Apprenticeship Manitoba

Manitoba

Power Electrician
Level 4

Rev. June 2017-February 2020-April 2023

Apprenticeship Manitoba

Power Electrician

Unit: D1 Electrical Code for Industrial Applications II

Level: Four

Duration: 45 hours

Theory: 20 hours

Practical: 25 hours

Overview:

This unit, which builds on *C1 Electrical Code for Industrial Applications I*, is designed to provide the apprentice with additional knowledge about the electrical code for industrial applications. The unit begins with coverage of fire alarm and cathodic protection systems. Part of the unit covers rules for PLC/data infrastructure and for hazardous locations. Finally, the unit covers single motors and groups of motors in industrial applications.

Objectives and Content:	**Percent of Unit Mark (%)**
1. Describe and demonstrate installation and maintenance of fire alarm systems. a. CEC requirements b. CSA (Canadian Standards Association) requirements c. Addressable and non-addressable systems d. Class A , B and C wiring methods e. Wiring and troubleshooting techniques	**35%**
2. Describe the installation and maintenance of cathodic protection systems. a. CEC requirements	**5%**
3. Describe rules for PLC / data infrastructure. a. CEC requirements b. Fiber optic cable c Electrical communications system	**10%**
4. Describe and demonstrate rules for hazardous locations. a. CEC requirements b. Class 1 and Class 2 locations	**25%**
5. Describe the installation of single motors and groups of motors in industrial applications. a. CEC requirements b. Duty cycles c. Temperature classes d. Motor circuit protection device (instantaneous trip breakers)	**25%**

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Unit: D2 Metering

Level: Four

Duration: 30 hours

Theory:	30	hours
Practical:	0	hours

Overview:

This unit is designed to provide the apprentice with the knowledge about metering. The unit begins with coverage of meters and instrument transformers. Part of the unit covers single and three phase metering systems. Finally, the unit covers specific requirements for customer, station and power sales agreement metering.

Objectives and Content:	**Percent of Unit Mark (%)**
1. Describe meters. a. Purpose b. Types c. Operations • Full-scale deflection • Extended ranges • Loading error	**10%**
2. Describe instrument transformers. a. Purpose b. Types • Current • Potential c. Perform related calculations d. Hazards	**10%**
3. Describe specific requirements for customer, station and power sales agreement (PSA) metering. a. Purpose b. Perform related calculations	**5%**
4. Describe single phase metering systems a. Purpose b. Types • 3 wire CT metering • 240V CT metering c. Perform related calculations	**25%**

5. Describe three phase metering systems **25%**

a. Purpose
b. Types
   - 3 phase-Wye
   - 3 phase-Delta
   - Open delta
c. Perform related calculations

6. Describe customer metering. **25%**

a. Purpose
b. Types
   - Energy
   - Demand
   - Pulse
   - Recording meters (analog, digital)
c. Perform related calculations
d. Related test and analysis equipment

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Unit: D3 Automation

Level: Four

Duration: 50 hours

Theory: 20 hours

Practical: 30 hours

Overview:

This unit is designed to provide the apprentice with advanced knowledge about building automation and automated controls, such as programmable logic controllers (PLCs). The unit begins with coverage of PLC operation and programming of ladder logic. Part of the unit covers analog I/O's and control system diagrams. Finally, the unit covers installing, designing, analyzing and troubleshooting of building automated systems.

Objectives and Content:	**Percent of Unit Mark (%)**

1. Describe and demonstrate advanced operation of programmable logic controllers (PLCs). **15%**

a. Purpose
b. Types
c. Components
   - Central processing unit (CPU)
   - Memory storage systems
   - Input/output (I/O) section
   - Power supply
   - Programming devices
d. Advanced operation and applications
   - Distributed control systems
   - Open/Closed loop control systems

2. Describe and demonstrate programming of advanced ladder logic. **15%**

a. Purpose
b. Types
c. Configurations
d. Programming and wiring considerations, including:
   - Memory limitations
   - Networks
   - Program Scan
   - Contact Nesting
   - Security (key lock and software)
   - Master control relay
   - Stop and emergency stop push buttons
   - Program documentation

3. Define and describe analog I/O's, their applications and external components. 15%

a. Purpose
b. Components
   - Transducers
   - Transmitters
   - Voltage sensing modules
   - Current sensing modules
c. Applications
   - Resolution/Scaling
   - Binary conversion
d. Wiring methods
e. Perform related calculations

4. Create, interpret and demonstrate advanced applications of industrial control system diagrams. 25%

a. Programming relay type instructions
b. Programming discrete inputs
c. Programming outputs
d. Timers
e. Counters
f. Function blocks

5. Demonstrate and perform troubleshooting methods. 10%

a. Purpose
b. Key considerations, including:
   - Bonding connections
   - Controller (including self diagnostics)
   - LED indicators
   - Power supplies
   - I/O modules (discrete, analog and specialty)
   - Search functions
   - Force/Disable functions
   - External inputs and outputs
   - Internal relays/contacts

6. Design, analyze and install automated control circuits. 20%

a. Common applications
   - Traffic signal lights
   - Alternating pumps
   - Automated carwashes
   - Security systems

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Apprenticeship Manitoba

Power Electrician

Unit: D4 Power Electronics

Level: Four

Duration: 80 hours

Theory: 70 hours

Practical: 10 hours

Overview:

This unit is designed to provide the apprentice with the knowledge about power electronics. The unit begins with coverage of rectifier circuits, converters and power filters. Part of the unit covers high voltage direct current (HVDC) transmission systems. Finally, the unit covers inverters and variable frequency drives.

Objectives and Content: **Percent of Unit Mark (%)**

1. Describe, construct and troubleshoot rectifier circuits. **25%**

a. Purpose

b. Characteristics of single phase, three phase and twelve pulse rectifiers

- Output current waveform for operation with a series inductor filter
- Pulse output
- Average output voltage
- Significant output voltage harmonics
- Output DC equivalent circuit
- Output AC equivalent circuit
- Input waveforms: voltage and current
- RMS value of line current
- Line current harmonics
- Input power: Active, Reactive, Apparent
- True Power Factor
- Diode voltage and current ratings
- Transformer kVA rating

2. Describe, construct, and troubleshoot converters. **30%**

a. Purpose

b. Characteristics of a single phase and three phase full converters

- Output waveforms: voltage and current
- Pulse output
- Average output voltage
- Significant output voltage harmonics
- Output DC equivalent circuit
- Quadrants of operation
- Modes of operation: rectifier and inverter mode
- SCR misfires in rectifier and inverter mode

- Practical range of firing angles
- Input waveforms: voltage and current
- RMS value of line current
- Input power: Active, Reactive, Apparent
- True Power Factor
- SCR voltage and current ratings
- Transformer kVA rating

c. Characteristics of single phase and three phase half converters
- Output waveforms: voltage and current
- Average output voltage
- Modes of operation
- Input waveforms: voltage and current
- Comparison of power factor between single phase half and full converters

d. Types of converters associated with the following representative applications
- Battery chargers
- Generator AVRs
- Cogeneration with wind power

3. Describe high voltage direct current (HVDC) transmission systems. 10%

a. Purpose

b. Advantages
- Relative cost of construction
- Protection
- Stability

c. Components
- Monopole
- Bipole

d. Operation
- Rectifier characteristic graph
- Inverter characteristic graph
- Control of power transmitted
- Reaction to AC system fluctuations
- Reaction to line to ground fault

4. Describe power filters. 10%

a. Purpose

b. Characteristics of a series resonant AC power filter
- Characteristic graph of impedance versus frequency
- Filter resonant frequency versus harmonic frequency
- Filter circuit for three phase, three conductor AC source
- Filter circuit for three phase, four conductor AC source
- Filter location
- Input filter line current versus output filter line current
- Effect of filter on: apparent power demand, transformer heat dissipation, power factor capacitor heat dissipation, conductor heat dissipation

c. Characteristics of series resonant DC power filters
- AC equivalent circuit
- Filters required for six and twelve pulse operation

d. Perform related calculations
- Filter component values (AC power filters)
- AC equivalent circuit (DC power filters)

5. Describe, construct and troubleshoot inverters. 10%

a. Purpose
b. Characteristics of single phase and three phase Variable Voltage Inverter (VVI)
   - Output voltage waveform
   - Output voltage control
   - Output frequency control
   - Output voltage harmonics for three phase VVI inverters
c. Characteristics of single phase and three phase Pulse With Modulation (PWM) inverters
   - Output voltage waveform
   - Output voltage control
   - Output frequency control
   - Output voltage harmonics for three phase PWM inverters
d. Characteristics of power electronics devices utilized in inverters
   - Gate Turn On/Off (GTO)
   - Power Transistors
   - Isolated Gate Bi-Polar Transistors (IGBTs)
e. Applications of inverters
   - Portable battery operated AC power supplies
   - UPS systems
   - AC variable speed drives
f. Comparison of PWM inverter versus VVI inverter with respect to output voltage harmonics.

6. Describe variable frequency drives (VFD). 10%

a. Purpose
b. Characteristics
   - AC motor torque dependency on motor voltage and frequency
   - Ideal torque versus RPM graph and line current for an AC motor operating at constant V/Hz below nameplate voltage and frequency
   - Basic linear and quadrant graphs of output voltage versus frequency for a VFD (rated output voltage, knee frequency, maximum frequency, constant torque load versus variable torque load)
   - Methods of acceleration for various mechanical loads (soft starting)
   - Methods of deceleration (dynamic braking, regenerative braking, DC injection braking)
c. Types
   - PWM
   - VVI

7. Describe static VAR compensators (SVCs). 5%

a. Purpose and applications
b. Operating procedures
c. Testing

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Unit: D5 Power Quality

Level: Four

Duration: 20 hours

Theory: 20 hours

Practical: 0 hours

Overview:

This unit is designed to provide the apprentice with the knowledge about power quality. The unit begins with coverage of power interruptions, voltage and surge suppression. Part of the unit covers uninterruptible power supplies (UPS), the displacement power factor, total harmonic distortion (THD) and transformer K-rating. Finally, the unit covers the effects of loading on electrical distribution systems and the effects of harmonics on various loads.

Objectives and Content:	**Percent of Unit Mark (%)**
1. Describe characteristics of power interruptions. a. Types • Sustained • Temporary • Momentary	**10%**
2. Describe the characteristics of voltage. a. Types • Voltage sag • Voltage swell • Over and under voltage condition • Voltage fluctuation • Transient voltage	**15%**
3. Describe the operation of uninterruptible power supplies (UPS). a. Types • Standby generator • Battery charger/battery bank • Electronic converters	**15%**
4. Describe surge suppression. a. Types • Lightning arrestors • Metal oxide varistors (MOV) b. Applications • Transmission lines	**10%**

- Primary distribution centers
- Secondary circuits

5. Describe the effects of loading on electrical distribution systems. 10%

a. Types
   - Linear
   - Non linear

6. List the frequency of different order harmonics. 5%

7. Identify the electrical harmonic effects on transformers, circuit breakers and neutral conductors. 15%

a. Types
   - Negative sequence
   - Positive sequence
   - Zero sequence

8. Describe the effects of harmonics on various loads. 15%

a. Types
   - Motors
   - Capacitors
   - Electronic equipment

9. Describe the displacement power factor, total harmonic distortion (THD) and transformer K-Rating. 5%

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Apprenticeship Manitoba

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Unit: D6 Digital Logic Concepts

Level: Four

Duration: 40 hours

Theory: 25 hours

Practical: 15 hours

Overview:

This unit is designed to provide the apprentice with the knowledge about digital logic concepts. The unit begins with coverage of basic logic gates, tristate buffers, Boolean algebra and Karnaugh maps. Part of the unit covers analyzing, constructing and troubleshooting combinational and sequential logic circuits. Finally, the unit covers application of digital logic concepts.

Objectives and Content:	**Percent of Unit Mark (%)**
1. Describe requirements for counting and performing conversions between decimal, binary, hexadecimal and Binary Coded Decimal (BCD) numbering systems.	**5%**
2. Describe basic logic gates and tristate buffers. a. Purpose b. Characteristics c. Operation	**10%**
3. Describe Boolean algebra and Karnaugh maps. a. Purpose and application • Boolean algebra theorems • Sum of products Karnaugh maps • NAND gate universality	**10%**
4. Describe, analyze, construct and troubleshoot combinational logic circuits. a. Decoders • Single gate decoder • 3 to 8 decoder • BCD to 7 segment decoder b. Multiplexers • 4 to 1 multiplexer • 2 to 1 bus multiplexer	**25%**
5. Describe, analyze, construct and troubleshoot sequential logic circuits. a. Latches • Set-Reset (SR) Latch • Delay (D) Latch	**25%**

- Switch de-bouncers

b. Flip-flops
   - Delay (D) Flip-flop
   - JK Flip-flop
   - Shift registers
   - Counters/Sequencers

6. Describe requirements and follow procedures for handling/storage of Electrostatic Discharge (ESD) sensitive semiconductor devices. 5%

7. Describe requirements for using manufacturer's external device markings and data sheets. 10%

a. Type identification
b. Case style
c. Maximum ratings
d. Electrical characteristics of integrated circuits

8. Describe requirements for applying Light Emitting Diodes (LEDs) and LED displays for logic circuit applications 10%

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Apprenticeship Manitoba

Power Electrician

Unit: D7 Relay and Protection Systems

Level: Four

Duration: 40 hours

Theory: 40 hours

Practical: 0 hours

Overview:

This unit is designed to provide the apprentice with the knowledge about relay and protection systems. The unit begins with coverage of protective relaying components of the power system. Part of the unit covers protection relays and pilot protection schemes. Finally, the unit covers special purpose and auxiliary relays.

Objectives and Content:	**Percent of Unit Mark (%)**
1. Describe protective relaying components of the power system. a. Purpose b. Application and operation • Major protection systems • Zones of protection • Primary and backup relaying • Aspects of relay design such as speed, selectivity, reliability, and sensitivity • Types and occurrences of faults in the power system	**25%**
2. Describe protection relays. a. Purpose b. Types • Over-current • Directional • Over / Under voltage • Differential / Percent Differential • Distance c. Characteristics and operation	**25%**
3. Describe pilot protection schemes. a. Purpose b. Types • Pilot wire • Power line carrier • Microwave • Fiber-optic c. Applications • Directional Comparison	**15%**

- Phase Comparison
- Current differential
- Direct/Permissive transfer tripping

4. Describe special purpose relays. **15%**

a. Purpose
b. Types
   - Current balance relays
   - Frequency protection relays
   - Power directional relays
   - Negative sequence relays
   - Phase comparison relays
c. Applications

5. Describe auxiliary relays. **20%**

a. Purpose
b. Types
   - Annunciating
   - Regulating
   - Reclosing
   - Lockout/Tripping
c. Applications

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Apprenticeship Manitoba

Power Electrician

Unit: D8 Journeyperson Trainer

Level: Four

Duration: 10 hours

Theory: 10 hours

Practical: 0 hours

Overview:

Level One in-school technical training offers an entry-level orientation to the challenges of apprenticeship training as it relates to the development of core tasks and skill requirements, as well as social competencies. This unit introduces senior apprentices to the responsibilities of workplace training that they will assume as supervising journeypersons. Most trades have a rich tradition of refreshing and sharing their trade skills from one generation of trade practitioner to the next. This unit orients senior apprentices to some of the practical and conceptual tools that can enable them to contribute to this trade heritage when they become certified journeypersons and, ultimately, journeyperson trainers.

The journeyperson's obligation to assist entry-level apprentices to develop skills and knowledge is complex and challenging. It involves safety considerations, employer expectations, provincial regulations, as well as the tradition of skills stewardship that links modern practice with the long history of workplace teaching and learning that defines the apprenticeable trades. The ability to offer timely and appropriate support to apprentices is itself an important area of trade learning. This unit presents material intended to help refine this ability through reflection and discussion by senior apprentices, and discussion with their in-school instructor and journeyperson trainer.

This content reflects Manitoba and Canadian standards prescribed for journeyperson-level supervisory capabilities, as well as key topics in current research on the importance of workplace training in apprenticeship systems. These detailed descriptors represent suggested focal points or guidelines for potentially worthwhile exploration, and are neither mandatory nor exhaustive.

Note: No percentage-weightings for test purposes are prescribed for this unit's objectives. Instead, a 'Pass/Fail" grade will be recorded for the unit in its entirety.

Objectives and Content:	**Percent of Unit Mark (%)**
1. Compare/contrast role-options and responsibilities of the supervising journeyperson. a. Implicit vs. explicit standards and content: training goals are/are not codified; assessment measures are/are not used b. Accountability for results: e.g. journeyperson is/is not required to prepare performance evaluation that could affect apprentice's employability or wage-rate, etc. c. Long-term vs. short-term supervision assignments – e.g., considerable latitude/little latitude for apprentice to learn from mistakes d. Formally vs. informally structured – e.g. supervision assignment is part of a prescribed cycle of assignments involving coordination among multiple journeypersons; apprentice is trained according to an individual training plan negotiated with employer e. Types of supervisory role options and what is implied by each:	**n/a**

- Journeyperson Trainer (JT) role: often initiated by someone other than apprentice, and limited to a particular skill set, task, or production requirement
- Mentor role: often initiated by apprentice, and relatively open-ended regarding content, duration, etc.
- Peer role: typically involves individual upgrading or cross-training of one journeyperson by another; can include senior apprentice assisting less-experienced trade learner
- Coordinator role: often a senior-level journeyperson appointed by an organization to assume responsibilities for monitoring progression of groups of apprentices
- Other roles: may be improvised by journeyperson, such as combination or multiple roles of the above

2. Describe and demonstrate common requirements about providing journeyperson level supervision. **n/a**

a. Apprenticeship learning adapted to journeyperson supervision assignments and a journeyperson perspective
   - Application of adult education concepts to trades teaching and learning (e.g. responsibilities and expectations of senior-level apprentices)
   - Practical significance of 'styles' of adult learning and teaching
   - Helping senior-level apprentices integrate in-school technical training and on-the-job practical training experiences
   - Providing help and guidance about new tasks and skills
   - Providing help and guidance about fixing mistakes
   - Learning and teaching "the ropes" – socialization of apprentice within a community of trade practice (e.g. how to borrow a tool, interrupt a journeyperson, seek advice of experienced co-workers)
   - Coverage and documentation of prescribed tasks and subtasks where applicable.
   - Discuss the limits of the journeyperson trainers' own responsibilities and competence (e.g. scope, willingness to train, etc.)
   - Benefits of maintaining a personal record of achievements, ideas, and needs as a journeyperson trainer (e.g. resume, portfolio, training credentials, logbook, etc.)

b. Individual reflection and guided group discussion about personal experiences of workplace learning as an apprentice
   - Identification of best and worst practices of journeyperson trainer
   - Identification of workplace and other factors that can contribute to good and bad trades teaching/learning experiences
   - Development of professional standards and work ethics about responsibility to share one's knowledge and skill with others in the workplace (e.g., use/misuse of humour, rigour, discretion, craft-pride, etc.)
   - Qualities of a good journeyperson trainer
   - Components of workplace journeyperson training
   - Processes and recommended practices re: journeyperson training
   - Troubleshooting problems re: supervision assignments

c. Role of assessment in supervising, coaching, or guiding other people to learn or improve their skills (e.g. formative and summative evaluation), and how this might contribute to how the journeyperson-level supervision task is approached in future

d. Compare and contrast discussion results with current knowledge and resources about workplace training methods as they apply to journeyperson-level supervision assignments

e. Other (as may be specified by instructor)

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Power Electrician

Unit: D9 Pre-Provincial Exam Review

Level: Four

Duration: 35 hours

Theory: 35 hours

Practical: 0 hours

Overview:

This unit offers senior apprentices a systematic review of skills and knowledge required to pass the Provincial Examination. It promotes a purposeful personal synthesis between on-the-job learning and the content of in-school technical training. The unit includes information about the significance of Provincial certification and the features of the Provincial Examination.

Note: No percentage-weightings for test purposes are prescribed for this unit's objectives. Instead, a 'Pass/Fail" grade will be recorded for the unit in its entirety.

Objectives and Content:	**Percent of Unit Mark (%)**
1. Describe the significance, format and general content of Provincial Examinations for the trade of Power Electrician. a. Scope and aims of Provincial certification; value of certifications b. Obligations of candidates for Provincial certification • Relevance of Provincial Examinations to current, accepted trade practices; industry-based provincial and national validation of test items • Supplemental Policy (retesting) • Confidentiality of examination content c. Multiple-choice format (four-option) item format, Red Seal standards for acceptable test items d. Government materials relevant to the Provincial Examinations for apprentice Power Electrician • Provincial Occupational Standard (POS); prescribed scope of the skills and knowledge which comprise the trade • POS "Pie-chart" and its relationship to content distribution of Provincial Examination items • Apprenticeship Manitoba Technical Training package	**n/a**
2. Identify resources, strategies and other considerations for maximizing successful completion of written examinations. a. Personal preparedness • Rest • Nutrition • Personal study regimen • Prior experience in test situations (e.g., Unit Tests) b. Self-assessment, consultation and personal study plan	**n/a**

- Self-assessment of individual strengths/weaknesses in trade related skills and knowledge
- Approved textbooks
- Study groups

3.	**Review program content regarding common occupational skills.**	**n/a**
4.	**Review program content regarding power utility systems.**	**n/a**
5.	**Review program content regarding high voltage equipment.**	**n/a**
6.	**Review program content regarding low voltage equipment.**	**n/a**
7.	**Review program content regarding rotating machines.**	**n/a**
8.	**Review program content regarding signaling and communication systems.**	**n/a**

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