

Electricity Standards and Skills

Table of Contents­­

[Health & Safety Standards 3](#_Toc161387472)

[**Standard 1: Safety and Health in a Construction Environment** 3](#_Toc161387473)

[Technical & Integrated Academic Standards 4](#_Toc161387474)

[**Standard 2: Print Reading** 4](#_Toc161387475)

[**Standard 3: Anchors and Fasteners** 4](#_Toc161387476)

[**Standard 4: Basics of Circuitry** 4](#_Toc161387477)

[**Standard 5: Codes, Regulations and References** 5](#_Toc161387478)

[**Standard 6: Raceways, Fittings, Supports and Boxes** 7](#_Toc161387479)

[**Standard 7: Fundamentals of Conductors, Cables, and Terminations** 7](#_Toc161387480)

[**Standard 8: Power and Distribution of Electricity** 8](#_Toc161387481)

[**Standard 9: Overcurrent Protection** 8](#_Toc161387482)

[**Standard 10: Transformers** 9](#_Toc161387483)

[**Standard 11: Motors and Motor Controls** 9](#_Toc161387484)

[**Standard 12: Fundamentals of Grounding and Bonding** 9](#_Toc161387485)

[**Standard 13: Luminaires and Luminaire Controls** 10](#_Toc161387486)

[**Standard 14: Basic Low Voltage Wiring** 11](#_Toc161387487)

[**Standard 15: Sustainable Practices in Electric Power Production Sources** 11](#_Toc161387488)

[Employability Standards 11](#_Toc161387489)

[**Standard 16: Employability** 11](#_Toc161387490)

[Entrepreneurship Standards 12](#_Toc161387491)

[**Standard 17: Entrepreneurship** 12](#_Toc161387492)

[Digital Literacy Standards 12](#_Toc161387493)

[**Standard 18: Digital Literacy** 12](#_Toc161387494)

[Sample Performance Tasks 13](#_Toc161387495)

[**Standard 1: Safety and Health in a Construction Environment** 13](#_Toc161387496)

[**Standard 2: Print Reading** 13](#_Toc161387497)

[**Standard 3: Anchors and Fasteners** 13](#_Toc161387498)

[**Standard 4: Basics of Circuitry** 14](#_Toc161387499)

[**Standard 5: Codes, Regulations and References** 14](#_Toc161387500)

[**Standard 6: Raceways, Fittings, Supports and Boxes** 14](#_Toc161387501)

[**Standard 7: Fundamentals of Conductors, Cables, and Terminations** 15](#_Toc161387502)

[**Standard 8: Power and Distribution of Electricity** 15](#_Toc161387503)

[**Standard 9: Overcurrent Protection** 15](#_Toc161387504)

[**Standard 10: Transformers** 16](#_Toc161387505)

[**Standard 11: Motors and Motor Controls** 16](#_Toc161387506)

[**Standard 12: Fundamentals of Grounding and Bonding** 16](#_Toc161387507)

[**Standard 13: Luminaires and Luminaire Controls** 16](#_Toc161387508)

[**Standard 14: Basic Low Voltage Wiring** 17](#_Toc161387509)

[**Standard 15: Sustainable Practices in Electric Power Production Sources** 17](#_Toc161387510)

# Health & Safety Standards

**Standard 1: Safety and Health in a Construction Environment**

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| Students will be able to demonstrate health and safety in a shop environment, including the management of tools and equipment, use of personal protective equipment (PPE), and workspace ergonomics. | OSHA 10 – Construction |

**Skills:**

1. Describe and demonstrate safety procedures and techniques using hand and power tools.
2. Identify the hazard, recognize the practice, describe, and demonstrate methods of safely working with electricity.
3. Appropriately document and communicate safety risks and equipment maintenance needs.
4. Select and use personal protective equipment, including safe use and maintenance of fall protection according to current industry and OSHA standards.
5. Describe OSHA 10 General Industry standards and explain their relevance to construction.
6. Comply with appropriate fire protection regulations, local permit regulations, and state/federal regulations.
7. Define Arc flash according to the National Fire Protection Association (NFPA-70 and NFPA 70E).
8. Explain and demonstrate electrical safety requirements per NFPA 70E.
9. Identify and demonstrate basic safety procedures that apply to ladder and power personnel lift safety.
10. Define a confined space and associated hazards.
11. Identify the hazards associated with “Hot Works” as it pertains to electricity. (Using State Board of Examiners of Electricians provided instructional material.)

# Technical & Integrated Academic Standards

**Standard 2: Print Reading**

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| Students will be able to identify, design, and evaluate technical drawings and blueprints. | Credit toward Massachusetts Electrician License |

**Skills:**

1. Describe the basic layout of a set of prints, as well as the importance of the accompanying job specifications document.
2. Identify and define basic print terms, abbreviations, line types, symbols, and notes.
3. Interpret and accurately follow drawing dimensions.
4. Convert blueprint measurements to architect’s scale.
5. Define and interpret floor plans, elevations, sections, details, ceiling plans, and finish schedules.
6. Discuss and demonstrate the use of estimating methods in pricing jobs using drawings/prints.
7. Use a drawing to design, develop and complete material sheets, indicating quantities and types of materials required for installation.
8. Use a Uniform Permit to discuss how state and/or local code requirements apply to prints.
9. Compare the layout on the drawing to the code required minimum requirements and identify omissions.

**Standard 3: Anchors and Fasteners**

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| Standard 3: Students will be able to safely install various types of fasteners using fastening power tools according to industry standards.  | Credit toward Massachusetts Electrician License |

**Skills:**

1. Explain the use of various trade related anchors, threaded, and non-threaded fasteners.
2. Explain and demonstrate the use and type of anchors.
3. Install an anchor in concrete and fasten a box to concrete or other masonry surface in compliance with current OSHA and silica standards.
4. Select and attach electrical equipment using proper fasteners and technique.
5. Use and maintain fastening, sawing, drilling, and boring tools.
6. Use and maintain portable power tools.
7. Demonstrate the use of the appropriate threaded, non-threaded fastener or anchor to fasten a box to a concrete or masonry surface.
8. Explain the current OSHA silica standard.

**Standard 4: Basics of Circuitry**

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| Standard 4: Students will be able to explain basic concepts of AC/DC electrical theory and interpret, measure, and build basic electrical circuits. | Credit toward Massachusetts Electrician License |

**Skills:**

1. Explain basic concepts of AC/DC electrical theory.
2. Compare and distinguish between conductors and insulators.
3. Calculate the electrical power of an electrical system.
4. Explain the relationship between voltage, current, and resistance.
5. Define the units of measurement that are used to measure the properties of electricity.
6. Calculate and apply an unknown value by using Ohms law formula.
7. Define voltage and identify the ways in which it is produced.
8. Compare and distinguish between single-phase and three-phase systems.
9. Measure voltage, current, resistance, and continuity of an electrical circuit and determine the relationships between them.
10. Build a series, parallel, and series-parallel circuit.
11. Demonstrate uses of Volt/Ohm and Ampere meters on given devices.
12. Identify and describe ground-fault circuit interrupters (GFCI) and arc-fault circuit interrupters (AFCI) and their appropriate use.
13. Identify circuit loads and installation requirements, including branch circuit needs.
14. Compute branch circuit loads and define branch circuit requirements.
15. Perform measurement of current.
16. Perform measurement of voltage.
17. Perform measurement of resistance.
18. Describe and demonstrate the operation of a circuit tracer.
19. Determine the continuity of a circuit.

**Standard 5: Codes, Regulations and References**

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| Students will be able to locate and interpret appropriate Massachusetts Electric Code (MEC) Amendments, the National Electrical Code (NEC), and the Electrical Board of Examiners regulations (527 and 237 CMR) to complete a given project. | Credit toward Massachusetts Electrician License |

**Skills:**

1. Explain the purpose and history of the National Electrical Code (NEC) and the Massachusetts Electrical Code (MEC) amendments.
2. Describe the layout of the Massachusetts Electrical Code (MEC).
3. Demonstrate how to navigate the MEC book, locate appropriate MEC articles for a specific wiring method and project.
4. Explain how to identify changes to the MEC.
5. Describe the differences between MEC and NEC.
6. Identify and summarize MGL’s and CMR’s as they apply to the electrical trade.
7. Locate appropriate Massachusetts Electric Code Amendments (527 CMR 12).
8. State appropriate Electrical Board of Examiners regulations (527 CMR and 237 CMR).
9. Describe the MEC Licensing requirements.
10. Describe the continuing education renewal requirements.
11. Determine conductor requirements.
12. Determine raceway requirements.
13. Determine electrical box requirements.
14. Describe the purpose of ground-fault circuit interrupters (GFCI) and arc-fault circuit interrupters (AFCI) and indicate where they must be installed.
15. Identify the circuit loads, number of circuits required, and installation requirements.
16. Compute branch circuit loads and define branch circuit requirements.

**Standard 6: Raceways, Fittings, Supports and Boxes**

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| Students will be able to install various items on a finished surface for a given project, including raceways, fittings, supports, and boxes. | Credit toward Massachusetts Electrician License |

**Skills:**

1. Locate MEC requirements for raceways, conductors, and boxes.
2. Perform various methods of bending, cutting, reaming, and threading raceways.
3. Select various types and sizes of raceways, fittings, and supports.
4. Describe the purpose of conduit bodies.
5. Demonstrate installation of raceways and fittings on various surfaces.
6. Install electrical boxes.
7. Describe the different types of nonmetallic and metallic boxes.
8. Explain how boxes are selected and installed.
9. Install boxes on various surfaces.

**Standard 7: Fundamentals of Conductors, Cables, and Terminations**

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| Students will be able to select and install conductors, common conductor terminations, and cables using different size wires. | Credit toward Massachusetts Electrician License |

**Skills:**

1. Describe and use the various sizes and gauges of wire in accordance with American Wire Gauge (AWG) standards.
2. Perform conductor terminations and splices, including the use of lugs, connectors, and various splicing techniques.
3. Demonstrate the proper use of hand and power crimping tools and insulation.
4. Identify and use insulation types according to conditions and applications.
5. List voltage ratings of conductors.
6. Read and identify markings on conductors.
7. Select electrical conductors for specific applications.
8. Demonstrate how to size conductors for a load.
9. Demonstrate and explain the purpose of adjusting and correcting for selection of conductors.
10. Describe the different conductors.
11. Describe the color coding of insulation.
12. Demonstrate the use of equipment and procedure for pulling wire through raceways.
13. Calculate wire size and demonstrate pulling wire through a raceway.
14. Perform conductor terminations.
15. Prepare conductor ends for terminations and splices.
16. Select and install lugs and connectors onto conductors.
17. Describe and apply splicing techniques.
18. Splice conductors using solderless connectors.
19. Describe and apply crimping techniques.
20. Insulate a splice joint.
21. Install cables.
22. Identify and apply different cable markings.
23. Secure and support cables.
24. Terminate cables using proper fittings.
25. Prepare cables for installation.

**Standard 8: Power and Distribution of Electricity**

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| Students will be able to calculate electric service requirements for dwellings, including grounding requirements, size of the service-entrance equipment and main disconnects, panelboards, and overcurrent protection devices. | Credit toward Massachusetts Electrician License |

**Skills:**

1. Describe the grounding and electric service requirements for dwellings.
2. Calculate and size service-entrance equipment.
3. Install main disconnect switches, panel boards, and overcurrent protection devices.
4. Calculate service size, select proper wire size, and develop a material list for installation of service.

**Standard 9: Overcurrent Protection**

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| Students will be able to articulate the importance of overcurrent protection in electrical circuits and to size and install appropriate overcurrent protection devices. | Credit toward Massachusetts Electrician License |

**Skills:**

* + - 1. Explain how a circuit breaker operates and its specific application.
			2. Size and install overcurrent protection.
			3. Define the terms associated with fuses and circuit breakers.
			4. Describe the operation of a circuit breaker and fuse.
			5. Select the most suitable overcurrent device for the application.
			6. Describe the operation of single-element and time-delay fuses.
			7. Describe the safety risks associated with improper overcurrent replacement.

**Standard 10: Transformers**

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| Students will be able to describe the different types of transformers and to properly evaluate, connect, and protect transformers. | Credit toward Massachusetts Electrician License |

**Skills:**

1. Identify and define different types of transformers.
2. Compute appropriate transformer sizes for various applications.
3. Describe the purpose and methods of grounding transformers.
4. Calculate and install overcurrent protection for transformers.
5. Identify power transformer connections and install overcurrent protection.
6. Calculate the loads for a single-family dwelling.
7. Size and install a main overcurrent protection device.
8. Size and install transformers.

**Standard 11: Motors and Motor Controls**

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| Students will be able to describe the operating principles of motors, define terms related to motors, and understand diagrams and structures of motors and programmable logic control circuits. | Credit toward Massachusetts Electrician License |

**Skills:**

1. Describe operating principles for motors, motor controls, control circuits, contractors, overload relays, and other devices.
2. Explain and demonstrate how the direction of a three-phase motor is reversed.
3. Describe the methods for determining various motor connections.
4. Draw basic wiring schematics with controls and interpret motor control diagrams and schematics.
5. Demonstrate the operating principles of motor controls and control circuits.
6. Size and select thermal overload relays and other protective devices for motor controls.
7. Describe the operating principles of contactors and relays.
8. Describe manual, automatic, and semi-automatic control circuits.
9. Identify and state the functions of limit switches and relays.
10. Size and install adjustable speed drives.
11. Install wiring per a given diagram.
12. Install motors and motor controls.
13. Develop and install a basic programmable logic control circuit.
14. Draw a schematic diagram for a stop/start motor control circuit and a ladder diagram for a given application.

**Standard 12: Fundamentals of Grounding and Bonding**

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| Students will be able to describe and evaluate system and equipment grounding, and to describe the roles of key concepts including electrodes, bonding jumpers, and effective grounding. | Credit toward Massachusetts Electrician License |

**Skills:**

1. Size and install grounding and bonding system.
2. Demonstrate the function of the main bonding jumper in the grounding system and size it for various applications.
3. Explain the terms ground, grounded conductor, bonding conductor, equipment grounding conductor, supplemental ground, supplementary ground, and installation requirements.
4. Distinguish between a short circuit and a ground fault.
5. Distinguish between system grounding and equipment grounding.
6. Explain and demonstrate the function of the grounding electrode system and determine which grounding electrodes shall be used.
7. Size the equipment grounding conductor for raceways and equipment.
8. Explain and demonstrate the function of the main bonding jumper in the grounding system and size the main bonding jumper for various applications.
9. Demonstrate effectively grounded and its importance in clearing ground faults and short circuits.

**Standard 13: Luminaires and Luminaire Controls**

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| Students will be able to identify, classify and install basic components of lighting and lighting control systems and fixtures. | Credit toward Massachusetts Electrician License |

**Skills:**

1. Identify and apply basic occupancy sensors, photoelectric sensors, and dimmers used to control lighting circuits and describe how each device operates.
2. Identify different kinds of lamps and define the advantages and disadvantages of each type.
3. Identify and install various types of luminaires.
4. Classify luminaires by layout, location, fixture type, and type of service.
5. Demonstrate and state the functions and rating of single-pole, double pole, three-way, four-way, and dimmer switches.
6. Describe the installation procedures and layout of lighting outlets.
7. Select appropriate wiring devices for various lighting installations.
8. Install various lighting and luminaire controls.

**Standard 14: Basic Low Voltage Wiring**

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| Students will be able to explain and apply the operating principles of fire, security alarm, and camera systems. | Credit toward Massachusetts Electrician License |

**Skills:**

1. Identify the components of fire alarm systems, security alarm systems, camera systems and network cabling.
2. Evaluate and install network cabling for low-voltage systems.
3. Terminate low voltage cables and devices.
4. Install Class 1, 2, and 3 low voltage systems.
5. Define the various codes and regulations related to alarm systems.
6. Prepare, install, and terminate low voltage cable and devices.

**Standard 15: Sustainable Practices in Electric Power Production Sources**

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| Students will be able to describe, identify and select the components and storage systems of a photovoltaic system. | Credit toward Massachusetts Electrician License |

**Skills:**

1. Identify the components associated with standby systems, energy storage systems, and photovoltaic systems.
2. Size and install inverters.
3. Size, select, and install photovoltaic panels.
4. Select and install support systems.
5. Size, select, and install storage system (as per MEC).
6. Size, select, and install standby system (as per MEC).

# Employability Standards

**Standard 16: Employability**

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| Students will understand and demonstrate the roles of professional communication, critical thinking, problem solving, professionalism, teamwork, and collaboration within the context of electricity careers. |  |

**Skills:**

1. Demonstrate the impact of communication skills on the success of an electrical system installation.
2. Describe appropriate methods of communication for internal and external stakeholders.
3. Evaluate the impact of poor communication by electricians on the safety of a job site.
4. Troubleshoot a project plan to find mistargeted or extraneous work that does not contribute to the ultimate objectives of the project.
5. Build a team-based project plan that results in a successful electrical system installation and that includes recruiting teammates and assigning roles for a project.
6. Examine the role of electricians in society, particularly in terms of their significance for employability and career opportunities.

# Entrepreneurship Standards

**Standard 17: Entrepreneurship**

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| Students will be able to describe opportunities for entrepreneurship and be able to evaluate the value proposition of business ownership in the electricity field. |  |

**Skills:**

1. Understand and describe the needs for a startup electrical services company (including initial equipment and staffing needs, a marketing/business development plan, and a basic revenue management strategy).
2. Describe the concept of professional networking and demonstrate personal introductions and an “elevator speech” appropriate for other electricians, contractors, developers, and other potential business partners.
3. Evaluate the licensing, regulatory, and tax implications of self-employment and business ownership as an electrician compared to W-2 employment.

# Digital Literacy Standards

**Standard 18: Digital Literacy**

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| Students will be able to demonstrate the use of common software and information technology in a modern electricity environment. |  |

**Skills:**

1. Describe the use of online resources in licensing and professional development as an electrician.
2. Demonstrate the use of a common ticketing/case management system for electrical services.
3. Demonstrate the use of common scheduling, resource management and customer relationship software systems.
4. Understand where to find online resources that support effective electrical work and how to be a safe and ethical consumer and creator of digital content.
5. Apply strategies for using digital tools and technology to drive business and commerce.

# Sample Performance Tasks

**Standard 1: Safety and Health in a Construction Environment**

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| Students will be able to demonstrate health and safety in a shop environment, including the management of tools and equipment, use of personal protective equipment, and workspace ergonomics | OSHA 10 – Construction |

**Sample Performance Tasks:**

* Students will participate in daily /weekly “Toolbox Safety Talks” and will pass a written and performance test for all shop tools and equipment.

**Standard 2: Print Reading**

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| --- | --- |
| Students will be able to identify, design, and evaluate technical drawings and blueprints. | Credit toward Massachusetts Electrician License |

**Sample Performance Tasks:**

* Student will perform shop/job site projects/work from given sets of prints/drawings.
* Student will develop a material sheet for given project/job.
* Student will develop a cost estimate from material sheet for given project/job.
* Student will prepare an application for a given electrical permit.

**Standard 3: Anchors and Fasteners**

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| --- | --- |
| Standard 3: Students will be able to safely install various types of fasteners using fastening power tools according to industry standards.  | Credit toward Massachusetts Electrician License |

**Sample Performance Tasks:**

* Student will install an anchor in concrete in compliance with current OSHA and silica standards.
* Student will select and attach electrical equipment using proper fasteners and technique.
* Student will demonstrate the approved use and maintenance of power tools used to fasten boxes to concrete or masonry.
* Identify and demonstrate the use of the appropriate threaded, non-threaded fastener, or anchor to fasten a box to a concrete or masonry surface.
* Student will explain the current OSHA silica standard.

**Standard 4: Basics of Circuitry**

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| --- | --- |
| Standard 4: Students will be able to explain basic concepts of AC/DC electrical theory and interpret, measure, and build basic electrical circuits. | Credit toward Massachusetts Electrician License |

**Sample Performance Tasks:**

* Student will describe the basic characteristics of a series/parallel and combination circuit.
* Student will calculate the voltage, amperage, resistance, and wattage of a circuit using Ohms law from given project.
* Student will describe and demonstrate the uses of Volt/Ohm and Ampere meters on given devices, including explaining and demonstrating safety practices and use of protective equipment.

**Standard 5: Codes, Regulations and References**

|  |  |
| --- | --- |
| Students will be able to locate and interpret appropriate Massachusetts Electric Code (MEC) Amendments, the National Electrical Code (NEC), and the Electrical Board of Examiners regulations (527 and 237 CMR) to complete a given project | Credit toward Massachusetts Electrician License |

**Sample Performance Tasks:**

* Student will describe the topic of each of the nine chapters in the Massachusetts Electrical Code (MEC).
* Student will determine the appropriate article of the Massachusetts Electrical Code MEC for a specific wiring method and apply to given project.
* Student will describe the value of informational notes and explain how they apply to given project.
* Student will explain how changes to the MEC are identified.
* Describe the difference between the National Electrical Code and the Massachusetts Electrical Code.
* Student will calculate a branch circuit load from a given project.

**Standard 6: Raceways, Fittings, Supports and Boxes**

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| --- | --- |
| Students will be able to install various items on a finished surface for a given project, including raceways, fittings, supports, and boxes. | Credit toward Massachusetts Electrician License |

**Sample Performance Tasks:**

* Student will install a box on a finished surface from a given project.
* Student will install a box in a finished surface from a given project.
* Student will identify the requirements for boxes and support luminaires.
* Student will identify the requirements for boxes that support paddle fans.
* Student will perform box fill calculations on a given project.
* Student will size and install a raceway for given project.

**Standard 7: Fundamentals of Conductors, Cables, and Terminations**

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| --- | --- |
| Students will be able to select and install conductors, common conductor terminations, and cables using different size wires. | Credit toward Massachusetts Electrician License |

**Sample Performance Tasks:**

* Student will calculate wire size, identify application, and install through a raceway.
* Student will prepare conductor for termination, strip appropriate insulation from the end of conductor, bend conductor end to terminate under terminal, and torque terminal to manufacturers’ specifications on a given project.
* Student will splice various solderless connections to different size wire for given project.

**Standard 8: Power and Distribution of Electricity**

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| --- | --- |
| Students will be able to calculate electric service requirements for dwellings, including grounding requirements, size of the service-entrance equipment and main disconnects, panelboards, and overcurrent protection devices. | Credit toward Massachusetts Electrician License |

**Sample Performance Tasks:**

* Install electrical services.
* Describe how to determine electric service requirements for dwellings.
* Describe and demonstrate the grounding requirements for services.
* Calculate and size service-entrance equipment.
* Install main disconnect switches, panelboards, and overcurrent protection devices.
* Student will calculate the service size for a residential dwelling.
* Student will select proper wire size and develop a material list for the service size calculated.
* Student will select and describe (or demonstrate) the proper grounding method for the service calculated.

**Standard 9: Overcurrent Protection**

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| Students will be able to articulate the importance of overcurrent protection and to size and install appropriate overcurrent protection devices. | Credit toward Massachusetts Electrician License |

**Sample Performance Tasks:**

* Student will explain the use of time delay fuses.
* Student will explain how a circuit breaker operates.
* Student will select the proper breaker for a specific application.
* Student will describe the safety risks associated with improper overcurrent replacement.

**Standard 10: Transformers**

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| --- | --- |
| Students will be able to describe the different types of transformers and to properly evaluate, connect, and protect transformers. | Credit toward Massachusetts Electrician License |

**Sample Performance Tasks:**

* Student will calculate the loads for a single-family dwelling from given project.
* Student will size the main overcurrent protective device from given project.
* Student will install the main overcurrent device in its proper location from given specifications.

**Standard 11: Motors and Motor Controls**

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| Students will be able to describe the operating principles of motors, define terms related to motors, and understand diagrams and structures of motors and programmable logic control circuits. | Credit toward Massachusetts Electrician License |

**Sample Performance Tasks:**

* Student will draw a schematic diagram for a stop/start motor control circuit.
* Student will draw a ladder diagram for a given application.
* Student will install wiring for a given project based on a diagram.

**Standard 12: Fundamentals of Grounding and Bonding**

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| Students will be able to describe and evaluate system and equipment grounding, and to describe the roles of key concepts including electrodes, bonding jumpers, and effective grounding. | Credit toward Massachusetts Electrician License |

**Sample Performance Tasks:**

* Student will size a grounding electrode conductor for a 100-amp service and install a grounding electrode.
* Student will size and install an equipment grounding conductor for a specific application.

**Standard 13: Luminaires and Luminaire Controls**

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| Students will be able to identify, classify, and install basic components of lighting and lighting control systems and fixtures. | Credit toward Massachusetts Electrician License |

**Sample Performance Tasks:**

* Student will identify and define industry terminology for lighting.
* Student will select and install lamps into luminaires.
* Student will recognize and install various types of luminaires.
* Student will select the appropriate luminaires for given lighting applications using manufactures’ lighting catalogs.

**Standard 14: Basic Low Voltage Wiring**

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| Students will be able to explain and apply the operating principles of fire, security alarm, and camera systems. | Credit toward Massachusetts Electrician License |

**Sample Performance Tasks:**

* Student will identify and install various components of fire and security alarm systems from given project.
* Student will define the various codes and regulations related to alarm systems (i.e., NFPA 72).

**Standard 15: Sustainable Practices in Electric Power Production Sources**

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| --- | --- |
| Students will be able to describe, identify, and select the components and storage systems of a photovoltaic system. | Credit toward Massachusetts Electrician License |

**Sample Performance Tasks:**

* Students will identify components of a photovoltaic system.
* Students will identify the components associated with an energy storage system.
* Students will identify the components associated with a standby system.