Skilled Trades Ontario | Métiers spécialisés Ontario

# Apprenticeship Curriculum Standard

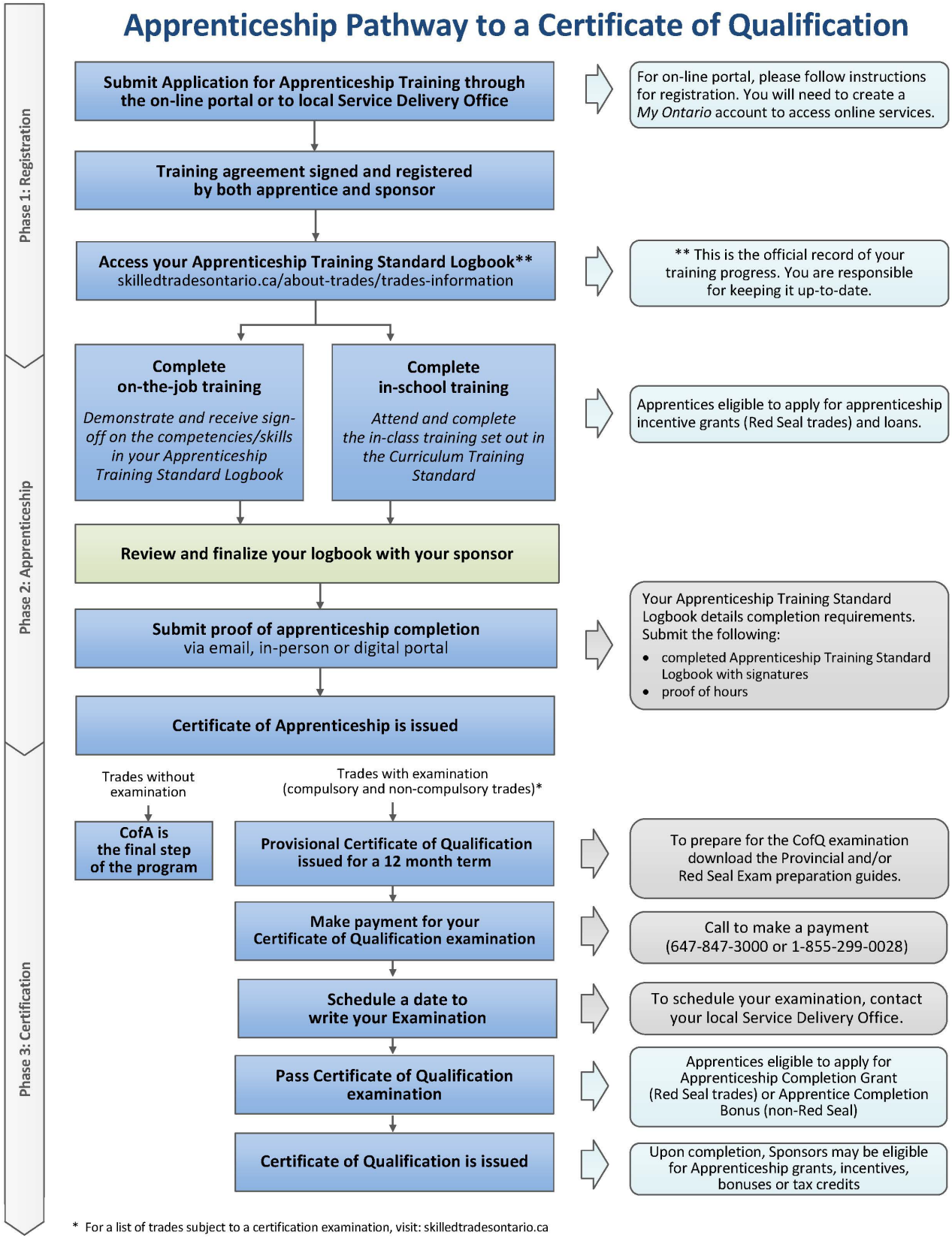
## Electrician — Construction & Maintenance (309A)

## Electrician — Domestic & Rural (309C)

## Industrial Electrician (442A)

## Levels 1, 2, 3, 4

# Apprenticeship Pathway to a Certificate of Qualification




* For a list of trades subject to a certification examination, visit: skilledtradesontario.ca

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*Revised 2019 (V300)*

**Preface**
This new curriculum standard for the three Electrical Trades is based upon the on-the-job performance objectives, located in the industry-approved training standards for the following participating trades: (Electrician, Construction and Maintenance (309A), Electrician, Domestic and Rural (309C) and Industrial Electrician (442A)).

The curriculum for the 3 electrical trades is organized into 4 levels of training. This document reflects all four levels. The first three levels are common core and apply to all three of the listed electrical trades. There is a distinct fourth level for each of the follow 2 trades: Electrician, Construction and Maintenance (309A) and Industrial Electrician (442A). These distinct fourth levels share 5 common core reportable subjects with the remainder being trade specific (2 for Electrician, Construction and Maintenance and 3 for Industrial Electrician). Electrician, Domestic and Rural does **not** have a fourth in school level. Apprentices in Electrician – Domestic and Rural are only required to complete Levels 1 through 3. The Program Summary of Reportable Subjects chart (located on page 7) summarizes the in-school training hours for each reportable subject.

The curriculum identifies the learning that takes place off-the-job. The in-school program focuses primarily on the theoretical knowledge and the essential skills required to support the on-the-job performance objectives of the Apprenticeship Training Standards for each of the 3 electrical trades. Employers/Sponsors are expected to extend the apprentice's knowledge and skills through practical training on the worksite. Regular evaluations of the apprentice's knowledge and skills are conducted throughout training to ensure that all apprentices have achieved the learning outcomes identified in this curriculum standard.

It is not the intent of the in-school curriculum to perfect on-the-job skills. The practical portion of the in-school program is used to reinforce theoretical knowledge. Skill training is provided on-the-job.

Please refer to Skilled Trades Ontario's website (www.skilledtradesontario.ca) for the most accurate and up-to-date information about Skilled Trades Ontario, including access to the Curriculum Standard and Supplemental Resource Guide for these trades. For information on the *Building Opportunities in the Skilled Trades Act* (BOSTA), please go to

**Pre-requisites**
Each preceding level is a pre-requisite for the following level. To advance to Level 2 of the apprenticeship program, an individual must have completed all of the units outlined in Level 1. To advance to Level 3 of the program, an individual must have completed all of the units outlined in Level 1 and 2. Similarly, in order to advance to Level 4 of the program (Industrial Electrician and Electrician, Construction and Maintenance only), an individual must have completed all of the units outlined in Level 1, 2 and 3.

**Hours Disclaimer** (if applicable)
It is agreed that Training Delivery Agents (TDAs) may need to make slight adjustments (with cause) according to Apprentice needs and may deviate from the unit sequencing and the prescribed practical and theoretical hours within the standard at the learning outcome and objective levels. However, all TDAs will comply with the hours at the reportable subject level.

**Suggested Equipment for Training Delivery Agencies**

The recommended listing of tools, equipment and materials is located in the Supplemental Resource Guide.

Personal and Safety Equipment: Personal protective equipment is at the discretion of the TDA who must conform to Ontario Provincial Health and Safety Regulations.

***Please note that all practices described in this standard must be performed according to the appropriate standard and industry best practices***

## Program Summary of Reportable Subjects and Recommended Hours

**The total hours for each level are as follows:**

- **Level 1– 270 hrs (9 weeks)**
- **Level 2 - 270 hrs (9 weeks)**
- **Level 3– 270 hours (9 weeks)**
- **Level 4 Industrial Electrician – 240 hours (8 weeks)**
- **Level 4 Electrician-Construction and Maintenance– 240 hours (8 weeks)**

### Level 1 Program Summary of Reportable Subjects*

| Number | Reportable Subjects | Hours Total | Hours Theory | Hours Practical |
|---|---|---|---|---|
| 3365 | Communication and Documentation | 27 | 27 | 0 |
| 3366 | Introduction to the Canadian Electrical Code | 36 | 36 | 0 |
| 3367 | Trade Practices | 36 | 36 | 0 |
| 3368 | Installation and Maintenance Methods | 54 | 9 | 45 |
| 3369 | Electrical Fundamentals | 81 | 54 | 27 |
| 3370 | Drawings, Specifications and Standards Fundamentals | 36 | 36 | 0 |
| | **Total** | **270** | **198** | **72** |

*This Level is 100% common core between the three electrical trades: Electrician - Construction and Maintenance, Electrician-Domestic and Rural and Industrial Electrician.

**Level 2 Program Summary of Reportable Subjects***

| Number | Reportable Subjects | Hours Total | Hours Theory | Hours Practical |
|---|---|---|---|---|
| 3371 | Electrical Systems | 72 | 63 | 9 |
| 3372 | Electronic Fundamentals | 36 | 18 | 18 |
| 3373 | Drawings, Specifications and Standards Intermediate | 36 | 36 | 0 |
| 3374 | Motor Controls and Devices | 45 | 18 | 27 |
| 3375 | Communication and Monitoring Systems | 45 | 18 | 27 |
| 3376 | Canadian Electrical Code II | 36 | 36 | 0 |
| | **Total** | **270** | **189** | **81** |

*This Level is 100% common core between the three electrical trades: Electrician - Construction and Maintenance, Electrician-Domestic and Rural and Industrial Electrician

**Level 3 Program Summary of Reportable Subjects***

| Number | Reportable Subjects | Hours Total | Hours Theory | Hours Practical |
|---|---|---|---|---|
| 3377 | Renewable Energy Generating and Storage Systems | 27 | 18 | 9 |
| 3378 | Electrical Theory and Application | 72 | 45 | 27 |
| 3379 | PLC Fundamentals | 27 | 9 | 18 |
| 3380 | Power Electronics | 36 | 18 | 18 |
| 3381 | Drawings, Specifications and Standards Advanced | 36 | 36 | 0 |
| 3382 | Introduction to Instrumentation | 36 | 18 | 18 |
| 3383 | Canadian Electrical Code III | 36 | 36 | 0 |
| | **Total** | **270** | **180** | **90** |

*This Level is 100% common core between the three electrical trades: Electrician - Construction and Maintenance, Electrician-Domestic and Rural and Industrial Electrician.

**Level 4 Program Summary of Reportable Subjects* - Industrial Electrician**

| Number | Reportable Subjects | Hours Total | Hours Theory | Hours Practical |
|---|---|---|---|---|
| 3384 | Building Automation Systems (Common Core) | 32 | 24 | 8 |
| 3385 | Professionalism and Ethics (Common Core) | 16 | 16 | 0 |
| 3386 | Power Conditioning (Common Core) | 24 | 24 | 0 |
| 3387 | Advanced Motors and Generators (Common Core) | 40 | 24 | 16 |
| 3388 | Advanced Instrumentation (Industrial only) | 32 | 16 | 16 |
| 3389 | Pneumatic and Hydraulic Control Systems (Industrial only) | 24 | 16 | 8 |
| 3390 | High voltage Service and Operation (Common Core) | 40 | 40 | 0 |
| 3391 | Automated Control systems (Industrial only) | 32 | 16 | 16 |
| | **Total** | **240** | **176** | **64** |

*The above list sets out the level 4 reportable subject requirements for Industrial Electricians (442A) only. 5 reportable subjects are common core with the level 4 requirements of Electricians, Construction and Maintenance (309A). The remaining 3 apply solely to Industrial Electricians. There are no level 4 requirements for Electrician, Domestic and Rural (309C).

**Level 4 Program Summary of Reportable Subjects* - Electrician, Construction & Maintenance**

| Number | Reportable Subjects | Hours Total | Hours Theory | Hours Practical |
|---|---|---|---|---|
| 3384 | Building Automation Systems (Common Core) | 32 | 24 | 8 |
| 3385 | Professionalism and Ethics (Common Core) | 16 | 16 | 0 |
| 3386 | Power Conditioning (Common Core) | 24 | 24 | 0 |
| 3387 | Advanced Motors and Generators (Common Core) | 40 | 24 | 16 |
| 3390 | High voltage Service and Operation (Common Core) | 40 | 40 | 0 |
| 3392 | Specialty Installations (Construction only) | 40 | 40 | 0 |
| 3393 | Canadian Electrical Code IV (Construction only) | 48 | 48 | 0 |
| | **Total** | **240** | **216** | **24** |

*The above list sets out the level 4 reportable subject requirements for Electricians, Construction and Maintenance (309A) only. 5 reportable subjects are common core with the level 4 requirements of Industrial Electricians (442A). The remaining 2 apply solely to Electricians, Construction and Maintenance (309A). There are no level 4 requirements for Electrician, Domestic and Rural (309C).

# Level 1

All reportable subjects in Level 1 are common core for:

Electrician, Construction and Maintenance (309A)

Industrial Electrician (442A)

Electrician, Domestic and Rural (309C)

**Level 1 Program Summary of Reportable Subjects – Common Core***

| Number | Reportable Subjects | Hours Total | Hours Theory | Hours Practical |
|---|---|---|---|---|
| 3365 | Communication and Documentation | 27 | 27 | 0 |
| 3366 | Introduction to the Canadian Electrical Code | 36 | 36 | 0 |
| 3367 | Trade Practices | 36 | 36 | 0 |
| 3368 | Installation and Maintenance Methods | 54 | 9 | 45 |
| 3369 | Electrical Fundamentals | 81 | 54 | 27 |
| 3370 | Drawings, Specifications and Standards Fundamentals | 36 | 36 | 0 |
| | **Total** | **270** | **198** | **72** |

*This Level is 100% common core between the three electrical trades: Electrician - Construction and Maintenance, Electrician-Domestic and Rural and Industrial Electrician.

| | | | |
|---|---|---|---|
| Number: | 3365 | | |
| **Title:** | **Communication and Documentation** | | |
| Duration: | Total Hours: 27 | Theory: 27 | Practical: 0 |

**Reference to theory in the case of this reportable subject relates to the location of the subject. While the outcomes include application exercises, they may be done in a computer lab or a classroom setting.*

## General Learning Outcomes

Upon successful completion, the apprentice is able to demonstrate communication techniques, use communication tools and computer software applications as well as describe documentation requirements (sector specific), strategies for learning skills and attitudes/attributes that contribute to on-the-job success.

## Learning Outcomes and Content

Upon successful completion the apprentice is able to:

3365.01 Demonstrate effective communication techniques in the workplace

- Identify the different types of communication techniques such as;
  - Verbal
  - Non-verbal
  - Written
- Apply communication techniques

3365.02 Demonstrate use of electronic communication tools (computer literacy)

- Describe the different methods and tools used in electronic communication such as:
  - Email
  - Internet
  - Forums

3365.03 Demonstrate use of computer software applications such as:

- Office applications
- Word processing
- Spreadsheets
- Cloud based applications
- PDF (fillable forms)

3365.04 Describe the requirements for locating, accessing and completing documentation and forms (written and electronic)

- Identify forms and documents commonly used in the sector
- Locate the forms and documents commonly used in the sector
- Identify the process for completing forms such as:
  - Work orders
  - Time sheets
  - Material list

3365.05 Identify personal responsibilities and attitudes that contribute to on-the-job success such as:

- Describe the importance of work ethic
- Identify the link between time management, productivity and accountability
- Describe the importance of showing respect, workmanship, pride in work, working effectively with other tradespeople
- Identify the value of working with others (colleagues, other trades)
- Describe factors that contribute to an individual presenting as a professional
  - Physical appearance/presentation/hygiene
  - Communication
    - verbal
    - written
    - body language
    - social media profile
  - Conduct

3365.06 Explain strategies for learning skills (being a mentee, working with a mentor)

- Describe the importance of the individual learning experience
- Describe the shared responsibilities for workplace learning
- Identify different ways of learning
- Identify different learning needs
  - Learning disabilities/disorders
  - Learning preferences
  - Language proficiency
- Identify strategies to meet learning needs
  - Describe basic principles of instruction
  - Describe the importance of attributes such as patience and maturity
  - Describe the importance of feedback
- Determine individual learning preferences
- Explain how learning preferences relate to learning new skills
- Describe the importance of essential skills in the workplace
  - Reading
  - Writing
  - Document use
  - Oral communication

    - Numeracy
    - Thinking
    - Working with others
    - Digital technology
    - Continuous learning
- Describe the importance of different types of skills in the workplace
- Identify strategies to assist in learning a skill

| **Evaluation Structure** | |
|---|---|
| Theory Testing | Application Exercises<br>(Including projects and assignments) |
| 50% | 50% |

| | | | |
|---|---|---|---|
| Number: | 3366 | | |
| Title: | **Introduction to the Canadian Electrical Code (CEC)** | | |
| Duration: | Total Hours: 36 | Theory: 36 | Practical: 0 |

**General Learning Outcomes**

Upon successful completion, the apprentice is able to navigate and apply sections of the Canadian Electrical Code (CEC).

**Learning Outcomes and Content**

Upon successful completion the apprentice is able to:

3366.01 Describe the terminology used in the CEC

- Identify the terminology used in the CEC
- Identify alternate or parallel terminology used in the trade
- Correlate trade terminology with CEC terminology

3366.02 Explain the objective, scope, and general arrangement of the CEC

- Identify the structure of the CEC
  - Preface
  - Table of contents
  - Sections
  - Tables
  - Diagrams
  - Appendices
  - Index
- Explain the difference between a general and supplemental section
- Identify the method used to indicate code regulation changes in new editions of the CEC
- Describe the objectives, scope and definitions contained in section 0 of the CEC
- Explain the relationship between the CEC and other regulations, codes/standards such as;
  - Ontario Electrical Safety Code (OESC)
  - National Fire Code (NFC), Ontario Fire Code (OFC) and other fire regulations
  - National Building Code (NBC), Ontario Building Code (OBC) and municipal building codes
  - Occupational Health and Safety Act (OHSA)
- Explain the relationship between the CEC and other Authorities Having Jurisdiction (AHJ) such as;
  - Electrical Safety Authority (ESA)
  - Technical Standards and Safety Authority (TSSA)
  - Building inspectors

- Local Distribution Companies (LDC)
- Describe the process for navigating the CEC
  - Identify how to use key words and initiate an index search
  - Describe how to use the table of contents to initiate a search

3366.03 Describe the process for rule interpretation

- Describe the use of words for interpretation purposes such as;
  - And/or
  - Not withstanding
  - Shall/shall not
  - Shall be permitted
- Describe the structure of the rules
  - Rules
  - Sub-rules
  - Items
  - Notes – Appendix B
- Interpret general rules of the CEC

3366.04 Demonstrate how to navigate and apply code rules

- Navigate and apply code rules related to conductors and cables
  - Identify insulation colour requirements
  - Identify the application of neutral/identified conductors
  - Identify conditions of use
  - Identify direct burial requirements
  - Identify overhead clearances
  - Determine support requirements
  - Perform calculations:
    - ampacity and apply correction factors for single conductors in free air
    - ampacity and apply correction factors for conductors in a raceway or multi-conductor cable
    - ampacity and apply correction factors for flexible cords and equipment wires
- Navigate and apply code rules related to raceways and fittings
  - Identify conditions of use
  - Determine support requirements
  - Identify direct burial requirements
  - Perform calculations:
    - raceway fill for installations where all conductors are the same size and have the same insulation type
    - raceway fill for installations where the conductors have different sizes and/or different insulation types
- Navigate and apply code rules related to boxes and enclosures:
  - Identify type or enclosure designation
  - Determine support requirements
  - Perform calculations:
    - maximum number of conductors sized #14 to #6

AWG permitted in a box
        - minimum size of pull boxes for straight, angle and u-pulls for conductors #4 AWG and larger
- Navigate and apply code rules related to equipment in dwelling units including;
    - appliances
    - luminaires
    - heating
    - receptacles
    - arc fault protection
    - ground fault protection
    - electric vehicle charging equipment
    - service equipment
  - Perform calculations:
    - size of service equipment for a single dwelling unit
- Identify code rules related to grounding and bonding of low and extra low voltage electrical systems and circuits
- Identify code rules related to Class 1 and Class 2 circuits
  - Class 1 extra low voltage power circuits
  - Class 2 power and data communication circuits (such as Power over ethernet (PoE), Fieldbus)
  - Circuit to safety control devices
  - Signal and remote-control circuits
- Identify the differences between a single-phase service and a temporary service

| **Evaluation Structure** | |
|---|---|
| Theory Testing | Application Exercises<br>(Including projects and assignments) |
| 100% | 0% |

| | | | |
|---|---|---|---|
| Number: | 3367 | | |
| Title: | **Trade Practices** | | |
| Duration: | Total Hours: 36 | Theory: 36 | Practical: 0 |

**General Learning Outcomes**

Upon successful completion, the apprentice is able to summarize trade specific practices related to safety requirements and the use of tools and equipment.

Note: The expectation for this reportable subject is that apprentices gain an awareness of safe work practices and jobsite hazards. It is not intended to provide apprentices with the related health and safety certifications.

**Learning Outcomes and Content**

Upon successful completion the apprentice is able to:

3367.01 Summarise the features and characteristics of the Occupational Health and Safety Act (OHSA)

- Describe the purpose of the OHSA
- Identify employer and worker rights and responsibilities
- Identify the sections of the OHSA
  - Act
  - Table of contents
  - Regulations
  - Conversion tables
  - Index
- Describe the content of the OHSA
  - Regulations
    - construction projects
    - mining
    - industrial/Institutional
    - confined space
- Describe the process for navigating the act and regulations
  - Definitions
  - Regulations
  - Sub-sections
  - Sub-clauses
- Compare the industrial and construction regulations

3367.02 Summarise the features and characteristics of safe work practices

- Identify electrical hazards in the workplace
  - Electrical shock
  - Arc flash and blast
- Identify the applicable standard for workplace electrical safety
  - CSA Z462
- Describe limits of approach and associated safeguards
- Identify hazards (non-electrical) in the workplace such as;
  - Combustible materials
  - Working at heights
  - Hazardous materials
    - Workplace Hazardous Material Information System (WHMIS)
    - safety data sheets (SDS)
- Identify emergency situations
  - Explosions
  - Shocks
  - Fires
  - Hazardous product releases
- Identify applicable emergency procedures
  - Site specific
  - General

3367.03 Explain the features and characteristics of lock out and tag procedures (CSA Z460- Control of hazardous energy/lock out and other methods)

- Describe lock and tag out procedures for electrical equipment
  - Describe procedures for de-energizing and re-energizing equipment
- Describe lock out and tag out procedures for non-electrical energy storage systems
- Describe safety checks to be performed to confirm zero energy state
- Describe how to determine if the testing equipment is matched to the voltage and energy rating (CAT rating)

3367.04 Explain the application, maintenance and storage procedures for Personal Protective Equipment (PPE) and Safety Equipment

- Identify types of PPE
  - Shock hazard PPE
  - Arc flash PPE
  - Hard hats
  - Safety glasses
  - Safety footwear
  - Hearing protection
  - Arc flash apparel
  - High visibility apparel

- Identify types of safety equipment
  - Fall protection (fall arrest and fall restraint)
  - Respiratory protection
  - Lock out and tag out equipment
  - Fire extinguishers
  - First aid equipment
  - Eye wash stations
  - Signage
  - Fume and toxic gas detectors
- Describe the applications of PPE and safety equipment
  - Hazardous locations
  - Heights
  - Confined spaces
- Describe the limitations of PPE and safety equipment
- Describe the procedures to care for, inspect and maintain PPE and safety equipment
- Describe the procedures to store PPE and safety equipment

3367.05 Apply the regulatory requirements pertaining to PPE and safety equipment

- Identify regulatory requirements and responsibilities
- Interpret regulatory requirements and responsibilities

3367.06 Describe the effects of the working conditions and environments (on the worker) such as;

- Temperature and Weather
  - UV exposure
  - Frostbite
  - Dehydration
  - Hypothermia
- Surface conditions
  - Ice
  - Standing water
- Dust
- Corrosive fumes and liquids

3367.07 Describe the function, application and use procedures for the following tools and equipment;

- Power tools and equipment
- Hand tools
- Trade specific tools
  - Benders
  - Threaders
  - Cutting tools
- Specialty tools and equipment
  - Luminance meters
  - Thermal imaging
- Welding equipment such as;

    - Exothermic welding
- Measuring equipment such as;
    - Tape measures
    - Levels
    - Torque wrenches
    - Laser levels
    - Laser layout system
        - Identify the functions and benefits of laser layout and site positioning systems
- Electrical measuring equipment such as;
    - Multi-meters
    - Clamp on Ammeters
    - Non-contact voltage testers
    - Insulation resistance testers
    - Power analyzers
    - Phase rotation meters

3367.08 Describe the function, application, limitations and use procedures for access equipment

- Identify types of access equipment
    - Ladders
    - Scissor lifts
    - Scaffolding
    - Articulating booms
- Describe the use of fall protection (fall arrest/fall restraint) in relation to access equipment
- Describe the inspection, maintenance and storage procedures for access equipment

3367.09 Describe the function, application, limitations and use procedures for hoisting, rigging and lifting equipment

- Identify types of hoisting, rigging and lifting equipment and accessories such as;
    - Types:
        - chain falls
        - come-alongs
    - Accessories:
        - slings
        - spreaders
        - shackles
- Identify techniques for hoisting, rigging and lifting
- Interpret codes and regulations pertaining to hoisting, lifting and rigging
- Identify types of knots, hitches, splices and bends and describe their applications
- Describe the considerations when rigging material/equipment for lifting
    - Load characteristics

    - Workload limit (WLL)
    - Equipment and accessories
    - Environmental factors
    - Anchor points
    - Sling angles
- Describe procedures used to communicate during hoisting, lifting and rigging operations such as;
    - Hand signals
    - Electronic communication
    - Audible/visible
- Describe safe work practices pertaining to hoisting, lifting and rigging
    - Identify potential hazards associated with hoisting, lifting and rigging
    - Describe the procedures to inspect, maintain and store hoisting, lifting and rigging equipment

3367.10 Demonstrate knot tying techniques such as;

- Bowline
- Square
- Figure eight
- Clove hitch
- Half hitch

| **Evaluation Structure** | |
|---|---|
| Theory Testing | Application Exercises<br>(Including projects and assignments) |
| 100% | 0% |

| | | | |
|---|---|---|---|
| Number: | 3368 | | |
| Title: | **Installation and Maintenance Methods** | | |
| Duration: | Total Hours: 54 | Theory: 9 | Practical: 45 |

**General Learning Outcomes**

Upon successful completion, the apprentice is able to demonstrate the installation and maintenance of single-phase service, distribution and branch circuit equipment as well as develop electrical schematics.

**Learning Outcomes and Content**

Upon successful completion the apprentice is able to:

3368.01 Demonstrate the installation of electrical circuits based on electrical schematics

- Identify the requirements for developing a schematic
  - Symbols
  - Schematic structure
  - Wire and rung numbering
  - labelling
  - Control vs power
- Interpret the function of a circuit using a schematic
- Develop schematic and install one or more normally open push buttons to control a signal device.
- Develop a schematic and install an extra low voltage relay to control a low voltage load

3368.02 Identify the purpose and requirements for bonding and grounding

- Identify grounding methods
- Identify grounding conductors, equipment and components
- Describe the characteristics and applications of grounding conductors, equipment and components
- Calculate minimum size of grounding conductors
- Identify bonding methods
- Identify bonding conductors, equipment and components
- Describe the characteristics and applications of bonding conductors, equipment and components
- Calculate the minimum size of bonding conductors
- Describe the methods used to maintain single-phase services and their components

3368.03 Describe the installation and maintenance procedures for terminating conductors on electrical devices including switches, receptacles, luminaires

- Identify CEC code requirements, standards, manufacturer's specifications and trade practices for installation and maintenance of circuit components
- Verify the installation and maintenance is compliant with CEC, standards and manufacturer's specifications
- Identify the causes and effects of problematic wiring connections

3368.04 Demonstrate the installation and maintenance of raceways, cables, enclosures, fittings and associated support components

- Identify types of raceways, cables, enclosures and fittings such as;
  - Non-metallic sheathed cables
  - Armoured cables
  - Mineral-insulated cable, aluminium sheathed cable and copper-sheathed cables
  - Rigid metal conduits
  - Rigid PVC conduits
  - Flexible metal conduits
  - Liquid-tight flexible conduits
  - Electrical metallic tubing
  - Electrical Non-metallic tubing
  - Flexible cords
- Identify CEC code requirements, standards and manufacturer's specifications for the installation and maintenance of raceways and cables
- Verify the installation and maintenance is compliant with CEC, standards and manufacturer's specifications

3368.05 Demonstrate the installation and maintenance of a single-phase service and distribution equipment and associated support components

- Identify the components on a layout drawing for a single-phase service and distribution equipment such as;
  - Service entrance raceway (overhead or underground)
  - Metering equipment
  - Service box/Main disconnects
  - Panel boards
  - Disconnects
    - feeder/distribution
    - branch
- Identify CEC code requirements, standards and manufacturer's specifications for the installation and maintenance of single-phase service and distribution equipment
- Verify the installation and maintenance is compliant with CEC, standards and manufacturer's specifications
- Identify service components, service conductors and fasteners and describe their purpose and applications

- Identify and describe the methods used to connect service conductors
- Identify the methods of grounding and bonding single-phase services
- Describe the methods used to maintain single-phase services and their components

3368.06 Demonstrate the installation and maintenance of branch circuits and wiring devices

- Identify types of branch circuits and wiring devices such as;
  - Single-pole circuits
  - Double-pole circuits
  - 120/240 V
  - Ampacity ranging from 15 to 100
  - GFCI protection devices
  - AFCI protection devices
  - Outside weatherproof receptacles
  - EVSE (Electrical vehicle supply equipment)
  - Split and switched receptacles
  - Lighting circuits
    - single-pole
    - three-way
    - four-way
- Identify CEC code requirements, standards and manufacturer's specifications for the installation and maintenance of branch circuits and wiring devices
- Verify that installation and maintenance is compliant with CEC, standards and manufacturer's specifications

| **Evaluation Structure** | |
|---|---|
| Theory Testing | Application Exercises<br>(Including projects and assignments) |
| 35% | 65% |

| | | | |
|---|---|---|---|
| Number: | 3369 | | |
| **Title:** | **Electrical Fundamentals** | | |
| Duration: | Total Hours: 81 | Theory: 54 | Practical: 27 |

**General Learning Outcomes**

Upon successful completion, the apprentice is able to apply electrical principles, concepts and associated calculations as well as demonstrate the following; how to measure circuit parameters, how to build series, parallel and combination circuits and the relationship between work, power and energy.

**Learning Outcomes and Content**

Upon successful completion the apprentice is able to:

3369.01 Apply formulations in relation to electrical fundamentals

- Fractions
- Transpositions
- Scientific notations
- Engineering notations
- Substitutions
- Algebra

3369.02 Describe atomic theory as it relates to the conduction of electricity

- Identify elements on the periodic table
- Define electricity
- Define a conductor and insulator
- Define the elements that produce conductors, insulators and semi-conductors
- Describe electron flow and conventional flow
    - Identify distinctions between the theories

3369.03 Describe common sources of electricity such as;

- Chemical (Battery)
- Magnetic (Generators)
- Solar
- Heat (Thermal pile)
- Pressure

3369.04 Explain the features and characteristics of resistors and colour coding

- State standard resistor colour code
- Identify resistor values using the colour code
- Identify the properties of resistors
    - Construction
    - Tolerance
    - Power rating

3369.05 Describe the requirements for a basic electrical circuit

- Define voltage, current, resistance and power
- Describe the components required to complete a basic circuit
    - Source
    - Conductors
    - Load
- Describe the relationship between voltage, current, resistance and power in a basic electrical circuit
    - Ohm's law
        - basic electrical symbols such as;
            - resistor
            - source
            - meters
            - single-pole switch
    - Power formulae

3369.06 Apply laws of electrical theory to DC circuits

- Apply Ohm's Law to analyze series DC circuits.
- Apply Kirchhoff's Law to analyze series DC circuits
- Apply Ohm's Law to analyze parallel DC circuits
- Apply Kirchhoff's Law to analyze parallel DC circuits
- Apply Ohm's Law to analyze combination DC circuits
- Apply Kirchhoff's Law to analyze combination DC circuits
- Calculate values of power for all types of DC circuits
- Analyze and calculate current, voltage, and power characteristics in 2-wire and 3-wire distribution systems for balanced, unbalanced, and faulted conditions
- Define and calculate efficiency of electrical distribution systems (line loss)

3369.07 Demonstrate how to measure circuit parameters using multi-meters (in support of 3369.06)

- Measure voltage, resistance, current and power

3369.08 Demonstrate how to build series, parallel and combination circuits to support Ohm's and Kirchhoff's laws (to support 3369.07)

- Measure circuit parameters using metering equipment

3369.09 Demonstrate the relationship between work, power and energy

- Define work, power, and energy
- Perform relationship calculations between work, power and energy
- Convert between mechanical and electrical units of work, power, and energy

| Evaluation Structure | |
|---|---|
| Theory Testing | Application Exercises<br>(Including projects and assignments) |
| 85% | 15% |

| | | | |
|---|---|---|---|
| Number: | 3370 | | |
| **Title:** | **Drawings, Specifications and Standards Fundamentals** | | |
| Duration: | Total Hours: 36 | Theory: 36 | Practical: 0 |

**General Learning Outcomes**

Upon successful completion, the apprentice is able to interpret and use information provided from drawings, specifications and standards for electrical installation and maintenance (single-phase). The apprentice is also able to create drawings and schedules.

**Learning Outcomes and Content**

Upon successful completion the apprentice is able to:

3370.01 Explain the process to interpret and extract information from drawings, schematics
and specifications

- Identify symbols and line types
- Identify and interpret the alphanumerical lines
- Describe how to use metric and imperial scales
- Extrapolate measurements from drawings using metric and imperial scales
- Interpret and extract information from drawings, schematics
- Describe how to convert between architectural and engineering scales

3370.02 Interpret imperial and metric (SI) units in trade documentation

3370.03 Describe the application of drawing types and views

- Identify types and views of drawings
  - Types:
    - architectural
    - structural
    - civil
    - mechanical
    - electrical
    - communications
    - site plan (underground locates)
    - shop
    - as-built
  - Views:
    - plan
    - elevation
    - section
    - detail

3370.04 Describe the application of the following elements;

- Schedules
- Tables
- Symbols
- Notes
- Documents

3370.05 Demonstrate how to prepare and use site documentation for single-phase branch circuit wiring

- Describe the procedures to plan and organize materials and supplies
  - Describe the considerations to organize materials and supplies
- Describe the procedures to plan and organize job tasks using critical path method
  - sequencing of trades and tasks
- Create and label an electrical panel schedule
- Draw and label a plan view drawing that includes device locations to scale
- Confirm projects comply with CEC, applicable standards and specifications

3370.06 Describe types of single-phase low voltage power distribution equipment

- Identify types and applications of single-phase low voltage power distribution equipment
  - Service entrance
  - Panels
  - Sub panels
  - Switchboards
  - Breakers
  - Fuses
  - Disconnects
  - Splitters
- Interpret codes and regulations pertaining to single-phase low voltage power distribution equipment
- Interpret information pertaining to single-phase low voltage distribution equipment on drawings and specifications
- Identify the considerations for selecting single-phase low voltage power distribution equipment and enclosures
  - Loads
  - Voltage ratings
  - Required circuit ampacity
  - Interrupting ratings

| **Evaluation Structure** | |
|---|---|
| Theory Testing | Application Exercises<br>(Including projects and assignments) |
| 75% | 25% |

# Level 2

All reportable subjects in Level 2 are common core for:
Electrician, Construction and Maintenance (309A)
Industrial Electrician (442A)
Electrician, Domestic and Rural (309C)

**Level 2 Program Summary of Reportable Subjects – Common Core***

| Number | Reportable Subjects | Hours Total | Hours Theory | Hours Practical |
|---|---|---|---|---|
| 3371 | Electrical Systems | 72 | 63 | 9 |
| 3372 | Electronic Fundamentals | 36 | 18 | 18 |
| 3373 | Drawings, Specifications and Standards Intermediate | 36 | 36 | 0 |
| 3374 | Motor Controls and Devices | 45 | 18 | 27 |
| 3375 | Communication and Monitoring Systems | 45 | 18 | 27 |
| 3376 | Canadian Electrical Code II | 36 | 36 | 0 |
| | **Total** | **270** | **189** | **81** |

*This Level is 100% common core between the three electrical trades: Electrician - Construction and Maintenance, Electrician-Domestic and Rural and Industrial Electrician

| | | | |
|---|---|---|---|
| Number: | 3371 | | |
| **Title:** | **Electrical Systems** | | |
| Duration: | Total Hours: 72 | Theory: 63 | Practical: 9 |

**General Learning Outcomes**

Upon successful completion, the apprentice is able to describe the construction, characteristics, operation and maintenance requirements for DC motors, DC generators and generating systems, describe the application of cathodic protection systems, apply the principles of single-phase AC theory as well as demonstrate procedures to connect single-phase AC RLC circuits and series, shunt and compound DC motors.

**Learning Outcomes and Content**

Upon successful completion the apprentice is able to:

3371.01 Explain magnetism and related concepts

- Identify the fundamental laws of magnetism
- Define permanent and electro-magnets
- Identify the characteristics of magnetic lines of forces
- Describe characteristics associated with magnetic energy
  - Magnetic potential difference
  - Flux density
  - Reluctance
  - Permeance
  - Permeability
  - Magnetic losses
    - hysteresis
    - eddy currents

3371.02 Explain the relationship between magnetism and EMF

- Explain the factors that affect the magnitude and direction of induced EMF in single conductors and coils
- Explain the relationship between motor action and magnetism
- Apply Fleming’s hand rules
- Explain Lenz’s law

3371.03 Describe the construction and characteristics of DC generators and generating systems such as portable, stationary, manually operated, automatically operated, 2-wire, 3-wire:

- Identify types and characteristics of DC generators
  - Permanent magnet
  - Separately excited
  - Self excited
- Identify the components of DC generators and generating systems such as;

- Transfer switches
- Brushes and commutators
- Prime movers
- Cables
- Conductors
- Overcurrent devices
- Governors
- Shafts
- Armature and field windings
- Bearings
- Frames
- Exciter windings

3371.04 Describe the construction, operation and characteristics of DC motors

- Identify types and characteristics of DC motors
  - Permanent magnet
  - Wound field
    - series
    - shunt
    - compound (cumulative and differential)
- Identify the components of DC motors
  - Frames
  - Armatures
  - Field windings
  - Commutators
  - End bells
  - Ventilation means
  - Brushes
  - Brush holders
  - Bearings
  - Bushings

3371.05 Describe the procedures to maintain commutators, brushes and bearings for DC generators and DC motors

3371.06 Describe the procedures to install new brushes and bearings for DC generators and DC motors

3371.07 Demonstrate procedures to connect series, shunt and compound motors

- Identify windings based on resistance values
- Determine torque and load characteristics of DC motors
- Control the direction of rotation of DC motors
- Control speed of DC motors
  - Overspeed
  - Under speed
- Demonstrate dynamic breaking to illustrate principles of counter EMF

3371.08 Describe the application of cathodic protection systems

3371.09 Describe single-phase AC theory principles

- Sine wave
- Electrical/mechanical degrees
- Root mean squared (RMS)/effective
- Average
- Peak/Peak to Peak
- Instantaneous values
- Cycle
- Frequency
- Period
- Alternations

3371.10 Apply formulations for voltage, current, resistance and power in relation to AC circuits

3371.11 Demonstrate procedures to connect single-phase AC RLC circuit

- Describe self inductance and inductors
- Describe the characteristics and operation of inductors
- Describe the characteristics and operation of capacitors
- Calculate values for RL/RC/RLC series, parallel and combination circuits
- Describe resonant circuits

| Evaluation Structure | |
|---|---|
| Theory Testing | Application Exercises<br>(Including projects and assignments) |
| 75% | 25% |

| | | | |
|---|---|---|---|
| Number: | 3372 | | |
| **Title:** | **Electronic Fundamentals** | | |
| Duration: | Total Hours: 36 | Theory: 18 | Practical: 18 |

**General Learning Outcomes**

Upon successful completion, the apprentice is able to demonstrate the operation and application of solid-state components that control AC and DC wave forms.

**Learning Outcomes and Content**

Upon successful completion the apprentice is able to:

3372.01 Apply formulations for voltage, current, resistance and power in relation to electronic circuits

3372.02 Test electrical circuitry using power supplies, oscilloscopes and other electrical test equipment
- Explain the importance of isolation as applied to test equipment

3372.03 Demonstrate the principles of a single-phase AC wave form
- Connect test equipment to an AC wave form
- Observe the characteristics
  - Sine wave
  - Electrical/mechanical degrees
  - Root mean squared (RMS)/effective
  - Average
  - Peak/Peak to Peak
  - Instantaneous values
  - Cycle
  - Frequency
  - Period
  - Alternations

3372.04 Demonstrate the operation of diodes
- Describe the properties of N and P type semiconductor materials.
- State current and voltage requirements for silicon diodes, and light emitting diodes (LEDs).
- Describe operating characteristics for silicon diodes and LEDs when connected in forward and reverse bias
- Explain the important diode characteristics used when selecting diodes.
- Explain the use of a zener diode as a regulator

3372.05 Demonstrate the operation of capacitors in RC timers and filters

- Describe the operation of a capacitor
  - Identify types and ratings of capacitors
- Explain charge and discharge curves
- Explain and calculate time constants in relation to the size of resistor and capacitor

3372.06 Demonstrate the operation of DC power supplies

- Describe and demonstrate single-phase, half and full wave rectification
- Calculate average DC voltage as it refers to rectified AC
- Connect capacitors to filter the output of a single-phase power supply

3372.07 Demonstrate the operation of solid-state switching devices (thyristors)

- Identify types of solid-state switching devices
  - SCRs
  - TRIACs
  - DIACs
- Describe the operation of an SCR in AC and DC circuits
- Demonstrate the operation of an SCR Controlled bridge rectifier
- Describe and demonstrate the operation of DIACs and TRIACs
- Describe and demonstrate how a DIAC and RC network can be used to phase shift a TRIAC.
- Describe and demonstrate how a DIAC, TRIAC and RC network can be used to modify the AC sine wave and vary AC voltage
  - Compare switch mode voltage control to series resistor voltage control

| Evaluation Structure | |
|---|---|
| Theory Testing | Application Exercises (Including projects and assignments) |
| 60% | 40% |

| | | | |
|---|---|---|---|
| Number: | 3373 | | |
| **Title:** | **Drawings, Specifications and Standards Intermediate** | | |
| Duration: | Total Hours: 36 | Theory: 36 | Practical: 0 |

**General Learning Outcomes**

Upon successful completion, the apprentice is able to navigate, use and apply drawings and specifications, prepare as-built sketches as well as explain the processes to install and maintain electric heating, HVAC systems, luminaires, wiring devices and exit and emergency lighting systems.

**Learning Outcomes and Content**

Upon successful completion the apprentice is able to:

3373.01 Demonstrate how to navigate specifications using the Construction Specifications Canada (CSC) format

3373.02 Apply site drawings and specifications to determine utility location and site features that affect electrical installations

3373.03 Apply architectural and structural drawings and specifications to determine methods of construction as they affect electrical installations

3373.04 Apply architectural and structural drawings and specifications to determine dimensions and elevations that affect electrical installations

3373.05 Explain the process for installing electric heating

- Identify types electric heating systems
  - Central units (furnaces, tanks boilers)
  - Convection heaters
  - Infrared radiant heaters
  - Trace heaters
  - Heating cable sets
  - Forced air unit heater
  - Dielectric heating
  - Impedance heating
  - Induction heating
  - Skin effect heating
- Identify types of electric heating system controls
  - Line voltage thermostats
  - Extra low voltage thermostats
  - Extra-low voltage relays
  - High temperature limit devices
  - Digital temperature controllers
- Describe the operation and application of electric heating systems and controls

- Identify the codes, standards and regulations pertaining to the sizing and installation of electrical heating systems and controls
- Describe the procedure to remove electric heating systems and controls
    - Identify the considerations and requirements for removing electric heating systems
        - safety
        - loss of heating capacity
- Identify the considerations and requirements for selecting electric heating systems and controls and components
    - Existing controls/systems
    - Service capacity
    - Heating application

3373.06 Explain the process for maintaining electric heating systems

- Describe the procedures for troubleshooting faults in the electric heating system and controls
- Describe the procedures to repair or replace electric heating system and controls
- Describe the procedure to verify the operation of repaired electrical heating systems and controls

3373.07 Apply mechanical drawings to determine the electrical characteristics of mechanical equipment and systems for electrical installation (power requirements)

3373.08 Explain the process for connecting power to HVAC Systems and equipment

- Identify types of HVAC systems and equipment
    - Circulating pumps
    - Dampers
    - Boilers
    - Air compressors
    - Refrigeration compressors
    - Condensers
    - Evaporators
    - Cooling tower fans
    - Chillers
    - De-humidifiers
    - VAV boxes
- Describe the characteristics and applications of HVAC systems and equipment
- Identify the information pertaining to HVAC systems and equipment on drawings, specifications and nameplates
- Identify the codes, standards and regulations pertaining the electrical components of HVAC systems and equipment

- Describe the procedures used to connect HVAC systems and associated equipment
    - Identify the considerations and requirements for connection

3373.09 Explain the process for installing HVAC Controls

- Identity types of HVAC control components such as;
    - Time clocks
    - Relays
    - Sensors
    - Thermostats
    - Actuators
    - Electrical interlocks
    - Multiple function controllers
    - Variable Frequency Drives (VFDs)
    - Discrete and analog devices
    - Flow switches
    - Pressure switches
- Describe the characteristics and applications of HVAC control components
- Identify the information pertaining to HVAC control components on drawings, specifications and nameplates
- Identify the codes and regulations associated with HVAC control components
- Describe the process to install, replace, connect and test HVAC control components
    - Identify the considerations and requirements for removing HVAC control components
    - Identify the considerations and requirements for selecting HVAC control components
    - Identify the procedures to isolate and remove HVAC control components
    - Identify the procedures to connect HVAC control components
    - Identify the procedures to test HVAC control components

3373.10 Explain the process for maintaining HVAC electrical components

- Identify electrical components of HVAC systems
    - Motors
    - Thermostats
    - Humidistats
    - Pressure switches
    - Temperature switches
    - Flow switches
    - Level switches
    - VFDs
    - Discrete and analog sensors

- Describe the interaction between the electrical component and their effect on the HVAC system
- Describe how the operation or failure of an individual electrical component impacts the other components or system as a whole
- Describe the procedure used to troubleshoot faults in electrical components
- Describe the procedure to repair and replace electrical components
- Describe the procedure to adjust or reprogram electrical components
- Describe the procedure to verify the operation of repaired components

3373.11 Apply mechanical drawings to determine the layout of mechanical equipment and systems for electrical installations (location)

3373.12 Apply drawings and specifications to layout commercial distribution and service equipment and wiring

3373.13 Update single-line, schematic, riser and wiring diagrams

- Interpret single-line, schematic, riser and wiring diagrams for:
  - Distribution systems
  - Control systems
  - Fire alarm systems
  - Mechanical systems

3373.14 Explain the process to install luminaires

- Identify types of luminaires
  - Surface mounted luminaires
  - Recessed luminaires
  - Track lighting
- Identify light sources and components
  - HID
    - mercury-vapor
    - metal-halide
    - sodium-vapor
  - LED
  - Incandescent
  - Halogen
  - Fluorescent
  - Neon
  - Support poles (structures)
  - Ballasts
  - Drivers
  - Sockets
- Describe the application and operation of luminaires and components

- Identify codes, standards and regulations pertaining to luminaires
- Identify information pertaining to luminaires on drawings and specifications
- Identify types of branch circuitry and components
    - Normal powered branch circuits
    - Emergency powered branch circuits
- Describe the operation and application of branch circuitry and components
- Describe the procedures used to remove, retrofit, install, dispose of and support luminaires
    - Identify mounting requirements
    - Identify the considerations and requirements for removing luminaires and components
    - Identify the considerations and requirements for selecting indoor and outdoor luminaires and emergency and exit luminaires, associated components
- Describe the procedures used to test luminaires and components
- Identify considerations/factors that influence lifespan
- Describe lighting terminology such as;
    - Efficacy
    - Efficiency
    - Colour rendering and temperature
    - Luminance

3373.15 Explain the process to maintain luminaires

- Describe the procedures to maintain branch circuitry and components

3373.16 Demonstrate the use of drawings, specifications and industry practices to layout commercial branch circuit wiring, lighting and equipment

3373.17 Explain the process to install exit and emergency lighting systems

- Identify types of exit and emergency lighting systems and components
    - Unit equipment
    - Normal and standby (emergency) powered
    - Remote lighting units
    - Associated wiring components and circuits
- Describe the application and operation of exit and emergency lighting systems and components
- Identify types of back up power supply
    - Batteries
    - Stand-by generators
- Identify the requirements for determining size and placement of emergency lighting systems according to

jurisdictional requirements (i.e. building codes)
- Identify information pertaining to exit and emergency lighting systems on drawings and specifications
- Identify the considerations and requirements for selecting exit and emergency lighting systems and components
- Identify the calculations used when selecting exit and emergency lighting systems and components
- Describe the procedure remove exit and emergency lighting systems and components
    - Identify the considerations for removing and/or disposing of exit and emergency lighting systems
- Describe the procedures to test exit and emergency lighting systems and components
- Identify the documentation requirements following testing

3373.18 Explain the process to maintain exit and emergency lighting systems
- Describe the procedures to maintain exit and emergency lighting systems and components
- Identity testing requirements
- Identify the documentation and record requirements related to test results

3373.19 Demonstrate the use of drawings and specifications to layout a control system such as lighting, temperature, occupancy

3373.20 Demonstrate the use of drawings and specifications to prepare a material take off

3373.21 Demonstrate how to prepare sketches to create as-built drawings

3373.22 Explain the process to install wiring devices

- Identify types of branch circuitry and wiring devices
  - Switches
  - Timers
    - astronomical
    - interval
  - Sensors
    - ambient
    - daylight
    - infrared
    - ultrasonic
  - Relays
    - dual voltage
    - emergency lighting bypass
    - latching
  - Controllers
  - Disconnects
  - Power outlets
  - Receptacles
- Describe the application and operation of branch circuitry and wiring devices
- Identify the codes, standards and regulations pertaining to wiring devices
- Identify the information on drawings and specifications pertaining to wiring devices
- Identify the considerations and requirements for removing wiring devices
- Identify the considerations and requirements for selecting wiring devices

3373.23 Explain the process to maintain wiring devices

- Describe the procedures to maintain branch circuitry and wiring device components

| Evaluation Structure | |
|---|---|
| Theory Testing | Application Exercises (Including projects and assignments) |
| 80% | 20% |

| | | | |
|---|---|---|---|
| Number: | 3374 | | |
| **Title:** | **Motor Controls and Devices** | | |
| Duration: | Total Hours: 45 | Theory: 18 | Practical: 27 |

**General Learning Outcomes**

Upon successful completion, the apprentice is able to demonstrate how to install motor control circuits, starters and controllers, demonstrate the development of ladder diagrams (power and control), demonstrate diagnostic, commissioning and troubleshooting methods for motor control circuits and components as well as explain the installation, connection and maintenance procedures for motor starters.

**Learning Outcomes and Content**

Upon successful completion the apprentice is able to:

3374.01 Describe the characteristics of motor control components

- Identify the functions, operations and symbols for motor control components
  - Push buttons and selector switches
    - normally open
    - normally closed
    - momentary
    - E-stop
    - latching
  - Pilot devices
    - limit switches
    - proximity switches
    - float switches
    - flow switches
    - photo detectors
  - Relays and contactors
    - Contacts
      - normally closed (NC)
      - normally open (NO)
      - maintaining
      - momentary
      - timed
      - overload
    - Coils
      - AC
      - DC

    - Indicators
        - pilot lights
        - audible signal
    - Across the line motor starters
        - for AC motors
        - for DC motors
        - single-phase AC
        - three-phase AC
        - manual motor circuit switch
        - automatic motor circuit switch
        - combination
- Identify information pertaining to motor starters on motor nameplates, drawings and specifications
- Identify codes and regulations pertaining to motor starters

3374.02 Demonstrate the installation of motor control circuits, starters and controllers

- Identify types of motor control circuits and their characteristics
    - Starting and stopping
        - low voltage release (2-wire control)
        - low voltage protection (3-wire control)
    - Multiple location control
    - Hand-off-auto
    - Jogging
    - Plugging
    - Anti-plugging
    - Sequencing/time function
    - Forward/reverse
- Explain the purpose and application of motor control circuits
- Identify types, characteristics and applications of protection devices
    - Overcurrent devices
    - Overloads
- Identify codes and regulations pertaining to motor control and motor branch circuits

3374.03 Demonstrate the development of ladder diagrams (both power and control) using the following:

- Symbols
- Wire and rung numbering
- labelling

3374.04 Demonstrate diagnostic, commissioning and troubleshooting methods for motor control circuits and components

- Assess circuit and components prior to energization
- Assess circuit and components after failure

3374.05 Identify the components of a motor controls that are prone to failure

- Control and power contacts
- Coils
- Overloads

3374.06 Explain the installation and connection procedures for motor starters, components and accessories

- Identify the importance of the manufacturer's specifications
- Describe the procedures to install motor starters
- Describe the procedures to install motor starter components
- Identify motor starter accessories
- Describe the procedures to install motor starter accessories
- Describe the procedures to connect motor starters, components and accessories
- Identify enclosure types and wiring methods for motor starter installation and connection

3374.07 Explain the maintenance procedures for motor starters

- Describe the procedures to maintain motor starters, components and accessories
  - Identify scheduled maintenance requirements
    - Preventative and predictive maintenance
  - Describe troubleshooting procedures
  - Identify indications/symptoms of problems
  - Identify causes
  - Describe the shutdown and start-up procedures
  - Describe the process for performing diagnostics
  - Describe the procedures to repair/replace components

| Evaluation Structure | |
|---|---|
| Theory Testing | Application Exercises<br>(Including projects and assignments) |
| 50% | 50% |

| | | | |
|---|---|---|---|
| Number: | 3375 | | |
| **Title:** | **Communication and Monitoring Systems** | | |
| Duration: | Total Hours: 45 | Theory: 18 | Practical: 27 |

**General Learning Outcomes**

Upon successful completion, the apprentice is able to demonstrate the installation, operation, testing, verification and troubleshooting of security and surveillance systems, fire alarm systems and communication systems and their components.

**Learning Outcomes and Content**

Upon successful completion the apprentice is able to:

3375.01 Describe the types, characteristics and applications, operation and wiring methods of security and surveillance systems

- Identify the standards pertaining to security and surveillance systems
- Identify types and applications of security and surveillance systems
  - Perimeter
    - outdoor
    - indoor
  - Location (Area being protected)
  - Spot (i.e. retail check out)
  - Associated systems such as;
    - central alarm monitoring
    - automatic doors
    - LAN
    - building Automation systems
    - lighting
- Identify security and surveillance system components such as;
  - Cameras
  - Monitors
  - DVRs
  - Motion sensors
  - Card readers
  - Bio-scanners
  - Voice recognitions
  - Magnetic locks
  - Electronic locks
  - Horns
  - Panels
  - Proximity sensors
  - Glass break sensors
  - Pressure sensors
  - RFID tags
  - Keypads

    - Power supplies
    - Servers
    - GUIs
- Identify the codes, standards and regulations pertaining to security, surveillance systems

3375.02 Describe the types, operation, applications and wiring methods of Fire Alarm Systems and associated systems and components

- Identify the codes, standards and regulations pertaining to fire alarm systems such as;
    - National/Provincial Building Codes
    - National/Provincial Fire Codes
    - ULC
    - CEC
    - Local building codes and/or regulations
    - Other authorities having jurisdiction
    - Manufacturer's specifications
- Identify types of fire alarm systems
    - Addressable
        - DCLA
        - DCLB
        - DCLC
    - Non-addressable
        - Class A
        - Class B
    - Associated systems
        - fire suppression systems
        - emergency power supplies
        - fan shutdown/start-up relays
        - PA systems
        - remote monitoring
        - magnetic door holders
        - elevator homing contactors
        - egress door securing and releasing devices
        - building automation systems
        - ancillary devices
        - fire pumps
        - jockey pumps
        - voice communication systems (i.e. fire phones)
- Identify fire alarm system components such as;
    - Initiation devices (IDC)
        - pull stations
        - fire/flame detectors
        - flow switches
        - monitoring modules
        - smoke detectors
        - end of line devices
    - Notification devices (NAC)
        - speakers

        - bells
        - horns
        - strobe lights
        - end of line devices
    - Supervisory devices
        - tamper switches
        - gate valves
        - end of line devices
    - Panels, relays and associated equipment
        - stand-by batteries and power supplies
        - fire alarm panels
        - annunciator panels
        - transponders

3375.03 Describe the types, characteristics, operations, applications and wiring methods of communication systems and components

- Identify the codes and standards pertaining to communication systems
    - Manufacturer’s specifications
    - Canadian Electrical Code
    - Telecommunication Industry Association
- Identify types and applications of Communication Systems
    - VDV and CCTV systems
    - PA Systems
        - perimeter
        - space
    - Inter-com systems
    - Nurse call systems
        - one way
        - two way
        - audible and visual
        - direct wire
        - IP based/structured cabling
    - Associated systems
        - building control systems
        - elevator systems
        - fire alarm and suppression systems
        - HVAC
        - lighting
        - energy management system
        - SCADA
        - PoE
- Identify Communication System components
    - Media
        - data cables
            - UTP
            - F/UTP
            - Coaxial
        - fibre optic

        - Multi-mode
        - Single mode
      - wireless
        - Wi-fi
        - DAS
    - Termination blocks
    - Outlet jacks
    - Patch panels
    - Face plates
    - Patch cables
    - Cable supports
    - Cable management devices
    - Surge protection for communication circuits
    - Connectors
    - Splice trays
    - Cabinets
    - Racks
    - Power supplies
    - Broadcast transmitters
    - Receiving equipment
    - EMI suppressors
    - Satellite antennas
    - Amplifiers
    - Splitters
    - Attenuators
    - Terminators
    - Bonding hardware
    - Microphones
    - Speakers
    - Bells
    - Tone generators
    - Panels
    - Handsets
    - Door release strikes
    - GUIs
    - Cameras
    - Monitors
    - RFID tags
    - Annunciator
    - Keypads
- Identify the diagnostic and test equipment used for communication systems
    - TDRs
    - OTDRs
    - Cable certifiers
    - Tone generator and probe kits
    - Fibre optic light source and power meters
    - Wire map testers
    - Multimeters

3375.04 Describe the procedures to install and connect fire alarm systems and components

- Identify the codes, standards and regulations pertaining to fire alarm system installation and connection
- Describe the considerations and requirements for selecting fire alarm systems and components
- Describe the procedures to install fire alarm systems and components
- Describe the procedures to upgrade and/or reconfigure fire alarm systems and components
- Describe the procedures to interconnect fire alarm systems to associated/ancillary systems
- Describe the procedures for testing fire alarm systems and components
- Describe the procedures to start up, commission and verify fire alarm systems

3375.05 Explain the requirements and procedures for maintaining fire alarm systems

- Identify the codes, standards and regulations pertaining to fire alarm testing and maintenance
- Describe the procedures for servicing and maintaining fire alarm systems and components
    - Scheduled testing
        - daily
        - monthly
        - annual
    - Preventative/predictive maintenance
    - Troubleshooting and diagnostics
- Describe the effects of fire alarm system maintenance on associated/ancillary systems

3375.06 Describe the procedures to install and connect security and surveillance systems and components

- Identify the standards pertaining to security and surveillance system installation and connection
- Describe the considerations and requirements for selecting security and surveillance systems and components
- Describe the procedures to install security and surveillance systems and components
- Describe the procedures to upgrade and/or reconfigure security and surveillance systems and components
- Describe the procedures to interconnect security and surveillance systems and components to associated systems
- Describe the procedures for testing security and surveillance systems and components
- Describe the procedures to start up, commission and verify security and surveillance systems and components

3375.07 Explain the requirements and procedures for maintaining security and surveillance systems and components

- Describe the procedures for servicing and maintaining security and surveillance systems and components
  - Manufacturer's recommended testing
  - Preventative/predictive maintenance
  - Troubleshooting and diagnostics
- Describe the effects of security and surveillance systems and components maintenance on associated systems

3375.08 Describe the procedures to install and connect communication components

- Identify the standards pertaining to communication system installation and connection
- Describe the considerations and requirements for selecting communication systems and components
- Describe the procedures to install communication systems and components
- Describe the procedures to upgrade and/or reconfigure communication systems and components
- Describe the procedures to interconnect communication systems and components to associated systems
- Describe the procedures for testing communication systems and components
- Describe the procedures to start up, commission and verify communication systems and components

3375.09 Explain the requirements and procedures for maintaining communication systems and components

- Describe the procedures for servicing and maintaining communication systems and components
  - Manufacturer's recommended testing
  - Preventative/predictive maintenance
  - Troubleshooting and diagnostics
- Describe the effects of communication systems and components maintenance on associated systems

3375.10 Demonstrate the installation, troubleshooting and testing of initiation, notification, and supervisory circuits and devices for fire alarm systems

- Non-addressable system
  - Class A
  - Class B
- Addressable system
  - Class A

3375.11 Demonstrate the installation, troubleshooting and testing of ancillary circuits and remote annunciators for fire alarm systems

3375.12 Demonstrate the operation and testing of alarm panels with respect to

fault condition indicators (i.e. ground fault indicators), power supplies, overcurrent devices, annunciators and common trouble conditions
- Addressable systems
- Non-addressable systems

3375.13 Demonstrate the termination, splicing, testing, verification and certification of various cable systems
- Coaxial
- UTP and F/UTP
- Fibre optic

3375.14 Demonstrate the installation, troubleshooting and testing of a security and surveillance system including components such as;
- Door and window contacts
- Motion detectors
- Keypads
- Card readers
- Glass break detectors
- Notification devices
- Low temperature and flood alarms

| Evaluation Structure | |
|---|---|
| Theory Testing | Application Exercises (Including projects and assignments) |
| 40% | 60% |

| | | | |
|---|---|---|---|
| Number: | 3376 | | |
| **Title:** | **Canadian Electrical Code II** | | |
| Duration: | Total Hours: 36 | Theory: 36 | Practical: 0 |

**General Learning Outcomes**

Upon successful completion, the apprentice is able to determine code requirements and perform calculations for maximum circuit loading, continuous and non-continuous duty motor branch circuits (single motor), lighting branch circuits, electric heating branch circuits, emergency systems, fire alarm systems and fire pumps, protection and control devices, fibre optics and communication cables and equipment, service and feeders for apartments and row housing, and patient care areas.

**Learning Outcomes and Content**

Upon successful completion the apprentice is able to:

3376.01 Perform calculations to determine conductor resistance

- Describe circular vs square mil area and the relationship with AWG
- Calculate conductor resistance based on conductor area, material, temperature and length

3376.02 Apply code requirements to perform calculations for maximum circuit loading

- Describe the process for identifying code requirements for maximum circuit loading
- Identify load types
- Explain how equipment ratings affect circuit rating
- Perform calculations to determine voltage drop by using conductor resistance values:
  - Load type
    - Continuous
    - Non-continuous
    - Equipment rating
  - Voltage drop
    - CEC table D3
    - CEC table D4
    - CEC table 68
    - Determine voltage drop using conductor resistance values

3376.03 Apply code requirements to perform calculations for continuous and non-continuous duty motor branch circuits (single motor)

- Describe the process for identifying code requirements for continuous and non-continuous duty motor branch circuits (single motor)
- Perform calculations for:
  - Conductor size

    - Size of overcurrent device
    - Overload device
- Determine code requirements for:
    - Control devices
    - Disconnecting means

3376.04 Apply code requirements to perform calculations for lighting branch circuits

- Describe the process for identifying code requirements for lighting branch circuits
- Perform calculations for:
    - Conductor size
    - Size of overcurrent device
- Determine code requirements for:
    - Control devices
    - Disconnecting means

3376.05 Apply code requirements to perform calculations for electric heating branch circuits

- Describe the process for identifying code requirements for electric heating branch circuits
- Perform calculations for:
    - Conductor size
    - Size of overcurrent device
- Determine code requirements for:
    - Control devices
    - Disconnecting means

3376.06 Apply code requirements to perform calculations for emergency systems

- Identify types of emergency systems
    - Exit and emergency lighting
    - Unit Equipment
    - Battery systems
    - Generator systems
    - Transfer switches
    - Life safety systems
    - Mandatory emergency systems power supply
    - Optional standby system
- Describe the process for identifying code requirements for emergency systems
- Explain how to perform calculations
- Perform calculations for:
    - Conductor size
    - Size of overcurrent device
- Determine code requirements for:
    - Control devices
    - Disconnecting means

3376.07 Apply code requirements to perform calculations for fire alarm systems and fire pumps

- Describe the process for identifying code requirements for fire alarms and fire pumps
- Explain how to perform calculations
- Perform calculations for:
    - Conductor size
    - Size of overcurrent device
- Determine code requirements for:
    - Control devices
    - Disconnecting means

3376.08 Apply code requirements to perform calculations for protection and control devices such as:

- Fuses
- Circuit breakers
- Ground fault protection
- Panel boards
- Tap conductors:
- Determine code requirements for
    - Control devices
        - switches
        - solid-state devices

3376.09 Determine code requirements for the installation of fibre optics and communication cables and equipment for the following;

- Protection
- Grounding
- Indoor
- Outdoor
- Underground
- Overhead

3376.10 Apply code requirements to perform calculations for service and feeders for apartments and row housing

- Describe the process for identifying code requirements for service and feeders for apartments and row housing
- Perform calculations

3376.11 Determine code requirements for patient care areas

3376.12 Determine code requirements for pools, tubs and spas

| Evaluation Structure | |
|---|---|
| Theory Testing | Application Exercises<br>(Including projects and assignments) |
| 100% | 0% |

# Level 3

All reportable subjects in Level 3 are common core for:
Electrician, Construction and Maintenance (309A)
Industrial Electrician (442A)
Electrician, Domestic and Rural (309C)

**Level 3 Program Summary of Reportable Subjects – Common Core***

| Number | Reportable Subjects | Hours Total | Hours Theory | Hours Practical |
|---|---|---|---|---|
| 3377 | Renewable Energy Generating and Storage Systems | 27 | 18 | 9 |
| 3378 | Electrical Theory and Application | 72 | 45 | 27 |
| 3379 | PLC Fundamentals | 27 | 9 | 18 |
| 3380 | Power Electronics | 36 | 18 | 18 |
| 3381 | Drawings, Specifications and Standards Advanced | 36 | 36 | 0 |
| 3382 | Introduction to Instrumentation | 36 | 18 | 18 |
| 3383 | Canadian Electrical Code III | 36 | 36 | 0 |
| | **Total** | **270** | **180** | **90** |

*This Level is 100% common core between the three electrical trades: Electrician - Construction and Maintenance, Electrician-Domestic and Rural and Industrial Electrician.

| | | | |
|---|---|---|---|
| Number: | 3377 | | |
| **Title:** | **Renewable Energy Generating and Storage Systems** | | |
| Duration: | Total Hours: 27 | Theory: 18 | Practical: 9 |

**General Learning Outcomes**

Upon successful completion, the apprentice is able to explain the installation and maintenance requirements and procedures for renewable energy generating and storage systems as well as demonstrate the connection of renewable energy generating and storage system components for the creation of a stand-alone system.

**Learning Outcomes and Content**

Upon successful completion the apprentice is able to:

3377.01 Describe the purpose of renewable energy generating and storage systems

- Identify types of renewable energy generating system connections
  - Grid dependent
    - power production
    - net metering
  - Grid independent (stand-alone)

3377.02 Describe the characteristics, ratings and storage capacity of cells/batteries

- Identify types of cells/batteries
- Identify cell/battery chemistry characteristics
- Identify the difference between primary and secondary cells
- Identify the considerations for cell/battery selection
- Describe the effect of connecting cells/batteries in parallel or series
- Describe the requirements of charge/discharge equalization (cell/battery connection)
- Perform cell/battery capacity calculations for cell/batteries in series and parallel
- Identify the considerations for safe handling and storage of cells/batteries

3377.03 Explain the characteristics, applications, operations and limitations of renewable energy generating and storage systems

- Identify types and sources of renewable energy generating and storage systems and components
    - Renewable energy generating systems such as;
        - solar photovoltaic (PV)
        - wind turbines
        - tidal
        - hydrokinetic
        - hydraulic turbine
        - wave
        - biomass
        - geothermal
    - Renewable energy storage systems such as
        - fuel cell
        - compressed air
        - thermal
        - pumped hydro-electric
        - flywheel
        - batteries
- Identify the characteristics of renewable energy generating and storage systems and components
- Describe the considerations for sizing components for a grid independent renewable energy generating and storage system
- Identify the applications and operations of renewable energy generating and storage systems and components
- Identify the limitations of renewable energy generating and storage systems and components
- Identify the applicable codes and regulations pertaining to renewable energy generating and storage systems
    - Rapid shut down (solar only)
    - DC arc fault
    - Inverters

3377.04 Explain the considerations for installing and/or upgrading renewable energy generating and storage systems

- Describe the considerations for installing renewable energy generating and storage systems
    - Mounting
        - methods
        - location
    - Structural
        - snow loading
        - building code
    - Environmental
        - solar window/shading
        - wind
        - regional

- Calculating efficiencies for cost savings regarding other technologies
  - energy production
  - financial payback

- Identify other system components such as;
  - Transfer switches
  - Sun-tracking systems
  - Batteries
  - Charge controllers
  - Load banks
  - Inverters
    - Low voltage ride through
    - Anti-islanding
  - Isolation disconnects
  - Combiners
  - Recombiners
- Describe the interconnection of components for renewable energy generating and storage systems

3377.05 Explain the process for maintaining renewable energy generating and storage systems

- Identify key inspection and service areas;
  - Manufacturer’s recommended service intervals
  - Battery level checks
  - Electrical and mechanical connections
    - corrosion
    - tightness
    - mechanical fastenings
    - photovoltaic (PV) connectors
  - Photovoltaic modules
    - cleanliness
    - shading
    - condition
    - delamination
    - environmental checks
      - vegetation
      - debris
      - snow
  - Inverters and charge controllers
    - trouble codes
- Identify the safety considerations
  - Live circuits
  - Isolation vs disconnect
  - Multiple energy sources

3377.06 Demonstrate the connection of renewable energy generating and storage system components for the creation of a stand-alone system using components such as;

- Solar modules
- Wind turbines
- Inverters
- Charge controllers
- Batteries
- Loads
- Transfer switches
- Energy usage metering devices

| Evaluation Structure | |
|---|---|
| Theory Testing | Application Exercises<br>(Including projects and assignments) |
| 80% | 20% |

| | | | |
|---|---|---|---|
| Number: | 3378 | | |
| **Title:** | **Electrical Theory and Applications** | | |
| Duration: | Total Hours: 72 | Theory: 45 | Practical: 27 |

**General Learning Outcomes**

Upon successful completion, the apprentice is able to describe the characteristics and applications of single and three-phase transformers and motors, explain the procedures for installing and maintaining transformers and AC motors, perform measurements to verify the connection and operation of transformers, motors and RLC circuits and to determine and verify polarity, impedance, winding ratio and insulation resistance of transformers as well as perform calculations for three-phase systems including voltage, current, power and AC RLC circuit performance.

**Learning Outcomes and Content**

Upon successful completion the apprentice is able to:

3378.01 Describe the characteristics and applications of single-phase transformers

- Identify types, categories and applications of single-phase transformers
  - Instrument transformers
    - voltage transformers (VT)
    - current transformers (CT)
  - Power and Distribution transformers
    - isolation transformers
    - auto-transformers
  - Control Transformers
- Identify components of single-phase transformers
  - Primary windings
  - Secondary windings
  - Core types
  - Cooling fans
  - Casings and enclosures
  - Bushings
  - Caps
  - Dielectric coolants
  - Temperature sensors
- Distinguish between single-phase three wire and single-phase two wire transformers
- Identify and interpret nameplate data for single-phase transformers
  - Impedance rating
  - Power rating
  - Voltage rating
  - Temperature rise
  - Efficiency

- Identify the codes and regulations pertaining to single-phase transformer installation
- Describe the configurations of single-phase transformers
    - Multi-taps
    - Multi-windings
- Perform calculations pertaining to single-phase transformers
    - Turn ratios
    - Voltage ratios
    - Current ratios
    - Fault currents
- Explain transformer polarity and terminal markings
    - Additive
    - Subtractive
    - Parallel connections
    - Series connections
- Describe the dangers and safety considerations associated with single-phase transformers
    - Describe the safety procedures when taking instrumentation transformers offline

3378.02 Describe the characteristics and applications of three-phase systems and circuits

- Identify the purpose of three-phase power/systems
- Identify types of three-phase systems
- Describe the relationship between line and phase values
    - Wye
    - Delta
- Perform line and phase calculations
    - Voltage
    - Current
- Describe the relationship between voltage, current and power wave forms
    - Resistive loads
- Identify components of three-phase systems
- Describe the operation of three-phase systems
- Identify the application of three-phase power/systems

3378.03 Compare three-phase and single-phase systems and circuits

- Identify the differences between three-phase and single-phase systems and circuits
- Describe the advantages and disadvantages of three-phase circuits over single-phase circuits
- Describe the advantages and disadvantages of three-phase Wye and Delta system

3378.04 Describe the characteristics and applications of three-phase transformers

- Identify the winding configurations for three-phase transformers
  - Wye-wye
  - Wye-delta
  - Delta-wye
  - Open-delta
  - Delta-delta
  - Zigzag
  - Scott
- Perform calculations pertaining to three-phase transformers
  - Calculate and apply turns ratio
  - Calculate voltages, currents and power for three-phase transformers
  - Determine transformer impedances
  - Calculate maximum available fault currents at the secondary of a transformer
  - Perform calculations related to three-phase open delta connections
  - Perform calculations related to auto transformers
- Identify types and applications of three-phase transformers
  - Dry-type
  - Cast resin
  - Oil cooled
  - Isolation
  - Step-down
  - Step-up
  - Auto
- Identify the components of three-phase transformers
  - Cooling fans
  - Casings and enclosures
  - Core types
  - Primary and secondary windings
  - Bushings
  - On-line and off-line tap changers
  - Dielectric coolants
  - Temperature sensors
- Explain the operating principles of three-phase transformers
- Identify the codes and regulations pertaining to three-phase transformers
- Identify and interpret nameplate data for three-phase transformers
  - Impedance rating
  - Power rating
  - Voltage rating
  - Temperature rise

- Explain transformer polarity and terminal markings
  - Additive
  - Subtractive
  - Parallel connections
  - Series connections

3378.05 Describe the methods and mediums used to cool transformers

- Identify types of transformer cooling mediums
- Describe the safety concerns related to transformer cooling mediums

3378.06 Perform calculations related to three-phase AC RLC circuit performance

- Calculate values for RL/RC/RLC series, parallel and combination circuits
- Describe resonant circuits

3378.07 Perform calculations related to voltage, current and power for three-phase systems

- Three-phase Wye and Delta systems with resistive loads
- Three-phase Wye and Delta systems with resistive, inductive, capacitive loads (RLC)

3378.08 Explain the principles of power factor and power factor correction

- Identify the purpose of power factor correction
  - Maximize current-carrying capacity
  - Reduce power losses
  - Reduce operational costs
- Identify the methods and devices used for improving power factor
  - Identify types of power factor correction equipment
    - synchronous motors
    - reactors
    - capacitors
  - Identify the characteristics, operation and application of power factor correction equipment
- Explain single-phase and three-phase power factor correction and related calculations
  - Calculate the amount of inductance or capacitance required to correct the power factor
  - Calculate changes in circuit values resulting from a three-phase power correction

3378.09 Explain the process for installing single and three-phase transformers

- Identify the considerations and requirements for selecting transformers and components
  - Describe the environmental considerations for optimal transformer operation such as;
    - temperature
    - dust/dirt
    - hazardous location
    - indoor/outdoor
    - Category 1 or 2 location
- Describe the procedures to install transformers
- Describe the procedures to install transformers in parallel
- Describe the procedures to install transformers using various winding configurations
- Describe the procedures for taking a parallel transformer offline
  - Identify the safety considerations and procedures for taking transformers offline

3378.10 Explain the process for maintaining single and three-phase transformers

- Describe the procedures to inspect transformers and components
- Identify requirements for predictive/preventive/scheduled maintenance of transformers
  - Manufacturer’s specifications
  - CSA Z463
- Describe the procedures to troubleshoot transformers and components
  - Infrared testing
  - Insulation testing
  - Turn ratio testing
- Describe the procedures to replace transformers and components

3378.11 Describe the characteristics and applications of single-phase AC motors

- Identify types and applications of single-phase AC motors
  - Split phase induction motor
    - resistor-start/induction-run
    - capacitor start
    - capacitor run
  - Shaded pole
    - universal motor
- Identify the components of single-phase AC motors
- Describe types of single-phase AC motor enclosures
  - Open
  - Totally enclosed – nonventilated
  - Totally enclosed – ventilated
  - Weatherproof

    - Submersible
    - Hazardous locations
- Describe the principles of operation of single-phase AC motors and components including reversing direction of rotation
- Describe the operational characteristics of single-phase AC motors and components
- Identify the information on single-phase AC motor nameplates
- Identify the codes and regulations pertaining to single-phase AC motors
- Identify the types of insulation classifications and applications used in single-phase AC motors

3378.12 Explain the process for installing single-phase AC motors

- Identify the considerations and requirements for selecting single-phase AC motors and components based on nameplate and load requirements
- Identify single-phase AC motor connections and terminal markings for multiple voltage and speed applications
- Describe the procedures to install single-phase AC motors and components
- Describe the procedures for pully installation and belt alignment for single-phase AC motors
- Describe the procedures to connect single-phase AC motors and components
- Describe the procedure to verify direction of single-phase AC motor rotation
- Identify the test equipment used in single-phase AC motor installation and commissioning
    - Amp meter
    - Voltmeter
    - Tachometer
    - Insulation tester

3378.13 Explain the process for maintaining single-phase AC motors

- Describe the procedures for inspecting single-phase AC motors and components
- Describe the procedures for performing preventive/predictive maintenance on single-phase AC motors and components
- Describe the procedure for troubleshooting single-phase AC motors and components
- Describe the procedures for replacing/repairing single-phase AC motors and components

3378.14 Perform measurements that determine and verify polarity, impedance, winding ratio and insulation resistance of transformers using test equipment for the following configurations (low and extra low voltage);

- Additive
- Subtractive
- Parallel

3378.15 Verify electrical performance characteristics by connecting and measuring transformer systems (individual and parallel)

- Verify single-phase
  - Isolation transformers
  - Autotransformers
- Verify three-phase
  - wye
  - delta
  - open delta
- Connect loads
- Perform current and voltage measurements

3378.16 Perform measurements that determine and verify connection and operation of motors (single and dual voltage) (low and extra low voltage)

- Demonstrate the connection and operation of motors
  - Single-phase motors such as;
    - split phase induction motor
      - resistor-start/induction-run
      - capacitor start
      - capacitor run
    - universal motor
  - Three-phase squirrel cage induction motors

3378.17 Compare motor measurement and observation results against nameplate ratings

- Speed
- Current

3387.18 Verify three-phase AC circuit performance related to RLC loads

- Connect inductors, capacitors and resistors
- Verify voltage and current measurements
- Connect capacitors to correct power factor

| Evaluation Structure | |
|---|---|
| Theory Testing | Application Exercises<br>(Including projects and assignments) |
| 65% | 35% |

| | | | |
|---|---|---|---|
| Number: | 3379 | | |
| **Title:** | **PLC Fundamentals** | | |
| Duration: | Total Hours: 27 | Theory: 9 | Practical: 18 |

**General Learning Outcomes**

Upon successful completion, the apprentice is able to describe basic PLC functions including numbering systems, programming and addressing requirements as well as perform testing of PLC inputs and outputs and demonstrate basic programming capacity.

**Learning Outcomes and Content**

Upon successful completion the apprentice is able to:

3379.01 Describe the functions, applications and operations of PLCs and components

- Identify types of PLCs
  - Modular
  - Integrated (shoebox/brick)
- Identify types of PLC components
  - Backplane
  - Processor
  - Power supply
  - Input/Output (I/O)
    - digital
    - analog
- Identify typical PLC applications
  - Automation
  - Data collection

3379.02 Describe computer numbering systems

- Identify types of numbering systems
  - Binary
  - Octal
  - Decimal
  - Hexadecimal
- Convert between numbering systems

3379.03 Explain programming and addressing requirements for PLCs

- Identify the difference between online and offline programming
- Identify programming methods
  - Ladder logic
  - Function block
- Identify the method of addressing the I/O
- Describe the relationship between the programming method and addressing the I/O
- Identify programming documentation
  - Headers
  - Rung comments
  - Descriptions
- Identify module configuration (I/O) parameters

3379.04 Identify methods of installing and wiring PLCs to equipment

- Wiring the I/O
  - Sinking versus sourcing I/O (NPN vs PNP)
  - Dry contacts vs solid-state
- Powering the PLC processor
- Methods of communication between PLC processor and programming device (i.e. computer, handheld device)

3379.05 Identify methods used to communicate with PLCs

- Handheld
- Computer

3379.06 Identify basic instructions sets for ladder logic

- Examine-on (normally open contact)
- Examine-off (normally closed contact)
- Output
- Internal coils
- Timers
- Counters

3379.07 Perform testing of PLC Inputs and Outputs

3379.08 Convert relay schematics into PLC ladder logic diagrams

- Interpret ladder logic diagrams
  - Identify the symbols on ladder logic diagrams

3379.09 Describe programming procedures

- Common relay instructions
- PLC timers and counters
- Mathematic functions
- Word comparisons

3379.10 Program common relay instructions

3379.11 Program PLC timers and counters

3379.12 Program basic mathematical functions into a PLC

3379.13 Demonstrate the creation of programs to operate automated equipment using timers, counters, internal bits, I/O, math and move functions

- Follow written instructions
- Convert from written instructions to ladder logic
- Program/edit ladder logic
- Download and upload programs
- Execute programs
- Test programs

| Evaluation Structure | |
|---|---|
| Theory Testing | Application Exercises<br>(Including projects and assignments) |
| 40% | 60% |

| | | | |
|---|---|---|---|
| Number: | 3380 | | |
| **Title:** | **Power Electronics** | | |
| Duration: | Total Hours: 36 | Theory: 18 | Practical: 18 |

**General Learning Outcomes**

Upon successful completion, the apprentice is able to demonstrate the use of a transistor in analog and digital modes, demonstrate the operation of an Op-Amp, explain the considerations and process for installing and maintain AC and DC drives and confirm the operation of AC drives.

**Learning Outcomes and Content**

Upon successful completion the apprentice is able to:

3380.01 Demonstrate the use of a transistor can be used in analog or digital modes

- Explain the functions of a transistor
- Identify different types of transistors
- Describe the characteristics, operation and application of different types of transistors
- Describe the operation and bias requirements of NPN and PNP transistors (sinking and sourcing)
- Identify the schematic symbols for NPN and PNP bipolar transistors
- Explain the operation of a power transistor (i.e. IGBT, SiC)
- Explain the procedures to test, remove and replace the output transistors in variable speed drives
- Demonstrate how a transistor is used as a switch
- Demonstrate how a transistor is used as an amplifier

3380.02 Demonstrate the operation of an Op-Amp as a comparator, amplifier and oscillator

- Explain the operation of an Operational Amplifier (Op Amp)
    - Calculate the expected gain of inverting and non-inverting Op-Amp Circuits

3380.03 Explain the purpose of motor drives

- Identify the benefits of motor drives
    - Process control
    - Precise speed control
    - Energy efficiency
    - Maintain torque to match load speed
    - Reduce mechanical stress
    - Reduce in rush current
    - Improve power factor
    - Reduce voltage sag

3380.04 Demonstrate three-phase rectification

- Describe and demonstrate three-phase, half and full wave rectification
- Calculate average DC voltage as it refers to three-phase rectified AC
- Connect capacitors to filter the output of a three-phase power supply

3380.05 Explain the characteristics, applications and principles of operation of DC drives

- Identify types of DC drives
  - Non regenerative
  - Regenerative
  - Four quadrant
- Identify the components of DC drives
- Identify the characteristics of DC drives
- Describe the application and operating principles of DC drives
- Identify types of DC drive controls
  - Open loop
  - Closed loop such as;
    - speed feedback
    - voltage feedback
    - current feedback
- Describe the impact of DC drives on motor operation
  - Speed control
  - Torque control
  - Acceleration
  - Deceleration
  - Direction of rotation

3380.06 Explain the considerations for installing DC drives

- Manufacturer’s specifications
- Identify the considerations for selecting DC drives and components
- Describe the considerations to install DC drives and components
- Describe the considerations to connect DC drives and components
- Describe the considerations for setting the parameters of the DC drives
  - Acceleration
  - Deceleration
    - dynamic braking
    - regenerative braking
  - Current limitations

3380.07 Explain the considerations for maintaining DC drives and components

- Identify the benefits of regular maintenance
- Identify tools and equipment used to perform maintenance on DC drives and components
- Identify some of the key goals for preventive maintenance
- Describe the procedures for troubleshooting DC drives and components
- Describe the procedures for replacing or repairing DC drives and components

3380.08 Explain the characteristics, applications and principles of operation of AC drives

- Identify AC drive primary components
  - Power input
  - Rectifier
  - Filter
  - Control
  - Inverter
- Identify the applications of AC drives and components
- Describe the operating principles of AC drives and their impact on motor operations
  - Speed control
  - Torque control
  - Acceleration
  - Deceleration
  - Direction of rotation

3380.09 Explain the considerations for installing and upgrading AC drives

- Identify the considerations for selecting AC drives and components
  - Single-phase/three-phase input and output
  - Supply voltage
  - Output voltage
  - Input frequency
  - Power (HP, watts)/output current
  - Speed
  - Environmental conditions
  - Continuous and variable torque loads
  - Motor compatibility (inverter rated)

- Describe the considerations for installing AC drives and components
    - Environmental
        - temperature
        - dust/dirt
        - hazardous location
        - indoor/outdoor
        - Category 1 or 2 location
    - Enclosure rating
    - Manufacturer's specifications
- Describe the considerations for setting parameters and/or programming AC drives such as;
    - Acceleration
    - Deceleration
        - dynamic braking
        - regenerative braking
    - Current limitations
    - Speed control
- Describe the considerations for tuning AC drives

3380.10 Explain the process to maintain AC drives and components

- Identify the benefits of regular maintenance
- Identify tools and equipment used to perform maintenance on AC drives and components
- Identify some of the key goals for preventive maintenance
    - Cleanliness
    - Restrict moisture ingress
    - Tight electrical connections
- Describe the hazards associated with maintaining AC drives
    - Capacitor charge retention
- Describe the procedures for troubleshooting AC drives and components

3380.11 Confirm the operation of AC and DC drives

- Connect the AC and DC drive
- Program the AC and DC drive
- Operate the AC and DC drive

| Evaluation Structure | |
|---|---|
| Theory Testing | Application Exercises<br>(Including projects and assignments) |
| 50% | 50% |

| | | | |
|---|---|---|---|
| Number: | 3381 | | |
| **Title:** | **Drawings, Specifications and Standards Advanced** | | |
| Duration: | Total Hours: 36 | Theory: 36 | Practical: 0 |

**General Learning Outcomes**

Upon successful completion, the apprentice is able to use and apply drawings and specifications related to industrial electrical installations, describe installation and maintenance procedures for three-phase consumer supply services and metering equipment as well as describe the considerations for connecting single and three-phase branch circuits to three-phase electrical distribution equipment.

**Learning Outcomes and Content**

Upon successful completion the apprentice is able to:

3381.01 Describe the purpose of electronic drawing software

- Identify types of electronic drawing software
- Identify circumstances where drawing software is used such as;
  - As-builts
  - Circuit design/edits
  - Drawing creation
  - Building information modeling (BIM) for site positioning systems

3381.02 Apply drawings and specifications to determine the layout of mechanical equipment and systems for an industrial electrical installation

3381.03 Apply drawings and specifications to determine the electrical characteristics of mechanical equipment and systems for an industrial electrical installation

3381.04 Apply drawings and specifications to layout three-phase industrial distribution and service equipment and wiring

3381.05 Apply drawings, specifications and industry practices to layout industrial branch circuit wiring, lighting and equipment

3381.06 Apply drawings and specifications to prepare a material take off for an industrial installation

3381.07 Interpret single-line, schematic and wiring diagrams.

3381.08 Describe the procedures for installing three-phase consumer supply services and metering equipment

- Interpret codes, regulations and standards pertaining to three-phase services
- Identify types, characteristics and applications of three-phase services
  - temporary service
  - overhead
  - underground
  - single and multiple metering
- Identify types, characteristics and applications of three-phase service components and conductors
  - Components
    - metering equipment
    - supports
    - enclosures
    - raceways
    - conduits
    - meter sockets
    - panels
    - switchgear
    - service entrance equipment
    - service masts
    - point of attachment
  - Conductors/Cables
- Identify the purpose and application of service components, conductors and fasteners
- Identify the considerations and requirements for selecting three-phase services, components and conductors
  - Type
  - Rating
  - Application
  - Environmental conditions
- Describe the procedures to install three-phase consumer supply services and metering equipment
- Describe the procedures to connect service conductors
- Identify methods and requirements for grounding and bonding of three-phase consumer supply services and metering equipment
- Identify ground fault and ground detection type protection systems for three-phase consumer supply services
- Calculate demand load for three-phase consumer supply service

3381.09 Describe the procedures for maintaining three-phase consumer supply services and metering equipment

- Identify what is looked for during inspection process
  - Corrosion
  - Discolouration
  - Odour
  - Moisture infiltration
  - Dust/dirt
  - Enclosure integrity
  - Identify the procedure for checking equipment using thermal imaging/infrared scan

3381.10 Explain the considerations for branch circuit layout for single and three-phase systems from panels to the points of utilization, employing load balancing techniques

3381.11 Explain the considerations and requirements for connecting single and three-phase branch circuits to three-phase electrical distribution equipment

- Identify electrical distribution system configuration
  - Three-phase three wire
  - Three-phase four wire
  - Three-phase four wire delta
- Identify types of electrical distribution equipment
  - Disconnects
    - feeder/distribution
    - branch
  - MCCs
  - Load centres
  - Panel board
    - lighting
    - power
  - Switch gear
  - Switch boards
  - Splitters
- Describe the standard size and ratings of electrical distribution equipment
  - Ampacity
  - Voltage
  - Number of Branch circuit positions
- Identify location and clearance considerations for electrical distribution equipment

3381.12 Determine the stresses on the conductor/cable during installation in a raceway

- Describe the effect of pulling stress on cables and conductors during installation

3381.13 Explain the factors for determining the selection of overcurrent devices based on voltage, continuous current and interruption (short circuit and withstand) ratings

- Compare the trip characteristics of fuses and circuit breakers (time current charts)

3381.14 Explain the purpose of overcurrent device coordination

- Selective
- Non-selective

| Evaluation Structure | |
|---|---|
| Theory Testing | Application Exercises (Including projects and assignments) |
| 80% | 20% |

| | | | |
|---|---|---|---|
| Number: | 3382 | | |
| **Title:** | **Introduction to Instrumentation** | | |
| Duration: | Total Hours: 36 | Theory: 18 | Practical: 18 |

**General Learning Outcomes**

Upon successful completion, the apprentice is able to explain the principles and considerations related to pressure, temperature, level and flow measurement in instrumentation, interpret Process (P) and Instrumentation (I) diagrams using ISA instrumentation symbols, perform the procedures to connect and verify the operation of pressure, temperature, flow and level measuring equipment/devices, perform calculations related to signal transmission, describe the operation of PIDs and describe instrumentation control voltage and current loop circuits.

**Learning Outcomes and Content**

Upon successful completion the apprentice is able to:

3382.01 Describe the fundamental terms and concepts used in instrumentation

- Define common terms used in instrumentation
  - Accuracy
  - Span
  - Zero
  - Repeatability
  - Dead time
  - Linearity
  - Hysteresis
  - Feedback
  - Transducer
  - Pressure
  - Temperature
  - Flow
  - Level
  - Objectionable current and EMI
  - Open loop and closed loop systems
- Identify ISA instrumentation symbols
- Describe the difference between point and continuous measurements
- Describe the difference between direct and indirect measurement
- Identify the importance of manufacturer’s instructions and specifications for instrumentation components

3382.02 Interpret Process (P) and Instrumentation (I) diagrams using ISA instrumentation symbols

- For pressure measurement devices
- For temperature measurement devices
- For flow measurement devices
- For level measurement devices

3382.03 Describe the principles and considerations related to pressure measurement in instrumentation

- Identify sensing methods for measuring pressure
  - Bourdon tubes
  - Bellows
  - Diaphragms
  - Piezoelectrics
- Identify the considerations for selecting pressure sensing methods
- Convert between SI and Imperial pressure measurements
- Describe the relationship between gauge pressure, absolute pressure and vacuum

3382.04 Perform the procedures to connect and verify the operation of point pressure measuring equipment

3382.05 Explain the principles and considerations related to temperature measurement in instrumentation

- Identify sensing methods and devices for measuring temperature
  - Thermometers
  - Thermocouples
  - Bi-metallic strips
  - Pyrometers
  - RTDs
  - Thermistors
- Identify the considerations for selecting temperature sensing methods
  - Contact
  - Non-contact
- Describe types, characteristics and applications of sensing methods and devices
- Convert between the temperature scales

3382.06 Perform the procedures to connect and verify the operation of point temperature sensing devices

3382.07 Describe methods of level measurement

- Identify the types, characteristics and applications of level sensing devices
  - Float switches
  - Level sight glass
  - Capacitance devices
  - Ultrasonics
  - Radiation gauges
  - Hydrostatic/Bubblers
- Identify the considerations for selecting level sensing devices
- Convert between SI and Imperial volume

3382.08 Perform the procedures to connect and verify the operation of point float level measurement devices to control or determine the level of a vessel

3382.09 Explain fluid flow

- Identify types of fluid flow meters
  - Differential pressure flow meters
  - Velocity flow meters
  - Positive displacement flow meters
  - Mass flow meters
- Describe fluid flow measurement
- Describe how flow rate is measured
- Convert between SI and Imperial flow rates

3382.10 Perform the procedures to connect and verify the operation of velocity flow switch, positive displacement flow meters and rotameters

3382.11 Describe instrumentation control voltage and current loop circuits

- Describe the different instrumentation signal transmission methods
  - Current
  - Voltage
  - Pneumatic
  - Wireless
  - Analog
  - Digital
- Explain the operation and applications of voltage and current instrumentation loops
- Explain the operation and application of transmitters and controllers in instrumentation control loops
- Describe the methods for installing and connecting an instrumentation control voltage and current loop circuit
  - Explain the purpose of shield cable in instrumentation systems
  - Describe shield grounding techniques

3382.12 Perform calculations related to signal transmission

- 4 to 20 milliamps
- 0-10 volts

3382.13 Describe the operation of PIDs

| Evaluation Structure | |
|---|---|
| Theory Testing | Application Exercises<br>(Including projects and assignments) |
| 50% | 50% |

| | | | |
|---|---|---|---|
| Number: | 3383 | | |
| **Title:** | **Canadian Electrical Code III** | | |
| Duration: | Total Hours: 36 | Theory: 36 | Practical: 0 |

**General Learning Outcomes**

Upon successful completion, the apprentice is able to determine code requirements and perform calculations (as applicable) for hazardous locations, motors, transformers, welders, capacitors, renewable energy and storage systems, and three-phase consumer supply service and metering equipment.

**Learning Outcomes and Content**

Upon successful completion the apprentice is able to:

3383.01 Determine code requirements for hazardous locations

- Explain the application of intrinsically safe (IS) electrical systems
- Select types of components based on the area classification
- Identify the wiring methods based on the area classification

3383.02 Apply code requirements to perform calculations for motors

- For the installation of two or more continuous and non-continuous duty service motors on a branch circuit or feeder
  - minimum conductor size
  - maximum overcurrent device size
- For the installation of a hermetic and semi-hermetic refrigerant motor-compressor on a branch circuit
  - Minimum conductor size
  - Maximum overload size
  - Maximum overcurrent device size
- Determine tap conductor sizes for motor and refrigeration motor compressor branch circuits
- Determine disconnecting means requirements

3383.03 Apply code requirements to perform calculations for transformers

- For the installation of transformers
  - Dry-type
  - Oil cooled
- For the selection of overcurrent devices based on voltage, continuous current and interruption (short circuit and withstand) ratings
- For the bonding and grounding of transformers
- For individual power and distribution transformers (high and low voltage)

    - Minimum conductor size
    - Maximum overcurrent device size
- For more than one power and distribution transformer (high and low voltage)
    - Minimum conductor size
    - Maximum overcurrent device size
- For secondary overcurrent protection
- For autotransformers
- Determine disconnecting means requirements

3383.04 Apply code requirements to perform calculations for welders

- For individual resistance and transformer type welders
    - Minimum conductor size
    - Maximum overcurrent device size
- For more than one resistance and/or transformer type welder on a feeder circuit
    - Minimum conductor size
    - Maximum overcurrent device size
- Receptacle requirements
- Determine disconnecting means requirements

3383.05 Apply code requirements to perform calculations for capacitors

- For the installation of capacitors
    - minimum conductor size,
    - maximum overcurrent device size
    - minimum disconnecting means size
- For placing capacitors in motor circuits

3383.06 Apply code requirements to perform calculations for renewable energy generating and storage systems

3383.07 Apply code requirements to perform calculations for three-phase consumer supply service and metering equipment

- Calculate minimum calculated load for service equipment
    - Table for other occupancies (Table 14)

3383.08 Determine code requirements for corrosive and excessive moisture locations

| Evaluation Structure | |
|---|---|
| Theory Testing | Application Exercises (Including projects and assignments) |
| 100% | 0% |

# Level 4

Reportable subjects in Level 4 are a combination of common core and non-common core subjects for:
Electrician, Construction and Maintenance (309A)
Industrial Electrician (442A)

*This level does **not** apply to
Electrician, Domestic and Rural (309C)

**Level 4 Program Summary of Reportable Subjects* - Industrial Electrician**

| Number | Reportable Subjects | Hours Total | Hours Theory | Hours Practical |
|---|---|---|---|---|
| 3384 | Building Automation Systems (Common Core) | 32 | 24 | 8 |
| 3385 | Professionalism and Ethics (Common Core) | 16 | 16 | 0 |
| 3386 | Power Conditioning (Common Core) | 24 | 24 | 0 |
| 3387 | Advanced Motors and Generators (Common Core) | 40 | 24 | 16 |
| 3388 | Advanced Instrumentation (Industrial only) | 32 | 16 | 16 |
| 3389 | Pneumatic and Hydraulic Control Systems (Industrial only) | 24 | 16 | 8 |
| 3390 | High voltage Service and Operation (Common Core) | 40 | 40 | 0 |
| 3391 | Automated Control systems (Industrial only) | 32 | 16 | 16 |
| | **Total** | **240** | **176** | **64** |

*The above list sets out the level 4 reportable subject requirements for Industrial Electricians (442A) only. 5 reportable subjects are common core with the level 4 requirements of Electricians, Construction and Maintenance (309A). The remaining 3 apply solely to Industrial Electricians. There are no level 4 requirements for Electrician, Domestic and Rural (309C).

**Level 4 Program Summary of Reportable Subjects* -
Electrician, Construction & Maintenance**

| Number | Reportable Subjects | Hours Total | Hours Theory | Hours Practical |
|---|---|---|---|---|
| 3384 | Building Automation Systems (Common Core) | 32 | 24 | 8 |
| 3385 | Professionalism and Ethics (Common Core) | 16 | 16 | 0 |
| 3386 | Power Conditioning (Common Core) | 24 | 24 | 0 |
| 3387 | Advanced Motors and Generators (Common Core) | 40 | 24 | 16 |
| 3390 | High voltage Service and Operation (Common Core) | 40 | 40 | 0 |
| 3392 | Specialty Installations (Construction only) | 40 | 40 | 0 |
| 3393 | Canadian Electrical Code IV (Construction only) | 48 | 48 | 0 |
| | **Total** | **240** | **216** | **24** |

*The above list sets out the level 4 reportable subject requirements for Electricians, Construction and Maintenance (309A) only. 5 reportable subjects are common core with the level 4 requirements of Industrial Electricians (442A). The remaining 2 apply solely to Electricians, Construction and Maintenance (309A). There are no level 4 requirements for Electrician, Domestic and Rural (309C).

| | |
|---|---|
| Number: | 3384 |
| **Title:** | **Building Automation Systems (Common Core)** |
| Duration: | Total Hours: 32 Theory: 24 Practical: 8 |

**General Learning Outcomes**

Upon successful completion, the apprentice is able to describe the considerations for installing and maintaining building automation systems and components and demonstrate the connection of building automation equipment.

**Learning Outcomes and Content**

Upon successful completion the apprentice is able to:

3384.01 Explain the characteristics and applications of building automation systems

- Describe the purpose of a building automation system
- Identify types of building automation systems such as;
  - Environmental control
  - Integrated control
  - Energy management
  - Security and surveillance systems
  - Analog electrical
  - Direct digital control (DDC)
  - Computer control
- Identify applicable standards pertaining to building automation systems such as:
  - ANSI/ASHRAE 135 (BACnet)
  - UL 916
  - ANSI/TIA 862
- Identify building automation system components
  - Network cabling
  - Sensors such as occupancy, vacancy and light levels
  - Servers
  - Power over Ethernet (PoE) switches
  - GUIs
  - Damper motors
  - Valves
  - Contactors
  - Contacts
  - Annunciators
  - Thermostats
  - Solenoids
  - Flow and sail switches
  - Humidistats
  - Pressure differential sensors
  - Level/float sensors
- Identify types of associated systems that interconnect with building

automation systems such as;
    - Elevator systems
    - Fire alarm and suppression systems
    - Security and surveillance systems
    - HVAC
    - Lighting
    - Communication systems
    - Energy management system
    - SCADA
    - PLC
- Describe how associated systems interconnect with building automation systems such as;
    - LAN
    - Internet
    - Wireless
    - Fibre optic
- Identify the considerations for selecting building automation systems
- Identify the codes and regulations that apply to building automation systems

3384.02 Describe considerations for installing building automation systems and components

- Describe how to locate, interpret and apply manufacturer's specifications
- Describe the procedures for testing building automation systems and components
- Describe the procedures to commission and verify building automation systems and components
- Describe documentation requirements

3384.03 Describe the considerations for maintaining building automation systems and components

- Identify faults and problems related to building automation systems and components
- Identify preventative, predictive and/or scheduled maintenance requirements for maintaining building automation systems and components
- Describe troubleshooting process for building automation systems and components

3384.04 Demonstrate the connection of building automation equipment

- Connect control devices to the control equipment
- Interconnect control equipment with a remote monitoring device

| Evaluation Structure | |
|---|---|
| Theory Testing | Application Exercises<br>(Including projects and assignments) |
| 70% | 30% |

| | |
|---|---|
| Number: | 3385 |
| **Title:** | **Professionalism and Ethics (Common Core)** |
| Duration: | Total Hours: 16 Theory: 16 Practical: 0 |

**General Learning Outcomes**

Upon successful completion, the apprentice is able to explain the importance of professional codes of ethics, conduct and standards of practice, describe how personal health and well being impact professional practice and healthy work environments, explain the purpose of personal and professional development plans as well as identify mentoring strategies.

**Learning Outcomes and Content**

Upon successful completion the apprentice is able to:

3385.01 Describe the purpose of professionalism and professional ethics

- Define professional ethics
  - Personal and/or corporate standards of behaviour expected by professionals
  - Values and guiding principles to guide individuals in performing job functions
- Identify the purposes of codes of ethics, codes of conduct and other professional standards
  - Defines professional obligations
  - Describes how to engage in the practice in professional way
  - Signals accountability to the public
  - Maintain public trust and credibility of the profession
  - Defines misconduct
- Identify why it is important for an electrician to be professional and ethical
- Identify how other factors impact professionalism such as:
  - Presentation of self
    - appearance
    - hygiene
  - Communication
    - verbal
    - written
    - body language
    - social media profile
  - Conduct

3385.02 Evaluate how legislation, regulation and policy impact professional practice

- Explain the rationale for professional self-regulation and accountability through regulatory bodies and professional associations
    - Explain how legislation is applied in different settings.
- Identify sources of professional standards, behaviour and code of ethics for electricians and apprentices
    - Regulatory bodies
    - Authorities having jurisdiction
    - Government ministries, agencies and departments
    - Associations, labour groups
    - Employer/company
- Identify other requirements that impact professional practice such as;
    - Workplace violence and harassment legislation
        - workplace harassment policies
        - code of practice to address workplace violence and harassment
    - Employment Standards Act
    - Consumer Protection Act
    - Other legislations and regulations
    - Cooperation between trades
    - Customer service

3385.03 Describe how personal health and well-being impact professional practice and healthy work environments

- Identify the physical and emotional requirements of the profession
    - Identify elements of workplace culture
    - Describe workplace stressors
- Assess personal physical and mental health
    - Identify signs and symptoms of fatigue and stress
    - Identify factors that affect job performance such as;
        - shift work
        - substance abuse
        - lack of sleep
    - Identify available support systems
    - Assess personal job satisfaction

3385.04 Explain the purpose of a personal and professional development plan

- Identify the link between professionalism and continuous learning
- Describe how to assess personal learning needs
- Identify factors that may impact learning needs and goals
    - New technology
    - Sector trends and practices
    - Skills updating
    - Legislative and regulatory changes

3385.05 Describe strategies for teaching workplace skills (mentoring)

- Explain the importance of identifying a learning opportunity
  - Timing
  - Relevance
- Explain the importance of balancing production with learning
- Identify the components of the skill (the context)
- Describe considerations in setting up opportunities for skill practice
- Explain the importance of providing feedback
- Identify techniques for giving effective feedback
  - Patience
  - Objectivity
- Describe a skills assessment
- Identify methods of assessing progress
- Explain how to adjust learning to different situations

| **Evaluation Structure** | |
|---|---|
| Theory Testing | Application Exercises<br>(Including projects and assignments) |
| 100% | 0% |

| | |
|---|---|
| Number: | 3386 |
| **Title:** | **Power Conditioning (Common Core)** |
| Duration: | Total Hours: 24 Theory: 24 Practical: 0 |

**General Learning Outcomes**

Upon successful completion, the apprentice is able to explain the causes and effects of power quality issues in AC systems, the applications of power conditioning and uninterruptable power supply (UPS) systems as well as describe the considerations and methods for installing and testing surge suppression/protection equipment.

**Learning Outcomes and Content**

Upon successful completion the apprentice is able to:

3386.01 Identify power quality issues in AC systems

- Harmonics
- Other issues:
  - Under/over voltage
  - Voltage transients
  - Unequal voltages on phases

3386.02 Explain harmonics

- Describe the causes of harmonics
  - Linear vs non-linear loads
- Describe how to identify harmonics
  - Use of test equipment
    - infrared scan
    - average responding and true RMS meters
    - power analyzers
- Describe the symptoms and effects of harmonics on AC power systems
  - Voltage
  - Frequency
  - Wave form
  - Neutral conductor heating
  - Premature motor bearing failure
  - Skin effect
- Explain methods of limiting the effects of harmonics on AC systems such as;

- Line and load reactors on AC drives
- K factor transformers
- Harmonic filters

3386.03 Explain other power quality issues

- Describe the causes
  - Utilities
  - Equipment start up
  - Types of loads on the system
- Describe the effects
  - Low/high voltage
  - Transient voltages

3386.04 Explain the characteristics and applications of power conditioning

- Identify the purpose of power conditioning equipment
- Identify types of power conditioning equipment
  - Surge suppressors
  - Voltage regulators
  - Isolation Transformers
  - Motor generators
  - Standby power supply
  - Uninterruptible power supply
  - Under/over voltage relays
- Identify the codes and regulations pertaining to power conditioning
- Explain the impact of power quality on equipment operation
- Interpret manufacturer’s specifications for installation and maintenance of power conditioning equipment

3386.05 Explain the characteristics and applications of uninterruptable power supply (UPS) systems

- Identify the purpose of UPS
- Identify types of UPS devices and components used in power distribution system conditioning
  - Online
  - Offline
  - Online interactive
  - Maintenance bypass
  - Static bypass
  - Battery systems
- Interpret manufacturer’s specifications for installation and maintenance of UPS systems
- Identify the codes and regulations pertaining to UPS systems
- Identify hazards associated with installing UPS systems

3386.06 Explain the characteristics and applications of surge suppression/protection equipment

- Describe the purpose of surge suppression/protection equipment
- Identify the codes and regulations applying to surge suppression/protection equipment
- Identify the information pertaining to surge suppression/protection equipment found on drawings on specifications
- Identify the considerations for selecting surge suppression/protection equipment

3386.07 Describe the considerations for installing surge suppression/protection equipment

3386.08 Describe the methods used to test surge suppression/protection equipment

| **Evaluation Structure** | |
|---|---|
| Theory Testing | Application Exercises<br>(Including projects and assignments) |
| 100% | 0% |

| | |
|---|---|
| Number: | 3387 |
| **Title:** | **Advanced Motors and Generators (Common Core)** |
| Duration: | Total Hours: 40 Theory: 24 Practical: 16 |

**General Learning Outcomes**

Upon successful completion, the apprentice is able to demonstrate the operation of DC and AC generating systems, explain the considerations for installing DC generating systems, explain the considerations for installing, connecting and maintaining AC generating systems, explain the process for installing three-phase AC motors as well as perform measurements to verify the operation and connection of three-phase AC motors.

**Learning Outcomes and Content**

Upon successful completion the apprentice is able to:

3387.01 Explain the operation of a DC generating systems and components
- Describe the characteristics of series, shunt and compound generators
- Describe the applications of series, shunt and compound generators

3387.02 Explain the considerations for installing DC generating systems and components
- Describe the methods to connect DC generating systems and components
- Describe the methods to control the output voltage of DC generators

3387.03 Demonstrate the operation of a DC generating system
- Connect a DC generator and prime mover
- Observe the output characteristics while varying the load and field strength

3387.04 Explain the difference between AC and DC generators

3387.05 Explain the characteristics, operations and applications of AC generating systems
- Describe the purpose of AC generating systems
- Describe the operating principles of AC generating systems
  - Rotating field
  - Rotating armature
- Identify types of single and three-phase AC generating systems
  - Portable
  - Stationary
  - Manually operated
  - Automatically operated

- Identify the components of AC generating systems such as;
  - Generator components:
    - shafts
    - armatures
    - stators
    - rotors
    - bearings
    - frames
    - exciter windings
  - Generator accessories:
    - transfer switches
    - prime movers
      - governor
      - fuel storage
    - overcurrent devices
    - overload devices
    - protection devices
    - AVR (automatic voltage regulator)
- Identify the considerations for selecting types of AC generating systems
- Identify the information pertaining to AC generating systems on drawings and specifications
- Identify applicable codes, standards and regulations pertaining to AC generating systems
  - Identify the standards for IEC and NEMA rated starters and contactors as per manufacturer's specifications.

3387.06 Explain the considerations for installing and connecting AC generating systems and components

- Describe the procedures to install AC generating systems
- Describe the procedures to install AC generating system components
- Describe the considerations for selecting and installing the disconnecting means for AC generating systems
- Identify the process and code requirements for establishing neutral grounding
- Describe code requirements for grounding an AC generator
  - Stationary
  - Mobile/vehicle mounted
- Describe the procedures to control the output voltage, phase sequencing and frequency of AC generators
- Describe the procedures to interconnect AC generating systems with stand-alone or parallel operations

3387.07 Explain the process for maintaining AC generating systems and components

- Identify faults and problems related to AC generating systems and components
- Identify preventative, predictive and/or scheduled maintenance requirements for maintaining AC generating systems and components

- Describe troubleshooting process for AC generating systems and components

3387.08 Describe considerations for synchronizing alternators

3387.09 Describe the characteristics and applications of three-phase AC motors

- Identify types of three-phase AC motors
  - Squirrel cage induction
  - Wound rotor induction
  - Synchronous
- Identify the components of three-phase AC motors
- Describe types of three-phase AC motor enclosures
  - Open
  - Totally enclosed – nonventilated
  - Totally enclosed – ventilated
  - Weatherproof
  - Submersible
  - Hazardous locations
- Describe the principles of operation of three-phase AC motors and components including reversing direction of rotation
  - Squirrel cage induction
  - Wound rotor induction
  - Synchronous
- Describe the operational characteristics of three-phase AC motors and components
- Identify the information on three-phase AC motor nameplates
- Identify the codes and regulations pertaining to three-phase AC motors
- Identify the types of insulation classifications and applications used in three-phase AC motors
- Identify the operation of synchronous motors that can be used in power factor correction and constant speed applications

3387.10 Explain the process for installing three-phase AC motors

- Identify the considerations and requirements for selecting three-phase AC motors and components based on nameplate and load requirements
- Identify three-phase AC motor connections and terminal markings for multiple voltage and speed applications
- Explain the importance of verifying direction of rotation for three-phase AC motors
- Identify the test equipment used in three-phase AC motor installation and commissioning
  - Phase rotation meter
  - Amp meter

- Voltmeter
- Tachometer
- Insulation tester

3387.11 Identify the standards for IEC and NEMA rated starters and contactors

3387.12 Perform measurements that determine and verify connection and operation of three-phase AC motors

- Demonstrate the connection and operation of three-phase AC motors
  - Squirrel cage induction (single and dual voltage)
  - Wound rotor induction
  - Synchronous

3387.13 Compare three-phase AC motor measurement and observation results against nameplate ratings for squirrel cage induction, wound rotor induction and synchronous motors

- Speed
- Current

3387.14 Demonstrate the operation of an AC generating system

- Connect an AC generator and prime mover
- Observe the output characteristics while varying the load, field strength and prime mover speed

| **Evaluation Structure** | |
|---|---|
| Theory Testing | Application Exercises (Including projects and assignments) |
| 50% | 50% |

| | |
|---|---|
| Number: | 3388 |
| **Title:** | **Advanced Instrumentation (Industrial Electrician only)** |
| Duration: | Total Hours: 32 Theory: 16 Practical: 16 |

**General Learning Outcomes**

Upon successful completion, the apprentice is able to determine liquid levels using hydrostatic pressure, perform testing of the output parameters of instrumentation, perform velocity flow rate and mass flow rate calculations, perform troubleshooting of instrumentation components as well as demonstrate the installation of the following systems; PID control system, position measurement system, flow measurement control loop system, level measurement control loop system.

**Learning Outcomes and Content**

Upon successful completion the apprentice is able to:

3388.01 Explain the concepts of weight, mass, density and specific gravity
- Distinguish weight and density
- Distinguish specific gravity and density
- Describe the relationship between specific gravity and density
- Calculate weight density, mass density and specific gravity
- Convert between SI and Imperial mass

3388.02 Explain the application of load cells
- Identify the purpose of load cells
- Identify types of load cells and how they are categorized
- Describe the principles of operation of load cells

3388.03 Determine liquid levels using hydrostatic pressure
- Explain the concept of hydrostatics
- Explain the procedure for measuring liquid level in a vessel using hydrostatic pressure
- Calculate liquid level using hydrostatic pressure

3388.04 Explain the principles of measured and controlled variables, feedback, open and closed loop and transducers
- Distinguish between measured and controlled variables
- Distinguish between open and closed loop systems
- Identify types and applications of transducers used in instrumentation

3388.05 Describe the operation and applications of position measurement devices

- Identify types of position measurement devices
  - Encoders
  - Resolvers
  - Proximity switches
  - Linear Variable Differential Transformer (LVDT)
  - Synchros
  - Hall effect sensors

3388.06 Describe servo-motor system operation and application

3388.07 Explain the advantages and limitations of different methods of communication instrumentation information

- Pneumatics
- Current
- Voltage
- Wireless
- Analog
- Digital

3388.08 Demonstrate the installation of a PID control system

- Describe the effects of varying P, I and D parameters
- Connect input devices and output device using PID control to PID controller
- Set the parameters of the input devices
- Tune the controller
- Connect and test calibration of analog input devices
- Connect and test calibration of analog output devices
- Modify and observe PID functions

3388.09 Demonstrate the installation of a position measurement system

- Connect position measurement device to a controller
- Calibrate the measurement device
- Calibrate the controller

3388.10 Perform testing of the output parameters of instrumentation devices such as;

- Flow measurement:
  - Venturi/orifice plate
  - Magnetic flow meters
  - Paddle wheel
- Temperature
- Level
  - Hydrostatic
  - Ultrasonic
  - Capacitive
- Position
- Pressure

3388.11 Demonstrate the installation of a flow measurement control loop system
- Connect flow measurement device to a controller
- Calibrate the measurement device
- Tune the controller

3388.12 Demonstrate the installation of a level measurement control loop system
- Connect level measurement device to a controller
- Calibrate the measurement device
- Tune the controller

3388.13 Interpret and modify instrumentation drawings

3388.14 Perform velocity flow rate and mass flow rate calculations

3388.15 Perform troubleshooting of instrumentation components using manufacturer's specifications
- Calibrate instrumentation components

| **Evaluation Structure** | |
|---|---|
| Theory Testing | Application Exercises<br>(Including projects and assignments) |
| 50% | 50% |

| | |
|---|---|
| Number: | 3389 |
| **Title:** | **Pneumatic and Hydraulic Systems (Industrial Electrician Only)** |
| Duration: | Total Hours: 24 Theory: 16 Practical: 8 |

**General Learning Outcomes**

Upon successful completion, the apprentice is able to describe the considerations for installing/replacing, troubleshooting, maintaining and upgrading pneumatic and hydraulic systems and components, perform pneumatic and hydraulic calculations as well as demonstrate the assembly of hydraulic systems using circuit drawings.

**Learning Outcomes and Content**

Upon successful completion the apprentice is able to:

3389.01 Explain the differences between hydraulic and pneumatic systems
- Describe the benefits and limitations of hydraulic systems
- Describe the benefits and limitations of pneumatic systems

3389.02 Describe the characteristics, applications and operations of pneumatic systems and components
- Identify the components of pneumatic systems
  - Regulators
  - Separators
  - Tubing
  - Actuators
  - Solenoids
  - Pumps
  - Positioners
  - Accumulators
  - Compressors
  - Receivers
  - Heat exchanger
  - Filters
  - Dryers
  - Automated oilers
- Identify the information pertaining to pneumatic systems on drawings and specifications
- Identify standards pertaining to pneumatic systems
- Identify pneumatic symbols
- Interpret documentation including schematics and manufacturer’s manuals to determine the operation of pneumatic systems
- Describe the types and functions of control valves in pneumatic systems
- Describe the process to control flow in pneumatic systems
- Describe safety considerations when working on pneumatic systems

3389.03 Describe considerations for installing/replacing pneumatic systems and components

- Identify considerations for selecting pneumatic systems components

3389.04 Describe the considerations for troubleshooting, maintaining and upgrading pneumatic systems and components

3389.05 Describe the characteristics, applications and operations of hydraulic systems and components

- Identify the components of hydraulic systems
  - Accumulators
  - Pumps
  - Motors
  - Heat exchangers
  - Filters
  - Reservoirs
  - Snubbers
  - Control valves
  - Servo/proportional valves
  - Sensors
  - Actuators
- Compare fixed vs variable displacement
- Explain the operation of the following components
  - Cylinders:
    - single and double acting
    - single and double rod
    - differential
    - cushioned
  - Hydraulic motors:
    - vane
    - gear
    - axial piston
    - fixed and variable displacement
  - Check valves
    - inline
    - right angle
    - pilot to open
    - pilot to close
  - pressure control valves:
    - relief
    - unloading
    - counterbalance
    - sequence
    - pressure reducing
    - brake
  - Directional control valves
    - sliding spool, poppet and rotary types

        - two, three and four-position
        - two, three, four and five-way valves
        - servo-proportional valves
        - various methods of actuating
        - different types of centre
    - Flow control valves
        - needle, restrictor, pressure and temperature compensated
        - meter in
        - meter out
    - Hydraulic pumps
        - gear
        - vane
        - reciprocating piston
        - plunger
        - axial piston
        - bent axis
        - radial piston
        - fixed and variable displacement
    - Hydraulic intensifiers
    - Hydraulic accumulators
        - weight
        - spring
        - gas
- Identify the information pertaining to hydraulic systems on drawings and specifications
- Identify the standards pertaining to hydraulic systems
- Identify hydraulic symbols
    - ANSI
    - ISO
- Interpret documentation including schematics and manufacturer’s manuals to determine the operation of hydraulic systems
- Describe the types and functions of control valves in hydraulic systems
- Describe the process to control flow in hydraulic systems
- Describe safety considerations when working on hydraulic systems
    - Pressure
    - Flammability

3389.06 Describe the considerations for installing/replacing hydraulic systems and components

- Identify considerations for selecting hydraulic systems components

3389.07 Describe the considerations to maintain, troubleshoot and upgrade hydraulic systems and components

3389.08 Perform pneumatic and hydraulic calculations

- Pressure
- Force
- Area
- Horsepower
- Flow rate
- Convert between SI and Imperial measurements

3389.09 Demonstrate the assembly of hydraulic systems using circuit drawings

- Interconnect components
- Test and commission system
- Identify and troubleshoot faults

| **Evaluation Structure** | |
|---|---|
| Theory Testing | Application Exercises<br>(Including projects and assignments) |
| 50% | 50% |

| | |
|---|---|
| Number: | 3390 |
| **Title:** | **High Voltage Service and Operation (Common Core)** |
| Duration: | Total Hours: 40 Theory: 40 Practical: 0 |

**General Learning Outcomes**

Upon successful completion, the apprentice is able to explain the considerations for installing, modifying, replacing, testing and maintaining high voltage installations, explain the considerations for installing, replacing, maintaining, troubleshooting and upgrading high voltage transformers and components as well as calculate minimum conductor size maximum overcurrent protection for high voltage transformers.

**Learning Outcomes and Content**

Upon successful completion the apprentice is able to:

3390.01 Explain the characteristics, operations and applications of high voltage systems and equipment

- Describe terminology and concepts used in high voltage systems such as;
  - Corona discharge
  - Ground potential rise
  - Boundary fence
  - Ground grid conductor
  - Maximum ground fault current
  - Step and touch
- Identify types of high voltage applications
  - Switchyards
  - Substations
  - Electrical vaults
  - Electrical service rooms
  - MCCs (Motor control centres)
  - Pad mounted transformers
- Identify types of high voltage equipment
  - Lightning protection
  - Distribution equipment
  - Contactors
  - Motor starters
  - Transformers
  - MCCs
  - Capacitors
  - Reactors
  - Rectifiers
  - Reclosers
  - VTs
  - CTs
  - Protection and control devices

        - overcurrent protection
        - disconnecting means
- Explain the function of high voltage equipment
- Identify types of high voltage cables
    - Armoured cables (with or without shielded conductor)
    - Trailing cables
    - TC tray cables
    - Shielded cables
    - Bus ducts
- Identify high voltage cable components
    - Potheads
    - Stress relief terminations (stress cones)
    - Strapping
    - Bracing
    - Splice kits
- Identify codes, regulations and standards associated with high voltage systems and equipment
    - Interpret the CEC regulations associated with high voltage installations
        - Definitions
        - Wiring methods
        - Grounding and bonding
        - Protection and control
- Identify information pertaining to high voltage systems and equipment in drawings and specifications
    - Single-line diagrams
- Describe the importance of low step and touch potential for high voltage systems
- Describe conditions that affect step and touch potential
- Identify high voltage specific tools and test equipment
- Distinguish between types of disconnecting means
    - Air break
    - Load break
    - Isolation

3390.02 Describe the characteristics and applications of grounding and bonding conductors, equipment and components in high voltage systems

- Explain the purpose of grounding grids in relation to step and touch voltages
- Explain the purpose of ground surface covering layer
- Explain the purpose of ground loops
- Explain the purpose for grounding metallic non-electrical equipment

3390.03 Describe methods and considerations for controlling and eliminating hazards when working with high voltage systems and equipment

- Describe the hazards associated with high voltage systems
  - Corona discharge
  - Ozone gas
- Describe preventative steps for eliminating and controlling electrical hazards
- Describe safety protocols for high voltage systems (work area protection (WAP)
  - Proximity to energized exposed equipment
  - Interlocking
  - Induced voltages
  - PPEs
  - Lock out procedures
  - Warning notices
  - CSA Z460 and Z462
  - IHSA Electrical Utility Safety Rules (EUSR)
  - Limits of Approach

3390.04 Explain the considerations for installing new high voltage installations as well as modifying and replacing existing high voltage installations

- Identify sources of information and documentation for the installation/modification/replacement of high voltage equipment
  - Schematic diagrams and drawings,
  - Maintenance schedules,
  - Single-line diagrams,
  - Drawings,
  - As-built drawings,
  - Manufacturers' specifications
- Describe the procedures to size ground grid and grounding conductors
- Describe the procedures to terminate and splice high voltage conductors
- Describe the procedures to isolate faults
- Describe clearance requirements

3390.05 Explain testing processes for high voltage installations

- Describe the procedures to perform ground resistance testing of high voltage installations
- Describe the procedures to perform commissioning testing of high voltage installations
    - Identify types of commissioning tests and devices
        - Transformer polarity
        - Hi-pot
        - Phasing
        - Interlocking functionality
        - Overcurrent coordination
        - Fault current levels (current injection)
        - Ultra-sonic detectors
        - Thermographic imaging device

3390.06 Explain the considerations for maintaining high voltage installations

- Identify the importance of manufacturer's specifications during maintenance
- Describe the procedures to maintain high voltage equipment and components
- Describe the procedures used to maintain high voltage cables and components
- Describe the methods to prevent re-energization
    - Describe methods to remove and install temporary protective grounds
        - Identify types of temporary protective grounds
            - ground clamps
            - straps
            - conductors

3390.07 Explain the considerations for installing and replacing high voltage transformers and components

- Identify types of high voltage transformers
    - Oil cooled
    - Dry
- Identify components of high voltage transformers
    - Oil pumps
    - Cooling fans
    - Casings and enclosures
    - Cores
    - Primary and secondary windings
    - Bushings
    - On-line and off-line tap changers
    - Dielectric coolant
    - Indicators
        - pressure gauges
        - level gauges
        - temperature gauges

    - Cooling fins
    - Conservator tanks
    - Desiccant breathers
    - Gas detector relays
- Identify winding configurations for high voltage transformers
    - Wye
    - Delta
    - Open delta
    - Autotransformer
- Identify the considerations and requirements for selecting high voltage transformers

3390.08 Explain the considerations for maintaining, troubleshooting and upgrading high voltage transformers and components

- Identify faults and problems related to high voltage transformers
- Identify preventative, predictive and/or scheduled maintenance requirements for maintaining high voltage transformers
- Describe troubleshooting process for high voltage transformers
- Describe the process for upgrading components

3390.09 Describe the types of overcurrent devices used to protect high voltage equipment

3390.10 Calculate minimum conductor size and maximum overcurrent protection for individual power and distribution high voltage transformers

3390.11 Calculate minimum conductor size and maximum overcurrent protection for more than one power and distribution high voltage transformer

| **Evaluation Structure** | |
|---|---|
| Theory Testing | Application Exercises<br>(Including projects and assignments) |
| 100% | 0% |

| | |
|---|---|
| Number: | 3391 |
| **Title:** | **Automated Control Systems (Industrial Electrician Only)** |
| Duration: | Total Hours: 32 Theory: 16 Practical: 16 |

**General Learning Outcomes**

Upon successful completion, the apprentice is able to describe the considerations for installing, maintaining, programming and optimizing automated control systems, perform the configuration of a PLC to communicate with another PLC via I/O, communication protocol, discrete and analog I/O as well as demonstrate how to integrate a PLC and HMI.

**Learning Outcomes and Content**

Upon successful completion the apprentice is able to:

3391.01 Describe the characteristics, applications and operations of automated control systems

- Define automated control system
- Identify the purpose of an automated control system
  - Control process
  - Interface with other systems
- Identify the types of automated control systems
  - PLC
  - DCS
  - SCADA
  - Safety PLC
- Explain the difference between PLC and DCS
- Explain the difference between PLC and Safety PLC
- Identify the types of operator interfaces
  - Physical hardware
  - PC and software
  - Human Machine Interface (HMI)
- Identify automated control system programming languages and describe their applications
- Describe how automated control systems are integrated with building automation systems
- Identify the components of automated control systems
  - Hardware
    - Power supply
    - central processing unit (CPU)
    - input/output system
    - programming terminals
  - Software
- Describe the use of numbering systems in automated control systems
- Describe the applications of code systems
  - Code systems

        - binary coded decimal (BCD)
        - American Standard Code for Information Interchange (ASCII)
        - gray code
    - Identify the standards and codes pertaining to automated control systems
        - CSA Z320

3391.02 Describe the requirements for safety control systems

- Identify the components of safety control systems such as;
    - E stops
    - Safety gates
    - Light curtains
    - Safety relays
    - Safety mats
    - Interlocks
    - Safety PLCs
- Describe the four categories of safety circuits
- Define pre-start safety review (commissioning)
- Describe the purpose of pre-start safety reviews

3391.03 Describe the process for installing safety control systems

3391.04 Describe the characteristics, applications and operations of automated control system data communication systems

- Identify types of automated control system data communication systems such as;
    - Ethernet
    - Modbus
    - Profibus
    - BACnet
    - Fieldbus
    - DeviceNet
    - ControlNet
    - TCP/IP
    - Wireless
- Identify automated control system data communication system components
- Identify the purpose and application of an HMI
- Identify advanced instruction sets for automated control systems
    - Sequencers
    - Shift registers
    - Block transfers
    - Data registers
- Identify basic function block sets for automated control systems such as;
        - input block
        - control block
        - output block

3391.05 Describe the considerations for installing automated control systems

- Describe the benefits and limitations of automated control systems
  - DCS
  - PLC
  - SCADA
- Describe the procedures to install automated control systems
- Describe the procedures to connect automated control systems

3391.06 Describe the considerations for maintaining automated control systems

- Identify faults and problems related to automated control systems and components
- Describe troubleshooting process for automated control systems and components

3391.07 Describe the considerations for programming automated control systems

- Describe the importance of manufacturer’s specifications in programming automated control systems
- Compare DCS and SCADA programming to PLC programming

3391.08 Describe the considerations for optimizing PLC automated control system performance

- Reducing the program scan time
- Optimizing memory

3391.09 Perform the configuration of a PLC to communicate with another PLC via I/O

- Create programs that communicate discrete information to another PLC via the PLC's outputs
- Create programs that use discrete information from another PLC via the PLC's inputs

3391.10 Perform the configuration of a PLC to communicate to another PLC via a communication protocol

- Create programs that send data to another PLC via a Write function
- Create programs that request data from another PLC via a Read function
- Create programs that utilize data from another PLC

3391.11 Perform the configuration of a PLC and drive to communicate via discrete and analog I/O

- Create programs to stop and start a drive
- Create programs to control the speed of a drive
- Create programs to control the direction of a drive

3391.12 Demonstrate the integration of a PLC and an HMI

- Create programs that allow the HMI to control equipment
- Create programs that allow the HMI to display equipment status

| Evaluation Structure | |
|---|---|
| Theory Testing | Application Exercises<br>(Oncluding projects and assignments) |
| 30% | 70% |

| | |
|---|---|
| Number: | 3392 |
| **Title:** | **Specialty Installations (Construction Electrician Only)** |
| Duration: | Total Hours: 40 Theory: 40 Practical: 0 |

**General Learning Outcomes**

Upon successful completion, the apprentice is able to explain the process to install and maintain specialty installations using drawings and specifications as well as interpret related documents and diagrams.

**Learning Outcomes and Content**

Upon successful completion the apprentice is able to:

3392.01 Describe the characteristics, operations and applications of specialty installations

- Identify types of speciality installations
  - Electric vehicle supply equipment
  - Airfield lighting systems (Airport runway, Airport visual aid systems)
  - Traffic signals and controls
  - Marinas
  - Factory built relocatable and non-relocatable structures
  - Cranes and hoists
  - Temporary installations
  - Diagnostic imaging
  - Elevators
  - Passenger ropeway and related equipment
  - TV, film sets and travelling shows
- Identify components of specialty installations
  - Electric vehicle supply equipment components
    - level chargers
    - energy management systems
    - communication systems
  - Airfield runway lighting system (airport runway, airport visual aid systems) components
    - constant current regulator (CCR)
    - series transformers
    - runway, apron and taxiway luminaires
    - transformer enclosures (pull pits)
    - ground counter poise
    - mounting stake
  - Traffic signals controls components
    - vehicle sensors
    - cameras
    - traffic signal controllers
    - communication control

    - Marina components
        - ground fault protection
    - Factory built relocatable and non-relocatable structure components
- Identify information pertaining to speciality installations on drawings and specifications

3392.02 Explain the process to remove and install Airfield lighting systems (airport runway, airport visual aid systems) and components

- Identify considerations for selecting Airfield lighting systems and components
- Describe the procedures to remove Airfield lighting systems and components
- Describe the procedures to install Airfield lighting systems and components

3392.03 Explain the process to maintain Airfield lighting systems (airport runway, airport visual aid systems) and components

- Identify faults and problems related to Airfield lighting systems (airport runway, airport visual aid systems) and components
- Identify preventative, predictive and/or scheduled maintenance requirements for maintaining Airfield lighting systems (airport runway, airport visual aid systems) and components
- Describe troubleshooting process for Airfield lighting systems (airport runway, airport visual aid systems) and components

3392.04 Explain the process to remove, install, connect and test traffic signal light systems and control components

- Identify considerations for selecting traffic signal light systems and control components
- Describe the procedures to remove traffic signal light systems and control components
- Describe the procedures to install traffic signal light systems and control components
- Describe the procedures to connect traffic signal light systems and control components
- Describe the procedures to test traffic signal light systems and control components

3392.05 Explain the process to maintain traffic signal light systems and control components

- Identify faults and problems related to traffic signal light systems and control components
- Identify preventative, predictive and/or scheduled maintenance requirements for maintaining traffic signal light systems and control components
- Describe troubleshooting process for traffic signal light systems and control components

3392.06 Explain the process to install and connect electric vehicle supply equipment systems

- Identify considerations for selecting electric vehicle supply equipment systems and components
- Describe the procedures to install electric vehicle supply equipment systems and components
- Describe the procedures to connect electric vehicle supply equipment systems and components

3392.07 Explain the process to maintain electric vehicle supply equipment systems

- Identify faults and problems related to electric vehicle supply equipment systems
- Identify preventative, predictive and/or scheduled maintenance requirements for maintaining electric vehicle supply equipment systems
- Describe troubleshooting process for electric vehicle supply equipment systems

3392.08 Explain the process to install other specialty systems such as;

- Marinas
- Factory built relocatable and non-relocatable structure
- Cranes and hoists
- Temporary installations
- Diagnostic imaging
- Elevators
- Passenger ropeway and related equipment
- TV, film sets and travelling shows
- Mobile home and recreational vehicle parks

3392.09 Explain the process to maintain other specialty systems such as;

- Marinas
- Factory built relocatable and non-relocatable structure
- Cranes and hoists
- Temporary installations
- Diagnostic imaging
- Elevators

- Passenger ropeway and related equipment
- TV, film sets and travelling shows
- Mobile home and recreational vehicle parks

3392.10 Apply drawings and specifications to determine installation, maintenance and repair requirements for a specialty installation

3392.11 Interpret documents and diagrams

- Single-line
- Schematics
- Wiring diagrams
- Specifications

| **Evaluation Structure** | |
|---|---|
| Theory Testing | Application Exercises<br>(Including projects and assignments) |
| 100% | 0% |

| | |
|---|---|
| Number: | 3393 |
| **Title:** | **Canadian Electrical Code IV** |
| Duration: | Total Hours: 48 Theory: 48 Practical: 0 |

**General Learning Outcomes**

Upon successful completion, the apprentice is able to determine code requirements for specialty installations

**Learning Outcomes and Content**

Upon successful completion the apprentice is able to:

3393.01 Determine code requirements for electric vehicle supply equipment

3393.02 Determine code requirements for airfield lighting systems (airport runway, airport visual aid systems) and components

3393.03 Determine code requirements for other specialty installations;

- Marinas
- Factory built relocatable and non-relocatable structures
- Cranes and hoists
- Temporary installations
- Diagnostic imagers
- Elevators
- Passenger ropeways and related equipment
- TV, film sets and travelling shows
- Mobile home and recreational vehicle parks

3393.04 Determine the area classifications for specific hazardous environments and/or locations

- Compressed natural gas refueling stations
- Propane dispensing, container filling and storage
- Finishing processes
- Gasoline dispensing

3393.05 Determine the code requirements and calculate the allowable ampacity for conductors and cables No. 1/0 AWG or larger and 5kV or less that are installed underground

- In accordance with CEC tables using the IEEE 835 methodology

| Evaluation Structure | |
|---|---|
| Theory Testing | Application Exercises<br>(Including projects and assignments) |
| 100% | 0% |

## APPENDIX A: ACRONYMS LIST

| | |
|---|---|
| AC | Alternating Current |
| AFCI | Arc Fault Circuit Interrupter |
| AHJ | Authority Having Jurisdiction |
| ANSI | American National Standards Institution |
| ASCII | American Standard Code for Information Interchange |
| ASHRAE | American Society of Heating, Refrigerating And Air-Conditioning Engineers |
| AVR | Automatic Voltage Regulator |
| BCD | Binary Code Decimal |
| BIM | Building Information Modelling |
| CAT | Overvoltage Category Rating |
| CCR | Constant Current Regulator |
| CCTV | Closed Circuit Television |
| CEC | Canadian Electrical Code |
| CSA | Canadian Standards Association |
| CSC | Construction Specifications Canada |
| CT | Current Transformer |
| DAS | Distributed Antenna System |
| DC | Direct Current |
| DCLA | Data Communication Link, Style A |
| DCLB | Data Communication Link, Style B |
| DCLC | Data Communication Link, Style C |
| DCS | Distributed Control System |
| DDC | Direct Digital Control |
| DIAC | Diode Alternating Current |
| DVR | Digital Video Recorder |
| E-STOP | Emergency Stop |
| EMF | Electromotive Force |
| EMI | Electromagnetic Interference |
| ESA | Electrical Safety Authority |
| EUSR | Electrical Utility Safety Rules |
| EVSE | Electrical Vehicle Supply Equipment |
| F/UTP | Foiled, Unshielded Twisted Pair |
| GFCI | Ground-Fault Circuit Interrupter |
| GUI | Graphical User Interface |
| HID | High Intensity Discharge |
| HMI | Human Machine Interface |
| HVAC | Heating, Ventilation, Air Conditioning |
| IDC | Initiating Device Circuit |

| | |
|---|---|
| IEC | International Electrotechnical Commission |
| IEEE | Institute Of Electrical and Electronics Engineers |
| IGBT | Insulated Gate Bipolar Transistor |
| IHSA | Infrastructure Health and Safety Association |
| I/O | Input/Output |
| IP | Internet Protocol |
| IS | Intrinsic Safety |
| ISA | International Society of Instrumentation |
| ISO | International Organization for Standardization |
| LAN | Local Area Network |
| LDC | Local Distribution Company |
| LED | Light Emitting Diode |
| LVDT | Linear Variable Differential Transformer |
| MCCs | Motor Control Centres |
| NAC | Notification Appliance Circuit |
| NBC | National Building Code |
| NC | Normally Closed |
| NEMA | National Electrical Manufacturer Association |
| NO | Normally Open |
| NPN | Negative Positive Negative |
| OBC | Ontario Building Code |
| OESC | Ontario Electrical Safety Code |
| OHSA | Occupational Health and Safety Act |
| Op-Amp | Operational Amplifier |
| OTDR | Optical Time-Domain Reflectometer |
| PA | Public Address |
| PC | Personal Computer |
| PID | Proportional Integral Derivative |
| PLC | Programmable Logic Controller |
| PoE | Power Over Ethernet |
| PNP | Positive Negative Positive |
| PPE | Personal Protective Equipment |
| PV | Photovoltaic |
| PVC | Polyvinyl Chloride |
| RC timers | Resistor Capacitor Timers |
| RFID | Radio Frequency Identification |
| RLC | Resistor Inductor Capacitor |
| RMS | Root Mean Squared |
| RTD | Resistance Temperature Detector |
| SCADA | Supervisory Control and Data Acquisition |
| SCR | Silicon-Controlled Rectifier |

| | |
|---|---|
| SDS | Safety Data Sheet |
| SI | Système International D'unités |
| SiC | Silicon-Carbide |
| TC | Tray Cable |
| TCP/IP | Transmission Control Protocol/Internet Protocol |
| TDR | Time Domain Reflectometer |
| TIA | Telecommunications Industry Association |
| TRIAC | Triode For Alternating Current |
| TSSA | Technical Standards and Safety Authority |
| UL | Underwriters Laboratories |
| ULC | Underwriters Laboratories of Canada |
| UPS | Uninterruptable Power Supply |
| UTP | Unshielded Twisted Pair |
| UV | Ultraviolet |
| VAV | Variable Air Volume |
| VDV | Voice Data Video |
| VFD | Variable Frequency Drive |
| VT | Voltage Transformer |
| WAP | Work Area Protection |
| WHMIS | Workplace Hazardous Material Information System |
| Wi-Fi | Wireless Fidelity |
| WLL | Workload Limit |

# APPENDIX B: GLOSSARY OF TRADE SPECIFIC TERMS

**Arc fault** - a high power discharge of electricity between two or more conductors

**Anti-islanding -** Islanding is the condition in which a distributed generator continues to power a location even though electrical grid power is no longer present. Islanding can be dangerous to utility workers, who may not realize that a circuit is still powered, and it may prevent automatic re-connection of devices

**Arc flash -** the light and heat produced as part of an arc fault; extremely high temperature electrical discharge produced by an electrical fault in the air that occurs on live equipment resulting from a low impedance connection to ground or another voltage phase in an electrical system. The intensity of the discharge is dependent on the size of the energy source and the size of the conductors

**Bonding –** low impedance path obtained by permanently joining all non-current- carrying metal parts to assure electrical continuity and having the capacity to conduct safely any current likely to be imposed on it

**Cable –** a complete manufactured assembly of one or more insulated conductors which may also include optical fibres, fillers, strength members, insulating and protective material, having a continuous overall covering providing electrical, mechanical and environmental protection to the assembly

**Cathodic protection systems** - protection technique to control the corrosion of a metal surface by making that surface the cathode of an electrochemical cell

**Commissioning -** initial start up of new equipment systematically to OEM specifications

**Extra low voltage -** any voltage up to and including 30 volts, as per the Canadian Electrical Code

**Ground fault** - an inadvertent contact between an energized conductor and ground or equipment frame

**High voltage** - any voltage exceeding 750 volts, as per the Canadian Electrical Code

**Learning disabilities/disorders** - a variety of disorders that affect the acquisition, retention, understanding, organisation or use of verbal and/or non-verbal information

**Learning styles and preferences** - refer to a person's characteristic patterns of strengths, weaknesses and preferences in taking in, processing, and retrieving information; way in which an individual generally responds to specific learning situations and prefers to process different forms of information

**Low voltage** - any voltage exceeding 30 volts but not exceeding 750 volts, as per the Canadian Electrical Code

**Luminaire -** a complete electric light unit

**MasterFormat –** a standard for organizing specifications and other written information for commercial and institutional building projects in the U.S. and Canada

**Mentor** - an experienced and trusted adviser; someone who gives help and advice over a period of time

**Raceway -** any channel designed for holding wires, cables, or busbars, and, unless otherwise qualified by rules of the CEC, the term includes conduit (rigid, flexible, metal, non-metallic), electrical, metallic and non-metallic tubing (EMT and ENT) underfloor raceways, cellular floors, surface raceways, wireways, cable trays, busways, and auxiliary gutters

**Resistor** - a device having a designed resistance to the passage of an electric current.

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(Industrial Electrician)