

**Reference Materials:** Note: This exam also contains many hands-on type questions you may not find in any reference material listed below  
NFPA reference listed below - National Fire Protection Association, Quincy, MA, (800) 344-3555 or [www.nfpa.org](http://www.nfpa.org)

**NFPA 1900:** Standard for Aircraft Rescue and Firefighting Vehicles, Automotive Fire Apparatus, Wildland Fire Apparatus, and Automotive Ambulances (**NFPA 1901 section**) 2024 edition Chapter 10

**NFPA 1910:** Standard for the Inspection, Maintenance, Refurbishment, Testing and Retirement of In-Service Emergency Vehicles and Marine Firefighting Vessels (**NFPA 1911 section**) 2024 edition Chapter 3,6,9,14,21,26

Any Heavy Truck Electrical Manual-- Suggestion listed below.

**Fundamental Electrical Troubleshooting**, by Dan Sullivan 800-227-1603 <http://www.esitest.com/182.html> or online retailers  
Any emergency apparatus service and operator manual (OEM)

### LEARNING OBJECTIVES FOR THE F-4 EXAM

#### 1. Basic Principles of Electricity-Define or identify:

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| <p>a. Principles of electron flow</p> <ol style="list-style-type: none"> <li>(1) Causes of resistance in circuits</li> <li>(2) Definitions and terms</li> <li>(3) Current flow in parallel circuits</li> <li>(4) Current flow in series circuits</li> <li>(5) Controlling current</li> <li>(6) Spike suppression</li> </ol> <p>b. Ohms Law as applied to electrical circuits</p> <ol style="list-style-type: none"> <li>(1) Relationship of volt, amp, resistance</li> <li>(2) Calculating resistance in parallel circuits</li> <li>(3) Units of measure for Ohm's Law</li> <li>(4) Calculating resistance and voltage in series circuits</li> </ol> | <p>c. Principles of electromagnetism</p> <ol style="list-style-type: none"> <li>(1) How an electromagnet is created</li> <li>(2) Uses of electromagnet</li> <li>(3) Straight conductor vs. coiled conductor</li> </ol> <p>d. Electrical symbols and schematics</p> <ol style="list-style-type: none"> <li>(1) Switch &amp; relay symbol &amp; terminal identification</li> <li>(2) General circuit &amp; symbols, i.e. ground, motors, etc</li> </ol> <p>e. Power Formulas as applied to Electrical circuits</p> <ol style="list-style-type: none"> <li>(1) Relationship of volts, amps, &amp; watts</li> <li>(2) Calculating power, amp, and voltage requirements</li> </ol> <p>f. Circuit types</p> <ol style="list-style-type: none"> <li>(1) Series &amp; parallel</li> <li>(2) Combo series/parallel</li> <li>(3) Shielded Circuits</li> </ol> |
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#### 2. Basic Principles of Operation-Describe or identify:

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| <p>a. Function &amp; application of electrical components and accessories</p> <ol style="list-style-type: none"> <li>(1) relays &amp; diodes</li> <li>(2) switches</li> <li>(3) solenoids</li> <li>(4) interlocks</li> <li>(5) interface</li> <li>(6) inverter &amp; convertors</li> <li>(7) load managers &amp; sequencer</li> <li>(8) electronic throttles</li> <li>(9) ECM/ECU</li> </ol> <p>b. Function and application of electronic components</p> <ol style="list-style-type: none"> <li>(1) diodes</li> <li>(2) capacitors</li> <li>(3) resistors</li> <li>(4) lighting-incandescent, halogen, L.E.D., &amp; strobes</li> <li>(5) data buses</li> <li>(6) multiplexing</li> <li>(7) traffic preemption devices</li> </ol> <p>c. System requirements and performance evaluation</p> <ol style="list-style-type: none"> <li>(1) voltage drop, current draw, resistance</li> </ol> | <p>d. Evaluation of wire size, insulation, and circuit protection</p> <ol style="list-style-type: none"> <li>(1) Fuses and circuit breakers-types</li> <li>(2) insulation ratings</li> <li>(3) wire gauge size</li> </ol> <p>e. Proper wire repair procedures and proper routing techniques</p> <ol style="list-style-type: none"> <li>(1) Solder techniques</li> <li>(2) wire termination, terminal &amp; crimping tool</li> <li>(3) wire loom ratings</li> <li>(4) corrosion protections</li> </ol> <p>f. Equipment and component protection</p> <ol style="list-style-type: none"> <li>(1) welding precautions</li> <li>(2) spike protections</li> <li>(3) static discharge</li> </ol> <p>g. Function, operation, &amp; testing of gauges &amp; warning devices</p> <ol style="list-style-type: none"> <li>(1) ammeters, voltmeters</li> <li>(2) gauges</li> <li>(3) Temperature gauge             <ol style="list-style-type: none"> <li>(a) instrument voltage regulators</li> </ol> </li> <li>(4) electric speedometers &amp; tachometer</li> </ol> |
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#### 3. Basic Use of Diagnostic Equipment/Tools

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| <p>a. Describe diagnostic equipment used to measure voltage, current, resistance &amp; impedance</p> <ol style="list-style-type: none"> <li>(1) Interpretation of oscilloscopes</li> <li>(2) Proper diagnostic equipment/meter connections             <ol style="list-style-type: none"> <li>(a) Voltmeter</li> <li>(b) Ammeter</li> <li>(c) Ohmmeter</li> </ol> </li> </ol> | <p>b. Evaluate quality and application of diagnostic equipment</p> <ol style="list-style-type: none"> <li>(1) Applications of DVOM(DMM)</li> <li>(2) Applications of load testers</li> <li>(3) Applications of analog meters</li> <li>(4) Diagnostic equipment usage             <ol style="list-style-type: none"> <li>(a) Testing diodes</li> </ol> </li> <li>(5) Inductive ammeters</li> <li>(6) Meter Impedance</li> </ol> |
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#### 4. Vehicle Batteries-Describe or Identify:

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| <p>a. Battery construction and performance</p> <ol style="list-style-type: none"> <li>(1) Safety-jump starting</li> <li>(2) Components             <ol style="list-style-type: none"> <li>(a) spark arrester</li> </ol> </li> <li>(3) Purpose-types-construction             <ol style="list-style-type: none"> <li>(a) lead-acid</li> </ol> </li> <li>(4) Define a battery</li> <li>(5) Causes of battery failure</li> </ol> <p>b. How to evaluate battery requirements</p> <ol style="list-style-type: none"> <li>(1) Reserve capacity</li> <li>(2) C.C.A/C.A.</li> </ol> | <ol style="list-style-type: none"> <li>(a) Battery cold cranking rating</li> <li>(3) BCI group identification</li> <li>(4) Operating temperature</li> <li>(5) Battery pack combinations</li> </ol> <p>c. Proper battery maintenance procedures</p> <ol style="list-style-type: none"> <li>(1) Types of chargers</li> <li>(2) Charging rates</li> <li>(3) Battery maintenance</li> </ol> |
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- d. Proper battery testing procedures
  - (1) Replacement
  - (2) Load Testing
  - (3) Conductivity testing
  - (4) Define surface charge
  - (5) Determine state of charge w/DMM

**5. Starting Systems -- Understand the construction and operation of starting system components**

- a. Describe starting system construction and operation
  - (1) Circuit component
  - (2) Mechanical components
    - (a) Starter solenoid
  - (3) Preventing starter motor over-speed
  - (4) Field winding types
  - (5) Pull in & hold in coils
- b. Proper cranking system & component testing procedure
  - (1) Wiring and connections
  - (2) Mechanical components/drive pinions
  - (3) Current draw
  - (4) Slow cranking engine
    - (a) Voltage drop
  - (5) Starter activation circuits
- c. Identify proper repair procedures
  - (1) Connections
  - (2) Solenoid switch contact
  - (3) Starter interlock system
  - (4) Armatures

**6. Charging Systems--Understand construction and operation of the charging system and components**

- a. Alternator construction and operation
  - (1) Function of components
    - (a) Alternator capacitor
    - (b) Voltage regulator
  - (2) Alternator output/operation
  - (3) Alternator Design
  - (4) Component recognition
    - (a) Stator
  - (5) Drive requirements
  - (6) Noise suppression
- b. Alternator & Regulator diagnosis and testing
  - (1) Unit testing
  - (2) Component testing
  - (3) On vehicle/off vehicle testing
    - (a) Undercharge/overcharge condition
  - (4) Battery isolator/isolated systems
  - (5) Mounting hardware
- (6) Regulator adjustment procedure
- (7) Belt tension and wrap
- (8) Maintenance Free vs. Low Maintenance batteries
  - (a) charge voltage
- c. Proper repair procedures
  - (1) Component failures
  - (2) Replacement of regulators and remote rectifier
  - (3) Alternator failures
- d. Evaluate charging system requirements
  - (1) Load analysis
  - (2) Cable size
  - (3) Set output requirements

**7. Troubleshooting --Understand accepted practices used to diagnose and repair electrical circuits.**

- a. Analyzing results
  - (1) Interpretation of functional drawing reading
  - (2) Circuit wiring/connection
  - (3) Current draw
- b. Components
  - (1) Relays/solenoids
  - (2) Interlocks & Interfaces
  - (3) Switches & proximity
  - (4) Load managers
  - (5) Sequencer
  - (6) Proper ground connections
  - (7) Terminals
  - (8) Gauges
- c. Tools and equipment
  - (1) DVOM/DMM
  - (2) Induction meters
  - (3) load tests
- d. Diagnostic tests
  - (1) Voltage drop

**8. NFPA 1911**

- a. Low Voltage Electrical Systems
  - (1) Inspection and Maintenance
    - (a) Automatic electrical load management systems
  - (2) Performance Testing
    - (a) Battery testing
    - (b) Alternator testing
      - (I) Parameters
      - (II) Electrical load
    - (c) Total continuous electrical load test
      - (I) Load Shedding
    - (d) Solenoid and Relay Test
      - (I) Voltage drop maximum
    - (e) Conductivity Test
    - (f) Starter wiring test
    - (g) Regulator test
  - (h) Voltage Drop Spec's
  - (i) Lighting Tests
  - (j) On Board Battery Charger/Conditioner Test
- (3) Out of Service Criteria
- b. Line Voltage Electrical Systems
  - (1) Inspection and Maintenance
  - (2) Performance Testing
  - (3) Out of Service Criteria
  - (4) Power Source Testing
    - (a) Receptacle wiring