

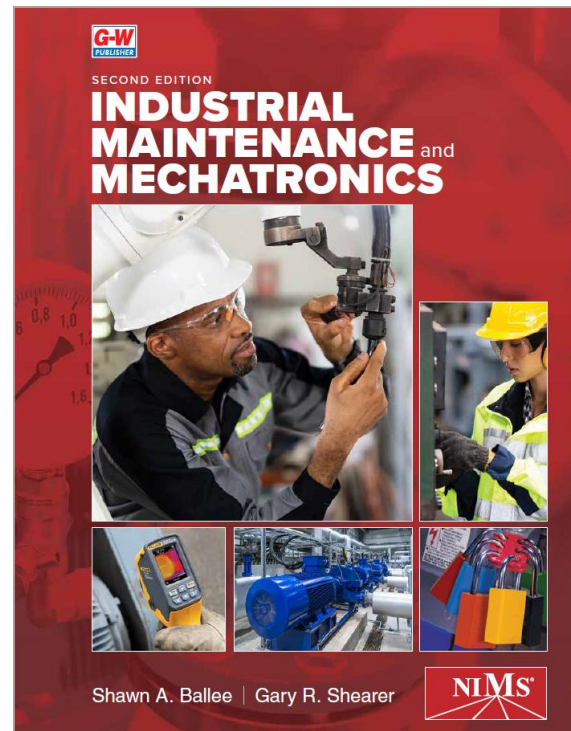


*Correlation of*  
**Industrial Maintenance and Mechatronics,**  
**Shawn A. Ballee and Gary R. Shearer**  
 Goodheart-Willcox Publisher ©2024  
 to  
**NIMS (National Institute for Metalworking Skills)**  
 Classic Credential:  
**Electrical Systems**

*Industrial Maintenance and Mechatronics* carries NIMS' exclusive endorsement and supports attainment of NIMS credentialing in Industrial Technology Maintenance (ITM).

The textbook is designed to work hand-in-glove with the NIMS Standards for Industrial Technology Maintenance. The standards-based learning package will help students pass the testing and performance requirements for NIMS credentialing.

The correlation below lists the standards for a specific NIMS Classic ITM Credential. The Classic ITM areas covered in *Industrial Maintenance and Mechatronics* include Maintenance Operations, Basic Mechanical Systems, Basic Hydraulic Systems, Basic Pneumatic Systems, Electrical Systems, Electronic Control Systems, Process Control Systems, and Maintenance Piping.



Standards	G-W Content
<b>Duty Title: 5.01. Adhere to electrical power and control systems safety rules.</b>	
Identify roles and responsibilities for safety, health, and environment.	Textbook: pg. 13, 24-28, 36-44, 70
Adhere to OSHA, NIOSH, EPA, and other federal and state safety requirements for the workplace.	Textbook: pg. 18, 24-25, 43-44
Identify and recognize common industrial hazards, per OSHA standards (including, ergonomics, laser safety, NFPA arc flash, confined space, gases and combustibles, steam and compressed air).	Textbook: pg. 24-26
Define elements of a lockout/tagout (LOTO) program, describe the LOTO process and test to ensure a zero energy state.	Textbook: pg. 28-32 Lab Workbook: Activity 2-1, Lockout/Tagout Procedure

Standards	G-W Content
Identify and explain how to select the appropriate personal protective equipment (eyes, head, breathing air apparatus, body, feet, hands, ears) for a job.	Textbook: pg. 13, 32-35 Lab Workbook: Activity 2-2, Personal Protective Equipment
Explain how to locate a material Safety Data Sheet (SDS) and describe how you interpret the information.	Textbook: pg. 24-27
List and select proper fall protection for working at heights and using ladders, scaffolding, and lifts.	Textbook: pg. 37
Identify and recognize hazardous situations and apply proper procedures (includes following guidelines to prevent spread of bloodborne pathogens, spill control, proper storage, handling, protection of equipment, first aid).	Textbook: pg. 28-32, 36-43
Describe the process used to perform a job safety analysis.	Textbook: pg. 43 Lab Workbook: Activity 2-3, Job Safety Analysis
Explain the principles of 6S program (Sort, Sweep, Sanitize, Set-to-order, Sustain, Safety).	Textbook: pg. 43
Identify fuel source and selection of correct extinguisher class.	Textbook: pg. 43
<b>ES Specific:</b>	
Adhere to NEC safety regulations.	Textbook: pg. 438,443, 446, 492, 494, 497, 626-627
Describe safety procedures for tightening, disconnecting, or connecting electrical conductors and components.	Textbook: pg. 438, 532
Define the hazards and how to avoid personal contact with live electrical systems.	Textbook: pg. 626-627
Describe the guidelines on the safe approach distances while working on electrical systems.	Textbook: pg. 627
<b>Duty Title: 5.02. Interpret electrical control and power schematics.</b>	
Identify electrical components given their NEC/ISO schematic symbol:  Resistors, potentiometers, inductors, capacitors, fuses, circuit breakers, pushbutton switches, selector switches, power supplies, transformers, lamps, motors, buzzers, control relays, motor starters, overloads, limit switches, pressure switches, level switches, electronic sensors, and solenoids	Textbook: pg. 127-128, 598, 600, 610, 611, 612, 613,
Interpret electrical control and power line types on a schematic.	Textbook: pg. 126-129
Interpret the operation of a basic electrical power and control circuits given a schematic (N.O. and N.C. contacts).	Textbook: pg. 558, 562, 598

Standards	G-W Content
Follow signal flow on an electrical control or power schematic.	Textbook: pg. 620, 671
Interpret control schematics given a ladder logic diagram.	Textbook: pg. 129, 605, 620-622
Interpret power diagrams associated with a PLC and all related input/output devices.	Textbook: pg. 597-602 608,
<b>Duty Title: 5.03. Adjust limit switches and electronic sensors.</b>	
Adjust and test the trip point of a limit switch, float switch, and pressure switch.	Textbook: pg. 598–602
Adjust and test the trip point of a capacitive sensor, inductive sensor, photoelectric sensor, Hall effect sensor, fiber optic, magnetic reed sensor, light curtain switches.	Textbook: pg. 720-722, 724-725 Lab Workbook: Activity 33-1, Capacitive, Inductive, Hall Effect, and Magnetic Reed Sensors Lab Workbook: Activity 33-2, Photoelectric Sensors
Describe the operation of limit, float, and pressure switches.	Textbook: pg. 598, 600-602 Lab Workbook: Activity 27-1, Adjusting Switches
Describe the operation of capacitive sensors, inductive sensors, photoelectric sensors, Hall effect sensors, fiber optic sensors, and magnetic reed sensors.	Textbook: pg. 720-727 Lab Workbook: Activity 33-1, Capacitive, Inductive, Hall Effect, and Magnetic Reed Sensors Lab Workbook: Activity 33-2, Photoelectric Sensors
<b>Duty Title: 5.04. Measure voltage, current, and resistance in an electrical circuit.</b>	
Use a multimeter to measure incoming voltage and current to an electrical circuit.	Textbook: pg. 444-445 Lab Workbook: Activity 21-1, Basic Circuit and Measurements Lab Workbook: Activity 21-2, Series Circuit and Measurements Lab Workbook: Activity 21-3, Parallel Circuit and Measurements Lab Workbook: Activity 21-4, Complex Circuit and Measurements Lab Workbook: Activity 20-1, Basic Digital Multimeter Readings Lab Workbook: Activity 23-1, Comparing AC and DC Series Circuits Lab Workbook: Activity 23-2, Comparing AC and DC Parallel Circuits

Standards	G-W Content
<p>Use a multimeter to measure voltage and current in an electrical circuit.</p>	<p>Textbook: pg. 444-445                      Lab Workbook: Activity 21-1, Basic Circuit and Measurements                      Lab Workbook: Activity 21-2, Series Circuit and Measurements                      Lab Workbook: Activity 21-3, Parallel Circuit and Measurements                      Lab Workbook: Activity 21-4, Complex Circuit and Measurements                      Lab Workbook: Activity 20-1, Basic Digital Multimeter Readings                      Lab Workbook: Activity 23-1, Comparing AC and DC Series Circuits                      Lab Workbook: Activity 23-2, Comparing AC and DC Parallel Circuits</p>
<p>Use a multimeter to measure resistance in an electrical circuit.</p>	<p>Textbook: pg. 445                      Lab Workbook: Activity 21-1, Basic Circuit and Measurements                      Lab Workbook: Activity 21-4, Complex Circuit and Measurements                      Lab Workbook: Activity 20-1, Basic Digital Multimeter Readings                      Lab Workbook: Activity 23-1, Comparing AC and DC Series Circuits                      Lab Workbook: Activity 23-2, Comparing AC and DC Parallel Circuits</p>
<p>Use a multimeter to perform a continuity check in an electrical circuit.</p>	<p>Textbook: pg. 446</p>
<p>Describe the concepts of resistance, voltage, current, and power.</p>	<p>Textbook: pg. 426,                      Lab Workbook: Activity 21-1, Basic Circuit and Measurements                      Lab Workbook: Activity 21-2, Series Circuit and Measurements                      Lab Workbook: Activity 21-3, Parallel Circuit and Measurements                      Lab Workbook: Activity 21-4, Complex Circuit and Measurements                      Lab Workbook: Activity 23-1, Comparing AC and DC Series Circuits                      Lab Workbook: Activity 23-2, Comparing AC and DC Parallel Circuits</p>
<p>Use an amp meter (clamp-on).</p>	<p>Textbook: pg. 448-449                      Lab Workbook: Activity 30-3, Motor Runs Erratically</p>

Standards	G-W Content
Describe the application of a multimeter to measure continuity, resistance, voltage, and current.	Textbook: pg. 444-446 Lab Workbook: Activity 21-1, Basic Circuit and Measurements Lab Workbook: Activity 21-2, Series Circuit and Measurements Lab Workbook: Activity 21-3, Parallel Circuit and Measurements Lab Workbook: Activity 21-4, Complex Circuit and Measurements Lab Workbook: Activity 20-1, Basic Digital Multimeter Readings Lab Workbook: Activity 20-3, Advanced DMM Measurements and Inspection Lab Workbook: Activity 23-1, Comparing AC and DC Series Circuits Lab Workbook: Activity 23-2, Comparing AC and DC Parallel Circuits
Define Ohm’s law and use it to determine power flow in electrical circuits.	Textbook: pg. 462-465
Calculate power in an electrical circuit given current and voltage.	Textbook: pg. 474-475
Describe the operation of parallel and series electrical circuits.	Textbook: pg. 428-429, 465-474 Lab Workbook: Activity 21-2, Series Circuit and Measurements Lab Workbook: Activity 21-3, Parallel Circuit and Measurements Lab Workbook: Activity 21-4, Complex Circuit and Measurements Lab Workbook: Activity 23-1, Comparing AC and DC Series Circuits Lab Workbook: Activity 23-2, Comparing AC and DC Parallel Circuits
<b>Duty Title: 5.05. Select, install, and test fuses and circuit breakers.</b>	
Size fuses and circuit breakers in accordance with NEC requirements for a given power draw in an electrical circuit with consideration to ampacity of wiring in that circuit.	Textbook: pg. 531-535, 537, 596-597 Lab Workbook: Activity 20-2, DC Power Supply Investigation
Install fuses and circuit breakers in electrical circuits.	Textbook: pg. 531-535, 594-597
Describe procedure to test fuses.	Textbook: pg. 532
Inspect circuit breakers to determine if tripped.	Textbook: pg. 532-533
Reset circuit breakers.	Textbook: pg. 532-535
Describe the operation of fuses, circuit breakers, GFCI.	Textbook: pg. 443, 531-535
Identify fuse types and their use.	Textbook: pg. 531-532

Standards	G-W Content
<b>Duty Title: 5.06. Install and test DC electric motors.</b>	
Install and connect DC electric motors to a manual switch given a power schematic.	Textbook: pg. 729-731
Describe the operation of DC electric motor (speed/direction).	Textbook: pg. 579-580, 728-731
Describe the operation of DC motor configurations: compound, series, and shunt.	Textbook: pg. 584, 728
Interpret DC motor specifications.	Textbook: pg. 576, 728
Use a multimeter and megohmmeter (megger) to test a DC motor.	Textbook: pg. 674
Describe the operation of a DC speed controller and its function/purpose.	Textbook: pg. 729-731
Interpret a DC motor name plate.	Textbook: pg. 576
<b>Duty Title: 5.07. Install and test AC electric motors.</b>	
Install and connect AC single-phase electric motors to a manual motor starter given a power schematic.	Textbook: pg. 603-605, 730-732 Lab Workbook: Activity 26-1, Motor Investigation Lab Workbook: Activity 26-3, Motor Wiring Methods
Install and connect AC 3-phase electric motors to a manual motor starter given a schematic.	Textbook: pg. 578, 603-605, 730-732
Describe the operation of single-phase electric motor: capacitor start, capacitor start/run, and split capacitor.	Textbook: pg. 582-583 Lab Workbook: Activity 30-3, Motor Runs Erratically
Interpret AC single phase and 3-phase motor specifications.	Textbook: pg. 576, 578, 582-583
Use a multimeter and megohmmeter (megger) to test an AC motor.	Textbook: pg. 674-675 Lab Workbook: Activity 20-4, Testing Motor Insulation
Describe the operation of a manual motor starter.	Textbook: pg. 602-605 Lab Workbook: Activity 27-3, Magnetic Motor Starters
Describe the operation of a 3-phase motor—i.e., multispeed motor (speed/direction).	Textbook: pg. 581, 605 Lab Workbook: Activity 26-2, Phase Rotation Testing
Describe the operation and function of a bearing grounding ring.	Textbook: pg. 582
Explain the function of a motor brake.	Textbook: pg. 585
Interpret an AC motor name plate.	Textbook: pg. 576
Explain how to select an AC motor overload.	Textbook: pg. 605-607

Standards	G-W Content
<b>Duty Title: 5.08. Install and test electrical relay control components and circuits.</b>	
Describe the operation of control transformers, pushbutton switches, selector switches, control relays, magnetic motor starters, overloads, indicator lamps, electronic sensors, drum switches, solenoid operated fluid power valves, capacitors, resistors, and disconnect switches.	Textbook: pg. 487-490 Lab Workbook: Activity 24-2, Investigating Relays Lab Workbook: Activity 27-2, Control Transformers and DMM Readings
Describe the operation of basic single direction and reversing direction motor control circuits with interlocks and sensors.	Textbook: pg. 688, 731 Lab Workbook: Activity 28-1, Wiring Start-Stop Stations Lab Workbook: Activity 28-4, Reversing a Three-Phase Motor
Install and connect NEMA/ IEC relay control components in a control circuit given a wiring diagram or schematic.	Textbook: pg. 731-736 Lab Workbook: Activity 28-2, Relay Logic
Install wiring between components in a control cabinet using raceways.	Textbook: pg. 640-641
Install wiring between components located in different enclosures via conduit.	Textbook: pg. 640
Replace failed relay contacts and coils.	Textbook: pg. 536-537
<b>Duty Title: 5.09. Install and test electro-fluid power components and circuits.</b>	
Describe the operation of solenoid-operated hydraulic and pneumatic valves.	Textbook: pg. 316-317, 320-321, 613-614 Lab Workbook: Activity 18-2, Basic Pneumatic Circuits 1
Describe the operation of relay-controlled sequence fluid power circuits.	Textbook: pg. 536-537
Install and connect solenoid-operated hydraulic and pneumatic valves in a control circuit given a wiring diagram or schematic.	Textbook: pg. 316-317, 320-321, 384, 385, 413 Lab Workbook: Activity 17-5, Vacuum Generator Circuit Lab Workbook: Activity 18-2, Basic Pneumatic Circuits 1 Lab Workbook: Activity 18-3, Basic Pneumatic Circuits 2
Use manual overrides to test operation and describe the potential negative effects or consequences.	Textbook: pg. 357, 413 Lab Workbook: Activity 17-3, System Start-Up and Operational Checks Lab Workbook: Activity 18-2, Basic Pneumatic Circuits 1
<b>Duty Title: 5.10. Test and repair machine electrical ground.</b>	
Describe methods of grounding and bonding machines per NEC code and their respective applications.	Textbook: pg. 560, 627-628
Describe the operation of electric motor grounding rings.	Textbook: pg. 582
Identify types of machine grounds.	Textbook: pg. 560, 627-628
Describe the operation of a grounding conductor.	Textbook: pg. 627-628
Test a machine ground to verify its correct operation.	Textbook: pg. 628
Repair a machine ground.	Textbook: pg. 587



Standards	G-W Content
<b>Duty Title: 5.11. Troubleshoot an electrical motor relay control circuit.</b>	
Describe types of failures of basic electrical relay components and electric motors.	Textbook: pg. 536
Troubleshoot basic electrical components (resistors, control transformers, potentiometers, pushbutton switches, selector switches, control relays, magnetic motor starters, overloads, indicator lamps, drum switches, and disconnect switches) in an electrical relay control circuit using in-circuit tests (define).	Textbook: pg. 442, 667-671, 673-679 Lab Workbook: Activity 24-1, Reading Potentiometers
Use a multimeter to take electrical circuit readings during in-circuit testing.	Textbook: pg. 444-445, 674
Use systematic methodologies to troubleshoot electrical relay control circuits with AC and DC motors with these symptoms: <ul style="list-style-type: none"> <li>Motor will not run</li> <li>Motor turns in wrong direction</li> <li>Motor runs erratically</li> <li>Motor is hot</li> <li>Motor runs high current</li> </ul>	Textbook: pg. 677-679 Lab Workbook: Activity 30-1, Motor Fails to Start Lab Workbook: Activity 30-2, Hot Motor Lab Workbook: Activity 30-3, Motor Runs Erratically
<b>Duty Title: 5.12. Troubleshoot a solenoid-operated fluid power valve relay control circuit.</b>	
Describe types of failures of solenoid-operated valves.	Textbook: pg. 357
Troubleshoot solenoid-operated hydraulic and pneumatic directional control valves using in-circuit tests.	Textbook: pg. 366, 402, 406-408, 413-414 Lab Workbook: Activity 18-2, Basic Pneumatic Circuits 1 Lab Workbook: Activity 18-3, Basic Pneumatic Circuits 2 Lab Workbook: Activity 18-4, Troubleshooting Pneumatic Circuits
Use systematic methodologies to troubleshoot electro-fluid power relay control circuits with these symptoms: <ul style="list-style-type: none"> <li>Actuator will not move</li> <li>Actuator moves in wrong direction</li> <li>Actuator moves erratically</li> </ul>	Textbook: pg. 393, 406-408, 413-414 Lab Workbook: Activity 16-1, Assembling and Testing a Basic Hydraulic Circuit Lab Workbook: Activity 18-1, Troubleshooting Hydraulic Components Lab Workbook: Activity 18-4, Troubleshooting Pneumatic Circuits
<b>Duty Title: 5.13. Replace electrical control wiring using terminal attachment.</b>	
Perform a continuity test on wiring connected via all types of terminals.	Textbook: pg. 443, 446
Size wiring for a control circuit given voltage and current requirements and NEC code.	Textbook: pg. 538, 627
Interpret wiring specifications including standard color coding.	Textbook: pg. 627-628
Strip wire.	Textbook: pg. 538-539



Standards	G-W Content
Attach wires to terminals.	Textbook: pg. 493-494 538-542
Describe types of wire and their application.	Textbook: pg. 537
<b>Duty Title: 5.14. Replace electrical control wiring using solder attachment.</b>	
Perform a continuity test on wiring connected via soldering.	Textbook: pg. 541-542
Prepare wire for soldering.	Textbook: pg. 539-541 Lab Workbook: Activity 24-3, Crimping and Soldering Electrical Connections
Solder wire to terminals.	Textbook: pg. 539-542
Test and inspect a solder joint for integrity.	Textbook: pg. 542
Describe types of soldering and solder materials and their application.	Textbook: pg. 539-542
<b>Duty Title: 5.15. Transformers</b>	
Define transformer ratio.	Textbook: pg. 550-553
Describe types and configurations (Y, Delta) of transformers and their application.	Textbook: pg. 564-567
Explain the rating of a transformer.	Textbook: pg. 487-489, 555 Lab Workbook: Activity 25-1, Transformer Ratings
Describe connection point and taps for each type of transformer.	Textbook: pg. 489, 555, 564-567
Test a transformer.	Textbook: pg. 490, 556-557, 563, 568 Lab Workbook: Activity 25-3, Troubleshooting Transformers
Disconnect and reconnect primary and secondary transformers.	Textbook: pg. 550, 552, 565-568 Lab Workbook: Activity 25-2, Wiring Transformers
Replace primary and secondary transformers.	Textbook: pg. 490, 565-566