



# Hydraulics Fundamentals I

## Single-Day Class

Factory or On-Site Availability

# HELP YOUR TECHNICIANS TAKE THEIR HYDRAULIC SKILLS TO THE NEXT LEVEL!

Hydraulics is a branch of technology and applied science that leverages engineering, chemistry, and physics to study the mechanical properties and behavior of liquids. At its core, hydraulics serves as the liquid-based counterpart to pneumatics and is a key component of fluid power systems.

This single-day course introduces the foundational principles of hydraulics, beginning with basic theory and progressing through practical applications.

### In this class, students will explore:

- Pascal's Law and its role in hydraulic pressure transmission
- Hydraulic system architecture, including pumps, valves, cylinders, and fluid reservoirs
- Hydraulic symbols and schematics, with guidance on how to interpret system diagrams
- Testing and troubleshooting techniques, enabling learners to diagnose and resolve common hydraulic issues

Through a combination of theoretical instruction and hands-on practice, participants will gain the skills needed to understand, operate, and maintain hydraulic systems with confidence and precision.



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# Hydraulics Fundamentals I

## Course Summary

### Course Objectives

After completing this course, the student will be able to:

- Explain Pascal's Law/Principle
- Demonstrate the flow of hydraulic fluid in a basic hydraulic circuit
- Interpret and explain a hydraulic hose layline
- Describe the importance of clean hydraulic oil
- Understand the benefits of using a good hydraulic oil filter and how to know the filtration ability
- Name all hydraulic components in basic hydraulic system
- Describe each hydraulic component function in a basic system
- Identify hydraulic schematic symbols in a basic system
- Point out schematic symbol functions
- Troubleshoot basic hydraulic system failures
- Name each type of hydraulic pump used in a hydraulic system
- Identify each type of hydraulic valve used in a hydraulic system
- Explain the difference between each type of hydraulic actuator
- Summarize how to perform a hydraulic cylinder bypass test on a hydraulic system

### Hydraulics I Outline

#### 1. Hydraulic Theory & Principles

- What is hydraulics?
- Pascal's Law and its application
- Incompressibility, energy conservation, flow continuity

#### 2. Basic Hydraulic System Operation

- How a hydraulic system works
- System components and their functions

#### 3. Hydraulic Oil & Contamination

- Oil selection, viscosity, contamination sources, and control
- Cost reduction and maintenance best practices

#### 4. Filter Quality & Beta Ratio

- Importance of filter quality
- Beta ratio explanation and ISO code for oil cleanliness

#### 5. Oil Change & Tank Design

- When to change oil
- Oil tank features and maintenance

#### 6. Hydraulic Pumps

- Types: Gear, Vane, Piston
- Operation, efficiency, failure modes, and schematic symbols

#### 7. Hydraulic Control Valves

- Manual, pneumatic, electrical, and proportional valves
- Valve operation, troubleshooting, and schematic symbols

#### 8. Pressure Relief Valves

- Function, adjustment, and troubleshooting

#### 9. Cylinders & Testing

- Cylinder types, failures, bypass testing, and troubleshooting rules

#### 10. Troubleshooting & Maintenance Rules

- Key rules for diagnosing and repairing hydraulic systems
- Common causes of component failure

#### 11. Knowledge Check / Test Questions

- Multiple slides with review questions on key concepts, troubleshooting, and component identification

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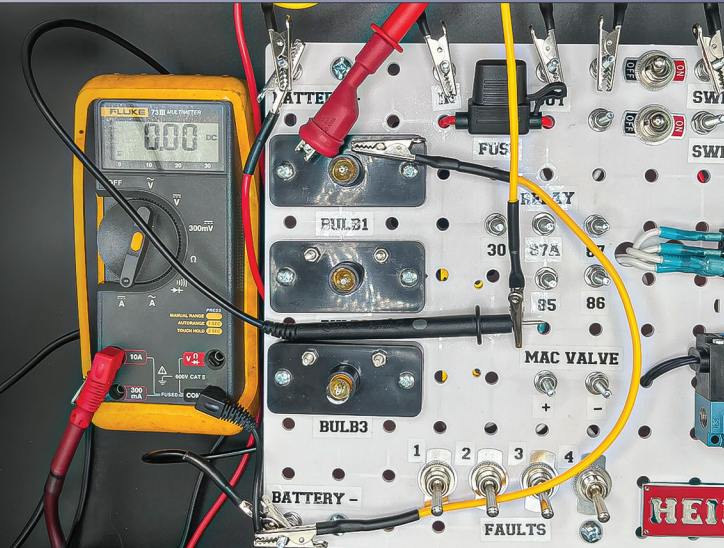
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# Electrical Fundamentals I

## Two-Day Class

Scheduled Upon Request  
(Factory or On-Site Availability Only)



# HELP YOUR TECHNICIANS TAKE THEIR ELECTRICAL SKILLS TO THE NEXT LEVEL!

Electrical systems play a critical role in today's refuse trucks and equipment. From basic controls to sensors and diagnostics, technicians must understand how electrical systems function and how to work on them safely and correctly. This course provides a clear, straightforward introduction to electrical fundamentals used in everyday service and maintenance work.

This two-day course introduces the foundational principles of electricity, beginning with core theory and progressing into practical, real world applications used in daily service and maintenance.

### In this class, students will explore:

- Electrical safety best practices and hazard awareness
- Fundamental electrical concepts, including voltage, current, and resistance
- Common electrical circuit types and how they function
- How to read and interpret electrical schematics
- Basic troubleshooting techniques for identifying and correcting electrical faults

Through a combination of classroom instruction and hands on learning, participants will gain the skills needed to confidently test, diagnose, and troubleshoot electrical systems with accuracy and consistency.



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# Electrical Fundamentals I - Course Summary

## Course Objectives

### Day 1:

- Understand essential safety practices by reviewing best practice procedures, proper use of PPE, hazard classifications, and lockout/tagout requirements.
- Explain the fundamentals of electricity, including how electricity is formed and the difference between AC and DC power.
- Identify individual types of circuits (Series, Parallel, & Series-Parallel) and understand the laws of each type of circuit. Understand how voltage, current, and resistance interact with each type of circuit.
- Apply core electrical theory by applying Ohm's Law and the Power Formula (Watt's Law) to evaluate wiring, connectors, and components and determine equipment performance without guesswork.
- Interpret electrical schematics through recognition of standard symbols and accurate reading of circuit diagrams.
- Understand how a relay works in a circuit and what is the purpose of a relay within that circuit.
- Identifying a fault within an electrical circuit and understanding how that fault makes the circuit react allowing for quick and efficient fault identification.
- Understanding the difference in test equipment and what happens when the wrong test equipment is used on a circuit.

### Day 2: (Hands-On activities using electrical boards)

- Understand how resistance reacts in a Series circuit when adding more loads to the circuit while verifying the resistance within the circuit with a digital multimeter.
- Using Watt's Law and Ohm's Law learn how to determine the resistance with a coil, such as the coil in a MAC valve.
- With power applied to the circuit, understand how voltage reacts in a Series circuit when adding more loads to the circuit while verifying the voltage with a digital multimeter.
- Understand how resistance reacts in a Parallel circuit when adding more legs/loads to the circuit while verifying the resistance within the circuit with a digital multimeter.
- With power applied to the circuit, understand how voltage reacts in a Parallel circuit when adding more legs/loads to the circuit while verifying the voltage with a digital multimeter.

- With power applied to the circuit, understand how voltage reacts in a Series-Parallel circuit by verifying the voltage with a digital multimeter.
- Understand how to use a schematic to verify wiring connections by using a schematic to wire a functioning relay circuit to operate a load.
- Understand how to properly set a digital multimeter and connect it into a Series circuit and a Parallel circuit to properly measure Amperage within the circuit.

## Course Outline

1. **Safety.** Adhering to safety rules and guidelines is always a top priority for everything we do. Review best practices, personal protective equipment (PPE), hazard definitions and lock out tag out procedures.
2. **What is Electricity?** Learn how electricity is formed and the differences between alternating current (AC) and direct current (DC).
3. **Types of Electrical Circuits.** Learn the types of electrical circuits and how voltage, amperage, and resistance affect each circuit.
4. **Electrical Theory.** Overview and apply OHM's Law and the Power Formula, which are important equations for testing electrical components and knowing whether a device has failed without guesswork.
5. **How to Read Electrical Schematics.** Learn schematic symbols and how to read an electrical schematic.
6. **Faults in an Electrical Circuit.** Learn different types of faults that can occur in an electrical circuit.
7. **Knowledge Check.** Test your knowledge by troubleshooting various fault scenarios in a circuit.
8. **Resistance.** Learn how resistance is affected within a circuit when another load/resistor is added to the circuit. Learn how that resistance affects a Parallel circuit differently from a Series circuit.
9. **Voltage.** Learn how voltage is affected within a circuit when another load/resistor is added to the circuit. Learn how that voltage affects a parallel circuit differently from a Series circuit.
10. **Amperage.** Learn how amperage flows through a circuit and how amperage flow is different in a Parallel circuit compared to a Series circuit.

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# Electrical Fundamentals II Diagnosis and Testing

## Two-Day Class

Scheduled Upon Request  
(Factory or On-Site Availability Only)



## HELP YOUR TECHNICIANS BUILD CONFIDENCE USING A DIGITAL MULTIMETER

A digital multimeter (DMM) is one of the most important diagnostic tools a technician uses, yet it is also one of the most commonly misused. Accurate electrical testing depends not only on having the right meter, but knowing how to use it correctly and safely in real service situations.

This two day course focuses specifically on proper digital multimeter operation, with an emphasis on hands on testing and real world troubleshooting. Students will learn how to confidently use a DMM to evaluate electrical circuits and components found on refuse trucks and related equipment.

### In this class, students will explore:

- Identify the components and functions of a digital multimeter
- Select the correct meter settings for different types of electrical tests
- Safely test live and non-live circuits
- Measure voltage, voltage drop, resistance, and amperage
- Apply DMM testing techniques to common electrical components
- Interpret test results to identify circuit and component issues

Through guided instruction and practical exercises, participants will gain the skills needed to use a digital multimeter accurately, safely, and consistently when diagnosing electrical problems in the field.



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# Electrical Fundamentals II

## Course Summary

**Please Note: Students must bring their own multimeter for this class**

### Course Objectives

After completing this course, the student will be able to:

#### DAY 1

- Review the laws of electrical circuits, Ohm's Law, Watts Law, use of relays, electrical symbols, electrical faults, and using the proper test equipment. Understand the test tools within a digital multimeter and how each is used to diagnose electrical circuits.
- Follow the rules for safety and accurately testing electrical circuitry, including the different types of diagnostic tests.
- Understand how to maintain the digital multimeter to ensure that test results are accurate and proper. Learn how to use the meter to test functions of the meter.
- Learn how to properly set the digital multimeter to perform circuit tests such as Static Resistance, Dynamic Resistance, Open Circuit Voltage, Available Voltage, Continuity tests, and Amperage checks.
- Understand how to properly connect the meter to the circuit to perform the listed tests without damaging the circuit, a module/controller, or the meter.
- Demonstrate comprehension through knowledge checks focused on how voltage, amperage, and resistance behave at various points in a circuit under different electrical conditions and how will the digital multimeter display these readings.

#### DAY 2 - Hands on activities using electrical boards & power supplies

- Understand the number line and use it to convert readings to the base/zero line.
- Understand how to properly test a relay and use the test results to properly diagnose the operation of the relay.
- Understand how to properly test a diode and determine the quality of the diode.

- Use generated wiring schematics to build circuits using relays, light bulbs, and MAC valves then activate faults in each circuit and use the learned test procedures with the digital multimeter to diagnose each circuit and describe how to properly repair the circuit fault. There are four different circuits to build and diagnose.
- Review diagnosis and testing procedures and processes.

### Course Outline

- 1. What is a Digital Multimeter (DMM)?** Learn the components of the DMM and how each function is used to diagnose problems in an electrical circuit.
- 2. Testing Resistance in Circuits.** Learn the proper procedure and understand the digital multimeter readings when testing circuits for Continuity, Static Resistance and Dynamic Resistance.
- 3. Testing Voltage in Circuits.** Learn the proper procedure and understand the digital multimeter readings when testing circuits for Open Circuit Voltage, Voltage Drop, and Available Voltage.
- 4. Testing Amperage in Circuits.** Learn the proper procedure and understand the digital multimeter readings when testing circuits for Amperage. Understand the difference in using the meter leads and an Amp Clamp.
- 5. Testing Circuits.** Learn to test for voltage, voltage drop, resistance and amperage.
- 6. Component Testing.** Apply your DMM to test various components such as relays, diodes and coils.
- 7. Knowledge Check.** Test your knowledge by identifying how voltage, amperage and resistance reacts in an electrical circuit at different points under various electrical conditions.

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# Networking

## Single-Day Class

Factory or On-Site Availability

## HELP YOUR TECHNICIANS TAKE THEIR ELECTRICAL SKILLS TO THE NEXT LEVEL!

J1939 is the standard protocol for electronic communication in heavy-duty vehicles, built on CAN (Controller Area Network) technology. Heil units use J1939 to connect and coordinate ECUs (Electronic Control Units) like the main controller, display, sensors, and actuators.

This single-day course is designed to equip truck technicians with the essential knowledge and hands-on skills needed to safely and effectively service refuse equipment using J1939 CAN network technology. The training covers foundational safety practices, electrical theory, and advanced troubleshooting techniques for modern refuse trucks, with a focus on Heil products and related Environmental Solutions (ES) equipment.

### In this class, students will explore:

- The fundamentals of J1939 communication and how CAN networks move information throughout a vehicle
- The structure and function of ECUs, including how controllers, sensors, and displays share data
- Key electrical concepts such as voltage, current, resistance, duty cycles, and PWM signal behavior
- Network design standards, including backbone layout, stub lengths, addressing, and termination
- Testing and troubleshooting methods that help technicians identify opens, shorts, interference, and failed components

Through a combination of classroom instruction and diagnostic exercises, participants will learn how to service, verify, and maintain CAN based systems on Heil and ES equipment with accuracy and increased confidence.



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# Networking Course Summary

## Course Objectives

After completing this course, the student will be able to:

### Demonstrate Safe Measurement Practices

- Identify the correct procedures for testing resistance in electrical circuits, including ensuring all power is disconnected before testing.

### Understand Key Terminology and Acronyms

- Define PWM (Pulse Width Modulation) and explain its significance in network communication.
- Explain the meaning of CAN and its role in vehicle and industrial networks.

### Interpret Network Signals and Measurements

- Describe what a duty cycle is and how it relates to PWM signals.
- Recognize the expected resistance values in a healthy CAN network and interpret resistance readings to diagnose network health.

### Apply Network Design Standards

- State the maximum allowable lengths for network backbones and cable stubs in a J1939 network.
- Understand the importance of network address assignment for communication between components.

### Diagnose and Troubleshoot Network Issues

- Analyze resistance measurements to identify open circuits, shorts, or failed ECUs in a CAN network.
- Evaluate bus load percentages and recognize recommended operational limits for network reliability.

### Follow Best Practices for Network Maintenance

- Assess the appropriateness of making wiring repairs within a network harness.
- Understand the function and placement of termination resistors in a network.

### Recognize and Mitigate Interference

- Identify sources and effects of electromagnetic and radio frequency interference in networked systems.

## Course Outline

### 1. J1939 Networks & Communication

- Objectives: CAN (Controller Area Network) networks, PWM (Pulse Width Modulation), communications, inputs/outputs
- Information Center (In-Sight Display) for operators and technicians

### 2. Electrical Theory & Ohm's Law

- Voltage, current, resistance definitions
- Circuit operation and troubleshooting basics
- Duty cycle and PWM explanation
- History and adoption of J1939
- CAN bus as the nervous system of the vehicle
- ECUs and network layers

### 3. Network Communication & Physical Layer

- Addressing, backbone, cable stubs, ECU connections
- Testing network resistance and troubleshooting tips

### 4. CAN Bus Networks in Heil Equipment

- Examples from Half/Pack with Odyssey Hydraulic Controls
- Network maps and connection points

### 5. Repairing CAN/Network Harness

- Recommended procedures for wire repair
- Avoiding damage, maintaining integrity, EMI/RFI precautions

### 6. 3rd Eye Camera Addition

- Proper connection to J1939 backbone
- Importance of following protocols

### 7. J1939 Connection Process

- Using PCAN-Diag scan tool for bitrate and resistance
- Bus load checks, message verification, adapter installation

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