  - vi. know the problem circuit
  - vii. test systematically
  - viii. verify your findings
  - ix. repair
  - x. test your repair
14. General vehicle electrical checks
- a. Accessory ground voltage drop
  - b. Engine ground voltage drop
  - c. High voltage
15. Theft deterrent testing
- a. Visual inspection of individual theft deterrent systems
  - b. Operational checks
    - i. inoperative
    - ii. vehicle will not start
16. Supplemental inflatable restraint (SRS)
- a. Safety warnings
    - i. safety glasses
    - ii. time delay after battery disconnect
    - iii. module handling
    - iv. never use a self-powered test light
    - v. follow manufacturer procedures
  - b. Visual inspection
  - c. Trouble code diagnosis
    - i. scan tool use
  - d. Clockspring replacement
  - e. Motion sensor replacement
  - f. Air bag module replacement
17. Lighting system service
- a. Headlamp replacement and aiming
    - i. headlamp replacement
    - ii. halogen bulb replacement
    - iii. headlight aiming
    - iv. aiming screens
      - 1. mechanical aiming devices
      - 2. photoelectric aiming devices
  - b. Small bulb replacement
  - c. General troubleshooting procedures
    - i. test equipment
      - 1. voltmeter or twelve-volt test light
      - 2. ohmmeter or self-powered test lamp
      - 3. jumper wire
    - ii. troubleshooting when one bulb does not light
    - iii. shorts and grounds
  - d. Specific circuit troubleshooting
    - i. headlamp
      - 1. dimmer switch testing
      - 2. headlamp delay system
    - ii. taillamp, license plate lamp, parking lamp, and side marker lamp
    - iii. stop lamp
    - iv. turn signal and hazard flashers
      - 1. multifunction switch testing
    - v. backup lamp
    - vi. panel and interior lamps
    - vii. foglights
18. Comfort and convenience accessories and circuits
- a. comfort and convenience accessories
  - b. security/anti-theft systems
  - c. entertainment systems
  - d. safety systems

- e. body electronic systems circuits
- f. software
- g. transfer
- h. updates
- i. reprogramming

## Resources

Halderman, James D. *Automotive Electricity and Electronics*. 6th ed. Hoboken, NJ: Pearson, 2021.

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Duffy, James E. *Modern Automotive Technology*. 9th ed. Tinley Park, IL: Goodheart-Willcox, 2017.

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"Automotive Excellence, Vol. 1-2"

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## Resources Other

1. <http://www.howacarworks.com/basics/how-the-charging-system-works/> (<http://www.howacarworks.com/basics/how-the-charging-system-works/>) - How the Charging System Works
2. <http://www.howacarworks.com/basics/how-the-starting-system-works/> (<http://www.howacarworks.com/basics/how-the-starting-system-works/>) - How the Starting System Works
3. <http://auto.howstuffworks.com/ignition-system.htm> - How Automobile Ignition Systems Work
4. <https://www.ericthecarguy.com/faq/solving-automotive-electrical-problems/> (<https://www.ericthecarguy.com/faq/solving-automotive-electrical-problems/>) - Solving Automotive Electrical Problems
5. <http://www.autoshop101.com/> - Automotive Training and Resource Site For Automotive Electronics
6. <http://www.secondchancegarage.com/public/98.cfm> - Auto Theory: Automotive Electrical Systems - Part 1

Top of page

Key: 759