AUTO-1502: AUTOMOTIVE ELECTRICAL FUNDAMENTALS

Cuyahoga Community College

Viewing: AUTO-1502 : Automotive Electrical Fundamentals

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Subject Code

AUTO - Automotive Technology

Course Number:

1502

Title:

Automotive Electrical Fundamentals

Catalog Description:

Fundamentals of electricity for automotive technicians. Electrical theory applied through construction of series, parallel and series-parallel circuits. Digital Volt Ohm Meter (DVOM) use in electrical diagnosing and testing of circuits covered, along with wire repair techniques. Emphasis on interpreting and using automotive electrical wiring schematics. Batteries, horn, wiper and lighting systems examined.

Credit Hour(s):

3

Lecture Hour(s):

2

Lab Hour(s):

3

Requisites

Prerequisite and Corequisite

None.

Outcomes

Course Outcome(s):

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

Essential Learning Outcome Mapping:

Not Applicable: No Essential Learning Outcomes mapped. This course does not require application-level assignments that demonstrate mastery in any of the Essential Learning Outcomes.

Objective(s):

1. Discuss jewelry and clothing items that are unsafe for the lab and automotive work environment.
2. Check operation of electrical circuits with fused jumper wires.
3. Use wiring diagrams during the diagnosis (troubleshooting) of electrical/electronic circuit problems.
4. Wear personal protective equipment in the automotive lab.
5. Identify and select appropriate personal protective items for working in the automotive lab.

Course Outcome(s):

Diagnose and repair automotive accessory systems and components.

Objective(s):

1. Diagnose (troubleshoot) incorrect operation of motor-driven accessory circuits; determine necessary action.
2. Diagnose (troubleshoot) incorrect electric lock operation (including remote keyless entry); determine necessary action.

3. Diagnose (troubleshoot) 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. Check for module communication errors (including CAN/BUS systems) using a scan tool.
8. Describe the operation of keyless entry/remote-start systems.
9. Verify operation of instrument panel gauges and warning/indicator lights; reset maintenance indicators.
10. Verify windshield wiper and washer operation, replace wiper blades.

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.

Objective(s):

1. Research vehicle service information including vehicle service history, service precautions, and technical service bulletins.Research vehicle service information including vehicle service history, service precautions, and technical service bulletins.
2. Calculate resistance totals in series, parallel, and series-parallel circuits, using Ohm's Law.
3. Demonstrate proper use of a test light on an electrical circuit.
4. Use wiring diagrams during the diagnosis (troubleshooting) of electrical/electronic circuit problems.
5. Demonstrate proper use of a digital volt ohm meter (DVOM) by accurately reading volts, ohms and amperage on constructed series, parallel, and series/parallel circuits.
6. Demonstrate ability to interpret electrical diagrams by locating conductors, components, connections, and grounds on a vehicle.
7. Display knowledge of electrical diagnostic process using electrical theory, tools and schematics.
8. Display knowledge of automotive battery construction, testing and maintenance.
9. Diagnose and repair horn, wiper/washer and lighting circuits using electrical theory, tools and schematics.
10. Apply electrical principles to assemble and diagnose series, parallel, and series-parallel circuits to measure resistance, voltage drops, and current flow.

Course Outcome(s):

Diagnose and service automotive electrical systems.

Objective(s):

1. Research applicable vehicle and service information, vehicle service history, service precautions, and technical service bulletins.
2. Demonstrate knowledge of electrical/electronic series, parallel, and series-parallel circuits using principles of electricity (Ohm's Law).
3. Demonstrate proper use of a digital multimeter (DMM) when measuring source voltage, voltage drop (including grounds), current flow and resistance.
4. Demonstrate knowledge of the causes and effects from shorts, grounds, opens, and resistance problems in electrical/electronic circuits.
5. Demonstrate proper use of a test light on an electrical circuit.
6. Use fused jumper wires to check operation of electrical circuits.
7. Use wiring diagrams during the diagnosis (troubleshooting) of electrical/electronic circuit problems.
8. Use wiring diagrams during the diagnosis (troubleshooting) of electrical/electronic circuit problems.
9. Diagnose the cause(s) of excessive key-off battery drain (parasitic draw); determine necessary action.
10. Inspect and test fusible links, circuit breakers, and fuses; determine necessary action.
11. Inspect, test, repair, and/or replace components, connectors, terminals, harnesses, and wiring in electrical/electronic systems (including solder repairs); determine needed action.
12. . Inspect and test switches, connectors, relays, solenoid solid state devices, and wires of electrical/electronic circuits; determine necessary action.
13. Replace electrical connectors and terminal ends.
14. Repair wiring harness.
15. Perform solder repair of electrical wiring.

Course Outcome(s):

Diagnose and service automotive batteries.

Objective(s):

1. Perform battery state-of-charge test; determine necessary action.
2. Confirm proper battery capacity for vehicle application; perform battery capacity test; determine necessary action.
3. Maintain or restore electronic memory functions.
4. Inspect and clean battery; fill battery cells; check battery cables, connectors, clamps, and hold-downs.
5. Perform slow/fast battery charge according to manufacturer's recommendations.
6. Jump-start vehicle using jumper cables and a booster battery or an auxiliary power supply.

7. Identify high-voltage circuits of electric or hybrid electric vehicle and related safety precautions.
8. Identify electronic modules, security systems, radios, and other accessories that require reinitialization or code entry after reconnecting vehicle battery.
9. Identify hybrid vehicle auxiliary (12v) battery service, repair, and test procedures.

Course Outcome(s):

Diagnose and service starting systems and components.

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.

Course Outcome(s):

Diagnose and service charging systems and components.

Objective(s):

1. Perform charging system output test; determine necessary action.
2. Diagnose (troubleshoot) charging system for causes of undercharge, no charge, or overcharge conditions.
3. Inspect, adjust, or replace generator (alternator) drive belts; check pulleys and tensioners for wear; check pulley and belt alignment.
4. Remove, inspect, and re-install generator (alternator).
5. Perform charging circuit voltage drop tests; determine necessary action.

Course Outcome(s):

Diagnose and service lighting systems and components.

Objective(s):

1. Diagnose (troubleshoot) the causes of brighter-than-normal, intermittent, dim, or no light operation; determine necessary action.
2. Inspect interior and exterior lamps and sockets including headlights and auxiliary lights (fog lights/driving lights); replace as needed.
3. Aim headlights.
4. Identify system voltage and safety precautions associated with high intensity discharge headlights.

Course Outcome(s):

Diagnose and repair gauges, warning devices, and driver information systems.

Objective(s):

1. Inspect and test gauges and gauge sending units for causes of abnormal gauge readings; determine necessary action.
2. Diagnose (troubleshoot) the causes of incorrect operation of warning devices and other driver information systems; determine necessary action.

Course Outcome(s):

Diagnose and repair horn and wiper/washer systems and components.

Objective(s):

1. Diagnose (troubleshoot) causes of incorrect horn operation; perform necessary action.
2. Diagnose (troubleshoot) causes of incorrect wiper operation; diagnose wiper speed control and park problems; perform necessary action.
3. Diagnose (troubleshoot) windshield washer problems; perform necessary action.

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. Safety
    a. Personal protective equipment
    b. Unsafe jewelry
    c. Unsafe clothing items
    d. Electric circuit safety guidelines
2. Fundamentals of electricity and electrical circuits
    a. Atomic structure
        i. matter
        ii. atom
            1. proton
            2. neutron
            3. electron
        iii. shells
            1. free electrons
            2. bound electrons
        iv. conductor
        v. insulators
        vi. semiconductors
    b. Electron flow
        i. electrical circuit
            1. source
            2. ground
            3. load
            4. conductor
            5. controls
            6. protection devices
        ii. conventional flow theory
        iii. electron flow theory
        iv. closed circuit
        v. open circuit
        vi. power side switched
        vii. ground side switched
        viii. normally open switches and relays
        ix. normally closed switches and relays
        x. voltage
        xi. amperage
            1. alternating current
            2. direct current
    c. Resistance to current flow
        i. resistance
        ii. determinants of resistance
            1. conductor material
            2. conductor length
            3. conductor cross-sectional area
            4. conductor temperature
            5. conductor condition
        iii. resistor types
            1. fixed value
            2. stepper resistor
            3. rheostat
            4. potentiometer
            5. Positive Temperature Coefficient (PTC)/Negative Temperature Coefficient (NTC)
        iv. voltage drop
    d. Ohm"s law

i. definition of an ohm

e. Common electrical parts
   i. switches
      1. hinged pawl
      2. mercury
      3. momentary contact
      4. temperature sensitive
      5. ganged
   ii. actuators
      1. relays
      2. solenoids
      3. motors
   iii. buzzers and chimes
   iv. protection devices
      1. glass fuses
      2. ceramic fuses
      3. mini blade fuse
      4. maxi blade fuse
      5. fuse panel
      6. cycling circuit breaker
      7. non-cycling circuit breaker
      8. fusible links

f. Electrical circuits
   i. series circuits
      1. series circuits and Ohm"s law
      2. current is constant throughout the circuit
      3. sum of all voltage drops equals the source voltage
      4. total resistance equals the sum of all the individual resistances
   ii. parallel circuits
      1. parallel circuits and Ohm"s law
      2. voltage is constant across each branch of the circuit
      3. sum of the current through every circuit branch equals total current
      4. total resistance is less than the lowest individual resistance
   iii. series-parallel circuits combine the two types of circuits

3. Magnetism and electromagnetism
   a. Sources of electricity
      i. friction
      ii. heat
      iii. light
      iv. pressure
      v. chemistry
      vi. magnetism
   b. Fundamentals of magnetism
      i. flux lines
      ii. polarity
         1. unlike charges attract
         2. like charges repel
      iii. permeability
      iv. reluctance
   c. Electromagnetism
      i. current-carrying conductor surrounded by magnetic fields
      ii. straight conductors
         1. concentric cylinders of flux lines
         2. strength of current determines number of flux lines
         3. left and right hand rules
         4. field interaction
         5. electrical energy into mechanical energy
      iii. loop conductor

iv. coil conductor
v. electromagnets

d. Electromagnetic induction
i. definition
ii. determinants of voltage strength
1. strength of the magnetic field
2. number of conductors
3. speed of the relative motion
4. the angle between the flux lines and the conductor
iii. generator principles
1. mechanical energy into electrical energy
2. induced voltage is called alternating current
3. commutator and brushes rectify alternating current
iv. alternator principles
1. changes mechanical energy into electrical energy
2. rectifier uses diodes
v. self-induction
1. counterelectromotive force (CEMF)
vi. mutual induction
1. primary windings
2. secondary windings

4. Wiring components
a. Wiring and harnesses
i. composition
ii. location
iii. poor connections and unwanted resistance
iv. voltage ratings
b. Wire types, materials, and sizes
i. types
1. solid wires
2. stranded wires
3. printed circuit boards
ii. materials
1. copper
2. aluminum
iii. wire gauge numbering
1. American wire gauge (AWG)
2. metric
c. Special wiring
i. battery cables
ii. ignition cables
1. metallic cables
2. non-metallic cables
d. Connectors
i. simple
ii. multiple
iii. bulkhead
iv. positive assurance locks
v. cavities
vi. silicone seals
e. Terminals
i. core wings
ii. insulation wings
iii. locking tang

5. Introduction to electrical circuit diagrams
a. Color coding on wires
i. function and methods of use
b. Diagrams
i. circuit numbering
ii. types of electrical diagrams

1. schematic
2. power source
3. ground distribution
4. wire routing diagram
5. component locator

c. Symbols
   i. grounds
      1. case ground
      2. remote ground
   ii. splices
   iii. connectors
      1. cavities
      2. pin locations
   iv. fuses
   v. relays
   vi. solenoid
   vii. loads
      1. motors
      2. resistors

6. Horn circuits
   a. Circuit diagram
   b. Horn switches
   c. Horns
7. Windshield wipers and washers
   a. Circuit diagram
      i. two speed wipers
      ii. three speed wipers
      iii. delay/intermittent wipers
   b. Switches
   c. Motors
   d. Washer pumps
      i. circuit diagram
8. Specification and service procedure sources
9. Electrical faults
   a. high resistance
      i. corrosion
      ii. damaged wire
      iii. defective parts
      iv. loose connections
   b. low resistance
      i. short-to-ground
      ii. component failure
10. Electrical test equipment
    a. Fused jumper wires
    b. Twelve volt test light
    c. Self-powered test light
    d. Meters and meter design
       i. analog meters
       ii. digital meters
          1. auto ranging
          2. high impedance
          3. metric prefixes
       iii. ammeter
          1. connected in series
          2. polarity important
          3. ammeter scales
          4. ammeter tests
          5. inductive ammeter
       iv. voltmeter

1. connections
2. polarity
3. available voltage
4. voltage drop across a load

v. ohmmeter
1. measures resistance of a conductor
2. circuit must be "dead"
3. zero meter leads first
4. continuity tests
5. continuity buzzer
6. relay testing
7. switch testing
8. fuse testing
9. high resistance testing
10. corrosion at connector
11. cut/chaffed wiring
12. poor grounding point
13. open circuit
14. short circuit or unintended ground
15. checking alternator diode

11. Wiring repair
    a. Safety
    b. Tools
        i. wire cutters
        ii. wire strippers
        iii. terminal crimpers
        iv. low watt soldering iron
        v. seam ripper
    c. Supplies
        i. 60/40 rosin core
        ii. electrical tape
        iii. silicone tape
        iv. heat shrink tubing
        v. crimp-and-seal connectors
    d. Repair methods
        i. splicing
        ii. soldering
        iii. connector attachment
            1. soldering
            2. crimping
        iv. insulation repair
        v. twisted or shielded cable repair
        vi. replacing fusible link
    e. Connector repair
        i. molded or single wire
        ii. position assurance locks
        iii. hard shell
    f. Terminal repair
        i. core wings
        ii. insulation wings
        iii. silicone seal installation
12. Circuit tracing
    a. Tracing current flow
        i. variable wiring schematics
            1. alternate wiring
            2. optional wiring
        ii. means of locating circuits

iii. diagram index and grids
iv. component location when diagram matches vehicle layout

b. Circuit components
i. power source
ii. related loads
iii. ground connection

c. Ground paths and system polarity
i. vehicle frame
ii. battery ground cable and hot cable
iii. ground-side unwanted resistance
iv. negative ground circuit prevalence

13. Horn system service
a. Horn circuit troubleshooting
i. horn will not sound - single horn system
ii. horns will not sound - multiple horn system
iii. one horn will not sound - multiple horn system
iv. horn will not shut off

b. Replacing horn parts

14. Windshield wiper and washer service
a. On-car system testing
i. one speed operation only
ii. no wiper operation
iii. slower than normal
iv. wipers will not park

b. Windshield washer system testing
i. pump operation
ii. hose routing
iii. nozzle check

c. Replacing wiper or washer parts

15. Automotive Batteries
a. Battery fundamentals and construction
i. flooded cell
ii. Absorbed Glass Mat (AGM)

b. Battery Testing
i. State of charge
1. open circuit volts
2. hydrometer
ii. Load testing
iii. Capacitance testing

c. Battery charging
i. slow charge
ii. fast charge

a. Battery maintenance
i. cleaning/neutralizing
ii. refilling

Resources

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

Duffy, James E. *Auto Electricity and Electronics*. 7th ed. Tinley Park, IL: Goodheart-Willcox, 2019.

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Resources Other

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3. http://www.automotivetroubleshootingsecrets.com/automotive_wiring.html - Automotive Troubleshooting Secrets
4. http://autorepair.about.com/library/weekly/aa101604a.htm - Battery Testing, Maintenance & Myths
5. http://www.howacarworks.com/basics/how-car-electrical-systems-work (http://www.howacarworks.com/basics/how-car-electrical-systems-work/) - How Car Electrical Systems Work
6. http://www.howacarworks.com/basics/how-car-electrical-systems-work (http://www.howacarworks.com/basics/how-car-electrical-systems-work/) - Automotive Training and Resource Site for Automotive Electronics
7. http://www.secondchancegarage.com/public/98.cfm - Auto Theory: Automotive Electrical Systems - Part 1

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