Apprenticeship and Industry Training

Power System Electrician

Apprenticeship Course Outline

4601.1 (2001)

Alberta

Apprenticeship and Industry Training

POWER SYSTEM ELECTRICIAN

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COURSE OUTLINE

Apprenticeship and Industry Training System

Apprenticeship is post-secondary education with a difference. It helps ensure Alberta has a steady supply of highly skilled employees, the foundation of our economy's future health and competitiveness.

Apprentices in more than 50 trades and crafts spend between one and four years learning their trade - 80% of the time on-the-job under the supervision of a certified journeyman or qualified tradesperson. The balance of the program is technical training in the theory, skills and technologies of their trade.

To become certified journeymen, apprentices must learn theory and skills, and they must pass examinations. Requirements for certification - including the content and delivery of technical training - are developed and updated by the Alberta Apprenticeship and Industry Training Board (the Board) and a network of local and provincial industry committees.

The goal of apprenticeship training is to develop a competent journeyman through a combination of on-the-job and technical training.

The graduate of the Power System Electrician apprenticeship training is a journeyman who will be able to:

* responsibly do all work tasks expected of a journeyman.
* supervise, train and coach apprentices.
* use and maintain hand and power tools to the standards of competency and safety required in the trade.
* read and interpret drawing, plans and specifications and layout and develop projects according to specifications.
* coordinate power system work with other trades employed in the industry in both construction and maintenance.
* perform assigned tasks in accordance with quality and production standards required in industry.

While government supports Alberta's apprenticeship system, it is driven by industry (a term which includes both employers and employees). The Board steers the system, but the system relies on a network of local and provincial apprenticeship committees (LACs and PACs), representing the interests of each of more than 50 trades and crafts. Partners in the apprenticeship system play critical roles through the local and provincial committees within each trade.

Local Apprenticeship Committees (LAC)

Wherever there is activity in a trade, the Board can set up a LAC. The Board appoints equal numbers of employees and employers for terms of up to three years. The committee appoints a member as presiding officer. LACs:

- monitor the apprenticeship system, and the progress of apprentices in their trade, at the local level
- help settle certain kinds of issues between apprentices and their employers
- recommend improvements in apprenticeship training and certification to their trade's provincial apprenticeship committee
- make recommendations to the Board regarding the appointment of members to their trade's PAC.

Provincial Apprenticeship Committees (PAC)

The Board establishes a PAC for each trade and, based on PAC recommendations, appoints a presiding officer and equal numbers of employees and employers for terms of up to three years. Most PACs have nine members. PACs:

- identify the training needs and content for their trade
- recommend to the Board the standards for training and certification for their trade
- monitor the activities of local apprenticeship committees in their trade
- make recommendations to the Board about the designation of trades and occupations
- determine whether training of various kinds is equivalent to training provided in an apprenticeship program in the trade
- may participate in resolving any apprenticeship-related disputes between employers and employees

Power System Electrician P.A.C. Members

Mr. B. Harburn	Calgary	Presiding Officer
Mr. D. Pratt	Calgary	Employer
Mr. L. Clouston	Edmonton	Employer
Mr. G. Auten	Fort McMurray	Employer
Mr. M. Johnson	Edmonton	Employee
Mr. J. Love	Edmonton	Employee
Mr. G. Barth	Medicine Hat	Employee

The Alberta Apprenticeship and Industry Training Board (Board)

The 13 members of the government appointed Board are aware of the training and certification needs of trades people and employers. Many Board members have previously served on an LAC or PAC. The Board:

- responds to industry's needs
- sets training and certification standards in all trades
- approves the technical training to be delivered by training establishments
- encourages the development of alternate methods of technical training delivery
- makes recommendations to the Minister of Learning about the designation of trades and occupations
- creates LACs, PACs, and appoints their members
- advises the Minister on the labour market's need for skilled and trained workers

Safety Education

Safe working procedures and conditions, accident prevention and the preservation of health are of primary importance in apprenticeship programs in Alberta. These responsibilities are shared and require the joint efforts of employers and employees. Safe learning experiences and environments can be created by controlling the variables and behaviors that may contribute to or cause an accident or injury.

It is generally recognized that a safe attitude contributes to an accident free environment. Everyone will benefit as a result of a healthy safe attitude towards prevention of accidents.

A tradesperson may be exposed to more hazards than others in the work force. Therefore, tradespersons should be familiar and comply with the Occupational Health and Safety Act and Regulations respecting personal safety and the safety in the work place.

Legal and Administrative Aspects of Safety

Accident prevention and the provisions of safe working conditions are the responsibilities of an employer and employee.

Employer's Responsibilities:

The employer is responsible for:

- provision and maintenance of safety equipment.
- provision of protective devices and clothing.
- enforcement of safe working procedures.
- safeguards for machinery, equipment and tools.
- observance of all accident prevention regulations.
- training of employees in safe use and operation of equipment.

Employee's Responsibilities:

The employee is responsible for:

- working in accordance with the safety regulations pertaining to job environment.
- working in such a way as not to endanger themselves or fellow employees.

Technical Training Establishments

The Power System Electrician apprenticeship training program is offered by Alberta Learning, Apprenticeship and Industry Training. Staff and facilities delivering the program are supplied by:

• Northern Alberta Institute of Technology	All 4 Periods
• Southern Alberta Institute of Technology	Periods 1 and 2 only
• Faiview College	Periods 1 and 2 only
• Keyano College	Periods 1 and 2 only
• Lakeland College	Periods 1 and 2 only
• Lethbridge College	Periods 1 and 2 only
• Red Deer College	Periods 1 and 2 only

Procedures for Recommending Revisions to the Course Outline

This course outline has been prepared by the Industry Programs and Standards of the Apprenticeship and Industry Training in partnership with the Provincial Apprenticeship Committee for the trade.

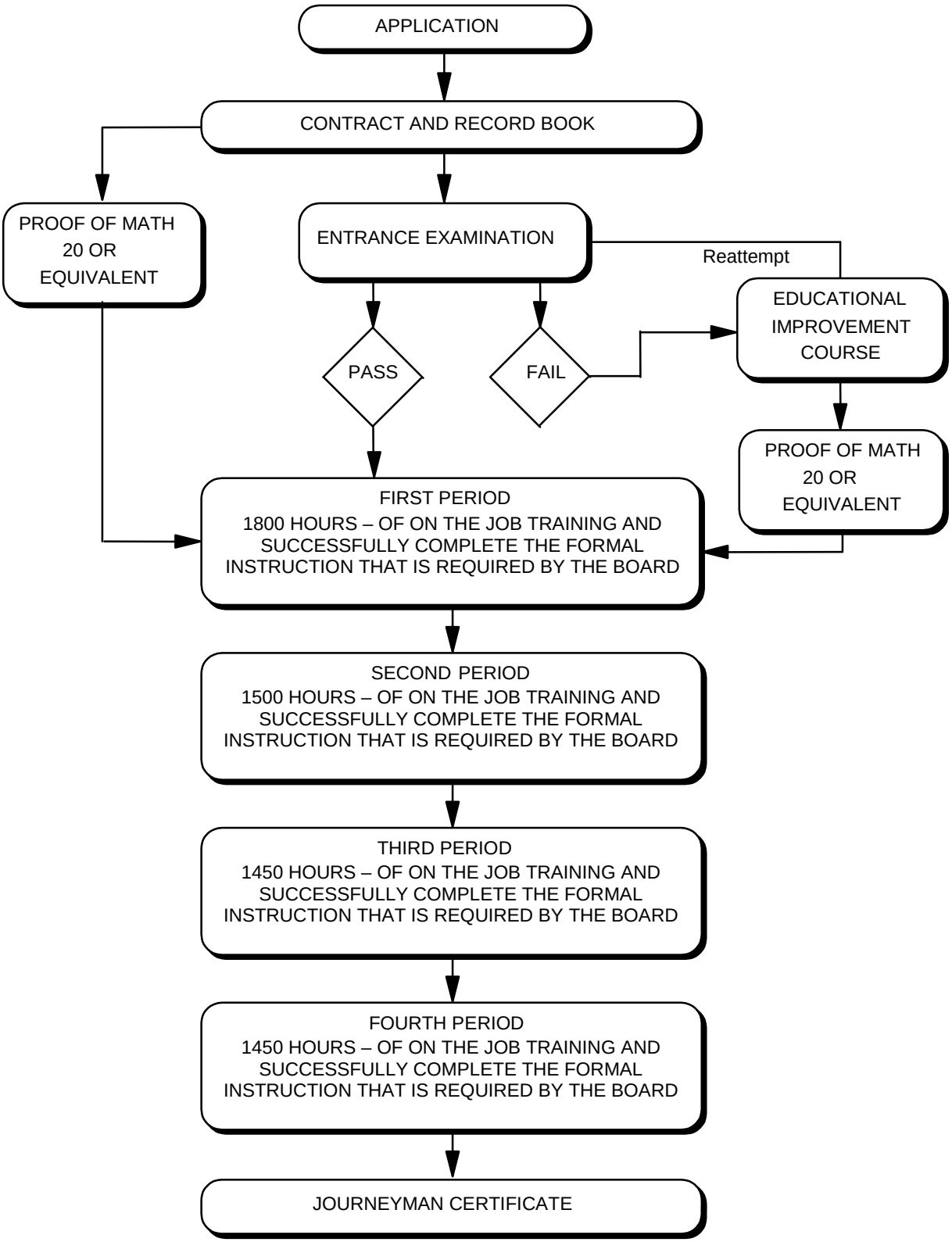
This course outline was approved on March 9, 2001 under the authority of the Alberta Apprenticeship and Industry Training Board on a recommendation from the Provincial Apprenticeship Committee. Valuable input is acknowledged from industry and the institute.

Any concerned citizen or group in the Province of Alberta may make recommendations for change by writing to:

Apprenticeship and Industry Training
Industry Programs and Standards
10th floor, Commerce Place
10155 - 102 Street
Edmonton, AB T5J 4L5

It is requested that recommendations for change refer to specific areas and state references used. Recommendations received will be placed before regular meetings of the Provincial Apprenticeship Committee.

Apprenticeship Route Toward Certification



Power System Electrician Training Profile

First Period
(8 Weeks 30 Hours Per Week - Total of 240 Hours)

SECTION ONE

PRINCIPLES OF ELECTRICITY
130 HOURS

A	B	C	D
Principles of Electricity 104 Hours	Magnetism 14 Hours	Direct Current Sources 4 Hours	Trade Mathematics 8 Hours

SECTION TWO

CANADIAN ELECTRICAL CODE PART I AND PLANS
50 HOURS

A	B
Canadian Electrical Code (Part I) with Alberta Amendments 42 Hours	Plans and Diagrams 8 Hours

SECTION THREE

CONTROLS AND SWITCHING CIRCUITS
28 HOURS

A
Controls and Switching Circuits 28 Hour

SECTION FOUR

MEASURING INSTRUMENTS
16 HOURS

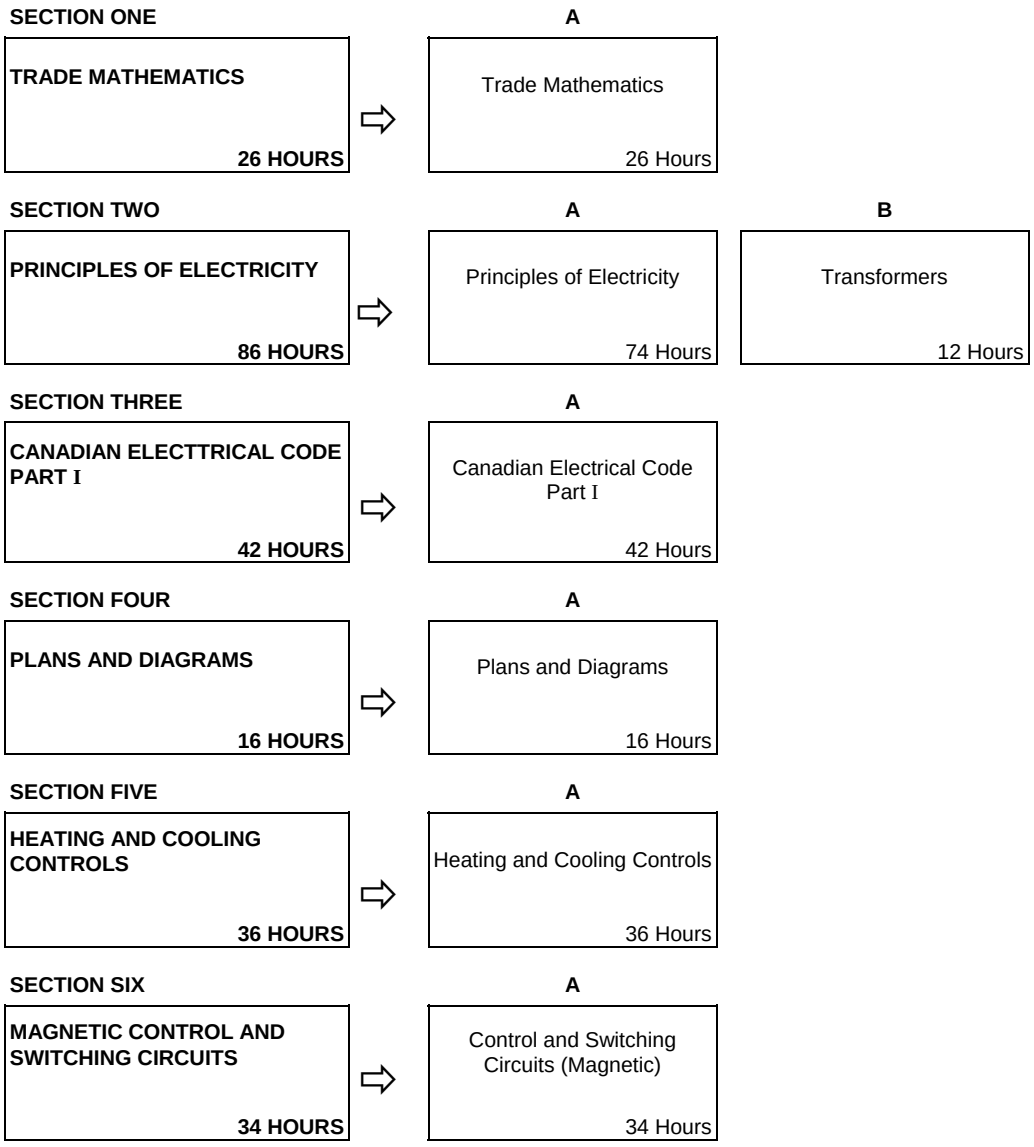
A
Measuring Instruments 16 Hours

SECTION FIVE

RESISTORS, SPLICING, TERMINATIONS, ALARMS AND SAFETY
16 HOURS

A	B	C	D
Resistors 2 Hours	Splicing and Terminations 4 Hours	Safety 6 Hours	Residential Alarm Systems and Smoke Alarms 4 Hours

Second Period
(8 Weeks 30 Hours Per Week - Total of 240 Hours)



Third Period
(10 Weeks 30 Hours Per Week - Total of 300 Hours)

SECTION ONE

ELECTRONICS THEROY

46 HOURS

A	B	C
Electronics Review 4 Hours	PN Junction (Diode) 2 Hours	Rectifiers 6 Hours
D	**E**	**F**
Filters 2 Hours	Voltage Regulators 2 Hours	Transistors 4 Hours
G	**H**	**I**
Operational Amplifiers (Op-Amp) 4 Hours	Silicon Controlled Rectifier (SCR) 4 Hours	Triac 2 Hours
J	**K**	**L**
Photoelectric Devices 4 Hours	Logic 4 Hours	Microprocessors 3 Hours
M		
Programmable Logic Controller (PLC) 5 Hours		

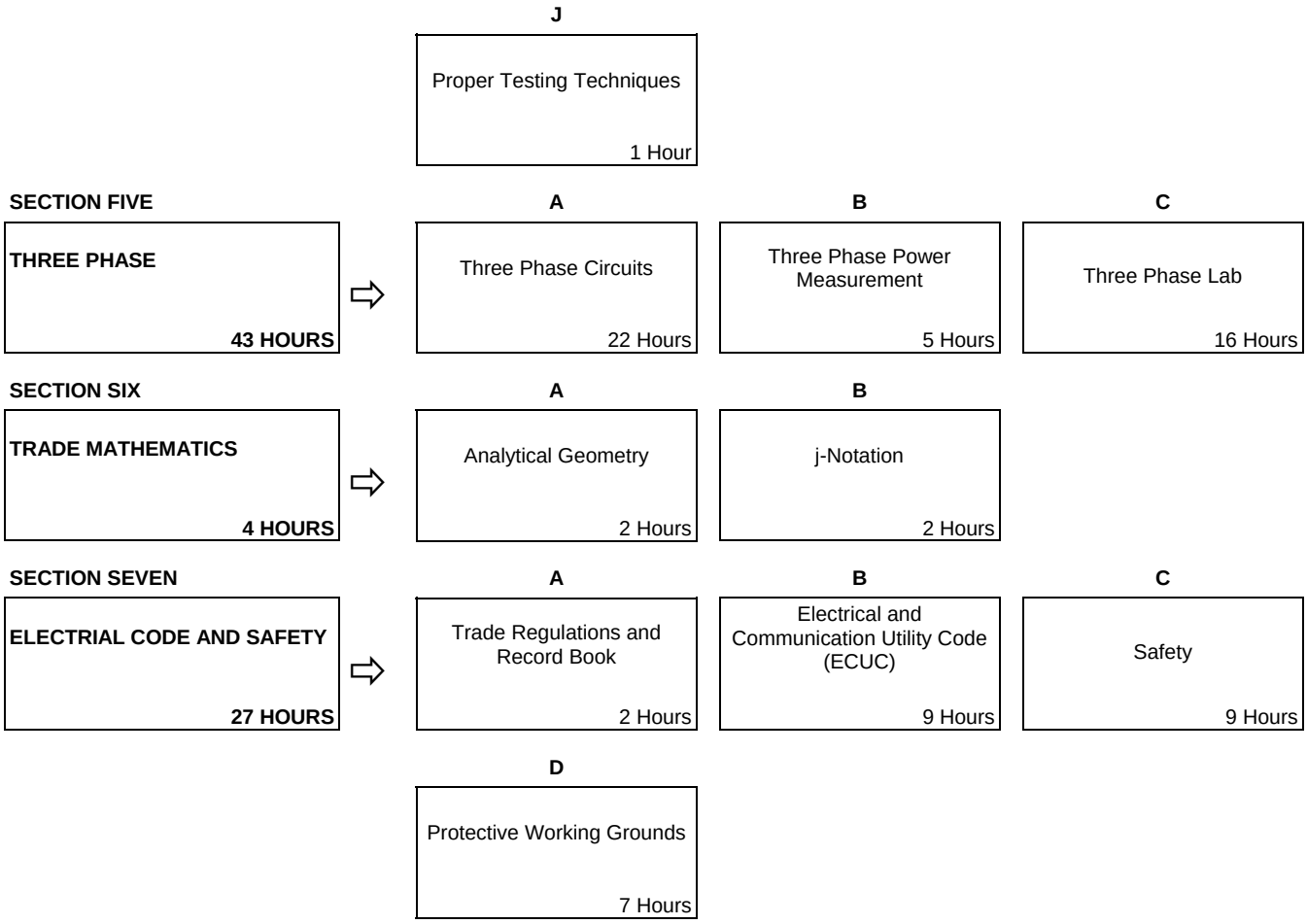
SECTION TWO

ELECTRONICS LAB

57 Hours

A	B	C
Lab Equipment and Components 8 Hours	Diodes 2 Hours	Rectifiers 5 Hours
D	**E**	**F**
Filters 2 Hours	Zener Diodes 2 Hours	Transistors 4 Hours
G	**H**	**I**
Op-Amps 4 Hours	Silicon Controlled Rectifiers (SCR) 5 Hours	Triac 4 Hours

	J	**K**	**L**
	Photoelectric Devices 3 Hours	Logic Gates 3 Hours	Programmable Logic Controllers (PLC) 15 Hours
SECTION THREE	**A**	**B**	**C**
SUBSTATION THEROY **66 HOURS** ⇨	Instrument Transformers 7 Hours	Power Circuit Breakers 8 Hours	Power Systems 2 Hours
	D	**E**	**F**
	BUS Configurations 3 Hours	Switching Equipment 3 Hours	System Fault Current 13 Hours
	G	**H**	**I**
	Relaying 2 Hours	Relaying Systems 4 Hours	Overcurrent Protection 7 Hours
	J	**K**	**L**
	Directional Relays 7 Hours	Differential Protection 5 Hours	Impedance Relay 2 Hours
	M	**N**	**O**
	Synchronism Check Relay 1 Hour	Frequency Relay 1 Hour	Network Relays 1 Hour
SECTION FOUR	**A**	**B**	**C**
SUBSTATION LAB **57 HOURS** ⇨	Instrument Transformer Testing 6 Hours	System Faults 7 Hours	Overcurrent Relay 16 Hours
	D	**E**	**F**
	Directional Relays 7 Hours	Symmetrical Components 3 Hours	Differential Relays 4 Hours
	G	**H**	**I**
	Connection Power Circuit Breaker 4 Hours	Demonstrate Fault Simulators 3 Hours	Mirco-Processor Based Digital Protection 6 Hours


J
Proper Testing Techniques
1 Hour
SECTION FIVE
THREE PHASE
43 HOURS
A
Three Phase Circuits
22 Hours
B
Three Phase Power Measurement
5 Hours
C
Three Phase Lab
16 Hours
SECTION SIX
TRADE MATHEMATICS
4 HOURS
A
Analytical Geometry
2 Hours
B
j-Notation
2 Hours
SECTION SEVEN
ELECTRIAL CODE AND SAFETY
27 HOURS
A
Trade Regulations and Record Book
2 Hours
B
Electrical and Communication Utility Code (ECUC)
9 Hours
C
Safety
9 Hours
D
Protective Working Grounds
7 Hours

Fourth Period
(10 Weeks 30 Hours Per Week - Total of 300 Hours)

SECTION ONE

MACHINES THEROY

30 HOURS

A	B	C
Single Phase Transformers 6 Hours	Auto Transformers 2 Hours	Three Phase Transformers 6 Hours
D	**E**	**F**
Three Phase Motors 6 Hours	Single Phase Motors 6 Hours	DC Motors 4 Hours

SECTION TWO

MACHINES LAB

40 HOURS

A	B	C
Single Phase Transformers 16 Hours	Three Phase Transformers and Transformer Banks 16 Hours	AC Motors 8 Hours

SECTION THREE

METERING THEROY

67 HOURS

A	B	C
Instruments 6 Hours	Watthour Meters (Induction Type) 6 Hours	Meter Connections 12 Hours
D	**E**	**F**
Demand Meters 4 Hours	Polyphase Meters (Instruments Transformers) 8 Hours	Special Metering 5 Hours
G	**H**	**I**
Analog Metering, Totalizing and Recording 5 Hours	Digital Metering, Totalizing and Recording 8 Hours	Telemetering 4 Hours
J	**K**	**L**
Regulatory Agencies 3 Hours	Detection and Prevention of Energy Theft 3 Hours	Rates 3 Hours

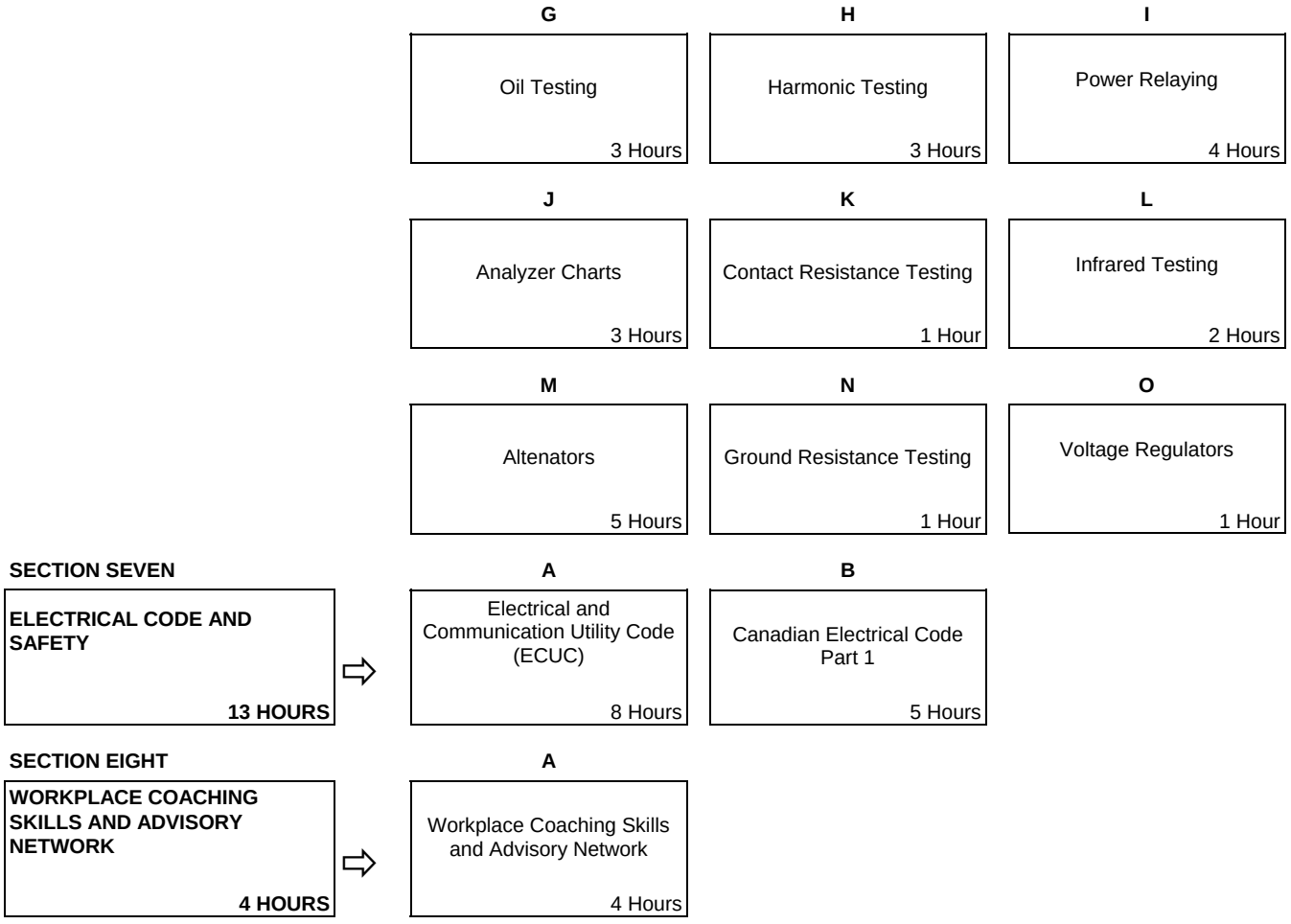
SECTION FOUR

METERING LAB

51 HOURS

A	B	C
Single Phase kWh Meters 6 Hours	Three Phase Self Contained Meters 10 Hours	Safety In Changing Meters 2 Hours

	D Instrument Transformers 7 Hours	**E** kW Demand Meters 2 Hours	**F** kVA Demand Meters 3 Hours
	G Polyphase kWH Meters 5 Hours	**H** Pulse Metering 4 Hours	**I** Totalizing Analog 3 Hours
	J Field Testing 4 Hours	**K** Safety in Changing Meters 5 Hours	
SECTION FIVE **SUBSTATION THEROY** **49 HOURS** ⇨	**A** Power Transformer 12 Hours	**B** Voltage Regulators 5 Hours	**C** Transmission Line 3 Hours
	D Lightning and Surge Protection 3 Hours	**E** Capacitors and Capacitor Banks 4 Hours	**F** Reactors 1 Hour
	G Alternators 9 Hours	**H** Synchronous Motor 1Hour	**I** Substation Batteries 2 Hours
	J Grounding 7 Hours	**K** Precommissioning and Commissioning of Substation 2 Hours	
SECTION SIX **SUBSTATION LAB** **46 HOURS** ⇨	**A** Transformer Connections 9 Hours	**B** Autotransformers 2 Hours	**C** Three Phase Autotranformers 3 Hours
	D Humidity and Dew Point Tests 3 Hours	**E** Ratiometer Test Equipment 3 Hours	**F** Insulation Testing 3 Hours



NOTE: The hours stated are for guidance and should be adhered to as close as possible. However, adjustments must be made for rate of apprentice learning, statutory holidays, registration and examinations for the training establishment and Apprenticeship and Industry Training.

FIRST PERIOD TECHNICAL TRAINING
POWER SYSTEM ELECTRICIAN TRADE
COURSE OUTLINE

TOPIC	OBJECTIVES Upon successful completion of this unit the apprentice will be able to:
SECTION ONE: ..... PRINCIPLES OF ELECTRICITY ..... 130 HOURS	
A. Principles of Electricity ..... 104 Hours	
1. Structure of matter	1. Explain the fundamental relationships between the structure of the atom and the flow of electrons.
2. Electron theory	1. Differentiate between conventional current and electron flow.
3. Conductors a) copper b) aluminum	1. Define conductor with reference to electricity. 2. Define resistivity. 3. State four factors that affect the resistance of conductors. 4. Calculate the resistance of conductors made of different materials. 5. Explain resistance using temperature coefficient of resistance. 6. Identify wire sizes (AWG) and recognize that different gauges of wire have different resistance. 7. Describe what is meant by "cold flow" of aluminum.
4. Fibre optics	1. Describe a fibre optic system. 2. State the advantages of a fibre optic system. 3. Describe the construction of a fibre optic cable. 4. Describe the safe handling, bending and installation of a fibre optic cable. 5. Describe two methods used for splicing and terminating these fibres.
5. Insulators	1. Define insulators with reference to electricity.
6. Generation of emf	1. Describe the methods used to generate ac and dc.
7. Electrical units	1. Define quantity, express symbols and units of measurement for the following electrical terms: a) potential difference/voltage b) current c) resistance d) power e) energy
8. Ohm's law	1. Describe the relationship between voltage, current and resistance in an electric circuit.

	2. Solve problems using Ohm's law.
	3. Analyze circuits by taking voltage, current and resistance measurements and verify using Ohm's Law.
9. Electrical circuits a) series b) parallel c) Kirchhoff's law d) three wire circuit i) balanced and unbalanced ii) neutral disconnected (balanced and unbalanced) e) line loss f) voltage drop g) schematic and wiring diagrams h) series-parallel	1. Analyze series, parallel and three wire circuits and identify their applications. 2. Apply Kirchhoff's current and voltage laws to circuits. 3. Solve problems involving series, parallel and three wire circuits. 4. Describe the effect that an open neutral or high resistance connection will have on electrical equipment. (balanced and unbalanced) 5. Define and distinguish between line loss and voltage drop as it applies to electrical power systems. 6. State the effects that an increase in load will have on the voltage across the load. 7. Solve applicable problems involving line loss and voltage drop. 8. State the relationship between the resistance of a conductor and its line loss. 9. Connect and take measurements in series and parallel circuits using schematic and wiring diagrams to verify Ohm's law.
10. Semi-conductors	1. Define semi-conductors with reference to electricity.
11. Power a) mechanical b) electrical c) work d) energy e) efficiency	1. Differentiate between work, energy and power. 2. State the units of work, energy and power. 3. Calculate mechanical power and work. (metric and imperial measurements) 4. Calculate electrical power and energy. 5. State relationship between horsepower and watts. 6. Define efficiency. 7. Calculate efficiency.

B. Magnetism..... 14 Hours

1. Magnetic fields and lines of force	1. Describe the characteristics of magnetic lines of force. 2. State the difference between magnetic and non-magnetic materials. 3. Define the terms flux, flux density and permeability. 4. State the laws of magnetic attraction and repulsion.

2.	Electromagnetism	1. Describe electromagnetism. 2. Describe saturation with respect to electromagnets. 3. Describe the field around a current carrying conductor and applied hand rules.
3.	Electromagnetic induction	1. State Faraday's law of induction. 2. State Lenz's law of induction. 3. Use Fleming's hand rule for generator action and its application.
4.	Self-induction	1. Describe self-induction in a coil.
5.	Mutual induction	1. Describe the relationship between current and magnetism to explain transformer action.

C. Direct Current Sources ..... 4 Hours

1.	Cells and batteries a) ratings b) checking c) hazards of charging d) interconnection e) maintenance and care	1. Define the voltage, current capacity and ratings applicable various types of batteries. 2. Describe the hazards associated with checking and charging various types of batteries. 3. Explain voltage and current changes when batteries are interconnected. 4. Describe the proper care and maintenance various types of batteries.

D. Trade Mathematics ..... 8 Hours

1.	Pre-requisite	1. Display the ability to do addition, subtraction, multiplication and division of: a) whole numbers b) decimals c) fractions
2.	Applied	1. Display the ability to use exponents, percentages, reciprocals, signed numbers and square root. 2. Solve problems involving ratio and proportions. 3. Solve equations by using correct sequence of operation. 4. Transpose simple algebra equations. 5. Solve problems using SI: a) linear b) area c) force d) temperature

SECTION TWO:.....CANADIAN ELECTRICAL CODE PART I AND PLANS.....50 HOURS

A. Canadian Electrical Code (Part I) with Alberta Amendments ..... 42 Hours

1.	General	1. List in order, the acceptance procedures of the C.E.C. by Canada, the provinces and the local authorities. 2. State how rules are amended to suit local authorities. 3. Obtain information by using the table of contents or the index and relate this information to rule numbers, table and appendices.
2.	Definitions a) Section 0	1. Explain and describe definitions that are pertinent to first period studies.
3.	General rules a) Section 2	1. Explain and describe general rules of Section 2.
4.	Ampacity a) Section 4	1. State the ampacity of a conductor given the load conditions: a) three conductors or less in a raceway b) more than three conductors in a raceway 2. Determine if there are any neutrals (by definition in the raceway or cable and deduct them for derating purposes). 3. Determine the conductor size based on ampacity using correction factors for temperatures above 30°C. 4. Calculate the required ampacity of service or feeder conductors given the load and determine the size of each ungrounded conductor, as well as the neutral. 5. Determine colour coding required for phase conductors.
5.	Service and service equipment for single dwellings a) Section 6	1. Explain and describe the general rules of Section 6 dealing with services operating at 750 V or less. 2. Explain and describe the rules of Section 6 dealing with control and protection equipment. 3. Explain and describe the rules of Section 6 dealing with wiring methods. 4. Explain and describe the general rules of Section 6 dealing with metering equipment.
6.	Circuit loading and demand factors of single dwellings a) Section 8	1. Explain and describe the general rules of Section 8 dealing with circuit loading and demand factors. 2. Calculate the demand of services and feeders for single dwellings. 3. Calculate the demand on branch circuits, excluding space and surface heating.

7. Grounding a) Section 10	1. Explain and describe the terminology that is applicable to single dwellings. 2. Explain and describe the procedures to determine the various grounding techniques. 3. Apply tables 16, 17 and 41 of the Canadian Electrical Code. 4. Describe and identify system and circuit grounding and connection points in a panel board. 5. Explain the difference between grounding and bonding and provide examples of each. 6. Identify and explain rules for grounding electrodes and artificial grounding electrodes.
8. Wiring methods a) Section 12	1. Explain and describe the general rules of Section 12 dealing with installation of conductors and cables. 2. Explain and describe the rules of Section 12 dealing with the installation of specific conductors and cable, their condition of use and installation methods. 3. Explain and describe the general and specific rules for various types of raceways. 4. Explain and describe the rules for installation of boxes, cabinets, outlets and terminal fittings.
9. Installation of electrical equipment a) Section 26	1. Identify rules pertaining to storage batteries. 2. Explain and describe the general rules for receptacles in residential occupancies. 3. Explain and describe the rules for electric water heating and cooking appliances excluding surface and space heating.
10. Lighting equipment (excluding electric discharge lighting) a) Section 30	1. Explain and describe the maximum circuit voltages for lighting systems, their protection, location and installation techniques. 2. Explain and describe the wiring techniques involved with lighting equipment including the grounding of the same.

B. Plans and Diagrams ..... 8 Hours

1. Identify the symbols and abbreviations nomenclature used in a typical electrical drawing.
2. Interpret terms used in electrical drawings.
3. State the drawings used to make up a set of architectural drawings and the reason for same.
4. Read and interpret electrical schematic drawings with an explanation of sequence of a simple operation.

		5. Distinguish between a block diagram and a wiring diagram.
		6. Interpret a pictorial diagram of an overhead and underground service for a single dwelling.
		7. Interpret plan of a simple residential electrical installation showing layout and complete a material take-off.

SECTION THREE: ..... CONTROLS AND SWITCHING CIRCUITS ..... 28 HOURS

A. Controls and Switching Circuits ..... 28 Hours

1.	Symbols	1. Describe and draw symbols for: a) single and multiple pole switches b) single and multiple throw switches c) multi position switches i) sliding type ii) rotary type d) momentary contact switches e) three way switches f) four way switches
2.	Relays	1. Describe the operating principles of a relay. 2. Identify the parts of a relay.
3.	Diagrams and connections	1. Draw schematic diagrams, wiring diagrams and connect low voltage remote control circuits. 2. Draw schematic diagrams, wiring diagrams and connect the following circuits: a) single bell, buzzer or chime and button circuits b) multiple bell, buzzer or chime and button circuits c) return call circuits 3. Draw schematic diagrams, wiring diagrams and connect the following circuits: a) single pole circuits b) double pole circuits c) three way switching d) four way switching 4. Draw schematic and wiring diagrams and connect relay circuits for NO and NC contacts.

SECTION FOUR: ..... MEASURING INSTRUMENTS ..... 16 HOURS

A. Measuring Instruments ..... 16 Hours

1. Use, care and safety of meters	1. Describe the proper use, care and safety precautions for: a) ammeters b) voltmeters c) ohmmeters d) meggers e) wattmeters f) multi meters
	2. Demonstrate proper range selection and connections of voltmeter, ammeter, ohmmeter and megger.
	3. Demonstrate accurate measurements.
2. External shunts and multipliers	1. Calculate the correct values of resistance to be used as shunts and multipliers for a given meter movement.

SECTION FIVE: ..... RESISTORS, SPLICING, TERMINATIONS, ALARMS AND SAFETY ..... 16 HOURS

A. Resistors ..... 2 Hours

1. Describe the construction of fixed resistors.
2. Explain a method used to identify the ohmic value of a fixed resistor.
3. Interpret colour code values from a table for fixed resistors.
4. Describe the difference between a potentiometer and a rheostat.
5. Demonstrate how to connect a potentiometer as a rheostat.

B. Splicing and Terminations (Splicing Techniques for Low Voltage) ..... 4 Hours

1. Demonstrate the mechanical methods for terminations and splicing conductors.
2. Demonstrate the proper method for insulating splices and terminations.
3. Describe the proper method for splicing and terminating copper/aluminum.

C. Safety ..... 6 Hours

1. Identify and describe the safe use of tools and equipment related to the trade.
2. Identify and describe lock-out procedures.
3. Provide an awareness of OH&S.
4. Describe workplace safety program requirements:
   a) CSTS
   b) OH&S
   c) WHIMS
   d) other identity requirements
5. Describe safety concerns associated with explosive actuated tools.
6. State the safety precautions when Thermit Welding.

D. Residential Alarm Systems and Smoke Alarms..... 4 Hours

1. Basic alarm systems
   1. Identify various types of sensing devices.
   2. Identify various types of alarm devices.
   3. Describe basic user functions of control panels.
   4. Describe the operation of a basic alarm system.
   5. Describe “event sequence” upon activation of an alarm system.
2. Smoke alarms
   1. Explain the basic function of ionization and photoelectric smoke alarms.
   2. Determine proper locations and number of smoke alarms required for an installation.
   3. Describe how smoke alarms are interconnected.

SECOND PERIOD TECHNICAL TRAINING
POWER SYSTEM ELECTRICIAN TRADE
COURSE OUTLINE

TOPIC	OBJECTIVES Upon successful completion of this unit the apprentice will be able to:
SECTION ONE: ..... TRADE MATHEMATICS ..... 26 HOURS	
A. Trade Mathematics ..... 26 Hours	
1. Phasors	1. Solve right angle triangles using trigonometry functions given unknowns. 2. Define the term phasor. 3. Calculate the resultant of two or more phasors using the component method. 4. Solve problems involving phasors with electrical applications.
SECTION TWO: ..... PRINCIPLES OF ELECTRICITY ..... 86 HOURS	
A. Principles of Electricity ..... 74 hours	
1. Alternating current a) sine waves b) phasors	1. Explain, define and calculate instantaneous value. 2. Explain, define and calculate maximum or peak value. 3. Explain and calculate RMS or effective value. 4. Illustrate directions and magnitude of phasors. 5. Define cycle and time period. 6. Define frequency and state its unit of measurement. 7. Describe the relationship between poles, frequency and rotational frequency. 8. Define: a) phase b) lead c) lag d) angles of degrees i) electrical ii) mechanical
2. Inductance and inductive reactance	1. Define inductance and state its symbol. 2. List the factors that effect inductance.

		3. Describe induction and its effects.
		4. Restate Faraday's law.
		5. Restate Lenz's law.
		6. Describe the dc inductive effects.
		7. Define time constant for RL circuit.
		8. Describe ac inductive effects.
		9. State the unit of measurement for inductance and its symbol.
		10. Define inductive reactance and state its symbol.
		11. State the unit of measurement for inductive reactance and its symbol.
		12. State the equation for inductive reactance.
		13. Calculate the total inductance when inductors are connected in series or parallel.
		14. State the phase relationship between voltage and current in an inductive circuit.
3.	Capacitance and capacitive reactance	1. Define capacitance.
		2. Describe the construction and characteristics of an elementary capacitor.
		3. List the factors which affect it.
		4. Describe capacitor types and applications.
		5. Calculate the value of a time constant for an RC circuit.
		6. Explain ac capacitive effects.
		7. State the unit of measurement for the charge of a capacitor and give its symbol.
		8. Define dielectric strength and its unit of measurement.
		9. State the unit measurement for capacitance.
		10. Define capacitive reactance.
		11. Give the symbol for capacitive reactance and state its unit of measurement.
		12. State the equation for capacitive reactance.
		13. State the phase relationship between voltage and current in a capacitive circuit.
		14. Calculate the total capacitance for capacitors in series or parallel.

		15. Calculate the capacitive reactance of any given circuit.
4.	Impedance	1. Define impedance.
		2. State the units of measurement for impedance.
		3. Restate formulae required to calculate impedance.
		4. State the factors that affect impedance.
		5. Use the "impedance triangle" to solve electrical problems.
5.	RLC circuits	1. Explain the phase relationship of a parallel RL circuit by the use of a phasor diagram and verify by circuit connection and measurement.
		2. Explain the phase relationship of a parallel RC circuit by the use of a phasor diagram and verify by circuit connection and measurement.
		3. Explain the phase relationship of a parallel RLC circuit by the use of a phasor diagram and verify by circuit connection and measurement: a) resonance b) power, apparent power and reactive power c) power factor d) power factor correction
		4. Explain the phase relationship of a series RL circuit by the use of a phasor diagram.
		5. Explain the phase relationship of a series RC circuit by the use of a phasor diagram.
		6. Explain the phase relationship of a series RLC circuit by the use of a phasor diagram.
		7. Identify the hazards of a series RLC circuit and verify by circuit connection and measurement.
6.	Power	1. Define power and give its SI symbol.
		2. State the unit of measurement for power and give its abbreviation.
		3. Define "apparent power" and give its SI symbol.
		4. State the unit of measurement for "apparent power" and give its abbreviation.
		5. Define "reactive power" and give its SI symbol.
		6. State the unit of measurement for "reactive power" and give its abbreviation.
7.	Power factor	1. Define "power factor".
		2. Define "phase angle" and give its symbol.
		3. State the relationship between "power factor" and "phase angle".

		4. State why it is desirable to operate electrical systems at a high power factor.
		5. Identify the devices that can be used for power factor correction.
		6. Perform power factor correction calculations and verify by connections and measurements.
		7. Explain why Alberta utilities use 0.9 (90%) as an acceptable power factor.
8.	Single phase circuit calculations	1. Calculate: a) impedance b) current c) voltage d) voltage drops e) apparent power f) reactive power g) true power h) power factor i) power factor correction for motors
		2. Solve problems involving resonance.

B. Transformers ..... 12 Hours

1.	General	1. List the purposes of a transformer.
		2. Describe the basic components of a transformer and the nameplate information.
		3. Define the term primary and secondary of a transformer.
		4. Differentiate between a step-up and a step-down transformer.
		5. Explain the standard terminal and winding identification.
2.	Operating principles	1. Describe transformer action.
		2. Describe the operation of a transformer as load is added.
		3. List the losses that occur in a transformer.
		4. Calculate the efficiency of transformers.
		5. Describe the operation of a class 2 transformers.
3.	Ratings and ratio	1. State how transformers are rated and sized.
		2. Describe and solve problems involving transformer voltage, turns and current ratios.
		3. Explain the reason why transformers are rated in voltage and volt-amperes.

		4. Describe the possible effects of operating a transformer at above its rated voltage.
		5. Differentiate between the high voltage and the low voltage windings of a transformer.
		6. Calculate the rated primary and secondary currents of a transformer from nameplate data.
		7. Select a properly rated transformer for a specified load.
4.	Single phase transformer connection	1. Connect a single phase transformer, single and dual voltages.

SECTION THREE: .....CANADIAN ELECTRICAL CODE PART I.....42 HOURS

A. Canadian Electrical Code Part I ..... 42 Hours

1.	Service and service equipment a) Section 6	1. Be familiar with the rules of Section 6.
2.	Circuit loading and demand factor a) Section 8	1. Single dwellings and apartment calculations: a) determine service conductor sizes b) establish the rating or setting of overcurrent devices and disconnection means for the above c) apply tables for bonding and grounding d) determine feeder and branch circuits e) apply tables for bonding and grounding f) determine feeder and branch circuits g) apply rules from Section 62 to heating loads h) apply tables to arrive at conduit sizes
		2. Determine, given a specific load supplied by conductors connected in parallel, the number of parallel runs, the size of conductor and conduits.
		3. Automobile heater receptacle: a) determine the demand load on both restricted and non-restricted parking lot feeders b) determine the overcurrent device rating or setting for either parking space branch circuit or parking lot feeders c) recognize that these demands are never to be exceeded when added to other types of demands
3.	Grounding and bonding a) Section 10	1. Apply the rules for the conditions for grounding alternating current systems.
		2. Apply the rules for connections of alternating current systems.
		3. Apply the rules for grounding connection for two or more buildings.
		4. State which conductor should be grounded in alternating current systems.
		5. Apply rules dealing with equipment bonding.
		6. Apply rules dealing with methods of grounding.

	7. Apply rules dealing with bonding methods.
	8. Apply the rules dealing with grounding electrodes.
	9. Apply the rules dealing with grounding and bonding conductors and connections.
4. Class 1 and Class 2 circuits a) Section 16	1. Differentiate between Class 1 and 2 circuits.
	2. State the current, voltage and apparent power limitations placed on Class 1 and 2 circuits.
	3. Determine minimum conductor size for an installation.
	4. Determine overcurrent protection for Class 1 circuits and current limitations for Class 2 circuits.
	5. State the special requirements for Class 1 and 2 wiring methods.
5. Hazardous locations a) Section 18	1. Differentiate between Class I, Class II and Class III hazardous locations including their divisions/zones.
	2. State the general rules for hazardous locations.
	3. State the grouping for different types of hazardous locations.
	4. Class I hazardous locations: a) state the equipment installation restrictions in these areas b) select proper wiring methods in these locations c) describe how to make a seal and their physical placement in the system d) determine the types of raceways or cable systems allowed and their fittings
	5. Class II hazardous locations: a) state the equipment installation restrictions in these areas b) select proper wiring methods in these locations c) describe how to make a seal and their physical placement in the system, if necessary d) determine the types of raceways or cable systems allowed and their fittings
	6. Class III hazardous locations: a) state the equipment installation restrictions in these areas b) select proper wiring methods in these locations c) state how to make a seal and their physical placement in the system d) determine the types of raceways or cable systems allowed and their fittings
6. Flammable liquid dispensing and service stations, garages, and bulk storage plants a) Section 20	1. Identify those areas or confines of the above locations as to Class and Zone.
	2. Identify which part of the locations are non-hazardous.
	3. Differentiate between a commercial garage and a residential garage.

	4. Determine the wiring methods in buildings and locations.
	5. Determine the types of equipment allowed in both the hazardous and non-hazardous areas in buildings.
7. Locations in which corrosive liquids or vapours or excessive moisture are likely to be present a) Section 22	1. Differentiate between a Category 1 and Category 2 location and explain when these rules apply.
	2. Select only specially constructed equipment for the two different categories.
	3. Describe the special wiring techniques involved with wiring in these locations.
	4. Describe the special techniques required to prevent problems from draining liquids.
	5. Describe how electrical equipment is installed so as to exclude moisture.
	6. Describe the special corrosion resistant materials that are used in these areas.
8. Patient care areas in hospitals a) Section 24	1. Define the special terminology for utilization in Section 24.
	2. Identify those areas of a hospital where these rules do not apply.
	3. State the types of equipment allowed in patient care locations as well as locations which are used to store these anesthetics, whether flammable or not.
	4. Determine installation techniques and types of equipment, both above and in hazardous locations.
	5. Define an isolated system.
	6. State the special requirements for essential electrical systems within a hospital.
9. Installation of electrical equipment a) Section 26	1. Determine the overcurrent protection for capacitors.
	2. Determine conductor sizes for various capacitor loads.
	3. Recognize the need for discharge circuits and how these circuits may be incorporated.
	4. Determine the location and rating of capacitor circuit disconnecting means.
10. Installation of lighting equipment a) Section 30	1. State the overcurrent limitations on electric-discharge lighting branch circuits.
	2. State the maximum voltage ratings of discharge lighting in dwelling units.
	3. Determine the type of control required for discharge lighting.
	4. Describe the wiring techniques associated with ballasts (lighting transformers).

	5. State the marking procedures for high voltage luminaries.
	6. State the special wiring techniques for ballasts.
11. Emergency systems and unit equipment a) Section 46	1. Describe the characteristics of supplies for emergency systems.
	2. List the types of controls for emergency systems.
	3. State the requirement for overcurrent protection.
	4. State the requirements for audible and visible trouble-signals.
	5. State the requirements for unit equipment supply connections.
	6. State the requirements for remote lamps.
	7. State the requirements for exit signs.
12. Plans and diagrams	1. Complete calculations for an apartment, including service and grounding detail.
	2. Detail an appropriate splitter with detail of 3 suites and a part of the house load.

SECTION FOUR: .....PLANS AND DIAGRAMS.....16 HOURS

A. Plans and Diagrams (Blueprints and Specifications on an Industrial Building) ..... 16 Hours

1. Typical presentation of: a) site b) structural c) architectural d) elevation plans e) mechanical f) electrical	1. Read and interpret a set of building drawings for the design of a structure. 2. Review a complete set of drawings for: a) site b) structural c) architectural d) elevation plans e) mechanical f) electrical g) piping h) instrument
2. Trade work	1. Study blueprints and determine the Electrician's work. 2. Determine and note accommodation required for other trades that follow. 3. Study sets of drawings which include plans, elevation(s) in order to assess: a) equipment location b) mechanical equipment c) layout of duct system d) layout of piping system and accessories
3. Schematic diagrams	1. Interpret schematic diagrams. 2. Explain sequence of electrical operation.

4. Electrical drawings	1. Interpret the terms used in electrical drawings.
	2. Read and interpret electrical drawings with one line diagrams.
	3. Identify symbols.
	4. State the purpose of specifications.
5. Views	1. Locate information contained within details and sections.

SECTION FIVE: ..... HEATING AND COOLING CONTROLS .....36 HOURS

A. Heating and Cooling Controls..... 36 Hours

1. Principles of automatic heating and cooling controls	1. Describe the principles of automatic heating and cooling controls.
	2. List the basic requirements of heating and cooling systems.
	3. List the components of a basic forced air heating system.
	4. Explain the function of each of the components of a basic forced air heating system.
	5. Differentiate between types of flame proving devices used in heating systems.
	6. Identify the various codes and applications.
2. Temperature control devices	1. Explain the function of various temperature control devices.
	2. Identify the operating principles of various temperature sensing devices.
	3. Differentiate between three different types of contacts used in thermostats.
	4. Explain the function and operation of an anticipator.
	5. Differentiate between the operation of heating thermostats and cooling thermostats and combined heating/cooling thermostats.
	6. Explain the purpose of and circuit requirements for programmable and special application thermostats.
	7. List four considerations regarding the installation of thermostats.
	8. Describe the purpose and operation of a high limit control.
	9. Describe the purpose and operation of a fan control.
	10. Describe the purpose and application of specialty devices such as Thermistors, RTDs and Pyrometers.
3. Gas fired systems	1. Describe the operation of basic gas fired heating systems.
	2. Explain the purpose and application of safety pilot devices.

		3. Differentiate between solenoid and diaphragm safety valves.
		4. Explain the purpose and application of a combination gas control.
		5. Describe the operation of 120 V heating systems c/w step-open gas valves.
4.	Gas fired heating systems operation	1. Observe and analyze the operation of a Basic Gas Fired Heating System.
		2. Describe the operation of a gas fired forced air heating system.
		3. Select the high limit control settings for proper operation of a heating system.
		4. Select the fan switch control settings for proper operation of a heating system.
		5. Explain the operation of a gas fired heating system using schematic and wiring diagrams.
		6. Describe the purpose and application of a thermocouple.
		7. Explain the purpose, application and circuit considerations for auxiliary equipment such as humidifiers, electronic air filters and sail switches.
		8. Explain the purpose and application of interlocks.
		9. Connect and observe the operation of a heating system.
		10. Perform tests on thermocouples including open circuit, closed circuit and response time.
5.	Mid-efficiency systems	1. Observe and analyze the operation of a mid-efficiency gas fired heating system.
		2. Explain the purpose and application of a flame rod flame proving device.
		3. Explain the application of solid state, hot surface and direct spark ignition systems.
		4. Explain the operation of a mid-efficiency gas fired heating system using schematic and wiring diagrams.
		5. Connect and observe the operation of a mid-efficiency heating system.
		6. Connect and observe the operation of a direct spark ignition system.
6.	Hot water systems	1. Observe and analyze the operation of a hot water heating system.
		2. Explain the operation of a multi-zone hot water system.
		3. Determine transformer loading requirements.
		4. Describe the purpose and application of safety and control devices used with hot water heating systems.
		5. Observe and analyze a multi-zone hot water system.

		6. Describe the operation of a basic boiler control.
7.	Cooling systems	1. Observe and analyze the operation of a cooling system.
		2. Describe the purpose and application of the four main components in a refrigeration system.
		3. Explain the basic refrigeration cycle.
		4. Observe and analyze a cooling system using schematic and wiring diagrams.
		5. Explain the purpose and application of auxiliary devices.
		6. Observe and analyze the operation of a combined heating/cooling system.
8.	Heating ventilation and air conditioning	1. Observe and analyze the operation of a heating ventilation and air conditioning system.
		2. Explain the operation of a roof top HVAC unit.
		3. Describe the purpose and application of makeup air units.
		4. Differentiate between 2-wire, 3-wire, 5-wire and 7-wire thermostats for heating/cooling systems.
		5. Observe and analyze the operation of a rooftop HVAC unit.
		6. Explain a block diagram of a roof-top HVAC unit.
		7. Define terminology used with basic HVAC systems such as closed loop, open loop, feedback, etc.
		8. List the consideration for combining a basic cooling system with a forced air heating system.
		9. Describe the purpose and application of heat pumps.

SECTION SIX: ..... MAGNETIC CONTROL AND SWITCHING CIRCUITS .....34 HOURS

A. Control and Switching Circuits (Magnetic) ..... 34 Hours

1.	Manual motor controllers	1. Describe the components of a manual controller.
		2. Explain the operation of the overload device in a manual controller.
2.	Relays	1. Explain the operation of relays, including: a) construction b) operation and connection c) nameplate data d) types i) single contact ii) multi contact

iii) enclosed and open contact
iv) plug in bases
v) latching mechanical reset
vi) latching electrical reset

3. Magnetic motor controller

1. List the components required for a magnetic motor controller.
2. Explain the operation of each component of a magnetic motor controller.
3. Identify the metals used in the construction of pole contacts.
4. Describe the difference between a contactor and a motor controller.
5. Describe general maintenance procedures for, and common failures of, magnetic controller.

4. Overload devices

1. Explain the purpose of the two components of an overload.
2. Describe the difference in construction and operation between:
   a) melting alloy
   b) bimetal strip
   c) magnetic
   d) electronic
3. State the information necessary for proper selection of overloads.
4. Explain the operation of an overload device.

5. Pilot circuit devices

1. Recognize and explain the use of the following devices and their symbols:
   a) momentary contact
   b) maintained contact
   c) push button start-stop station
   d) float switches
      i) mechanical
      ii) bulb
   e) pressure switches
   f) limit switches
      i) mechanical
      ii) proximity

6. Circuits and connections

1. Troubleshoot and demonstrate control circuits containing:
   a) forward-reverse-stop stations
   b) electrical interlocking
   c) mechanical interlocking
   d) push button interlocking
   e) control transformers
2. Develop schematic and wiring diagrams.
3. Interpret shop drawings and circuit diagrams.
4. Differentiate between low voltage release and low voltage protection.

THIRD PERIOD TECHNICAL TRAINING
POWER SYSTEM ELECTRICIAN TRADE
COURSE OUTLINE

TOPIC	OBJECTIVES Upon successful completion of this unit the apprentice will be able to:
SECTION ONE: ..... ELECTRONICS THEORY ..... 46 HOURS	
A. Electronics Review ..... 4 Hours	
1. Voltage	1. Identify and calculate basic voltage conversions, waveforms, notations for: a) instantaneous values of a sine wave b) ac and dc combined waveforms c) frequency of periodic waveforms d) double subscript notation e) SI prefixes f) RC time constant
2. Resistance	1. Review the characteristics of placing resistors in series and parallel.
3. Inductance	1. Review the characteristics of placing inductance in series and parallel.
4. Capacitance	1. Review the characteristics of placing capacitance in series and parallel.
B. PN Junction (Diode) ..... 2 Hours	
1. Specifications	1. Reproduce the symbol for a diode. 2. State the ratings for a diode. 3. Identify the diode terminal identification and ratings from a specification sheet. 4. Testing procedures for a diode using testing instruments.
C. Rectifiers ..... 6 Hours	
1. Types	1. Describe common types of half and full wave rectifier circuits: a) single phase b) three phase c) six phase 2. State the diode ratings associated with each rectifier.
2. Waveforms	1. Draw the waveform associated with each rectifier. 2. Calculate the average dc value of voltage for each rectifier.
3. Heat dissipation	1. Describe the methods and materials used for heat sinking and isolating diodes in rectifier circuits.

D.	**Filters**		**2 Hours**
1.	Components	1.	State the need for filters on rectifier circuits.
		2.	State the components used in filtering circuits.
2.	Waveform	1.	Draw the output waveform for a capacitor filter circuit.
3.	Loading and ripple factor	1.	Define ripple factor.
		2.	Calculate the ripple factor for a filtered output.
		3.	Calculate the voltage regulation of a filtered output.
E.	**Voltage Regulators**		**2 Hours**
1.	Zener diode	1.	Describe the electrical characteristics of a zener diode.
		2.	Draw a circuit for a zener diode used as a voltage regulator and examine the waveforms.
2.	IC regulator	1.	Define an IC voltage regulator.
		2.	Identify the IC voltage regulator ratings and terminals from a specification sheet.
		3.	Draw an IC voltage regulator circuit to regulate the output voltage.
F.	**Transistors**		**4 Hours**
1.	Theory	1.	Explain the basic operation of a transistor.
		2.	State the transistor rating from a specification sheet.
2.	Applications	1.	State the common applications of transistor circuits.
G.	**Operational Amplifiers (Op-Amp)**		**4 Hours**
1.	Theory	1.	Define an operational amplifier.
		2.	Define open loop and closed loop operational amplifier circuits.
		3.	Explain the meaning of op-amp specification and their importance in applications.
H.	**Silicon Controlled Rectifier (SCR)**		**4 Hours**
1.	Basic theory	1.	Explain the operation of an SCR.
		2.	State the ratings for an SCR.

2.	Circuit analysis	1.	Analyze the operation of a SCR in a circuit, including the firing control.
3.	Application	1.	Describe common applications for SCR's and any special utility applications.

I. Triac ..... 2 Hours

1.	Basic theory	1.	Explain the operation of the triac.
		2.	State the ratings of a triac.
2.	Circuit analysis	1.	Analyze the operation of a triac in a circuit.
3.	Application	1.	Describe common applications for triacs.

J. Photoelectric Devices ..... 4 Hours

1.	Photo devices	1.	Explain the operation of the following photo sensitive devices: a) thermistors b) photoconductive cells c) solar cells d) photo diodes e) light emitting diodes f) phototransistor g) optoisolators h) light activated SCR
2.	Applications	1.	Identify the circuit connections for the above mentioned photo sensitive devices.
		2.	List the common applications of the above mentioned photo sensitive devices.

K. Logic ..... 4 Hours

1.	Introduction to digital	1.	Compare digital to analog devices and signals.
2.	Number systems	1.	Describe the common underlying principles of different number systems.
		2.	Describe binary, octal, hexadecimal and BCD number systems.
		3.	Convert from one number system to another.
3.	Logic gates	1.	Explain the purpose of logic gates.
		2.	Show the truth tables for the common logic gates (AND, OR, NOT, NAND and NOR).
		3.	State the Boolean logic equation for the above logic gates.
		4.	Convert AND-OR logic into circuits using only NAND or NOR gates.

4. Memory	1.	Describe various types of read-only memories and their applications.
	2.	Describe various types of read-write memories and their applications.
	3.	Discuss the differences of static and dynamic read-write memory devices.

L. Microprocessors ..... 3 Hours

1. Components	1.	Describe the purpose of the microprocessing unit.
	2.	Sketch a block diagram of a basic microprocessor system.
	3.	Explain the function of the various blocks of a microprocessor system.

M. Programmable Logic Controller (PLC) ..... 5 Hours

1. Components	1.	Describe the overall function of a programmable logic controller (PLC).
	2.	Illustrate in block diagram form the major sections of a PLC.
	3.	Describe the CPU unit of a PLC.
	4.	Explain how the CPU communicates with other circuits in the PLC.
	5.	Describe the types of I/O modules available.
	6.	Explain how the I/O modules work.
	7.	Describe a data highway.
	8.	Differentiate between ladder logic, Boolean and function block.
2. Programming	1.	Describe the user keyboard interface.
	2.	Describe how a typical PLC is programmed.

SECTION TWO: ..... ELECTRONICS LAB ..... 57 HOURS

A. Lab Equipment and Components ..... 8 Hours

1. Components	1.	Define passive and active components used in electronic integrated circuits.
	2.	State the different construction types and ratings of resistors, inductors, capacitors used in electronic integrated circuits.
	3.	Describe the soldering techniques for mounting and removing components from IC printed circuit boards.

2. Lab equipment	1. Demonstrate proper use of instruments: a) multimeters (digital and analog) b) signal generator c) electronic power supplies d) oscilloscope e) hazards in connecting instruments to energized circuits

B. Diodes ..... 2 Hours

1. Verify diode ratings and terminal identification using a specification sheet.
2. Test the diode condition using measuring instruments.

C. Rectifiers ..... 5 Hours

1. Construct single and three phase rectifiers.
2. Measure single and three phase rectifier waveforms.
3. Measure single and three phase rectifier average dc voltage values.

D. Filters ..... 2 Hours

1. Construct a filter circuit.
2. Measure the ripple voltage from a rectified filtered output.
3. Calculate the ripple factor of the filter.
4. Calculate the voltage regulation of the loaded filter circuit.

E. Zener Diodes ..... 2 Hours

1. Verify zener diode ratings and terminal identification using a specification sheet.
2. Measure the voltages in a zener diode circuit.
3. Measure the regulated output voltage in a zener diode circuit.

F. Transistors ..... 4 Hours

1. Verify transistor ratings and terminal identification using a specification sheet.
2. Test the condition of the transistor using measuring instruments.
3. Measure the biasing voltages of an amplifier.

4. Measure the input/output voltages and calculate the voltage gain.

G. Op-Amps ..... 4 Hours

1. Measure the input/output voltages and calculate the gain of an op-amp circuit.

H. Silicon Controlled Rectifier (SCR) ..... 5 Hours

1. Verify SCR ratings and terminal identification using a specification sheet.
2. Test the condition of the SCR using measuring instruments.
3. Analyze the operation of an SCR circuit and control circuit.

I. Triac ..... 4 Hours

1. Verify triac ratings and terminal identification using a specification sheet.
2. Analyze the operation of a Triac and control circuit.

J. Photoelectric Devices ..... 3 Hours

1. Verify the ratings and terminal identification using a specification sheet for different types of photoelectric devices.
2. Analyze the operation of various photoelectric circuits.

K. Logic Gates ..... 3 Hours

1. Verify the ratings and terminal identification using a specification sheet for AND, OR, NOT, NAND and NOR logic gates.
2. Observe an analyze the above logic gates to verify the truth table and Boolean expression.

L. Programmable Logic Controllers (PLC) ..... 15 Hours

1. Demonstrate an ability to program simple ladder logic circuits.

SECTION THREE: ..... SUBSTATION THEORY ..... 66 HOURS

A. Instrument Transformers ..... 7 Hours

1.	Potential transformers	1. Identify/describe types of potential transformers: a) PT b) CVT 2. Identify/describe ratings of potential transformers. 3. Explain/describe polarities of potential transformers. 4. Explain/describe accuracy of potential transformers: a) phase angle b) ratio 5. Explain/describe testing procedures: a) ratio b) polarity c) insulation 6. Explain/describe connections. 7. Identify/describe purpose of potential transformers: a) metering b) relaying c) paralleling current transformers
2.	Current transformers	1. Identify/describe types of current transformers. 2. Identify/describe ratings of current transformers. 3. Explain/describe polarities of current transformers. 4. Explain/describe accuracy of current transformers: a) phase angle b) ratio 5. Explain/describe testing procedures: a) ratio b) saturation c) polarity d) burden 6. Explain/describe connections. 7. Identify/describe purpose of current transformers: a) metering b) relaying c) paralleling current transformers 8. Explain/describe metering tanks. 9. Explain/describe test blocks.

		10. Explain precautions of paralleling CT's for totalizing of two or more different feeders.
B.	**Power Circuit Breakers ..... 8 Hours**	
1.	Characteristics	1. Explain/describe the physical characteristics of power circuit breakers. 2. Compare/explain electrical and operating characteristics: a) trip free b) anti pump
2.	Types	1. Identify/describe common types of power circuit breakers: a) bulk oil b) minimum oil c) di-ion air d) air blast e) gas f) vacuum g) circuit switcher 2. Explain/describe the advantages and disadvantages for each type of circuit breaker. 3. Describe switch gear enclosures: a) metal clad switch gear b) Gas Insulated Systems (GIS)
3.	Applications	1. Identify common applications for each type of circuit breaker. 2. Explain/describe a typical control schematic associated with circuit breakers.
C.	**Power Systems ..... 2 Hours**	
1.	Components	1. Identify/describe common types and functions of power systems: a) generation i) conventional ii) co-gen b) transmission i) Alberta Integrated System (AIS) c) distribution i) overhead ii) underground residential iii) network
D.	**Bus Configurations ..... 3 Hours**	
1.	Single bus switching system	1. Explain/describe the single bus switching system.
2.	Transfer bus switching system	1. Explain/describe the transfer bus switching system.

3.	Double bus switching system	1. Explain/describe the double bus switching system.
4.	Ring bus switching system	1. Explain/describe the ring bus switching system.
5.	Breaker and one-half	1. Explain/describe breaker and one-half.
6.	Breaker and one-third	1. Explain/describe breaker and one-third.

E. Switching Equipment ..... 3 Hours

1.	High voltage switches	1. Identify the types of high voltage switches. 2. Describe the ratings of various types of interrupters. 3. Describe the methods used for arc interruption. 4. Explain the operation of a motor controlled switch.
2.	Air switches	1. Identify/describe air switches. 2. Identify/describe applications of air switches.
3.	Fused switches	1. Identify/describe fused switches. 2. Identify/describe applications of fused switches.
4.	Bypass switches	1. Identify/describe bypass switches. 2. Identify/describe applications of bypass switches.
5.	Disconnect switches	1. Identify/describe disconnect switches. 2. Identify/describe applications of disconnect switches.

F. System Fault Current ..... 13 Hours

1.	Fault current	1. Identify/describe fault current: a) sources b) symmetrical c) asymmetrical d) dc component e) X/R ratio f) mechanical and thermal stress
2.	System faults	1. Calculate secondary voltages on various 3 phase transformer connections when primary fuse failure occurs: a) explain single phasing b) explain open delta and loss of power 2. Calculate wye connected PT secondary voltages on grounded and ungrounded systems.

3.	Reactance	1.	Define the following: a) sub transient reactance b) transient reactance c) synchronous reactance
4.	Per unit	1.	Explain the per unit method used in short circuit calculations by: a) preparing a one-line diagram b) selecting a base kVA c) obtaining proper reactance values d) converting the one-line diagram into a reactance diagram based on per unit values e) determine the short circuit kVA at specified points in the system f) determine the short circuit current at specified points in the system g) determine the per-unit fault current of line-line-line, line-line and line to ground faults
5.	Delta-wye transformation	1.	Simplify circuits using delta-wye and wye-delta transformations.
6.	Applications	1.	Identify/describe applications for: a) breaker ratings (thermal capacity I^2t) b) bus rating c) relay setting d) fuse size
7.	Symmetrical components	1.	Define the positive, negative and zero sequence components.
		2.	Calculate the positive, negative and zero sequence components for balanced and unbalanced conditions.
		3.	Calculate fault currents using symmetrical impedances.
		4.	Calculate relay settings for current unbalance using I_1 and I_2.

G. Relaying ..... 2 Hours

1.	Construction	1.	Explain/describe construction features.
2.	Designations	1.	Define IEEE device numbers for relay designations.
3.	Types	1.	Identify/describe relaying types.
4.	Classification	1.	Identify/describe relaying classifications.

H. Relaying Systems ..... 4 Hours

1.	Primary and back up protection	1.	Explain/describe function and operation of primary and back up protection relay systems.
		2.	Identify/describe zones of protection.
2.	Circuits	1.	Explain/describe single line circuits.
		2.	Explain/describe ac elementary circuits.

3.	Communication aided protection	1. Identify/describe common channel types: a) pilot wire i) opposed voltage principle ii) circulating current principle b) fibre optic c) microwave 2. Identify/describe common schemes.

I. Overcurrent Protection ..... 7 Hours

1.	Types	1. Identify/describe phase, ground and instantaneous protection.
2.	Curves	1. Explain/describe overcurrent characteristic curves.
3.	Connection	1. Explain/describe overcurrent protection connection in a circuit.
4.	Coordination	1. Coordinate relays on a radial system using CT's, relay curves and time dial settings.
5.	Clearing times	1. Explain/describe clearing times for overcurrent protection.
6.	Feeder protection	1. Using a microprocessor based relay and computer: a) apply/explain the following settings on the microprocessor relay - instantaneous, phase and ground overcurrent protection - automatic reclosure - sequence coordination - breaker interrupting duty 2. Interpret relay man-machine interface. 3. Interpret relay current and demand values. 4. Interpret relay fault reports. 5. Interpret the disturbance data.

J. Directional Relays ..... 7 Hours

1.	Theory	1. Explain/describe the theory of operation of directional relays.
2.	Power	1. Explain/describe the application and selection of actuating quantities for power directional relays.
3.	Overcurrent	1. Explain/describe the application and selection of actuating quantities for current directional relays.

K. Differential Protection ..... 5 Hours

1.	Theory	1. Identify/describe the theory of differential protection.

2.	Transformer	1.	Identify/describe common applications of transformer differential protection.
3.	Application	1.	Select correct CT connections on wye-delta transformer primary and secondary.
		2.	Select correct relay taps.
		3.	Define % mismatch.
4.	Generator	1.	Identify/describe common applications of generator differential protection.
5.	Bus	1.	Identify/describe common applications of bus differential protection.

L. Impedance Relay ..... 2 Hours

1.	Theory	1.	Explain/describe the theory of operation of an impedance relay.
		2.	Explain distance relay characteristics on the R-X diagram.

M. Synchronism Check Relay ..... 1 Hour

1.	Theory	1.	Explain the purpose and connection of synchronism check relays.

N. Frequency Relay ..... 1 Hour

1.	Theory	1.	Explain/describe the theory of operation of a frequency relay.
2.	Applications	1.	Identify/describe application of frequency relays.

O. Network Relays ..... 1 Hour

1.	Theory	1.	Explain/describe the theory of operation of a network relay.

SECTION FOUR: ..... SUBSTATION LAB ..... 57 HOURS

A. Instrument Transformer Testing ..... 6 Hours

1. Perform tests on a CT:
   a) saturation
   b) polarity
   c) ratio
   d) insulation

2. Perform test on a PT/CVT:
   a) ratio
   b) polarity
   c) insulation

B. System Faults ..... 7 Hours

1. Simulate fuse failures on the primary side of three phase transformer banks (wye, grounded wye, delta) and then analyze the secondary voltages.

2. Simulate the per-unit fault current of a line-line-line, line-line and line to ground faults.

3. Determine the secondary potential transformer voltages that will exist in a grounded and ungrounded system using PT's.

C. Overcurrent Relay ..... 16 Hours

1. Describe the steps in testing an overcurrent relay.

2. Review the test equipment controls and functions.

3. Describe the operation and parts of electro-mechanical overcurrent relays.

4. Test electro-mechanical relays.

5. Test electronic overcurrent relays.

6. Compare the differences and accuracy of electro-mechanical and electronic relays.

7. Coordinate overcurrent relays.

D. Directional Relays ..... 7 Hours

1. Test a mechanical overcurrent directional relay and adjust to the manufacturer's specifications.

2. Test an electronic overcurrent directional relay and examine the sensitivity of the relay.

3. Explain the differences in the applications and connections for phase directional, ground directional and power directional relays.

4. Connect the various relays for the various applications.

E. Symmetrical Components ..... 3 Hours

1. Determine the positive, negative and zero sequence voltages in a "floating" neutral circuit using the system neutral as a reference.
2. Determine positive and negative sequence currents in an unbalanced three phase load.
3. Draw phasors of the sequence components to show that their sum is equal to the measured currents.
4. Calculate the % unbalance of currents using I_1 and I_2.

F. Differential Relays ..... 4 Hours

1. Explain the difference between transformer and generator differential relays.
2. Perform a pick-up, through fault and slope test on differential relays.
3. Interpret manufacturers curves for various % slope differential relays.

G. Connecting Power Circuit Breaker ..... 4 Hours

1. Explain a schematic diagram.
2. Connect complete relay system (simulate fault and operate).
3. Demonstrate the principles and purposes of auto reclosing.
4. Set an auto recloser to perform various reclosing sequences and observe breaker operation.

H. Demonstrate Fault Simulators ..... 3 Hours

1. Observe a simulated supply network, and compare calculated values of short circuit fault MVA to measured values.
2. Observe faults on a radial system using computer software.

I. Micro-Processor Based Digital Protection ..... 6 Hours

1. Set the following protection on the micro-processor relay using a keypad interface:
   a) instantaneous, phase and ground overcurrent protection
   b) automatic reclosure
   c) sequence coordination
   d) breaker interrupting duty
2. View current and demand values on a relay keypad interface.

3. Set the following protection on the computer and down load them to the relay:
   a) instantaneous, phase and ground overcurrent protection
   b) automatic reclosure
   c) sequence coordination
   d) breaker interrupting duty

4. View relay current and demand values on the computer.

5. Connect the micro-processor based relay to a simulated circuit and observe operation of the relay, breaker and reclosure under various fault conditions.

6. Request fault reports from the computer terminal.

7. Save the disturbance data to a file.

8. Plot the relay demand data, breaker interrupting duty (I^2t) and disturbance data using the relay software and computer printer.

J. Proper Testing Techniques ..... 1 Hour

1. Discuss benefits of scheduled inspection and test programs.

2. Explain general maintenance requirements.

SECTION FIVE: ..... THREE PHASE .....43 HOURS

A. Three Phase Circuits..... 22 Hours

1. Introduction
   1. Explain the advantages of three phase power.
   2. Explain the generation of three phase power.

2. Three phase phasors
   1. Explain double subscript notation used on phasor drawings.
   2. Explain phase rotation.
   3. Explain phase sequence.

3. Wye connected circuits
   1. Describe the voltage and current relationships for balanced and unbalanced circuits.
   2. Draw a phasor diagram for balanced and unbalanced circuits.
   3. Calculate the neutral current for unbalanced circuits.
   4. Calculate the power factor for balanced and unbalanced circuits.
   5. Calculate the true power consumed for balanced and unbalanced circuits.
   6. Calculate the reactive power consumed for balanced and unbalanced

		circuits.
		7. Calculate the apparent power consumed for balanced and unbalanced circuits.
		8. Draw a power triangle for balanced and unbalanced circuits.
		9. Perform power factor correction calculations.
4.	Delta connected circuits	1. Describe the voltage and current relationships for balanced and unbalanced circuits.
		2. Draw a phasor diagram for balanced and unbalanced circuits.
		3. Calculate the power factor for balanced and unbalanced circuits.
		4. Calculate the true power consumed for balanced and unbalanced circuits.
		5. Calculate the reactive power consumed for balanced and unbalanced circuits.
		6. Calculate the apparent power consumed for balanced and unbalanced circuits.
		7. Draw a power triangle for balanced and unbalanced circuits.
		8. Perform power factor correction calculations.
5.	Delta-Wye transformation	1. Perform Delta-Wye/Wye Delta transformation calculations.

B. Three Phase Power Measurement ..... 5 Hours

1.	Three wattmeter	1. Explain power measurement using three wattmeters for balanced and unbalanced circuits.
		2. Draw phasor diagram indicating the electrical quantities applied to each wattmeter for balanced and unbalanced circuits.
2.	Blondel's theorem	1. Describe Blondel's theorem.
3.	Two wattmeter	1. Explain power measurement using two wattmeters.
		2. Draw phasor diagrams indicating the electrical quantities applied to each wattmeter for balanced and unbalanced circuits.

C. Three Phase Lab..... 16 Hours

1.	Three phase circuits	1. Measure voltage, current and phase angle in balanced and unbalanced three phase four-wire circuit.
		2. Measure neutral current for a three phase four-wire circuit.
		3. Measure voltage, current and phase angle in balanced and unbalanced three phase three-wire circuits.

		4. Verify phase reversal on a three phase motor.
		5. Operate phase sequence indicator.
2.	Three phase power measurement	1. Connect wattmeters to measure power in a three phase four wire balanced and unbalanced circuits.
		2. Connect wattmeters to measure power in a three phase, three wire balanced and unbalanced circuits.
3.	Three phase power factor correction	1. Correct power factor in three phase circuits using wye and delta connected capacitor banks.

SECTION SIX: ..... TRADE MATHEMATICS ..... 4 HOURS

A. Analytical Geometry ..... 2 Hours

1.	Rectangular form	1. Locate a point in the correct quadrant when given its rectangular co-ordinates.
2.	Polar form	1. Locate a point in the correct quadrant when given its polar co-ordinates.
		2. Convert from polar to rectangular form and vice-versa.

B. j-Notation ..... 2 Hours

		1. Explain the meaning of the j-operator.
		2. Properly locate a phasor on the horizontal or vertical axes following repeated multiplication by the j-operator in both clockwise and counterclockwise directions.
		3. Solve electrical phasor problems with the j-operator.

SECTION SEVEN: ..... ELECTRICAL CODE AND SAFETY ..... 27 HOURS

A. Trade Regulations and Record Book ..... 2 Hours

1.	Trade Regulations	1. State the terms of apprenticeship for an apprentice entering the Power System Electrician trade.
		2. Describe the advancement criteria for an apprentice entering the trade.
2.	Record book	1. Explain/describe the purpose of the apprentice record book for: a) apprentice's role b) employer's role c) competency task check-off requirements d) updating procedures

B. Electrical and Communication Utility Code (ECUC) ..... 9 Hours

1. Section 0 Definitions	1. Locate and use the definitions to interpret the ECUC.
2. Section 2 General Rules	1. Locate and interpret the rules in Section 2.
3. Section 4 Safety Rules	1. Describe procedures to obtain authorization to perform operations or work. 2. Locate and describe, rules in Section 4 applicable to work on electric utility lines. 3. Identify isolation points on site. 4. State the safe limits of approach for equipment working near lines. 5. State the safe limits of approach distances and explain how it applies to the work of the Power System Electrician. 6. Explain the difference between various limits of approach. 7. Give a typical work situation and be able to identify applicable ECUC rules.

C. Safety..... 9 Hours

1. Protective equipment: care, maintenance and testing gloves, sleeves, live line tools and live line cover-up a rubber gloves b) rubber sleeves c) cover-up d) hot sticks and accessories	1. Describe the proper care, maintenance and storage of protective rubber gloves, sleeves, live line tools and live line cover-up. 2. Illustrate the daily inspection of protective rubber gloves, live line cover-up and live line tools. 3. Describe the visual and di-electric testing of protective rubber gloves, sleeves, live line tools and cover-up. 4. List the applications of commonly used hot sticks and accessories.
4. Rigging a) safety i) critical angle of slings ii) load limits iii) shock loading	1. Describe the effect that sling angles have on safe lifting. 2. Identify the load limits of commonly used wire rope slings and synthetic slings. 3. Describe the causes and effects of shock loading on rigging. 4. Identify OHS regulations regarding rigging safety factors.

D. Protective Working Grounds..... 7 Hours

TOPIC	OBJECTIVES
1. Reasons for use	1. List the hazards that personal protective grounds guard against.
2. Requirements	1. List the electrical and mechanical requirements of a personal protective ground.
	2. Describe the principle of equi-potential grounding.
	3. Understand the requirements of equi-potential grounding.
3. Procedures	1. Outline the procedure of installing and removing personal protective grounds.
	2. Outline the procedure for installing and removing equi-potential grounds.
4. Locations	1. Explain the required locations of personal protective grounds according to ECUC.
	2. Explain the required locations of personal protective grounds when using the equi-potential ground methods.

FOURTH PERIOD TECHNICAL TRAINING
POWER SYSTEM ELECTRICIAN TRADE
COURSE OUTLINE

TOPIC	OBJECTIVES Upon successful completion of this unit the apprentice will be able to:
SECTION ONE: .....MACHINES THEORY.....30 HOURS	
A. Single Phase Transformers ..... 6 Hours	
1. Review of single phase transformers	1. Review of single phase transformers.
2. Voltage regulation	1. Describe transformer voltage regulations. 2. Explain how manufacture design can effect voltage regulation.
3. Ratings	1. Define %IZ. 2. Explain the purpose of %IZ on the nameplate.
4. Tap changers	1. Explain the function and operation of transformer tap changers. 2. Describe how to set a tap changer to increase and decrease secondary voltage levels. 3. Describe the steps required to safely change the tap changer position on a transformer.
5. Cooling	1. Describe the various methods of cooling for distribution transformers and the liquids used. 2. State the standard type designations for air and liquid filled transformers.
6. Types	1. State the kVA and voltage range for the following transformers: a) distribution b) transmission c) network
7. Backfeed	1. Explain the possible hazards of backfeed from: a) paralleled secondary lines b) standby generators
8. Oil testing	1. Describe how to take an oil sample and how it is tested. 2. Explain how impurities in oil affect its di-electric strength. 3. Describe the hazards of PCB's as related to transformer oil.
9. Polarities	1. Differentiate between subtractive and additive internal and external polarity. 2. Explain why it is necessary to know the polarity of the windings and transformer.

		3. Describe how the polarity of a transformer can be determined.
10.	Paralleling	1. List the conditions to be met before operating two transformers in parallel.
		2. Explain how two transformers share the total connected load.

B. Auto Transformers ..... 2 Hours

1.	Theory	1. Explain the theory of operation of an auto transformer.

C. Three Phase Transformers ..... 6 Hours

1.	Voltage, current and power relationships	1. Explain voltage, current and power relationships in all three phase transformer connections.
		2. Determine the expected voltages, current with the use of a phasor diagram.
		3. Determine the rated phase and line current of a three phase bank.
2.	Ratings	1. Describe the common transformer ratings.
		2. Explain the ratio of transformation.
		3. Calculate the turns ratio.
		4. Explain the purpose of nameplate data.
3.	Connections a) wye - wye b) delta - delta c) delta - wye d) wye - delta e) open delta - open delta f) open wye - open delta g) delta - four wire delta	1. Determine rated and load values for line and phase currents for any transformer connection.
		2. Determine rated voltage for line and phase of any transformer connection.
		3. Define angular displacement.
		4. Determine the angular displacement for any transformer bank.
		5. Design a transformer connection to have a certain angular displacement.
4.	Parallel operation	1. Explain the operation and connection of two three-phase transformers in parallel.

D. Three Phase Motors ..... 6 Hours

1.	Construction	1. List the main types of three phase motors.

		2. State the functions of the principle parts of the squirrel cage induction motor, including: a) stator windings b) rotor c) end bells and bearings d) frame
2.	Operation	1. Explain the principle of operation of an induction three phase motor.
		2. Explain how a rotating magnetic field is obtained.
		3. Explain speed regulation and machine efficiency.
		4. Describe the effects of motor over and under voltage.
3.	Starters	1. Describe the effect of full voltage starting on circuits, load and motor.
		2. Explain reasons for some common motor starters.
		3. Describe methods for reversing three phase motors.

E. Single Phase Motors ..... 6 Hours

1.	Construction	1. Explain the general construction of single phase motors.
		2. Describe how the construction changes for each type of single phase motor.
2.	Operation	1. Explain the theory of operation of a single phase motor.
		2. Describe the effects of over and under voltage on a single phase motor.
		3. Explain how a rotating magnetic field is developed in single phase motors.
		4. Describe how torque is developed in single phase motors.
		5. Explain the operation of the starting centrifugal operated switch.

F. DC Motors ..... 4 Hours

1.	Construction	1. Explain the different types of construction for dc motors.
		2. Draw a correctly labeled diagram of each type of dc motor.
2.	Operation	1. Explain the operation of each of the following dc motors: a) series b) shunt c) compound

SECTION TWO:.....MACHINES LAB .....40 HOURS

A. Single Phase Transformers ..... 16 Hours

1. List the items to be checked prior to energizing a transformer.
2. Describe the hazards involved and how to avoid them when connecting transformers.
3. Verify by measurement the turns ratio and winding resistance on single phase transformers.
4. Measure voltages and currents to verify calculated load values.
5. Measure transformer losses and calculate efficiency of single phase transformers.
6. Connect two transformers in parallel and check how they share the load.
7. Identify the terminals of a dual winding transformer and check its polarity.
8. From the efficiency tests, determine the maximum fault current for that transformer.
9. Determine the voltage regulation of single phase transformers.

B. Three Phase Transformers and Transformer Banks ..... 16 Hours

1. Compare voltages of phase and line to line values to turns ratio of each transformer.
2. Connect the following transformer configurations:
   a) wye - wye
   b) delta - delta
   c) wye - delta
   d) delta - wye
   e) open delta - open delta
   f) open wye - open delta
   g) delta - delta (four wire)
3. Connect to three phase banks in parallel to feed a common load.
4. Measure angular displacement of three phase transformer banks.

C. AC Motors ..... 8 Hours

1. With a single phase motor:
   a) identify the windings
   b) connect the motor to a source of voltage for which it is designed to operate
   c) reverse the direction of rotation on single phase

2. With a three phase motor:
   a) identify the windings
   b) connect the motor to a source of voltage for which it is designed to operate
   c) reverse the direction of rotation on a three phase motor with reversing magnetics

SECTION THREE: ..... METERING THEORY ..... 67 HOURS

A. Instruments ..... 6 Hours

1.	Types	1. Identify common types of metering instrument movements: a) permanent magnet b) moving iron vane c) electronic
		2. Describe the operation of each of the above instruments.
		3. Explain how the accuracy of analog meter movements is given by the manufacture and how this would compare to the electronic meter.
		4. Explain the methods used to increase the range of a voltmeter and ammeter.
2.	Loading	1. Explain the effect that meter loading has on a circuit.
		2. Describe the effect that circuit loading has on the instrument.
		3. Describe the limitations of a permanent magnetic movement when used in an ac voltmeter.
3.	Recording meters	1. Describe the basic operation of a recording voltmeter.
		2. Describe why recording voltmeters are installed in secondary circuits.
4.	Maximeters	1. Explain the basic operation of a demand maximeter.
		2. Determine how correct tap settings for a maximeter are determined for a given primary load current.
		3. Explain the operation of the demand ammeter in a maximeter.
		4. Explain the proper method of installing a maximeter related to: a) personnel hazards b) resetting demand c) meter accuracy

B. Watthour Meters (Induction Type) ..... 6 Hours

1.	Construction	1. Explain the function of each part of a watthour meter.
2.	Theory	1. Describe the theory of operation of induction type watthour meters.

2. Describe how the meter converts a unit of power to a unit of energy.

3. Describe the electrical and mechanical operation of the induction watthours meters.

4. Explain why watthour meters have the following built-in compensations:
   a) voltage
   b) temperature
   c) power factor

5. Explain how the following meter constants are developed for a watthour meter:
   a) kh
   b) Rg
   c) Rr

6. Give a formula to determine the above constants of a watthour meter.

7. State how the watts of the connected load can be determined by timing the meter disk.

3. Maintenance

1. Explain under what conditions the following meter shop tests are performed:
   a) full load
   b) light load
   c) lag test

2. Describe what part of the meter is adjusted to improve the accuracy of the watthour meter when the above tests are conducted.

3. Interpret meter readings on a dial register.

4. Explain how shop and field tests are performed.

C. Meter Connections ..... 12 Hours

1. Single phase

1. Review two and three wire meter connections.

2. Explain the operation of a three-wire CT meter connection on a three-wire circuit.

3. Describe the two CT method of metering a three-wire circuit using a two-wire watthour meter.

4. Explain the operation of a network watthour meter.

5. Describe how a single phase watthour meter is connected to measure varhours.

6. Describe the basic concept of varhour metering using a standard watthour meter and a voltage network supply.

7. Verify all the above connections by formulae and phasor diagrams.

2. Three phase	1. Explain three phase self-contained watthour meter connections for the following circuits and meters: a) three wire - two element meter b) four wire wye - three element meter c) four wire wye - $2^1/_2$ element meter d) four wire delta - $2^1/_2$ element meter 2. Verify all above metering methods by using formulae and phasor diagrams.

D. Demand Meters..... 4 Hours

1. Definition	1. Define "demand meter". 2. Describe why metering of demands is important to a Utility.
2. Types	1. Identify common types of demand meters: a) thermal b) block c) sliding window 2. Explain the operation of a kVA or kW demand meter using the thermal method.
3. Resetting	1. Explain the procedure used in the field to reset demand meters, and how this procedure may vary between Utilities. 2. Explain how the demand part of the meter can be damaged when resetting the maximum demand on an energized meter.
4. Billing	1. Explain how the demand value is used in billing. 2. Describe how the basic consumption is determined in an energy bill.
5. kVA demand	1. Define "kVA demand". 2. Describe the difference between arithmetic and phasor kVA demand. 3. Explain how kVA demand elements convert kWh to kVA demand.

E. Polyphase Meters (Instruments Transformers) ..... 8 Hours

1. Three phase meters: a) two element b) two and a half element c) 4 wire delta and wye d) three element	1. State the correct formula of voltage and current used by each meter to register the correct consumption of energy used. 2. Verify all metering methods using phasor diagrams. 3. Identify on wiring diagrams, the correct polarity of VT's and CT's to supply energy to the meter. 4. Explain the resultant effect with each meter of the following condition: a) loss of potential to one element of meter b) loss of common potential conductor (open) from supply to meter only

		5. Describe how to verify the accuracy of a connected meter (perform a load check).
2.	Test switches	1. Describe the function of the test switches.
		2. Explain the operation of the current test switches (two blades).
		3. Explain possible hazards that may occur when operating the test switches to isolate or energize a meter.
		4. Describe the standard colour code outlined by Measurement Canada for the wiring between the test switch and meter.
3.	Delta connected CT's	1. Describe where delta connected CT's can be used.
		2. Explain how delta connected CT's are connected with a two element meter.
		3. Verify the metering method using delta CT's by phasor diagrams and formulae.
4.	Change meters	1. List possible reasons for changing revenue meters.
		2. Describe possible hazards that may be present when changing a meter.
		3. Explain safety precautions to be followed when changing a meter.
		4. Describe the steps that should be taken to verify the metering point after the meter has been changed.

F. Special Metering ..... 5 Hours

1.	kVA metering	1. Explain why kVAh metering is required.
		2. Describe the difference between arithmetic and phasor kVA on a three phase system.
		3. Verify kVA metering methods with formulae and phasor diagrams.
2.	kVARh metering	1. Describe why kVARh metering is required by the utility companies.
		2. Explain methods used to determine kVARh's with: a) electro-mechanical meters and cross-phasing b) electro-mechanical meters and phase shifting transformers
		3. Verify both of the above methods using formulae and phasor diagrams.
3.	kQ metering	1. Explain the general principles involved with kQh metering.
		2. State the advantages of kQh metering over kVARh metering.
		3. Describe how the kQh reading can be used to determine the kVARh reading over a billing period.
		4. Verify all kQh metering methods with formulae and phasor diagrams.

4.	Methods of phase shifting	1. Explain the general function of a phase shifting transformer. 2. Describe how a phase shifting transformer lags the voltage, so that a standard kWh meter can be used to measure kVARh on the following systems: a) 3 phase - 3 wire (delta) b) 3 phase - 4 wire (wye) 3. Verify the above phase shifting methods with formulae and phasor diagrams.
5.	Bi directional metering	1. Describe locations in the utility system that this type of metering would be required. 2. Explain general methods used with electro-mechanical metering to obtain bi directional metering. 3. Demonstrate how electronic meters would handle bi directional metering.

G. Analog Metering, Totalizing and Recording..... 5 Hours

1.	Transducers	1. Determine the input ratings of different transducers from nameplate data. 2. Explain how to interrupt the output ranges from nameplate data. 3. Describe how the output of a transducer can be changed from current to voltage outputs. 4. Explain the "Hall effect" transducer and its general use today.

H. Digital Metering, Totalizing and Recording..... 8 Hours

1.	Pulse initiators	1. Explain the advantages of electronic pulse initiators over the mechanical type of initiators. 2. Calculate the watthours per pulse (Ki) of pulse initiators using the kh of meter nameplate and pulses per disk revolution.
2.	Electronic totalizing	1. Describe the general principle involved with electronic totalization. 2. Explain the advantages of electronic totalization over mechanical totalization.
3.	Solid state meters	1. Explain how manufacturers set up their display registers on solid state meters. 2. Describe the accuracy range of solid state meters to electro-mechanical meters. 3. List the advantages of solid state meters over electro-mechanical meters.
4.	Analog to pulse converters	1. List two methods of analog to pulse conversion.

		2. Describe briefly how analog to pulse converters operate.
		3. Explain how auxiliary pulses are produced.
		4. Describe why auxiliary pulses may be required at a metering location.
5.	Recorders	1. Describe general methods used for sending pulses from metering point to the recorder.
		2. Explain what happens if storage capacity has been exceeded on electronic recorders.
		3. Describe how stored information can be removed from electronic recorders.
		4. Explain the procedure of how pulse values are calculated, so that storage capacity of the recorder is not exceeded.

I. Telemetering ..... 4 Hours

1.	Computerized metering systems	1. Explain how it's possible to verify a metering point when using computerized metering equipment.
		2. Describe what extra information is possible to obtain with this method of metering.
		3. Describe the physical connections required between computer and meter or recorder.

J. Regulatory Agencies ..... 3 Hours

1.	Standard connections	1. State the basic wire color code for secondary current conductors on the three wire CT and two CT methods.
		2. Explain how the polarity marks on the CT's are placed to follow the standard.
2.	Testing and verification	1. Explain what accuracy range is acceptable for revenue metering by the regulatory agencies.
		2. Explain how regulatory agencies can test and verify meters, as well as installations in: a) the meter shop b) field test
3.	Seal extension	1. Describe what is meant by "seal extension".
		2. Explain what is required by Measurement Canada for a seal extension program.
4.	Dispute testing	1. Describe what is meant by dispute testing.
		2. Explain who and how a dispute test with a customer is performed.

5. Regulations	1.	Explain what regulations effect revenue metering.
	2.	Describe how Measurement Canada control all metering equipment.
	3.	Explain how approval of new equipment for revenue metering is obtained.

K. Detection and Prevention of Energy Theft ..... 3 Hours

1. Sealing	1.	Explain what seals are installed at a metering point by the Utility and Measurement Canada.
	2.	Describe the importance of a sealing program with any utility for prevention of energy theft.
2. Internal meter tampering	1.	Describe what safeguards exist to prevent internal tampering of meters in the field.
	2.	Explain how internal tampering can be done to electro-mechanical meters.
3. Energy diversion	1.	Describe how energy diversion can be performed: a) internal to meter only b) external i) at meter socket ii) to the wiring
	2.	Explain what action an employee should take in reporting a case of energy theft.

L. Rates..... 3 Hours

1. Standard application rates	1.	Explain the basic rates available and normal service charges.
	2.	Describe the method used to determine energy consumption for each billing period.
	3.	Explain how the Utilities use demand charges to determine customers energy costs.
	4.	Explain the power pool and pool opportunity rates.
2. Metering versus typed rate	1.	Explain the difference between metered and typed rates.
	2.	Give example of where the two previous rates are used in your company.
3. Demand and consumption	1.	Define "block" demand.
	2.	Explain the principle behind lag demand.
	3.	Explain how "sliding window" demand is determined and used in billing.
	4.	Explain normal time interval as related to demand metering.

4.	Load factor	1. Define load factor. 2. Explain how load factor is used to determine energy costs. 3. Explain how a billing multiplier is used to determine overall costs of energy.
5.	Power factor	1. Explain how power factor will effect energy costs. 2. Describe what metering methods are used to determine customers power factor.

SECTION FOUR: .....METERING LAB .....51 HOURS

A. Single Phase kWh Meters ..... 6 Hours

1. Connect and verify a three wire current transformer to properly measure the energy of a three wire, single phase load using a two wire kWh meter.
2. Connect and verify the connection of 2 current transformers to properly measure the energy of a three wire single phase load using a two wire kWh meter.
3. Connect and verify the results of a network kWh meter used to properly measure the energy of a three wire circuit feed from a wye supply.
4. Determine and verify the billing multiplier for a metering point that uses CT's in the circuit.
5. Explain and check the results of incorrect primary or secondary polarity connections on the preceding CT connections.

B. Three Phase Self Contained Meters..... 10 Hours

1. Connect and verify a two element kWh meter feed from a three phase delta supply.
2. Install and verify a $2^1/_2$ element kWh meter for the following supplies:
   a) wye - four wire
   b) delta - four wire

C. Safety In Changing Meters ..... 2 Hours

1. Properly verify all self-contained meter connections at the socket, and at the terminals of a bottom connected meter by:
   a) voltage check at empty socket
   b) visual check of connections
2. List hazards when installing a kWh meter at a new location.
3. Explain the proper procedure to safely change an existing kWh meter.

4. Demonstrate how a connected meter can be verified by checking voltage, current, power factor of load and timing meter disk.

D. Instrument Transformers ..... 7 Hours

1. Verify potential polarity marks by:
   a) comparative test
   b) open circuit ac method
   c) inductive kick method

2. Connect potential transformers and provide proper protection for transformers.

3. Verify current transformer polarity by:
   a) comparative test
   b) open circuit ac method
   c) inductive kick method

4. Explain and demonstrate the proper method of de-magnetizing a current transformer.

5. Connect different types of current transformers.

E. kW Demand Meters ..... 2 Hours

1. Connect a polyphase kW demand meter to measure the demand on 3 and 4 wire load.

2. Verify meter demand readings by measuring current, voltage and power factor.

3. Plot demand over time and compare maximum actual to load.

F. kVA Demand Meters ..... 3 Hours

1. Connect a polyphase kVA demand meter to measure the demand of a 3 and 4 wire load.

2. Verify meter demand readings by measuring current, voltage of both.

3. Explain why the maximum demand of meter is different than calculated maximum on unbalanced loads.

G. Polyphase kWh Meters ..... 5 Hours

1. Connect and verify three phase, three wire, 2 element meter with CT and PT's.

2. Connect and verify three phase, four wire with CT and PT's:

a) wye supply
b) delta supply

3. Connect and verify kVARh meters to polyphase circuits as mentioned above.

4. Connect and verify kQh meters to polyphase circuits as mentioned above.

H. Pulse Metering ..... 4 Hours

1. Connect polyphase meters with pulse initiation to recorders to accumulate pulses.

2. Verify results of metering to be correct from pulses and Ki values.

I. Totalizing Analog ..... 3 Hours

1. Connect digital revenue meterings in master, slave and arrange to totalize two circuits.

2. Connect output of transducer to dc ammeter and determine input amount.

3. Connect transducer outputs to totalize two feeders.

J. Field Testing ..... 4 Hours

1. Verify polyphase instrument rated meter installation:
   a) colour code
   b) connectors
   c) grounding
   d) consumption

K. Safety in Changing Meters ..... 5 Hours

1. Meters

1. List hazards when installing self-contained and instrument rated meters.

2. Explain hazards of removing self-contained and instrument rated meters.

SECTION FIVE: ..... SUBSTATION THEORY ..... 49 HOURS

A. Power Transformer ..... 12 Hours

1. Operating principles

1. Recall ac transformer action.

2. Identify primary and secondary.

3. Recall and solve problems involving transformer voltage, turns and current

			ratios.
		4.	State how power transformers are rated.
		5.	Identify information on a transformer name plate.
2.	Core and windings	1.	Describe the types of core construction.
		2.	Recall the types of losses in the core.
		3.	Explain the reasons for core grounding.
		4.	State the method of testing the core.
3.	Transformer tank	1.	Describe the types of transformer tanks.
4.	Conservator tank	1.	State the purpose of a conservator tank.
5.	Bushings	1.	State the purposes of the bushings.
6.	Cooling methods	1.	Explain the types of cooling methods.
		2.	Identify the standard type designations from the nameplate.
		3.	Define ambient temperature and the effect of temperature on transformer life.
		4.	Identify the methods of circulating insulating medium.
		5.	Describe the purpose of radiator valves.
7.	Breather	1.	Explain the purpose of the breather.
		2.	Explain the proper maintenance of the breather.
8.	Pressure relief	1.	Describe the purpose of the explosion vent.
		2.	Explain the importance of inspection.
		3.	Describe the purpose of the pressure relief vent.
		4.	Explain the alarm or signal switch.
9.	Oil level gauges	1.	Describe the parts of an oil level gauge.
		2.	Explain the temperature effect on the oil level indicator.
10.	Temperature gauges	1.	Describe the types of temperature indicators.
		2.	Explain how and when to reset temperature gauges.
		3.	Describe the operating and alarm circuit of a winding temperature indicator.
11.	Gas detector	1.	Explain the function of a gas detector.
		2.	List the types of faults that could operate the gas detector.

		3. Identify different types of gas detectors.
		4. State how to take a gas sample.
12.	Tap changers	1. Recall the tap changer on a distribution transformer.
		2. Explain the operation of an off-load and an on-load tap changer.
		3. Calculate the voltages with different tap positions.
13.	Oil	1. Explain the purpose of transformer oil.
		2. Describe the proper procedures for taking an oil sample.
		3. Describe sampling for gas in oil analysis.
		4. Interpretation of gas in oil analysis results.
		5. State reasons for testing transformer oil.
		6. Explain the tests for determining the condition of insulating oil: a) di-electric breakdown b) neutralization c) interfacial tension d) pour point e) API gravity f) colour g) visual inspection h) power factor
		7. Interpretation of oil test results.
14.	Harmonics	1. Explain how harmonics are caused.
		2. Describe the effect of transformer connections on harmonics.
		3. Explain the application of a tertiary winding.
		4. Explain the effects of harmonics on a power system.
15.	Ratio testing	1. Describe the methods for testing the ratio of a power transformer.
		2. Interpret the results of a ratio test.
		3. Discuss the phase angle test using a ratiometer.
16.	Insulation testing	1. Test insulation using a megger.
		2. Interpret megger readings.
		3. Describe the factors affecting insulation resistance: a) temperature b) moisture c) di-electric absorption d) moisture on exposed terminals and bushings

e) manufacturer type
f) voltage rating
g) capacity of the transformer

4. Determine insulation resistance:
   a) by formula
   b) polarization index

5. Describe the power factor test (Dissipation Factor Test).

6. Explain temperature on power factor test results.

7. Explain high voltage testing (dc versus ac).

8. Explain:
   a) leakage current vs. voltage, and
   b) current vs. time

9. Describe test connections.

17. Drying

1. Describe methods of drying out transformers.

2. State how to determine the end point of the drying process:
   a) megger test
   b) power factor or dissipation factor
   c) dew point
   d) cold trap

18. Inspecting

1. State routine checks required on transformers and step regulating equipment.

2. Explain safe practices when inspecting faulted equipment.

3. State the tests and inspections that are considered after a fault:
   a) core
   b) current carrying conductors and devices
   c) cooling system

4. Identify circumstances surrounding a failure.

B. Voltage Regulators..... 5 Hours

1. Applications

1. Explain the applications of voltage regulation in a power system.

2. Types

1. Describe the different types of voltage regulation methods.

2. Identify the different parts of a step voltage regulator.

3. Describe the different types of step voltage changers:
   a) simple step changers
   b) series transformers
   c) autobooster

3. Maintenance and testing

1. Identify the maintenance procedures for a step voltage regulator.

		2. Explain how to test the operation of a: a) step voltage regulator b) autobooster
4.	Switching	1. State how to remove and place into service: a) step voltage regulators b) autobooster
		2. Describe the operation of a sequenced and non-sequenced bypass switch.
5.	Wiring controls	1. Explain the operation of the control circuit in a: a) step voltage regulator b) autobooster

C. Transmission Line..... 3 Hours

1.	Voltage regulation	1. Explain the voltage regulation of a transmission line: a) unity power factor load b) lagging power factor load c) no load (capacitive)
		2. Briefly explain charging current.
		3. Briefly explain the factors affecting the transmission line efficiency.

D. Lightning and Surge Protection..... 3 Hours

1.	Theory of operation	1. Explain the formation of lightning.
		2. Identify the different types of lightning.
		3. Explain the generation, the properties and the effects of switching surges in a power system.
		4. Describe the types of lightning protective equipment.
2.	Shielding	1. Explain the concept of shielding a power line.
3.	Mounting and position	1. Describe the placement and grounding of lightning arrestors in a power system.
4.	Classification	1. List the voltage ratings of lightning arrestors.
		2. Explain the classification of arrestors according to location.
5.	Maintenance and testing	1. Explain the type of maintenance required for lightning arrestors.
		2. Describe the types of tests that can be performed on a lightning arrestor.

TOPIC	OBJECTIVES	FOURTH PERIOD

E. Capacitors and Capacitor Banks ..... 4 Hours

1.	Construction	1. Describe the construction of capacitors. 2. Explain the insulation medium used in power capacitors. 3. Explain kVAR rating of capacitor banks.
2.	Connections and grounding	1. Explain how capacitors are connected to form banks to obtain: a) desired kVA b) desired voltage 2. Describe the grounding of capacitors and capacitor banks.
3.	Protection	1. Describe the fusing for: a) individual units b) group of capacitor banks c) overvoltage d) phase unbalance
4.	Switching	1. Describe the generation of transient voltages and currents due to the switching of capacitors. 2. Explain the ratings required by switches and circuit breakers.
5.	Application	1. Calculate the currents, voltages and kVARS when capacitors are connected in: a) series b) parallel 2. Calculate the amount of kVARS required to correct the power factor of a power system. 3. Explain the operation of a static shunt compensator (static var system).

F. Reactors ..... 1 Hour

1.	Applications	1. Identify the applications of reactors in power systems. 2. Explain the application of: a) shunt reactors b) series reactors

G. Alternators ..... 9 Hours

1.	Components	1. Describe the function and operation of an alternator stator and rotor. 2. Explain the methods used in connecting a stator winding.
2.	Generation	1. Explain the principles of EMF induction.

		2. Describe the characteristics and parameters associated with: a) speed b) poles c) frequency
		3. Explain generator output voltage.
		4. Explain generator output waveform.
		5. Describe generator voltage regulation.
3.	Loading	1. Explain loading curves.
		2. Describe overload capacity.
		3. Describe shifting kW and kVAR load.
4.	Excitation methods	1. Describe alternator excitation methods by: a) separate excitation b) self excitation c) residual magnetism
5.	Parallel operation	1. Describe parallel operation.
		2. Explain conditions for parallel operation.
		3. Explain methods for parallel operation.
6.	Standby power plants	1. Describe a standby unit.
		2. Explain the switching procedures for a standby power supply.
7.	Testing	1. Explain briefly: a) resistance testing b) short circuit test c) open circuit test
8.	Co-generation	1. Explain the principles of co-generation.
9.	Load shedding	1. Explain the principles of load shedding.

H. Synchronous Motor ..... 1 Hour

		1. List the components of a synchronous motor.
		2. Explain the principal of operation.
		3. Explain the ability of a synchronous machine to operate within its rating as: a) a synchronous motor b) power factor correction device

TOPIC		OBJECTIVES	FOURTH PERIOD
I.	**Substation Batteries..... 2 Hours**		
1.	Types	1. Identify the types of batteries used in substation battery banks.	
		2. Describe the hazards and precautions associated with different types of substation battery banks.	
		3. Describe the applications for different types of substation battery banks.	
2.	Ratings	1. Explain the ratings associated with substation battery banks.	
3.	Maintenance	1. Describe maintenance procedures for substation battery banks.	
		2. Describe testing procedures for substation battery banks.	
		3. Explain charging procedures for substation battery banks.	
J.	**Grounding..... 7 Hours**		
1.	Rationale	1. Explain the reasons and rationale for grounding.	
		2. Describe the types of hazards that may occur during a fault condition.	
		3. Describe factors affecting earth gradients.	
2.	System grounding	1. Explain the grounding in different electrical systems.	
		2. Describe factors affecting system grounds.	
		3. Describe ungrounded systems.	
		4. Explain factors affecting ungrounded systems.	
		5. Explain how a ground source is provided in an underground system: a) zig-zag transformer b) wye-delta grounding	
		6. Explain the methods used for the detection of ground faults in ungrounded systems.	
3.	Equipment grounding	1. Describe equipment grounding.	
		2. Describe the factors affecting equipment grounding.	
4.	Static grounding	1. Explain static grounding.	
		2. Describe the factors affecting static grounding.	
5.	Substation grounding	1. Explain the function of a grounding system.	
		2. Explain the reasons for surface gradient control.	
		3. Explain what affects the soil resistivity.	

4. State the maximum allowable ground resistance.
5. Describe how grid conductor, grounding conductor and connectors are selected.
6. Explain how the maximum ground fault current is determined.
7. Describe how to measure the resistivity of the substation yard.
8. Describe how to measure the resistance of a ground rod and grid.
9. State the guidelines for grounding substation fences.
10. Explain the hazards associated with:
    a) overhead shielded wires
    b) underground cables
    c) repairing of static ground grids

K. Precommissioning and Commissioning of Substation ..... 2 Hours

1. Procedures
   1. Describe the importance of receiving and cataloging new equipment.
   2. Describe the requirement of acceptance testing.
   3. Identify the schematic prints required.
   4. Explain the reasons for becoming familiar with the site layout and current status.
2. On site testing
   1. Explain the requirement of the following checks:
      a) installation
      b) function
      c) energization
      d) in-service

SECTION SIX: ..... SUBSTATION LAB .....46 HOURS

A. Transformer Connections..... 9 Hours

1. Calculate voltages and currents for various transformer connections.
2. Supply 3-phase loads from two 3-phase transformer banks using a high voltage switch board.
3. Verify all calculations with measured values.
4. Draw schematic diagrams of three phase wye delta and delta-wye transformer banks connected according to ANSI standards.
5. Connect 3-phase transformer banks following American Standard procedures.

6. Verify the connections using a phase angle meter.

B. Autotransformers ..... 2 Hours

1. Calculate transformed kVA and output kVA.
2. Determine the current rating of series and common windings.
3. Connect a mutual induction transformer as an autotransformer.

C. Three Phase Autotransformers ..... 3 Hours

1. Calculate the rated value of load that could be supplied by autotransformers connected in wye.
2. Verify all calculations with measured values.

D. Humidity and Dew Point Tests ..... 3 Hours

1. Measure and calculate humidity and dew point using electronic and sling psychrometer instruments.
2. Interpret charts of the various instruments.

E. Ratiometer Test Equipment ..... 3 Hours

1. Measure the ratios and phase angle of a single and three phase transformer.

F. Insulation Testing ..... 3 Hours

1. Perform a capacitance and dissipation factor bridge test on a transformer according to manufacturer's operating instructions.
2. Make a comparison to previous test using conversion factors for temperature.
3. Measure the insulation di-electric of a transformer or circuit breaker with a dc hypot, megger and power factor.

G. Oil Testing ..... 3 Hours

1. Test an oil sample for di-electric breakdown.
2. Test an oil sample for neutralization value.
3. Test an oil sample for interfacial tension.

4. Test an oil sample for colour.

H. Harmonic Testing ..... 3 Hours

1. Describe and record wave forms of output voltage and excitation current (at various voltage levels) for a transformer.
2. Connect a transformer bank wye-wye with a tertiary winding.
3. Observe and record wave forms of output voltage, excitation and tertiary current for various conditions.

I. Power Relaying..... 4 Hours

1. Draw a 3-phase ac elementary diagram of a single line diagram provided.
2. Connect the 3-phase power system from the 3-phase elementary diagram.
3. Connect a directional power relay (complete with breaker and CT's) to protect this system from reverse power flow.
4. Describe the operation of the system.

J. Analyzer Charts ..... 3 Hours

1. Explain the various breaker characteristics that can be determined from an analyzer chart.

K. Contact Resistance Testing ..... 1 Hour

1. Measure the contact resistance of a circuit breaker and switch.

L. Infrared Testing ..... 2 Hours

1. Determine hot spots on energized current carrying equipment.

M. Alternators ..... 5 Hours

1. Connect a 3-phase alternator and study its characteristics under lagging and leading load conditions.
2. Parallel 3-phase alternators.

N. Ground Resistance Testing ..... 1 Hour

1. Measure the ground resistance of a ground electrode with test equipment.

O. Voltage Regulators ..... 1 Hour

1. Connect an auto-booster.
2. Describe operation and change in voltage when load is varied.

SECTION SEVEN: ..... ELECTRICAL CODE AND SAFETY ..... 13 HOURS

A. Electrical and Communication Utility Code (ECUC) ..... 8 Hours

1.	Section 6 Grounding	1. Locate and interpret the rules in Section 6.
2.	Section 8 Substation, Generators	1. Locate and interpret the rules in Section 8.

B. Canadian Electrical Code Part I ..... 5 Hours

1.	Section 14 Protection and Control	1. Locate and apply the general requirements pertaining to protective and control devices. 2. Determine when protective and control devices are required and: a) select the proper types b) select the proper ratings to protect conductors and equipment
2.	Section 26 Installation of Electrical Equipment	1. Locate and apply the rules pertaining to: a) liquid filled equipment (indoor and outdoor) b) vaults c) transformers d) lightning arrestors e) battery rooms
3.	Section 28 Motors and Generators	1. Locate and apply the rules pertaining to the protection and control of generators.

SECTION EIGHT: ..... WORKPLACE COACHING SKILLS AND ADVISORY NETWORK ..... 4 HOURS

A. Workplace Coaching Skills and Advisory Network ..... 4 Hours

1. Describe the following coaching skills used for training apprentices:
   a) identify the point of the lesson
   b) link the lesson
   c) demonstrate a skill
   d) provide opportunity to practice a skill

e) give feedback to learner
f) assess the learner's progress

2. Describe the role and purpose of the advisory network and the Provincial Apprenticeship Committee for the Power System Electrician trade.

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