Apprenticeship Manitoba

Manitoba

# Industrial Electrician
# Level 3

Rev. June 2017

Apprenticeship Manitoba

# Industrial Electrician

## Unit: C1 Industrial Electrical Code I

**Level:** Three

**Duration:** 77 hours

Theory: 77 hours

Practical: 0 hours

**Overview:**

This unit is designed to provide the apprentice with the knowledge about the industrial electrical code. The unit begins with coverage of industrial wiring methods, overcurrent protection, and lighting types and applications. Part of the unit includes coverage of transformers and capacitors and single motors and groups of motors. Finally, the unit covers arc flash protection and batteries.

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

**1. Describe industrial wiring methods and practices.** **15%**

a. CEC requirements

b. Multi-conductor cables, free air conductors, busways and raceways
- Ampacities
- Derations
- Conditions of use
- Metallurgy (compatibility of materials)

c. Bonding and grounding

d. Underground ampacities and installations

e. Disconnects
- Types and applications (high and low voltage)
- Isolating means
- Equipment withstand ratings

f. Lightning protection
- High voltage applications
- Low voltage applications

g. Class 1 and Class 2 circuits
- Extra low voltage power circuits
- Low energy power circuit

h. Considerations in hazardous locations
- Classification
- Grounding
- Bonding

i. Considerations in high voltage installations
- Grounding methods
- Bonding methods
- Touch and step voltages

j. Perform related calculations
   - Voltage drop calculations
   - Raceway fill calculations

**2. Describe industrial overcurrent protection. 10%**

a. CEC requirements
b. Circuit breaker fundamentals
   - High and low voltage breakers
   - Characteristics and operation
   - Selective coordination for high and low voltage systems
   - Moulded case and switchgear
   - Interpret breaker time (current curves)
   - Arc extinguishing means (air, air/magnetic, oil, vacuum, gas)
c. Fuse fundamentals
   - Types and applications
   - Characteristics and operation
   - Selective coordination for high and low voltage systems
   - Interpret fuse time (current curves)
   - Arc extinguishing means
d. Short circuit calculation

**3. Describe industrial lighting applications. 5%**

a. CEC requirement
b. Types, including:
   - Incandescent
   - Fluorescent
   - High-intensity discharge (HID)
   - Light emitting diode (LED)
c. Theory of lightning
d. Considerations in lamp selection
   - Colour rendition
   - Efficacy
   - Maintenance
   - Purpose and location
e. Control options

**4. Describe transformers and capacitors. 10%**

a. CEC requirements (overcurrent protection)
b. Transformer types
   - Dry
   - Liquid-filled
   - High and low voltage
c. Transformer installations
   - Single phase
   - Three phase
d. Perform related calculations
e. Grounded and ungrounded systems
   - Ground fault detection

**5. Describe the installation of single motors and groups of motors. 20%**

a. CEC requirements
b. Single phase AC
c. Three phase AC

d. Various duty cycles
e. Size and type of overcurrent protection
f. Size and type of overload protection
   - Thermal
   - Magnetic
   - Electronic
g. Perform related calculations
   - Overload protection
   - Service factor
   - Tap conductors

**6. Describe the installation of single arc welders and groups of arc welders. 10%**

a. CEC requirements
b. Single phase AC
c. Three phase AC
d. Various duty cycles
e. Size and type of overcurrent protection
f. Perform related calculations
   - Tap conductors

**7. Describe busway and raceway systems. 10%**

a. CEC requirements
b. Busways
   - Types and applications
   - Rationings and ampacities
   - Components and connections
   - Metallurgical considerations
   - Support systems
   - Torque specifications
c. Raceways
   - Types and applications
   - Cable trough
   - Surface raceways

**8. Describe arc flash protection. 10%**

a. National codes
b. Hazard analyses
c. Personal protective equipment (PPE)
d. Personal protective grounds
e. Limited approach boundary limitations
f. Energized electrical work permits

**9. Describe battery applications. 5%**

a. CEC requirements.
b. Battery installations
c. Size and type of conductors
d. Size and types of overcurrent protection
e. Perform related calculations

**10. Describe three-phase consumer/supply services and metering equipment. 5%**

a. CEC requirements
b. Types and applications
   - Overhead

- Underground
- Temporary

c. Metering equipment

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## Unit: C2 Three Phase Theory and Transformers

**Level:** Three
**Duration:** 77 hours
Theory: 56 hours
Practical: 21 hours

**Overview:**

This unit is designed to provide the apprentice with the knowledge about three phase theory and transformers. The unit begins with coverage of three phase systems and loads in wye and delta configurations. Part of the unit covers transformers and transformer connections. Finally, the unit covers transformer testing and connection techniques.

| **Objectives and Content:** | **Percent of Unit Mark (%)** |
|---|---|
| **1. Define and describe three phase systems in wye and delta configurations.** | **5%** |
| a. Relationship between phase and line<br>• Voltage<br>• Current<br>b. Vector (phasor) relationship<br>• Phasor diagram<br>c. Connections | |
| **2. Define and describe three phase loads in wye and delta configurations.** | **10%** |
| a. Perform related calculations<br>• Balanced and unbalanced loads<br>b. Draw and interpret vector (phasor) diagrams<br>• Unity and non-unity power factor loads<br>c. Effects of a broken neutral | |
| **3. Determine the power draw and power ratings of three phase loads and sources.** | **15%** |
| a. Power factor<br>b. Perform related calculations<br>• Balanced and unbalanced loads<br>• Power factor correction<br>• Power measurement (two and three wattmeter method) | |
| **4. Describe principles of transformers.** | **10%** |
| a. Purpose<br>b. Basic components<br>c. Operation<br>• Transformer action<br>• Regulated and non-regulated transformers | |

- Cooling methods

d. Nameplate data

e. Types and application
   - Isolation
   - Auto transformer

f. Transformer polarities
   - Inductive kick test
   - Low voltage polarity test
   - Paralleling

g. Efficiencies
   - Types of losses

h. Perform related calculations
   - Percent impedance and fault current
   - Rated primary and secondary currents (based on nameplate data)
   - Efficiency calculations
   - Determine primary and secondary currents under various loads
   - Maximum fault current (based on nameplate data)

**5. Describe instrument transformers. 15%**

a. Current transformers (CT)
   - Connection and safety

b. Potential transformers (PT)
   - Connection

c. Perform related calculations for metering

**6. Describe and draw three phase transformers and transformer banks. 15%**

a. Connections
   - Wye
   - Delta (3 and 4 wire)
   - Open delta

**7. Describe special transformer connections. 5%**

a. Applications

b. Connections
   - Scott
   - T-connection
   - Zig zag (ground bank)

**8. Demonstrate principles of three phase systems in wye and delta configurations. 15%**

a. Verify phase and line relationship by connections and measurements.

b. Verify power measurement

**9. Perform transformer testing to verify nameplate data. 5%**

a. Verify polarity of transformers
   - Inductive kick test
   - Low voltage polarity test

b. Verify primary and secondary voltages

**10. Demonstrate connections of three phase transformer banks. 5%**

a. Wye

b. Delta
   - Delta closure test

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## Unit: C3 Power Quality

**Level:** Three

**Duration:** 7 hours

Theory: 7 hours

Practical: 0 hours

**Overview:**

This unit is designed to provide the apprentice with the knowledge about power quality. This unit covers power quality issues, harmonics and ground fault protection. This unit also covers uninterruptible power supply.

| **Objectives and Content:** | **Percent of Unit Mark (%)** |
|---|---|
| **1. Describe power quality issues.**<br>a. Key considerations<br>b. Causes<br>• Voltage sag<br>• Voltage swell<br>• Over and under voltage condition<br>• Voltage fluctuation<br>• Voltage transient.<br>c. Mitigation Methods<br>• Transient Voltage Surge Suppression (TVSS) in transmission lines, primary distribution centers and secondary circuits | **25%** |
| **2. Describe harmonics.**<br>a. Characteristics<br>• Frequency of different order harmonics<br>b. Causes<br>• Linear and non-linear loads<br>• Negative, positive and zero sequence harmonics in transformers, circuit breakers and neutral conductors<br>• Harmonic currents in motors, capacitors and sensitive electronic equipment<br>c. Mitigation Methods | **25%** |
| **3. Describe Ground Fault Protection (GFP).**<br>a. Purpose and application<br>b. Systems | **25%** |
| **4. Describe uninterruptible power supply (UPS) and demonstrate its operation.**<br>a. Operation and application | **25%** |

b. Codes
c. Test procedures
d. Standby generators

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## Unit: C4 Electronic Concepts II

**Level:** Three

**Duration:** 42 hours

Theory: 21 hours

Practical: 21 hours

**Overview:**

This unit, which builds on *B5 Electronics Concept I*, is designed to provide the apprentice with the knowledge about additional electronic concepts. The unit begins with coverage of filtration and percent ripple in a circuit. Part of the unit covers triacs and transistors. Finally, the unit covers application of electronic concepts.

| **Objectives and Content:** | **Percent of Unit Mark (%)** |
|---|---|
| **1. Describe filtration and percent ripple in a circuit.**<br>a. Perform related calculations | **20%** |
| **2. Describe a silicone controlled rectifier (SCR).**<br>a. Purpose and applications<br>• DC circuits<br>• AC circuits<br>b. Phase shifting<br>c. Identify the schematic symbols and terminal connections<br>d. Perform related calculations | **20%** |
| **3. Describe a triac.**<br>a. Purpose and applications<br>b. Phase shifting<br>c. Identify the schematic symbols and terminal connections<br>d. Perform related calculations | **20%** |
| **4. Describe a transistor.**<br>a. Purpose and applications<br>• Switching<br>• Amplification<br>b. Types<br>• Bi-polar<br>• Junction field effect transistor (JFET)<br>• Metal oxide semiconductor field effect transistor (MOSFET)<br>• Depletion enhancement metal oxide semiconductor field effect transistor (DEMOSFET)<br>c. Identify and label schematic symbols and terminals | **20%** |

d. Describe transistor characteristics
   - Operating point
   - Current gain
   - Voltage gain
   - Load lines

e. Perform related calculations

**5. Demonstrate and apply electronic concepts. 20%**

a. Measure the voltages and verify the percent ripple
b. Test an SCR.
c. Connect an SCR to control a DC circuit.
d. Connect an SCR to control a single phase AC circuit.
e. Analyze the operation of SCR and triac phase control.
f. Test a transistor in a circuit and out of a circuit.
g. Use an oscilloscope to demonstrate transistor characteristics.

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## Unit: C5 Industrial Control Systems I

**Level:** Three

**Duration:** 77 hours

Theory: 38 hours

Practical: 39 hours

**Overview:**

This unit is designed to provide the apprentice with introductory knowledge about industrial control systems. The unit begins with coverage of control system pilot and sensing device for motor control. Part of the unit covers programmable logic controllers (PLCs) and discrete I/O's. Finally, the unit covers PLC numbering systems.

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

**1. Describe and demonstrate operation of control system pilot devices for motor control.** — **10%**

a. Purpose
b. Basic components
   - Push buttons
   - Float switches
   - Temp switches
   - Flow switches
   - Pressure switches
   - Limit switches
   - Selector switches
c. Operation and application

**2. Describe and demonstrate operation of control system sensing devices for motor control.** — **20%**

a. Purpose
b. Basic components
   - Inductive detector
   - Capacitive detector
   - Magnetic detector
   - Photo detector
c. Operation and application

**3. Describe and demonstrate the basic operation of programmable logic controllers (PLCs).** — **25%**

a. Purpose
b. Types
   - Fixed

- Modular
- Remote

c. Components
- Central processing unit (CPU)
- Memory storage
- Input/output (I/O) section
- Power supply
- Programming devices

d. Basic operation and applications

**4. Describe and demonstrate programming of basic ladder logic using discrete I/O's. 15%**

a. Interpret basic ladder logic
b. Field and internal addressing
- Examine on and examine off contacts
- Internal and external I/O's
- Time on and time off timers
- Count up and countdown counters

c. Contact nesting

**5. Describe and demonstrate programming and wiring practices for PLC controlled systems. 10%**

a. Devices
- Master control relays
- Emergency stop stations
- Internal and external I/O's (discrete and analog)
- Communications modules
- Numerical modules

b. Programming
- Processor security
- Procedures for using force functions
- Program documentation
- Processor scan time

c. Wiring practices
- Overcurrent protection
- Bonding and shielding

**6. Create, interpret and demonstrate basic applications of industrial control system diagrams. 10%**

a. Schematic diagrams for pilot and sensing devices
b. Ladder diagrams for PLCs.

**7. Describe and apply basic principles of PLC numbering systems for computerized equipments. 10%**

a. Binary
b. Binary- coded decimal (BCD)
c. Octal
d. Hexadecimal

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# Industrial Electrician

## Unit: C6 AC Machines and Controls

**Level:** Three

**Duration:** 35 hours

Theory: 17 hours

Practical: 18 hours

**Overview:**

This unit is designed to provide the apprentice with the knowledge about AC machines. This unit covers three phase and single phase motors and AC generators. This unit also covers the operation of reduced voltage starting methods.

| **Objectives and Content:** | **Percent of Unit Mark (%)** |
|---|---|
| **1. Review unit *B6 DC Machines and Controls.*** | **5%** |
| **2. Describe three phase motors.**<br>a. Types<br>• Squirrel cage induction motors<br>• Wound rotor induction motors<br>• Synchronous motors<br>b. Purpose and applications<br>c. Operating characteristics<br>d. Basic construction<br>e. Terminal markings<br>f. Nameplate ratings<br>g. Perform related calculations | **25%** |
| **2. Describe single phase motors.**<br>a. Types<br>• Split phase induction motors<br>• Alternating current series motors<br>• Shaded pole motors<br>b. Purpose and applications<br>c. Operating characteristics<br>d. Basic construction<br>e. Terminal markings<br>f. Nameplate ratings<br>g. Perform related calculations | **20%** |
| **3. Describe AC generators.**<br>a. Types and construction details<br>b. Operating characteristics and losses | **25%** |

c. Paralleling requirements

**4. Describe and demonstrate operation of reduced voltage starting methods. 25%**

a. Principles and applications
   - Across the line start
   - Reduced voltage start (reason for use)

b. Types of reduced voltage starting methods
   - Resistive start
   - Wye-start
   - Delta-run start
   - Part winding start
   - Auto transformer start
   - Wound rotor motors

c. Manual and automatic control for synchronous motors

d. Variable frequency drive and soft start controllers

e. Interpret and create related diagrams (design methods)

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# Industrial Electrician

## Unit: C7 Predictive and Preventive Maintenance I

**Level:** Three

**Duration:** 35 hours

Theory: 17 hours

Practical: 18 hours

**Overview:**

This unit is designed to provide the apprentice with introductory knowledge about predictive and preventive maintenance. This unit covers insulation testing, maintenance and troubleshooting procedures for stationary and rotating equipment. This unit also covers insulation testing methods on electrical systems and apparatus.

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

**1. Describe insulation testing for stationary and rotating equipment.** **50%**

a. Purpose

b. Procedures for insulation testing and safety considerations
- Lockout / tag out procedures
- Equipment and personal protective grounding
- Maximum test voltages
- Meter lead connections
- Testing and cleaning of insulating liquids
- Additional hazards associated with high potential testing methods

c. Institute of Electrical and Electronics Engineers (IEEE) standard for minimum resistance for electrical systems and apparatus
- Low voltage wiring systems
- Motors and generators
- Transformers
- HV cables and equipment

d. Types of insulation testing using a megohmmeter allowing for temperature correction
- Sixty second test
- Step voltage test
- Dielectric absorption test
- Polarization Indexing

e. Interpret and perform trend analysis on insulating materials using megohmmeter readings

**2. Demonstrate and perform insulation testing methods on electrical systems and apparatus.** **25%**

a. Megohmmeter
- Basic function and operation
- Lockout / tag out procedures

- Equipment and personal protective grounding
- Meter lead connections

**3. Describe and demonstrate maintenance and troubleshooting procedures for stationary and rotating equipment.** **25%**

a. Transformer maintenance
   - Insulation Test
   - Polarity Test
   - Ratio Test
   - Core loss Test
   - Impedance Test

b. Testing and maintenance for AC and DC machines
   - DC motors and generators
   - AC motors and generators
   - Rotors and stators
   - Commutator and slip rings
   - Brushes and brush rigging
   - Bearings

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