WORK PROCESSES
Supervisory Control and Data Acquisition Technician (SCADA)
O*NET Code: 49-2094.00 RAIS Code: 1106

Description: SCADA individuals maintain, repair, install, and trouble shoot various water system instruments, electronic devices and motor control devices, including but not limited to calibration and/or repair of all primary sensors, chlorination equipment, meters, pressure switches, etc.

ON THE JOB LEARNING:
Minimum Requirements: In order to provide each apprentice with at least a minimum amount of experience on each of the various types of equipment, upon which he may be required to work as a journeyman, he should be assigned to work and given instructions in amounts meeting or exceeding those shown in the following tabulation:

Type of Work (Suggested Hours)	Hours
Generator/Exciter	50
Motors/Motorized Drives	50
Motor Controllers	200
Low Voltage Switchgear	120
Med/High Voltage Switchgear	120
Electronics/Digital Hardware	500
Transformers	50
Batteries	50
Battery Chargers	50
HVAC Systems	50
Emergency Generators	100
Splices/Terminations	50
Conduit Installation	50
Water Treatment Equipment	250
Plant Systems Familiarization	100
Flow Control Measurement	700
Temperature Control/Measurement	700
Level Control/Measurement	700
Pressure Control/Measurement	700
Valves	60
Operating Mechanisms and Positioners	100
Programmable Controllers	500
Computers	150
Chart Recorders	50
Tool Familiarization	30
Print/Schematic Reading	150
Use of Test Equipment	200
Safety (First Aid, CPR, Hazardous Mat.)	100
Training (Specific Equip.Vendors, Seminars)	100
Electric Shop	200
Electric Water	200
Auto Generation Control	40
I/O	100
Computer Remotes	260
Switching Systems	50
Termination Protection	40
Lease Lines	80
Instruments	50
FSK Tones	100
DC Systems	50
UPS Systems	50

Standby Generators/Transfer Panels	**100**
Networking/Digital Transport	**160**
SCADA (wireless)	**80**
Equipment	**100**
Splicing	**50**
Wiring General	**80**
LAN	**80**
Care and Use of personal tools	**50**
Care and use of Company tools and equipment	**50**

TOTAL ON THE JOB LEARNING HOURS 8000 hours

*These are recommended hours; the categories or amounts may vary depending upon the nature of the workload.

RELATED INSTRUCTION
Supervisory Control and Data Acquisition Technician (SCADA)
O*NET Code: 49-2094.00 RAIS Code: 1106

First Six Months:

Trade Safety: Getting Started (ICS 186001) 5 hours
Every industrial worker should be familiar with accident prevention techniques, fire safety methods, and the use of personal protective equipment. Many injuries can be prevented by understanding how accidents and injuries can occur. Areas that will be discussed are: agencies that make and enforce safety regulations and an employee's responsibilities under those regulations, the physical hazards associated with chemicals and how to avoid those hazards. Electrical shock hazards and the techniques used to prevent shocks. The steps in a lock-out / tag-out procedure. The importance of machine guarding and several types of machine guards. The four classes of fire and how to extinguish each of them. The proper technique used to lift a heavy load. How to avoid hand injuries when using hand and power tools. The hazards involved in welding and hot cutting operations and how to prevent them.

Working Safely with Chemicals (ICS 186002) 5 hours
This unit deals with the safe use of chemicals in the workplace. The two primary causes of chemical accidents are the misuse of chemicals and the improper disposal of chemical wastes. Apprentices will learn how to perform a job analysis to look for potential chemical dangers in their daily tasks. Items discussed include: the six different ways in which a chemical can cause physical injury, the routes or paths of entry by which chemicals can enter the body, the types of injuries caused by chemicals, potential chemical dangers in their workplace, how to identify, store and label hazardous chemicals, methods used to prevent chemical accidents.

Fire Safety (ICS 186003) 5 hours
At the end of this unit the apprentice will be able to: describe the types of property losses and injuries associated with fires, how fires are ignited, identify the four classes of fire, the primary fire hazards found in the workplace, the various ways in which fires can be prevented, the operation of several different fixed fire protection systems, the proper type of portable fire extinguisher to use on a fire, the operation of several different types of fire extinguishers.

Material Handling Safety (ICS 186006) 5 hours
Apprentices will learn the procedures necessary to avoid physical injury to themselves and co-workers, for both manual handling methods and mechanical handling methods. They will also learn procedures that minimize damage to the materials being moved and to facility property. At the end of this unit the apprentice will be able to: recognize the hazards associated with handling materials, know the types of injuries that can be caused by these hazards, understand how to effectively use safe material handling practices, how to avoid physical injury when handling loads, rules for safe operation of powered industrial material handling equipment, the limits and restrictions placed on powered material handling.

Electrical Safety for the Trades (ICS 186005) 5 hours

This study unit introduces the apprentice to many workplace situations that require you to work safely with electricity. The apprentice will learn how and why electricity can be dangerous and various methods used for protection. At the end of this unit the apprentice will understand: how electricity can harm you and your property, the importance of properly using quality electrical components, the basic methods of protection when wiring electrical installations, why it is important to ground electrical equipment and systems. The type of electrical equipment to use in a hazardous location, safety practices required in an electrical work area and the importance of a clear working space around electrical equipment are discussed.

Computational Skills (GP BA01) 20 hours

This topic contains twenty-five lessons. The apprentice will complete the following training objectives: the purpose and placement of decimal points, solve math problems using addition, subtraction, multiplication, and division, solve math problems using whole numbers and decimals, solve math problems transposing decimals and fractions into percentages, solve math problems transposing percentages into decimals and fractions, solve math problems with negative powers of ten notations, solve math problems with positive power of ten notations, calculate the area of various geometric shapes, calculate the volume within various geometric shapes, calculate the density of various materials and shapes, calculate the specific gravity of substances, understand units of length, distance, time, speed, volume and density, calculate standard-to-metric conversion factors, solve math problems using various conversion factors, understand dimensional properties and their units of measure, solve dimensional problems using units of length, understand basic tables and graphs, understand the mathematical use of tables and graphs, solve math problems associated with tables and graphs, calculate the correct dimensions relating to the hypotenuse of a right triangle and solve math problems with decimal placement to ten thousands.

Introduction to Algebra, Geometry and Trigonometry (ICS Block X02) 72 hours

Algebra: Monomials and Polynomials (X0201)

The apprentice will learn to remove grouping symbols from algebraic expressions, dividing by a monomial when indicated, multiply binomials by monomials, trinomials, and other binomials, calculate the square root and the third power of given monomials, find special products involving binomials and divide one polynomial by another polynomial of lower degree.

Algebra: Factoring (X0202)

The apprentice will learn to find the prime factors of certain binomials and trinomials, factor a given trinomial, use the Factor Theorem to factor a given polynomial, use factoring to find the roots of an equation, divide one polynomial by another polynomial of lower degree and find the lowest common multiple of several polynomials.

Algebra: Addition and Subtraction of Fractions (X0203)

The apprentice will learn to recognize equivalent algebraic fractions, perform additions and subtractions involving algebraic fractions, reduce an algebraic fraction to its lowest terms and find the least common denominator for a group of algebraic fractions

Algebra: Multiplication and Division of Fractions (XO204)
The apprentice will learn to perform multiplication's and divisions involving algebraic fractions, reduce an algebraic fraction to its lowest terms, find the least common denominator for a group of algebraic fraction, solve equations involving fractions or decimals and simplify complex fractions.

Algebra: Linear Equations (X0205)
The apprentice will be able to recognize equations expressing mixture problems and other word problems, solve number problems, digit problems, and age problems, recognize the graph of a linear equation, given the graph or a set of points.

Algebra: Simultaneous Linear Equations (X0206)
This unit teaches the apprentice to recognize essential steps in the solving of simultaneous linear equations by addition, subtraction, comparison, graphing, and clearing of fractions, identify the classification of a system of equations, solve a system of linear equations, solve interest problems, lever problems, and work-sharing problems.

Algebra: Determinants (X0207)
The apprentice will be able to evaluate a second-order determinant and expand a third-order determinant, recognize the standard form to be used in solving simultaneous equations by determinants, recognize determinants that represent the solutions of simultaneous equations in two or three unknowns.

Algebra: Quadratic Equations (X0208)
At the end of this unit the apprentice will be able to recognize the graphical solution of two equations, solve and recognize steps in the solution of systems of quadratic equations and systems of a quadratic and linear equation, solve a fourth-degree polynomial equation in quadratic form, use the quadratic formula to solve a quadratic equation, calculate the discriminate of a quadratic equation, and point out what can be known from a given discriminate, write a quadratic equation which has given roots and solve word problems involving quadratic equations.

Algebra: Exponents (X0209)
This unit demonstrates the meaning of a fractional exponent, applies the rules for positive and negative exponents in multiplication, division, and rising to powers, uses radicals to convert fractional exponents and uses fractional exponents to convert radicals. The apprentice will be able to write a given number in standard form.

Algebra: Radicals and Imaginary Numbers (X0210)
This unit teaches the apprentice how to simplify several radicals and then add like terms, rationalize the denominator of a fraction and eliminate an imaginary number from the denominator of a fraction, solve an equation containing several square roots, multiply, divide, and raise to powers terms containing radicals.

Applied Geometry (X0211)
This unit will teach the apprentice to recognize characteristics of angles and closed plane figures, distinguish between common geometric solids, apply the Pythagorean Theorem, calculate perimeters and areas of a polygon, circle, and ellipse, and to apply the formula for area and volume of geometric solids.

Practical Trigonometry (X0212)
The apprentice will learn to define trigonometric functions, use trigonometric tables and apply interpolation, solve right triangles and apply the laws of sines and cosines in solving oblique triangles.

Hand and Power Tools (ICS X24) 60 hours
Common Hand Tools 1 and 2 (186052 & 185053)
Part 1 - The apprentice will learn about various types of tools as well as how to use them safely, properly, the results of improper use, how work pieces are held in place, the manner in which work pieces are marked prior to actually starting a given job, and how to make the most of a workbench's many useful features. Next, apprentices will be introduced to a group of hand tools which most technicians use on a daily basis -- wrenches, pliers, screwdrivers, and hammers. At the end of this unit the apprentice will be able to: identify common hand tools and their function, know how to safely use and maintain common hand tools and the benefits of several special features available for some hand tools.

Part 2 - Apprentices will learn how to choose the correct chisel or punch for the job, how to care for it, and use it safely. Next, apprentices will learn about the variety of different cutting tools such as snips, knives, and hacksaws. Apprentices will learn the different types of files, how to care and use them safely. Also discussed in this unit are various specialized maintenance tools. At the end of this unit the apprentice will be able to: identify and use various chisels and punches safely, use and care for cutting tools, understand the need for specialized maintenance tools, and correctly use threading and other precision tools.

Precision Measuring Instruments Part 1 (186068)
The apprentice will learn the purpose and language of measurement; scale instruments and accessories; vernier caliper; micrometers, gages and protractors.

Electric Drilling and Grinding Tools (186054)
At the end of this unit the apprentice will be able to: safely set up and operate a portable electric drill, electric drill press, and electric hammer, choose the proper drill bit for many drilling applications, set up and use a variety of hand and bench grinders, safely use the proper grinder for various jobs, follow the necessary steps for proper tool maintenance.

Power Cutting Tools (186055)
This unit introduces the apprentice to the most common portable power saws used in construction and repair work, namely circular, saber, jig, and reciprocating saws, and the stationary cutting tools found in most maintenance and fabrication shops. At the end of this unit the apprentice will be able to understand: the most common portable and stationary power saws, the various parts of a saw and how they work, the types of cuts made by each type of saw. They will be able to choose the most appropriate saw and blade for the type of work being done, recognize a portable circular saw, name its parts, and (with practice) operate it safely, select and (with practice) use the proper saw; saber saw, portable band saw, reciprocating saw, cut-out saw, cut-off saw, for a given application. Operate (with practice) the stationary circular, radial, band and scroll saws safely. The apprentice will know the various safety precautions when using power saws and stationary power tools.

Pneumatic Hand Tools (186056)

This text discusses the selection, use and safe practices of using different types of pneumatic tools. At the end of this unit the apprentice will be able to: describe the various pneumatic tools used for plant maintenance, identify and describe the safe use of impact, cutting, and grinding tools, understand how pneumatic hammers, nailers, and staplers are selected and used in a safe manner, the use of pneumatic assembly tools such as grinders, sanders, screwdrivers, and drills and how other types of production tools are selected and used. The apprentice will understand the proper procedures for pneumatic tool and system care, safe tool use procedures and how vibration and excess noise can cause bodily injury.

Plumbing and Pipefitting Tools (286042)

The apprentice will learn to identify the various tools available for various tasks by appearance, job and tool safety, tools required to join and assemble pipes of different material composition, when and how to use pipe-joint assembly tools, the tools required to perform layout, cutting, and boring tasks, tools needed for testing and maintaining piping systems and how to determine when and how to use finishing, testing, and maintenance tools for piping systems.

Electrician's Tools (006026)

In this unit the apprentice will learn about electricians' equipment which includes: basic hand tools; wire-working tools; conduit-working tools; and power tools. The apprentice will also learn about symbols and terminology used by electricians.

Tool Grinding and Sharpening (186057)

At the end of this unit the apprentice will understand: the use of a grinding machine and all safety procedures, hone or whet tools with an oilstone, the procedures for grinding metal stock, the methods used in grinding screwdrivers, snips, chisels, plane irons, and twist drills.

Jacks, Hoists and Pullers (186060)

This unit will teach the apprentice the many forms and how to safely operate jacks and hoists, the construction details and proper use and maintenance of fiber ropes, wire ropes, and chains, and how to properly use jaw and push pullers.

Preventive Maintenance (ICS 286085) 5 hours

At the end of this unit the apprentice will understand the function of inspection and scheduled maintenance as the basis of preventive maintenance, why preventive maintenance is performed and how it's scheduled, the causes, effects, and goals of a successful preventive maintenance program, how a computerized preventive maintenance program can be developed and implemented.

Preventive Maintenance Techniques (ICS 286086) 5 hours

This unit will cover how to inspect and properly maintain a belt, chain, and gearbox power transmission system, why proper alignment is necessary when operating a power transmission system, the steps needed to properly maintain an AC or DC motor, and how to perform a start-up or bump test of a motor. Also discussed how to perform PM tasks on pneumatic systems, how to maintain both floor and elevated conveyor systems, the types of elevators and vertical lifts in your plant and the proper PM procedures for this

equipment, how to maintain liquid and vacuum pump systems, how to perform a basic alignment of in-line shafts and the proper PM procedures for electronic controllers and robot systems.

Predictive Maintenance (ICS 286087) 5 hours

At the end of this unit the apprentice will understand what PDM is and how it can be used in industry, the various types of technologies used in PDM, what goals should be considered for a new and a maturing PDM program, the scope of basic mechanical PDM, and how a time waveform and a frequency spectrum can be used to identify machine faults.

Total Hours First Six Months 192 hours

<u>Second Six Months</u>:

Prints and Drawings (GP EL01) 10 hours

In this unit the apprentice will learn: how to classify types of prints and drawings, how to read schematic, logic, single line, elementary, and connection diagrams, how to read electrical-electronic prints and drawings, how to trace flow path of plant P and ID drawing and where plant print indexes are and how to find prints.

DC Principles (ICS A21) 30 hours

Nature of Electricity (086001)

This unit explains the operation of a simple circuit, the terms: conductor, insulator, and resistor, demonstrates that unlike charges attract and like charges repel, lists the dangers and benefits of static electricity, defines the terms: volt, ampere, and ohm, describes common notations and prefixes used to identify electrical and electronic values. The unit further discusses carbon resistors, potentiometers, and rheostats, and explains how they work, identifies the common electrical symbols used in schematic diagrams and explains the difference between a series and parallel circuit.

Circuit Analysis and Ohm's Law (186002)

The apprentice will learn how to find the total resistance in series, parallel, and series-parallel circuits, the use of Ohm's law to calculate the current, voltage, or resistance in circuits, how to calculate the amount of power supplied and dissipated in a DC circuit and the steps for finding current, voltage, and resistance with a digital or analog meter.

Capacitors and Inductors (086003)

This unit will explain how a capacitor holds a charge, common types of capacitors and ratings, how to calculate the total capacitance of a circuit containing capacitors in series or in parallel, and how to calculate the time constant of a resistance-capacitance or RC circuit. The unit further discusses how inductors are constructed, the system used to rate inductors, how an inductor regulates the flow of current in a DC circuit and how to calculate the total inductance of series or parallel connected inductors.

Magnetism and Elecromagnetism (086004)

This unit will identify the north and south poles of permanent magnets and electromagnets, magnetic and nonmagnetic materials, how to magnetize a piece of steel by induction, the difference between simple, compound, and closed magnetic circuits, and how to locate the direction of magnetic lines of force around a conductor (if the direction of current is known). The unit further discusses the use of the right-hand rule to locate the poles of a solenoid, the operation of simple electromagnetic relays, buzzers, and stepping

switches, how a DC motor operates and gives a simplified explanation for generator action and motor action with electromagnetic induction.

Conductors, Insulators and Batteries (086005)
This unit describes the various types of conductors and discusses their conductivity, the American Wire Gage System of sizing copper conductors, the size of conductor needed for an application and the various types of insulating materials and their temperature ratings. The unit will explain the difference between a dry cell and a storage battery, how to connect cells together to obtain more voltage, more current, or more of both voltage and current, the proper safety precautions used when working with storage batteries, how to properly clean and care for storage batteries, the instruments used for testing storage batteries and how NiCad, lithium, and other types of special batteries operate, and describe their ratings.

DC Motors and Generator Theory (086006)
This unit will identify a series, shunt, and compound wound motor and discuss their application, explain how a permanent magnet and stepper motor operate, the steps to reversing a DC motor's direction and discuss how the speed of a DC motor can be controlled. The unit will explain the basic principle for generating a direct current, the factors that affect the strength of the induced voltage, the purpose of a commutator and brush assembly, the difference between the field connections of series, shunt, and compound-wound machines, the reason for shifting brushes, the use of commutating poles and compensating windings for better generator operation and the various types of machine losses.

AC Principles (ICS A22) 40 hours
Alternating Current (086007)
Apprentices receive a complete introduction to AC terminology and basic AC circuit configurations. The apprentice will learn the uses of capacitors and inductors in AC circuits and the importance of these components in AC theory. Also discussed, the generation, control, and distribution of AC power on alternators, transformers, and energy distribution. How electricity is generated at a power plant and sent to consumers is covered. The apprentice will also be introduced to basic electronics through a study unit on rectification and basic electronic components.

Alternating Current Circuits (086008)
This unit will teach the apprentice to identify electric circuits in terms of their circuit characteristics, several circuit characteristics that are used to describe a circuit for a particular load application, how to connect electrical components in series and parallel circuits, control loads from one or two switch points, how delta- and wye-connected three phase circuits are different, how grounding a circuit increases its safety and how to recognize the difference between control circuits and power circuits.

Inductors in AC Circuits (086009)
This unit will explain how an inductor is made and how it operates in a DC and AC circuit, describe inductive reactance and impedance, and how AC frequency effects inductance, Ohm's law in an AC circuit that includes an inductor, how to calculate the impedance of a series RL circuit and how to calculate the impedance of a parallel RL circuit.

Capacitors in AC Circuits (086010)
This unit describes how a capacitor stores a charge and how series connected and parallel connected capacitance values are calculated, covers capacitive reactance and

use Ohm's Law in AC circuits that contain a capacitor, how to calculate the impedance of a series RC circuit and explains how changing the frequency of an AC signal changes capacitive reactance.

Transformers (086011)
In this unit the apprentice will learn what the main components of a transformer are, how mutual inductance makes it possible to change an AC voltage from one value to another when using a transformer, how to determine the turns ratio of a transformer when the primary and secondary voltages are known, how to calculate primary or secondary voltages or current when either one of these and the turns ratio are known, why transformers are laminated, how to connect three single-phase transformers for three-phase operation, how to calculate line current (if phase current is known) in delta-connected transformers and the operating principles of an auto transformer.

Alternators (086012)
This unit explains how single- and three-phase alternators operate, lists and describes the major components of an alternator, discusses alternator ratings in terms of power, voltage, speed, and temperature, the steps required for starting, stopping, and operating alternators and the similarities and differences of the three main types of alternators.

Electrical Energy Distribution (086013)
The apprentice will learn the difference between feeder and branch circuits, the different types of systems available for distributing power within a plant, be able to recognize and identify utilization equipment, understand the use of transformers in energy distribution, be able to identify by name and describe the uses of various types of raceways, and distinguish between panel boards and switchboards. The apprentice will be able to describe the electrical system of a power utility and how electricity is generated at a power station or utility.

Rectification and Basic Electronic Devices (086014)
This unit explains how diodes are used as rectifiers, the basic operation of a diode and a triode electron tube, how to connect a PN junction for forward and reverse bias, how a transistor operates as an amplifier, how to recognize transistor input and output circuits and compares rectifier circuits with and without filter circuits. The unit also discusses the operation of an SCR and a triac and how to calculate the ripple frequency of a half-wave and full-wave single-phase and three-phase rectifier.

Electrical Theory for Troubleshooters: I
Introduction to Digital Devices (ICS ITET07) 6 hours
This interactive multimedia training program consists of seven lessons that train apprentices in the principles of AC/DC and solid-state theories. Digital electronic theory is also introduced. This lesson explains how digital electronic components process and transmit information. This lesson leads apprentices through the fundamentals of digital devices - from the binary, hexadecimal, and BCD number systems and truth tables to logic devices, symbols and circuitry. After completing the lesson, the apprentice will be able to: differentiate between analog and digital signals and explain their benefits. Convert numbers from the base ten number system to the binary number system and vice-versa. Define a byte, the most significant bit, and the least significant bit. Convert numbers from the binary number system to the hexadecimal number system. Explain the relationship between conversion accuracy and number of bits. Identify the symbol and truth table for the AND, OR, NOT, NAND, NOR, XOR and XNOR function. Determine logic functions

performed by a circuit and determine how a logic function can be used as a gate. Identify the characteristics of TTL and CMOS.

Analog Circuit Measurement (ICS A23) 15 hours
Basic Test Equipment (086025)
This unit covers how to use the multimeter, the terms voltage, current and resistance, and explains their relationship in a circuit. It also discusses how voltage, current and resistance is measured with a multimeter, the schematic symbols used to represent various reactive devices, the major features of analog and digital VOMs, how to use both analog and digital VOMs to measure voltage, resistance and current in a circuit, the special probes used with a digital VOM and the important safety precautions.

Troubleshooting with Volt-Ohm-Milliamp Meters (086026)
This unit reviews the functions of a multimeter, the safe practices you should use when troubleshooting with a VOM, how to measure circuit resistance, the purpose of, and how to perform, tests for continuity and short circuits, how to perform resistance tests on resistors, fuses, solenoids, relays, switches, transformers, motors and semiconductors, how to take basic current measurements on power supplies, AC feeder lines and other such circuit areas, how to measure current by using a direct series connection or by using a clamp-type ammeter, how to take basic voltage measurements on both AC and DC systems, how to measure the output voltage of a DC power supply and the voltage of an AC feeder line, how to measure voltage at disconnect switches, circuit breakers, contractors and transformers and how to perform voltage tests on circuit boards, PLC systems and motor circuits.

Using Basic Oscilloscopes (086027)
This unit is an introduction to the basic controls and functions of an oscilloscope. It describes the component parts and features of a standard, dual-trace oscilloscope, how to use the front panel controls, how to connect an oscilloscope to a circuit, how to perform low-voltage measurements on circuit boards, measure the voltage output of a power supply and AC ripple, how to perform measurements in SCR and TRIAC circuits, how to test both DC and AC servo motor controller circuits and heater controller circuits, how to perform basic scope measurements on digital circuits and how to use an oscilloscope to troubleshoot industrial systems.

Component Testers (ICS 086062) 6 hours
The apprentice will learn to identify the type of component testers for such "piece parts" as resistors, capacitors and inductors; calculate turns ratio; show the correct connection scheme for testing diodes, SCRS, and transistors; relate proper soldering and desoldering techniques; cite the safety procedures to be used when handling electronic chemicals and lubricants.

Digital Test Equipment (ICS 086063) 6 hours
The apprentice will learn the use of binary math in digital circuits; identify various types of gate circuits; understand the use of a logic probe; and the differences between an oscilloscope and a logic analyzer.

Working with Multimeters (ICS 006021) 10 hours
In this study unit, the apprentice will learn how to use digital multimeters and their special features and capabilities. When apprentices complete this study unit, they will be able to: define the terms voltage, current and resistance, and explain their relationship in a circuit, discuss how voltage, current and resistance are measured with a multimeter, discuss

some of the most important safety precautions to take when working with a multimeter, understand the purpose of a continuity test, be able to perform tests for short circuits and resistance tests on resistors, switches and transformers. The apprentice will also be able to measure current by using a direct series connection and to measure the output voltage of a DC power supply.

Electrical Equipment (ICS A24) 60 hours

Conductors and Insulators in Industry (08670)

This unit provides electricians with information on conductors and insulators in industry. This unit covers a range of conductors from the standard plastic-coated, copper conductors to the large and high-temperature conductors. Apprentices will learn about the different types of insulators and how the type of insulator can influence the maximum temperature and current-carrying capability of the conductor. At the end of this unit, apprentices will learn how to troubleshoot and repair conductor and insulator problems.

Working with Conduit (08671)

At the end of this unit the apprentice will be able to: define the characteristics of different types of conduit, describe how to install various types of conduit fittings and support, understand how to properly cut and thread conduit using manual and machine methods, identify and understand the use the proper tools for bending conduit, the equipment used in installing large conduit and its conductors. The apprentice will be able to determine conduit sizing when given a particular wiring assignment.

Electrical Boxes (086872)

This study unit provides the apprentice with information on the types of electrical boxes their covers, and discusses boxes for pulling and splicing. Apprentices will learn how to select the proper sized box for a situation and the proper ways of installing electrical boxes. At the end of this unit the apprentice will be able to: describe the role of electrical boxes in an installation, understand why circuits are interrupted and when and where electrical boxes are used in installations. The apprentice will be able to properly install electrical boxes, identify the types of electrical pulling and splicing boxes, understand how to properly install conductors in a system with electrical boxes.

Industrial Enclosures and Raceways (086073)

This study unit provides apprentices with the information they will need to construct and install an industrial enclosure, and to connect the panel board to the field devices through one or more kinds of raceways. When an apprentice completes this study unit, they will be able to: describe the basic construction of industrial control cabinets and similar enclosures, understand how to connect conduit to enclosures, understand the proper procedures for installing a disconnect switch or main breaker in an enclosure and the procedures for connecting conductors to the switch. The unit will explain how to properly ground the enclosure, how to properly install wire ways, such as wiring troughs, how plugs and receptacles can be used to prefabricate a system.

Connecting Electrical Equipment 1 and 2 (086074 & 086075)

Part 1 - This study unit provides apprentices with information on how intermediate or main junction boxes are connected to the main system by means of raceway. Then, they will learn how devices are connected into a wire way, to a junction box, or to another location, using raceway or cabling and strain relief fittings. The next section discusses how connections are made inside control-panel board enclosures. Apprentices will be introduced to terminal block connections and connections to devices

such as fuse holders, circuit breakers, and motor starters. The final section of this unit covers connections to remote operator stations and remote control stations.

Part 2 - In this study unit, apprentices will learn how to make good electrical connections using the proper type of electrical connector. This study unit covers solderless terminals, wire nuts, and butt splices. They will learn about larger compression-type connectors and about connections made to smaller devices.

Industrial Fuses (086076)
This unit focuses on fuses. First, the unit discusses the need for over current protection in modern industrial circuits. Next, fuse ratings and specifications are covered. This section discusses the selection of the correct type and size of fuse in a system. The following section focuses on typical fuse holders. This unit shows how to address the problem until the fuse holder can be replaced. Finally, the unit ends with a discussion of how to safely test and replace fuses in their fuse holders.

Industrial Circuit Breakers (086077)
This study unit will look at the types of circuit breakers that are commonly used in industry; how they are designed and how they work. It will also look at typical branch circuits for single-phase and three-phase loads. Finally, the study unit will discuss ground fault circuit breakers and outlets, and how to safely work with circuit breakers.

Plugs, Receptacles and Lampholders (086078)
This study unit will introduce the apprentice to industrial plugs and receptacles. This study unit will begin with information on the common 120 VAC plug and duplex receptacle systems used in both residential and industrial locations. Next apprentices will see the various types of plugs and receptacles used in single phase and three-phase AC power systems. Information on various types of signal plugs and receptacles that are used in industry is covered. Finally, this study unit will conclude with information on various types of lampholders.

Industrial Switches (086079)
This unit introduces apprentices to the many designs and technologies of industrial switches, and provides insight into their operation and applications. At the end of this unit the apprentice will be able to: identify switch symbols on electrical drawings, have a basic understanding of the process control hierarchy, be able to identify the various types of industrial switches and components of various types of industrial switches. The unit ends with an explanation of the applications for various types of industrial switches.

Industrial Relay Ladder Logic (086080)
At the end of this unit the apprentice will be able to: describe the fundamentals of relay ladder logic, be able to identify the different types of relays used in ladder logic and the symbols for input and output elements used in ladder logic. The apprentice will understand the principles such as power, current flow, rules of reading, numbering systems, and component interconnections applied in relay ladder logic, interpret simple and complex ladder logic by applying the fundamentals learned.

Industrial Relays, Contractors, and Solenoids (086081)
This study unit will delve deeper into the various types of industrial control relays, magnetic starters, contractors, and solenoids, covering their operating principles, construction, components, and applications. At the end of this unit, the apprentice will be able to: distinguish between types of control relays, contractors, magnetic starters, and solenoids, describe how each type operates, identify the part of each type and specific applications for each type.

Total Hours Second Six Months **183 hours**

Third Six Months:

A+ Software* **(TMCC CIT111)** **45 hours**
This class taught by Truckee Meadows Community College provides a comprehensive overview of the primary operating systems used on PCs, including DOS and Windows. It defines utilities, memory management, troubleshooting, diagnosis and system maintenance using the operating system.

Electrical Equipment 1 and 2 **(ICS006027 and 006028)** **20 hours**
Part 1 -This study unit will teach apprentices about the different types of equipment and hardware that are required to mechanically support or complete interrupted electric circuits; receptacles, switches, lampholders, boxes, and fittings. When apprentices complete this unit, they will be able to: recognize several common types of wiring equipment, define the important terms that apply to electrical equipment, recognize the electrical symbols that relate to electrical equipment, understand when and where boxes, cabinets, and panels are used in electrical installations, how to properly install boxes, cabinets, and panels, when and where cable and conductor fittings and conduit fittings are used in electrical installations and how to install cable and conductor fittings and conduit fittings.

Part 2 - In this unit, the apprentice will learn about the equipment and hardware that are needed at locations where the wiring has stopped and must be connected to loads or devices. At the end of this unit the apprentice will be able to: recognize and identify various types of control devices, including hand operated switches, automatic switches, magnetically controlled devices, and remote control systems, understand how to install various types of control devices, various types of protective devices, including fuses, circuit breakers, and ground fault circuit interrupters, understand the installation of various protective devices and classify and define various types of electrical loads.

Electrical Grounding **(ICS 086E01)** **25 hours**
This unit is composed of five lessons. These are broken down as follows**:**

Lesson 1 - Principles of Grounding Understanding National Electric Code Grounding Requirements (article 250); Grounding for Safety; Fault Detection; Grounding Electrode Systems and Types.

Lesson 2 - Grounding Systems: Grounding Electrode Conductor (AC and DC) Material, Types and Sizing; Circuit Grounding; System Grounding; Grounded Conductor Installation, Sizing and Identification; Main Bonding Jumper Locations, Sizing and Connections.

Lesson 3 - Equipment and Enclosure Bonding and Grounding: Understanding Effective Ground Paths; Equipment Grounding Conductor Types, Installation, and Sizing; Equipment Grounding Conductor Raceways, Connections and Boxes; Using Earth as an Equipment Grounding Conductor; Bonding Service Equipment; Working with Bonding Jumpers.

Lesson 4 - Equipment and Enclosure Bonding and Grounding: Grounding Panelboards, Receptacles, Towers and Computers; Ground-Fault Protective Equipment; GFCI's.

Lesson 5 - High Voltage Grounding Applications: System and Circuit Grounding for 1kV and Over; Separately Derived Systems; Dedicated Five-Wire Systems; Grounding Two or More Buildings; Calculating Fault Currents and Grounding Conductor Withstand Ratings.

Wiring Electrical Components 1 and 2 (ICS006029 &006030) 20 hours

Part 1 - In this unit, the apprentice will learn how to combine what they know about electrical equipment and conductors in order to wire typical new residential circuits. They will also learn many of the features of electrical systems. When the apprentice completes this unit, they will be able to: identify the function of various electrical components, recognize and work with various types of electrical systems, describe the function of grounding wires and connect them properly, select the correct terminals on electrical equipment and properly connect them to circuit conductors, select the proper switches, receptacles, and device boxes needed for given applications, identify the terminals on light fixtures and how they are wired.

Part 2 - This unit discusses certain special wiring situations that are commonly encountered but not part of every job. It also explains how electricians use circuit measurement techniques to troubleshoot problems. When apprentices complete this study unit, they will be able to: explain how old work differs from electrical jobs for new construction, identify several ways to run wire in existing structures, describe the steps to take when installing new electrical devices in existing structures, outline the acceptable procedure for adapting existing aluminum wire for use with modern devices and explain how electricians rely on electrical measurements to troubleshoot an existing circuit.

Working with Conduit (ICS 006015) 10 hours

At the end of this unit the apprentice will be able to: identify and define the types and characteristics of conduit, describe and install various types of conduit fittings and supports, identify the tools needed to bend conduit and use those tools correctly, determine conductor and conduit sizing; rating; types of core and windings; insulation; bushings; tap changers; polarity; single-phase and polyphase transformers; delta, star, open-delta, and scott connections; special transformers, autotransformers, reactors, step-voltage regulators; instrument transformers; maintenance of transformers; design of small low-voltage transformers.

Electrical Control Devices (GP EL08) 10 hours

This unit will teach the apprentice about troubleshooting control devices, control device faults, control device components, control device functions, the difference between AC and DC controllers, and how to identify the "normal" position of a control device.

Motors and Generators (GP El 07) 10 hours

The objectives for this unit are: operating characteristics of various types of motors, identifying the basic types of motors, AC generators, operational theory of induction

motors, determining appropriate application of motors, identifying types of motor construction, induction motors and their functions, troubleshooting motors, troubleshooting motor system faults, generator component troubleshooting, internal cleaning of various types of motors, motor disassembly and reassembly techniques, operational checks to perform when a motor is returned to service, operating characteristics of various types of generators, generator applications, generator construction techniques, troubleshooting generators, internal cleaning of generators, and generator disassembly and reassembly techniques.

Transformers (GP EL 04) 10 hours
This unit has the following objectives: describe transformer characteristics, lists the essential parts of a simple transformer, states the relationship between primary and secondary voltages and transformer turns ratio. The apprentice will learn the definitions of: potential transformer, current transformer, and power transformer. The unit goes on to explain transformer cooling system characteristics, different types of transformer cooling systems and their components, transformer cooling system operation, transformer troubleshooting techniques, identifies the causes of transformer failure, how to remove transformers from service and safety hazards related to transformers.

Instrument Transformers (ICS 6793) 10 hours
This unit covers the fundamentals of current and potential transformers; types of instrument transformers; instrument transformer construction standards, such as ratings and insulation classes; instrument transformer performance standards as to burden, accuracy, and correction factors; practical application of instrument transformers with regard to grounding, rating, connections, and burden; polarity and accuracy testing of Instrument transformers utilizing various methods and procedures.

Voltage Regulators for Generators (ICS 4368) 10 hours
This unit discusses the need for proper voltage regulation; characteristics of voltage regulation; causes and effects of poor voltage regulation; types of voltage regulators for generators; direct-acting regulator; indirect-acting regulator; rotating-amplifier regulator; regulator with inductor-alternator excitation system; electron-tube regulator; saturable-reactor regulator; silicon-controlled rectifier regulator; and regulator with static excitation system.

Storage Batteries (ICS 4343) 10 hours
This unit discusses lead-acid batteries; types of batteries; construction of lead-acid batteries; operating principle of lead-acid batteries; characteristics of lead-acid batteries; battery-testing instruments; charging of lead acid batteries; battery-charging equipment; installation; lead-acid batteries; maintenance of lead-acid batteries; alkaline-electrolyte batteries; nickel-iron batteries and nickel-cadmium batteries.

Telemetering (ICS 4048) 10 hours
This unit discusses: definition and classification of telemetering; analog telemetering systems; frequency telemetering system; impulse duration telemetering system; digital telemetering system; transmission of data signals; telemetering channels; computations in telemetering; telemetering for automatic control; and electric-power-system control.

Controlling Industrial Motors (ICS 086053) 10 hours
In this unit the apprentice will learn how stepper motors are electronically controlled; steps to follow when troubleshooting stepper motor controls; how AC line frequency sets motor speed; how frequency inverters control motor speed in three-phase installations; how servo motors are controlled; how brushless motors work and how their shafts are precisely positioned, and the steps to follow when troubleshooting brushless motor controller systems.

Motor Control Fundamentals (ICS 006010) 10 hours
In this unit the apprentice will learn: motor control standards; operating characteristics of motors motor starters, NEMA and IEC starters, reversing and multi-speed starters; motor control fundamentals; interpreting control devices and circuits using control diagrams automatic and manual signaling devices, capacitive and inductive switches.

Total Hours Third Six Months 210 hours

Fourth Six Months:
Introduction to Programming* (TMCC IS 115) 45 hours
This class taught by Truckee Meadows Community college is the first course in programming. It may use any BASIC as the language tool. It deals with the ideas of typical processes, internal computation, input/output, decision and control and typical applications.

Industrial Motor Control (ICS 006011 & 006012) 20 hours
Part -1 This unit discusses the history and concepts of programmable logic controllers (PLCs); number systems; the central processing unit (CPU): CPU scan, analog and discrete signals, types of PLC memory; the input/output system (I/O); special function I/O; elements of a relay ladder logic program; and the operation of timers and counters.

Part 2 - The second part of this unit discusses programmable logic controllers (PLCs) fundamentals: contacts, coils, ladder logic terminology and symbology, scanning and solving ladder logic programs; application/troubleshooting exercise one: the pick-and-place robot; application/troubleshooting exercise two: the mixing vat; application/troubleshooting exercise three: the paper roll stand; troubleshooting skills using LED indicators and programming console procedures; PLCs in motor speed control; PLC system troubleshooting and repair.

Industrial Motor Applications (ICS4341) 10 hours
This unit discusses motor torque; inertia of loads; motor types and characteristics; power-supply factors; types of drives; braking of motors; intermittent service; mechanical connecting devices; motor-driven power pumps; Fans and blowers; reciprocating, rotary, and centrifugal compressors.

Analog Electronic Components (ICS B23) 42 hours
Basic Semiconductor Components: Diodes (086019)
This unit describes how diodes work in a rectifier and how to determine if they are working properly, how different types of diodes function, a variety of diode uses in electronic systems, the characteristics that make a particular diode useful in a given situation, how a diode works with other components in an electronic circuit, how to perform basic measurements in diode circuits, that will assist in troubleshooting tests and how to select a proper diode for replacement in a circuit.

Basic Semiconductor Components: Transistors (086020)
In this unit the apprentice will learn how transistors control the flow of electricity in a circuit, the construction of bipolar transistors, how the operation of bipolar transistors resembles that of the diode, how biopolar transistors can control and amplify current in a circuit, the construction and operation of JFETs and MOSFETs, how to use an ohmmeter to perform basic tests on bipolar transistors, and how to perform basic troubleshooting measurements and calculations on circuits that contain amplifying devices.

Switching Devices (086021)
In this unit the apprentice will learn how a switch changes, voltage levels and current levels, the DC polarity of the delivered voltage, the direction of direct current, from one delivered frequency to another, how the above functions can be performed by mechanical switches or by electronic circuitry, the advantages and disadvantages of various switch types and how they function, analyze basic relay ladder diagrams, how a diode can be used as a switch, some of the problems of diode switching, how very rapid electronic switching is accomplished and the circumstances in which a mechanical switch may be preferable to a rapid electronic switch.

Electronic Sensors (086022)
In this unit the apprentice will learn how certain electronic components are used as sensors and as parts in control mechanisms, what sensors and transducers do, important thermoelectric effects, how these types of transducers operate and the effects they cause; electromagnetic, electroacoustical, piezoelectric, photoelectric, and electromechanical. The apprentice will understand the importance of a bridge circuit in certain types of electronic instrumentation, how certain nonlinear resistors are used in circuits, and how certain components can be used as protection devices for circuits and the scientific terms stress and strain.

Special Rectifiers: Electron Tubes (086023)
In this unit the apprentice will learn how electron tubes work and how to troubleshoot tubes when necessary, the four different methods of obtaining electronic emission, how vacuum tubes and gas-filled tubes operate, how the following special purpose tubes work: cathode ray tubes (CRTs), transmitter tubes,iImage orthicon tubes, vidicon tubes, describes how a triode uses a control grid to control electron flow, why a screen grid is used in a tetrode, the function of a suppressor grid in a pentode, and how electron beams are controlled in a cathode ray tube (CRT). The apprentice will understand half-wave and full-wave rectification, how to select a diode for replacement in a circuit and how to troubleshoot a half-wave rectifier power supply.

Optoelectronic and Fiber Optic Components (086024)
This unit provides an introduction to the high technology field of optoelectronics. It discusses the theory and applications of the components used in this field; compact discs, bar code readers, lasers, light emitting diodes (LEDs) and light activated diodes (LADs),explains why electronics and optics are natural partners. The unit will identify the modern theories of light and the relationship to optoelectronic applications, describe the basic theory of light communications, how a fiber optic communications system works, the operation of electron microscopes and their advantage over optical microscopes and explains how fluorescent light and other light sources operate.

Electronics Hardware (ICS 086040)
In this unit the apprentice will learn the uses and applications of these components that are critical to the repair and maintenance of an analog circuit or system: fasteners,

connectors, jacks, component sockets, cables, strain gages, relays, wires, heat shrink tubing, batteries and UPSs, how to construct a circuit board for a personal computer, the correct and safe soldering techniques and surface mount technology.

Reactive Circuits (ICS B22) 15 hours

Reactance and Impedance (086037)

This unit defines capacitive and inductive reactance, how resistors, capacitors and inductors work in DC circuits, how to calculate time relationships in circuits, how to determine reactive and impedance values for series and parallel AC circuits, how to calculate the values of voltage, current, and impedance in RC, RL, and RLC circuits, how to determine the voltage-current phase angle relationships in capacitive and inductive circuits and how to work with J operators to analyze circuit behavior.

Resonant Circuits (086038)

In this unit the apprentice will learn how to recognize the conditions required for series and parallel resonance, the factors affecting capacitive reactance and inductive reactance in series and parallel circuits, how to determine the resonant frequencies of LC series and LCR parallel circuits, how to calculate the value of the quality (Q) factor and bandwith of a circuit, the relationship between Q and bandwidth and the practical uses for tuned circuits.

Applications and Troubleshooting of Resonant Circuits (086039)

During this unit the apprentice will learn how to estimate voltage for troubleshooting AC and DC circuits, the need for impedance matching and how it is accomplished, how to identify the circuits for low-pass, high-pass, band-pass, band-reject and power-supply filters, how to interpret a filter's characteristic curve, how to determine cut-off frequency for various filters, how to select the particular type of series or parallel-tuned circuit for certain applications, how transmission lines are related to resonant circuits and waveguides and how transmission lines are used as components in tuned circuits.

Basic Electronic Circuits (ICS B24) 48 hours

Rectifiers and Power Supplies (086041)

In this unit the apprentice will learn to identify the basic types of rectifiers, the operation of various power supply filters, the advantages for different rectifier connection schemes, the values for a voltage divider, how voltage dividers are used in power supplies and how to determine the current through, and voltage across, nonlinear components, such as diodes.

Amplifiers (086042)

In this unit the apprentice will learn the advantages of various classes of transistor amplifier operation, how to calculate the dB gain of an amplifier circuit, how to identify the several types of transistor amplifier circuits, the proper polarity for NPN and PNP transistor connections, the methods used for biasing a transistor, the types of distortion introduced by amplifiers and how to troubleshoot amplifiers.

Oscillators (086043)

This unit explains the differences between several types of oscillator circuits, identifies the feedback components of an oscillator circuit, including LC and RC types, describes the flywheel effect and how it is produced, indicates the principle difference between various oscillator circuits, calculates the resonant frequency of an oscillator circuit, describes the effects of temperature on crystal oscillators, discusses various applications of oscillator circuits and describes how a frequency synthesizer works.

Modulation and Detection Circuits (086044)
This unit describes the various types of detector circuits, explains the various forms of modulation, calculates bandwidth of signals, describes how to determine the frequencies resulting from combining or mixing two signals, describes the advantages and disadvantages of pulse code modulation, explains the operation and applications of phase locked loops and applications of detector and modulation circuits.

Switching Circuits (086054)
In this unit the apprentice is taught how to match the output conditions for various gate circuits, shows how transistors are used as logic gates, discusses the operation of flip flops, names the applications of registers and memory and indicates the proper output for a specific multivibrator circuit.

Logic Circuits (086055)
This unit deals with working with number systems, the use of encoders and decoders, how to convert decimal numbers to binary and hexadecimal numbers, how to develop truth tables and explains how adders, subtractors, and comparators are used.

Gating and Counting Circuits (086056)
This unit discusses the use of arithmetic logic gates, work with half-adder and full-adder circuits, discusses the use of subtractor circuits, the applications for decade and binary counters and how to determine the modulus of a counter.

Pulse and Digital Circuits (086057)
This unit discusses the basic parts of a pulse waveform, the difference between limiter and clamper circuits, how to calculate the time constants for integrating and differentiator circuits, the action of trigger circuits and how to work with binary numbers.

Total Hours Fourth Six Months 180 hours

Fifth Six Months:
Beginning Programming (TMCC CIT 131) 45 hours
This class taught by Truckee Meadows Community College. Apprentices will study the "C" programming language. Topics covered include computer organization, language and data structures and technical computer applications.

Troubleshooting Electronic Equipment and Systems (ICS B06) 36 hours
Introduction to Troubleshooting (B0601)
The apprentice will learn to locate the causes of trouble in basic electronic circuits by the logical process of eliminating various alternatives, to read electronics schematics and recognize component symbols, recognize actual components and circuits by comparison with a schematic, good troubleshooting habits, safety measures and first-aid care. The apprentice will learn how to isolate, localize, pinpoint, and remove trouble sources.

Basic Troubleshooting Methods (B0602)
The apprentice will learn to recognize trouble symptoms, know what they are, how to use them, and how to refine them. The methods of quickly isolating trouble areas by separating what's right from what isn't are discussed. The unit also describes the various troubleshooting techniques, tells how to troubleshoot by comparison and by substitution, explains where and how to use different troubleshooting methods, either separately or in

tandem, to speed up the resolution of your troubleshooting assignments and compares troubleshooting by signal injection, circuit disturbance, and shotgunning methods.

Selecting Instruments for Troubleshooting (B0603)
This unit discusses the different kinds of basic meters and oscilloscopes, how to select the right kind of VOM, FETVOM, or DMM for a given job, explains instrument response, circuit loading, accuracy, and other data, demonstrates how to use a meter to make both out-of-circuit and in-circuit tests on several basic components, how to read and explain both analog and digital readouts, describes instrument specifications and explain how to interpret them and defines common oscilloscope and meter controls and their uses.

Measurement Techniques in Troubleshooting (B0604)
This unit teaches the apprentices to measure AC and DC voltages and currents, understand how instrument loading can affect tests and how to minimize loading effects, make high-voltage measurements safely, measure alternating current without opening the circuit, set up and make AC (alternating current), DC (direct current) frequency, and time measurements with an oscilloscope, use wattmeters, frequency counters, capacitor meters insulation testers and other special instruments found in industry and test digital circuits using digital probes and pulse injectors.

Support Services for Troubleshooting (B0605)
This unit demonstrates good soldering techniques, reviews the use of solder flux and heat sinks, selects and maintain solder tips, describes the various desoldering methods, shows the proper care for desoldering irons, discusses troubleshooting aids including special tools, sprays, extensions, clips, and cleaners, explains troubleshooting strategies and illustrates logical approaches to troubleshooting.

Practical Troubleshooting Problems (B0606)
In this unit the apprentice will learn to identify the various kinds of power supplies and list the troubles to be expected from each, how ohmmeters, voltmeters, and oscilloscopes are used to locate power-supply troubles, how regulators work, including what trouble symptoms they develop and how to cure them. Further discussion includes how to test electrolytics, transistors, diodes, and other parts within, and outside the circuit, how to troubleshoot glitches, ripple, and transients, the testing of digital circuits, including how it differs from and compares with, other kinds of troubleshooting, test microprocessor inputs, outputs, and supply voltages and will be able to find troubles in them and in other digital systems.

Troubleshooting Industrial Electrical- Electronic-
Computer Systems (ICS B26) 36 hours
Industrial Electronic Troubleshooting (086064)
In this study unit, apprentices will learn about some of the more abstract troubleshooting procedures. These procedures will require the troubleshooter to collect information and focus on the failed component, not just connect a meter to make measurements. At the end of this unit, the apprentice will be able to: explain why a safety inspection is the first inspection that should be made on a failed piece of equipment, discuss how to make safety a part of all troubleshooting and repair procedures, understand how to collect accurate data on trouble clues, describe how to use system indicators to help you troubleshoot an electronic system problem, list the steps for proper basic troubleshooting, such as identifying failure trends, seeking obvious causes, and circuit board swapping, describe how to perform advanced troubleshooting, such as using binary divide techniques and focusing on one of many failure possibilities, list the aptitude and attitude qualities needed to be a good industrial troubleshooter.

Electronic Troubleshooting of Industrial Motor Controllers (086065)
This study unit will begin by discussing how to troubleshoot simple DC motor controllers and stepper motor control systems. Although small DC motors are covered in this unit, the apprentice can apply what they learn to larger DC motors since these motors simply have larger components. This unit will also examine the electronic troubleshooting of servo systems. This section begins with the typical industrial DC servo system where a precision DC motor can be controlled to an exact location and speed. It then covers the troubleshooting of the newer DC brushless systems. In the final section of this study unit, it will look at the troubleshooting of AC inverter drive systems. These drive systems control AC motors. At the end of this unit the apprentice will be able to: describe various methods of controlling the speed and direction of a DC motor, explain the proper steps for troubleshooting a DC motor controller, list the various types of stepper motor drives and explain how to troubleshoot these systems, define how DC servo systems operate and explain the normal test points for locating faults in these systems, list the types of adjustable frequency drives and explain how to troubleshoot their circuits, describe how brushless servo systems operate and how to troubleshoot various problems with these systems.

Troubleshooting Sensing Devices and Systems (086066)
Apprentices will learn about different types of industrial input devices. In addition, apprentices will study some troubleshooting procedures that will prove useful when one of these devices has failed. When an apprentice complete this study unit, he and she will be able to: identify the components of a typical limit switch and describe how to test these devices, describe the operation of pressure switches, identify, the components of, and troubleshooting procedures for, temperature sensing devices and level indicators, describe, the operation of, and troubleshooting methods for, proximity, ultrasonic, photoelectric, fiber optic, and laser sensors, define the proper troubleshooting methods for sensors that are connected to input modules.

Troubleshooting Industrial Control Systems and Output Devices (086067)
This study unit focuses on various forms of output devices, output modules, closed-loop systems, and human and machine interfaces. This study unit also covers troubleshooting procedures for these systems. When an apprentice completes this study unit, he and she will be able to: describe the operation of relays and solenoids, and procedures for troubleshooting them, explain how to troubleshoot across-the-line starters and contractors, including solid state controlled contactors, explain the importance of arc suppression diodes and resistor and capacitor networks in ouput-device circuits, define the operation of, and repair methods for, simple numeric readouts, explain how DC and AC output modules operate and how to troubleshoot them, identify different types of closed-loop control systems and methods to troubleshoot and repair them, and explain how to troubleshoot and repair human and machine interface systems.

Troubleshooting Industrial Computer Systems and Software (086068)
When an apprentice completes this study unit, he and she will be able to: discuss the principle parts and memory types of a computer motherboard, identify power supply components and ratings, locate the main power supply fuse and identify the type of power supply by its connectors, identify the various types of computer drive systems and their cables, list the repair and troubleshooting procedures for computer hardware and software problems, describe the operation of, and troubleshooting procedures for, optical and radio frequency identification systems, and explain the purpose of vision system hardware and software, and the troubleshooting procedures for them.

Industrial Computer Networks (086069)
This study unit provides apprentices with an introduction to industrial networks. Apprentices will become familiar with the terminology and learn about the components used in these systems. Apprentices will realize that industrial networking is an exciting and fast growing field. When an apprentice completes this study unit, he and she will be able to: describe the methods of communication within networks, explain the configurations of various types of industrial network systems, identify and describe different types of network cables, discuss various network protocols, describe troubleshooting methods for networks.

Logic Circuits (ICS B08) 42 hours
Logic Circuit Fundamentals (B0801)
This unit will explain the principles of logic according to Aristotle and Bode; describe logic in electronic systems using correct vocabulary; describe the binary approach to electronic logic, how gates express logic, electronic logic systems. The apprentice will understand the symbology of logic expressing logic concepts and principles, practical uses for logic concepts, symbols of logic gates, concepts of logic circuitry, how to read logic circuitry diagrams and how to apply them to real circuitry. The unit describes logic devices in industry including kinds of devices that put logic concepts into operation, devices for combinational logic circuitry, devices for sequential logical circuitry and families of logic devices, reviews the fundamentals that apply to logic systems, including diode hookups that perform logic functions, bipolar transistor logic, MOS transistor logic, open-collector logic circuits, saturated and nonsaturated logic operation, and ECL circuit concepts, and explains how to relate logic symbols to discrete circuitry; relate logic functions to monolithic logic devices and interconnect logic components and devices; describe logic circuit functions.

Introduction to Number Systems (B0802)
This unit discusses what a number system is; defines numbering; explains why there is more than one system, describes applications for numbering concepts, number systems common to electronics, how number systems are put to work, concept of a numbering base and principles of positional value. The apprentice will learn numbering including decimal and the base 10, how it came about and why it's practical, how decimal numbering applies to metrics, how base-10 numbering works, positional values in base-10 numbering and manipulating base-10 numbers, binary numbering including binary and the base 2, how binary numbering came about, what binary numbers are used for, how binary numbering applies to logic systems, how base-2 numbering works, positional values in base-2 numbering, and manipulating base-2 numbers. The unit describes octal numbering including octal and the base 8, how octal numbering came about, what octal numbers are used for, what is meant by split octal, how octal numbering applies to industrial systems, how base-8 numbering works, positional values in base-8 numbering and manipulating base-8 numbers. The unit concludes with a description of hexadecimal numbering including hexadecimal and the base 16, how hexadecimal numbering came into existence, what hex numbers are used for, notation conventions for hexadecimal numbers, how base-16 numbering works, positional values in base-16 numbers, manipulating base-16 numbers.

Logic Devices and Diagrams (B0803)
This unit describes AND gates: what AND does, construction of an AND gate, truth tables for AND devices and typical applications; shows an understanding of diagrams using various AND devices, describes NAND gates: what NAND does, construction of a NAND

gate, truth tables for NAND devices and typical applications, shows an understanding of diagrams using NAND devices, describes OR gates: what OR does, construction of an OR gate, truth tables for OR devices and typical applications; shows an understanding of diagrams using OR devices. The unit goes on to describe NOR gates: what NOR does, construction of a NOR gate, truth tables for NOR devices and typical applications; shows an understanding of diagrams using NOR devices. Describes XOR gates: what XOR (EOR) does, construction of an XOR gate, truth tables for XOR devices and typical applications; shows an understanding of diagrams using XOR devices. Describes XNOR gates: what XNOR does, construction of an XNOR gate, truth tables for XNOR devices and typical applications; shows an understanding of diagrams using XNOR devices. Describes the packaging of Logic Devices including nomenclature and package characteristics and specs; shows an understanding of SSI, MSI, LSI, and VLSI specification sheets for logic devices, symbols for gates, and other logic devices, pinout diagrams - partial and complete - interpreting operation speed of logic devices, propagation delay, logic device fanout, input loading characteristics and noise figure.

Logic Families (B0804)
This unit describes RTL logic: how RTL is constructed, relevant specifications, typical applications, and diagrams, describes DTL logic: how DTL is constructed, relevant specifications, typical applications, and diagrams. Describes TTL-T 2 L logic: how TTL is constructed, relevant specifications, typical applications, and diagrams. Describes CMOS, NMOS, PMOS, and HMOS logic: how MOS devices are constructed, relevant specifications, typical applications, and diagrams. Describes I 2 L logic: How I 2 L devices are constructed, relevant specifications, typical applications, and diagrams. Describes ECL logic: how ECL devices are constructed, relevant specifications, typical applications, and diagrams. Describes other logic families: how they are constructed, relevant specifications, typical applications, and diagrams. Describes sequential logic devices: how flip flops operate, how R-S flip-flops are made, how D-T flip-flops are made, truth tables for R-S and D-T flip-flops, and applications. Describes advanced sequential logic: what's inside a J-K flip-flop, how a J-K operates, J-K truth table, and recent solid-state indicators. Describes display devices for logic systems: light-emitting diodes, seven-segment LEDS, and more recent logic indicators.

Applications of Logic Circuits (B0805)
This unit explains simple logic circuits including divider networks, binary ladder, and magnitude comparator, explains gates in logic circuits, understand simple binary decoding, figure out combinational arrangements, understand Boolean combination techniques, and three-state buffer drivers, lists applications for sequential logic-latching and binary storage, registers, shift registers, binary multipliers, ripple counters, waveform timing in counters, half- and full-adders, decoder techniques, multiplexers and parallel serial converters, arithmetic-logic unit: show how to add, subtract, multiply and divide; and explains the relationship of ALU in digital computers.

Troubleshooting Logic Circuits (B0806)
This unit identifies what to test in logic circuitry: source voltage levels for TTL, CMOS, ECL, purity of DC voltages, foil runs system grounds, steady-state logic values, timed logic streams, identify the instruments for testing logic circuitry, DMM requirements; simple LED logic indicators, logic probes, with pulse latches, logic injector, triggered oscilloscope specifications. The unit describes the techniques for logic circuit testing including precautions with instrument connections, DMM measurement techniques; connecting and using a logic probe for steady-state logic tracing, pulse streams, and trap glitch pulses; where and when to use a logic pulser measuring logic high-time and low-

time, timing of clock signals, verifying system grounds and bus analysis, and describes the technique for replacing logic devices including MOS-device precautions, selecting the right replacement, speed in logic devices, demounting logic components and remounting logic components.

Basic Industrial Computer Systems (ICS B10) 35 hours
Industrial Computer Fundamentals (B1001)
This unit gives an overview of industrial computer uses including a history of computing in industry, analog computer development, digital logic in computer development, advent of bit-slice "microprocessors," monolithic microprocessors and LSI, and the microprocessor as the heart of the industrial computer, describes industrial computers: what goes on inside an industrial computer, what goes on outside an industrial computer, microcomputer on a single chip, readout displays for industrial computers, industrial computers without displays, how micro- and mini-computers suit industrial applications, and where mainframe computers fit into industrial operations. The unit gives examples of computers at work in industry including computer-aided design, computer-guided machinery, computer-directed research and analysis, controlling industrial and chemical processes, failure analysis and maintenance, programmable controllers for materials handling, nondestructive testing, measurements, inventory and supply logistics, and project control, reporting, and modeling. Lists the software required for industrial computers and tell what is needed (for systems in the above examples), who supplies it, and requirements for writing software; explain the function of programmers, systems analysts and technicians; describes methods for developing and debugging software. Explains the future of computers in industry.

Digital and Analog Systems (B1002)
This unit gives a detailed overview of analog computer development: describes what analog computing is, underlying principles, examples of present-day analog computers, mechanical vs. electrical analogs and how analog computers fit into industry. Gives a detailed overview of digital computer development: describes what digital computing is, underlying principles, why digital computing has largely replaced early analog computers. Describes the principles of control as used in industry including sensing control variables, switching control, proportional control and its variants, three-mode control, loop concepts of controlling processes, and open and closed loops. Tells how analog control systems operate including measurement techniques, processing analog signals and applying analog control. Tells how digital control systems operate including the nature of digital signals, converting analog measurements to digital signals, processing digital signals, applying digital control and converting digital back to analog.

Software and Programming (B1003)
This unit discusses software for industrial systems: defines software, what systems need software, and gives industrial software examples. Describes the types of industrial software: what is available, where does it originate, how to prepare your own software, ladder diagrams, BASIC-language programs, Boolean algebra for logic systems, and assembly language programs. Identifies the symbology for controller programs including: the symbols used to portray ladder logic, BASIC, how to apply Boolean algebra principles, and how to use assembly language. How to write simple programs, using ladder logic, in BASIC, using Boolean algebra in assembly language.

Computer-Aided Control Systems (B1004)
This unit describes computer-aided design and computer-aided manufacturing: including what they are, who uses CAD and CAM and for what, and required hardware and

software. Gives a brief history of CAD and CAM. Explores the benefits of CAD and CAM: how they increase productivity, decrease costs, improve product quality, reduce project turnaround time and benefit personnel. Explains how to select and install CAD and CAM systems in industry: identifies applications for CAD and for CAM in circuit board design, integrated circuit design, hardwired circuit design, generating Numerical Control data, plant design and other possibilities. Lists sources of CAD and CAM information.

Interfacing Principles (B1005)
This unit explains the concept of interfacing and tells why interfacing hardware is needed: describes serial interfacing, parallel interfacing and input-output categories. Understands analog to digital interfacing; explains when you need A to D, A to D methods, and applying A to D principles; describes sample and hold methods; explains why you need signal conditioning. Identifies applications (closing the loop); making measurements, controlling machines, and controlling processes. Explains multiplexing and time sharing; tels why and when to multiplex, how to multiplex digital data and how to multiplex analog data. Explains communications standards: reviews synchronous and asynchronous data; serial RS232C, RS442, RS423; parallel S100, 6800, IEEE488, IEEE583; reviews ASCII; long distance communications techniques; process control loop standards; sources for communications standards.

Total Hours Fifth Six Months **194 hours**

Sixth Six Months:
Introduction to Microprocessors (ICS B11) 28 hours
Introduction to Computers (B1101)
This unit gives an overview of how computers are used in industry and business, lists the main types of computers, names the important activities performed by people who work with computers, explains how computers are selected and what must be considered before they are selected and installed.

Introduction to Microprocessor Applications (B1102)
This unit explains what microprocessors are and the kinds of work they do, tells what makes it possible for them to accomplish so much, lists some of the recent applications microprocessors are found in.

Microprocessors Basics, Part 1 Underlying Principles and Concepts (B1103)
This unit explains the importance of binary arithmetic in microprocessor work, sketches the common logic circuits, identifies the output conditions for the different possible input conditions for logic gates.

Microprocessors Basics, Part 2 Overview of what's in a Microprocessor (B1104)
This unit draws a block diagram of a basic microprocessor unit (MPU), tells what bytes and bits are and how they enter and exit an MPU, explains how the MPU identifies, sorts, and holds bytes, lists some of the activities of the ALU work center.

Pulse Circuits (ICS B07) 42 hours

Pulse Techniques (B0701)

This unit describes the term pulse and how it differs from nonpulse waveforms, names and explains six terms that specify pulse dimensions, lists four ways that pulses are generated or developed, and describes the frequency content or makeup of square waves, rectangular waves, sawtooth, and triangular waves, spikes, and half sine waves.

Pulse Generators (B0702)

This unit reviews the main methods of generating pulses, reviews the concept of time constant and its relationship to pulse circuits, explains the response of differentiator and integrator circuits to sine waves and pulses, discusses pulse generation by sine wave clipping, describes how pulses are developed by the relaxation oscillator, multivibrators, and switching circuits and describes the operation of the Schmitt trigger.

Waveshaping Circuits (B0703)

This unit explains the operation of circuits for forming square and rectangular waves, sawtooth waves and triangular waves, tells how pulses are stretched, narrowed, widened, and otherwise shaped or reshaped, discusses the response of pulses to capacitors, transformers, and inductors and illustrates how a clamper is used to restore shape to a pulse or a pulse series.

Timing (B0704)

This unit discusses free-running and nonsynchronized pulses, describes the 555 timer and names its applications, shows examples of using crystals for frequency stabilization.

Pulse Circuit Applications (B0705)

This unit reviews the uses of pulses in switching circuits, tells how pulses are used in computers, explains the concept of how pulses fits into data communication, discusses digital audio and television techniques and describes five uses of pulses in industry.

Troubleshooting Pulse Circuits (B0706)

This unit sketches typical oscilloscope waveforms for good pulses, identifies possible causes of trouble while examining photos or sketches of distorted pulses, shows how to use a logic probe in troubleshooting digital pulse circles, demonstrates the use of a pulse generator in circuit troubleshooting and describes the steps to troubleshoot resistance welding and other industrial equipment using pulses.

Linear and Digital Integrated Circuits (ICS B09) 42 hours

Linear and Digital Circuit Principles (B0901)

This unit explains the operating principles for linear devices: what is "linear" operation, curve characteristics in diodes, transfer curves in bipolar transistors, Class A amplifier operation, classes B, AB, and C with linear devices, from bipolar to JFET to IGFET to metal-oxide-silicon and concepts in the evolution of linear ICs. Explains the operating principles for digital devices: what digital operation is and how it came about; advantages of digital operation (over linear), switching diodes and transistors, bi-polar digital transistors, MOSFET technology for digital applications, and digital IC concepts. Describes the operating characteristics of linear ICs: what you learn from the specification sheet, explanation of major parameters, construction of linear ICs, connecting linear devices in practical circuits, transfer curves, what they mean to operation and densities of IC packaging. Describes the operating characteristics of digital ICs: what you learn from

the specification sheet, explanation of major parameters, construction of digital ICs, connecting digital devices in practical circuits and densities of digital IC packaging.

Integrated Circuit Techniques (B0902)
This unit describes how integrated circuits are made including materials in linear ICs, manufacturing techniques for ICs, functions built into linear ICs, functions built into digital ICs, and how techniques affect operating characteristics. Understands data sheets and IC operation, read spec sheets and relate parameters to functions, describe transfer curves for linear IC devices, transfer curves for digital IC devices, and how ICs are selected for industrial purposes. Describes modern integrated circuits for industry; understand linear IC application principles, digital IC application principles, and hybrid IC application principles. Understands integrated circuit applications including typical uses for RTL, DTL, TTL, ECL, CMOS, NMOS, and PMOS. Describes IC packaging for industrial uses, package outlines, pinout conventions, and effects of environment on packaging, and how environment affects mounting.

Linear Integrated Circuits (B0903)
At the end of this unit the apprentice will understand advanced linear operating concepts: linear operation in solid-state devices, basic analog functions, analog functions in common use, and analog functions in industrial applications, the uses of linear ICs in industry: circuits for linear ICs, linear ICs in industrial research, control operations for linear ICs, and sensing and processing with linear ICs, how to select a linear IC for industrial purposes including input requirements and output capabilities. The unit identifies circuit applications for linear ICs: oscillators and frequency control, operational amplifiers, differential amplifiers, phase comparators, and other linear applications in industry; how to find more applications information.

Digital Integrated Circuits (B0904)
At the end of this unit the apprentice will understand advanced digital operating concepts: digital operation in solid-state devices, basic digital functions, digital functions in common use and digital functions in industrial applications. Identifies the uses of digital ICs in industry: circuits for digital ICs, digital ICs in industrial research, control operations for digital ICs, and sensing and processing with digital ICs; how to select a digital IC for industrial purposes including input requirements and output capabilities. Identifies circuit applications for digital ICs: clocks, oscillators and frequency control, analog-to-digital conversion, digital-to-analog conversion, processing digital sense signals, time phase relationships in digital operation and other digital applications in industry; how to find more applications information.

Integrated Circuit Logic Systems (B0905)
At the end of this unit the apprentice will understand logic diagrams for industrial equipment: recognize various symbols, identify logic operations common to industrial purposes and how gate combinations are designed. This unit shows how to use logic devices in industrial circuits: interchangeability of logic gates, truth tables affected by gate material, simple flip flop latches, clocked flip flops, monostable and bistable multivibrators, and other pulse generators. Shows how to interface logic devices including source requirements, buffering and fan-in, fan-out, three-state logic and its purposes and managing open-collector logic. Shows how to use gates and flip-flops including AND, NAND, OR, NOR, exclusive-OR, exclusive-NOR; describe the effects of family on gate functioning - TTL, ECL, MOS.; explain memories in industrial equipment. Identifies industrial equipment using logic concepts including industrial robotics, programmable

controllers, computer-aided design systems, computer-aided manufacturing processes and industrial data-processing.

Troubleshooting IC Systems (B0906)
This unit explains the principles of testing integrated circuits: verifying Vcc, Vss, Vdd, Vbb; how to identify pins, and reach them; adapters for IC testing; bent pins and cold joints; verifying inputs; verifying quality and timing of outputs, and multichannel testing. Lists the instruments for IC testing: explains how to use a DMM for simplified testing, how to interpret logic probe indications, uses for pulse injection, clip-on logic analyzers for ICs, signature analysis as an IC test tool, oscilloscope testing in IC circuitry. Describes advanced IC troubleshooting methods including special jigs to save time, pretesting on unfamiliar equipment, storage scopes, and advanced equipment. Describes the techniques for replacing ICs: desoldering, resoldering, sockets, precautions in handling ICs, and tools for removal and reinsertion.

Total Hours Sixth Six Months 112 hours

7th Sixth Months:
Microprocessor Applications (ICS B12) 96 hours
Working with an Uncomplicated Microprocessor (B1201)
The MC6802, Part 1
In this unit the apprentice will learn to power up the XK-300 Microprocessor Trainer, measure AC, DC, and ripple voltage in an MPU power supply, trace and test Vcc and Vss and other connections, bring data from direct or extended addresses memory, set a CCR flag to force a program branch, decode an address and use the memory-mapping concept of in/out control and address either on-chip or external RAM.

Microprocessor Programming Principles, Part 1 (B1202)
In this unit the apprentice will learn to convert numbers between hexadecimal, octal, and binary forms, follow and write simple programs in hexadecimal, store a program and run a program using the microprocessor trainer, prepare and run a program which subtracts hexadecimal numbers and use two's complement to find the decimal value of a negative-signed binary number.

Working with an Uncomplicated Microprocessor (B1203)
The MC6802, Part 2
In this unit the apprentice will find the entry vectors for four major types of interrupts, arrange either a one-bit or a whole-byte prompts, locate output addresses in a memory-mapped MPU system, explain how an MPU receives binary input data from a hexadecimal keypad, display contents of memory chips in D5 RAM and ROM, and mapping the memory and use single-step execution for software debugging.

Microprocessing Programming Principles, Part 2 (B1204)
This unit provides a flow chart and streamline programs, uses mnemonics, document program plans with comments, differentiates between effective address and object code, programs the MPU to do advanced arithmetic, builds a reference book of routines and subroutines and control program execution by judicious use of jumps and branches.

Interfacing through Serial and Parallel Ports (B1205)
The apprentice will learn an explanation of the difference between serial and parallel data transfer, memory-map a peripheral interface adapter, configure PIA ports for input or output or both, uses interrupts to bring an outside task to the attention of the MPU,

describes the concept of parity, explains synchronous and asynchronous events, inputs and output data in the pulse mode and the handshake modes, discusses how data is recorded on magnetic tape through a cassette and manages the protocol between MPU, line printer, and video terminal.

Troubleshooting Microprocessor Equipment (B1206 & B1207)
Part 1 -The apprentice will be taught to arrange trial runs to judge performance and locate faults, the four main steps in tracing a specific breakdown, how to use key test points to check software and eliminate bugs how to design diagnostic routines that exercise various portions of a system, how to assess system operation by using breakpoints and the uses of assemblers, compilers, and interpreters.

Part 2 - In this unit the apprentice will learn how to use test instruments for troubleshooting, including triggered and storage oscilloscope, digital multimeter, logic probe, logic analyzer, signature analyzer, and digital pulser, how to check out a microprocessor against system specs, about necessary precautions around an MPU, how to check out buses and control fines and clock and how to check out RAM and ROM keyboards, video terminals, printers, disk drives, and cassette machines.

Other Families of Microprocessors (B1208)
This unit describes other popular MPUs and their special features, tells of unusual instructions and addressing modes and how to order and use spec sheets for MPUs and devices.

Industrial Electronic Circuit Applications (ICS B14) 35 hours
Interfacing Process Variables (B1401)
This unit gives the apprentice an understanding of process measurement and control; describes process variables, closed loop control, how to classify sensors, error source circuits, compares computer control with traditional control; describes traditional closed loop control, SPC computer control, and DDC computer control; identifies the advantages of computer control and its hardware/software. The unit continues with a description of temperature, pressure, flow, humidity, weight, and level; explains how each is measured and controlled; list the types of sensors used for each and identifies the applications, describes typical position sensors and their applications, defines analysis and speed; explains how to measure and control them; and describes the sensors used and their applications.

Motor Control and Servo Systems (B1402)
This unit provides a review of AC and DC motors: converting electric power to rotational power, DC motor concepts, electronic commutation, AC motor concepts; explains the concepts of work, load, torque, and slippage. Discusses how industrial motors are controlled: describes motor, control diagrams, and the principles of controlling motors; explains how speed and torque are sensed and indicate motor performance; explains how to process motor performance feedback and apply corrective signals to AC and DC motors. The unit continues with a discussion of the principles of electronic servomechanisms including older analog systems, modern digital servo systems, positional sensing in rotational devices, reference signals, developing correction signals, applying correction signals, speed correction, phase correction, and programming industrial servo systems, describes motor control systems: types still using gaseous-tube controllers, solid-state controllers, and servo systems. The unit concludes with how to read motor-servo diagrams.

Numerical Control Systems (B1403)
This unit explains what is meant by numerical control including point-to-point control and contour control; compares absolute and incremental systems, describes what makes up an NC system, what the controller does, some typical drives, and the servo components. The unit discusses the operation of an NC machine: data and control inputs, outputting control signals, closed vs. open loop, and ancillary features; identifies the media for control programs: paper tape, magnetic tape and computers. The unit identifies applications for NC: milling, drilling, reaming, counter boring and laping, spot facing, and boring.

Programmable Controllers (B1404)
This unit states the basic purpose of a programmable controller and its relationship to computers and to robots, provides an understanding of a simple PC system: the block diagram, programmer (operator I/O), memory (PROM & ROM), and sequencer. The unit describes programming formats including Boolean algebra, and ladder logic, explains flow charting and program coding, and describes interfacing: include analog input, analog output, and parallel I/O. The unit ends with a detailed description of a typical controller including operator I/O, memory, and sequencer.

Industrial Robots (B1405)
This unit gives an overview of industrial robotics, provides an understanding of the make-up of an industrial robot including the controller, manipulator, and gripper, explains how to classify industrial robots: low technology-LTR's, medium technology MTR's, and high technology-HTR's, gives a detailed explanation of a typical LTR, MTR, and HTR including the controller, manipulator, and gripper, identifies present applications for industrial robots when press loading, die casting, welding, and others and list sources of additional information.

Programmable Controllers: Principles of Operation (ITPL01) 6 hours
This comprehensive Activ® and INVOLVE interactive multimedia training program consists of three lessons that train apprentices to understand programmable controller system operations; interpret power flow through ladder logic; and principles of operation, characteristics, and capabilities of analog control using programmable logic controllers. This lesson covers the basics of programmable controller systems. It describes what a programmable controller is, its hardware and software components, and how it functions in an industrial environment. After completing the lesson, the apprentice will be able to: identify the major hardware components of a programmable controller system and how they work together, identify the various software components of a programmable controller system and their functions. Identify I/O terminals through addresses and use I/O documentation to find the addresses of field devices as well as use I/O modules indicators and tables to determine status of input and output devices.

Programmable Controllers: Interpreting Ladder Logic (ICS ITPL02) 6 hours
This comprehensive Activ® and INVOLVE interactive multimedia training program consists of three lessons that train apprentices to understand programmable controller system operations; interpret power flow through ladder logic; and principles of operation, characteristics, and capabilities of analog control using programmable logic controllers. This lesson teaches how to interpret programmable controller ladder logic. The lesson defines the program elements of ladder logic and the functions that they perform. This includes contacts, coils, and data functions as well as many of the common ladder logic arrangements. After completing the lesson, the apprentice will be able to: interpret power

flow in circuits containing many program elements, recognize circuits designed to start equipment, start circuits with sealing (holding contacts), stop circuits, and in circuits that contain the following: normally open contacts to represent normally closed field devices, timer functions, counter functions, math functions, data comparison functions and data transfer functions.

Programmable Controllers: Analog Control (ICS ITPL03) 6 hours

This comprehensive Activ® and INVOLVE interactive multimedia training program consists of three lessons that train apprentices to understand programmable controller system operations; interpret power flow through ladder logic; and principles of operation, characteristics, and capabilities of analog control using programmable logic controllers. This lesson teaches the difference between discrete and analog control and how PLC's implement PID control modes. It shows different hardware configurations and how process data is transmitted between components on a data highway. Programming languages including ladder logic and function block statements are presented. Additionally, the lesson shows how PLCs actually work in different process applications and some routine and preventative maintenance techniques. After completing the lesson, the apprentice will be able to: describe the differences between discrete control and continuous process control, describe how PLCs implement proportional, integral, and derivative process control, list and explain hardware for PID control, explain the purpose of A/D converters, describe typical field devices connected to PID modules, describe the types of input signals generated by analog field devices, explain the functions of a data highway, explain factors that could affect the speed of data transfer and communications between PID modules, understand the PLC/PID systems to monitor a given process, explain the uses of single loop and group displays, identify typical programming languages for PID control, explain how PID algorithms are configured in PLC software, identify other configuration functions available for analog control, identify other configurations for advanced control strategies, describe the execution of a typical PID program, explain how scan times affect program execution, describe how to change from automatic to manual control modes, describe the application of PID control using a PLC in a blending process, describe the application of PID control using a PLC for water quality control and explain analog I/O verification.

Industrial Process Control: Single-Loop Control (ICS ITPC01) 6 hours

This comprehensive INVOLVE® interactive multimedia training program was produced in association with the Instrument Society of America. (ISA). This two lesson program trains participants in the concepts and principles of process control modes. This lesson presents the principles of single-loop control and the applications of feedback control in the industrial environment. Also introduced are various control modes including on/off, proportional, integral, and derivative control. After completing the lesson, the apprentice will be able to: define and site industrial control, define process variable, compare manual and automatic process control, adjust the set point on a pictorial representation of an industrial controller, identify the controlled, measured, and manipulated variables of a heat exchanger system, define deviation, identify the system response for various control modes, define load change, identify the elements of process control, identify the action of the final control element of various control systems, identify the dead zone or dead band on an on/off control response curve, compare and contrast the action of a final control element in an on/off control system with a proportional control process, identify reverse- or direct-acting control with an example of measurement and subsequent output response, define proportional control in relation to response error, determine the setting of the controller's proportional band and gain on a pictorial representation of process control action, identify offset on an example of proportional only control, define integral control in

relation to error signal, identify minutes per repeat and repeats per minute with an example of the units used in integral control, define reset wind up on a process response curve for an integral controller, identify the effects of reset wind up on the elements of process control on a heat exchange system and define derivative process control in relation to error signal.

Industrial Process Control: Multiple-Loop Control (ICS ITPC02) 6 hours
This comprehensive INVOLVE® interactive multimedia training program was produced in association with the Instrument Society of America. (ISA). This two lesson program trains participants in the concepts and principles of process control modes. This lesson explains the application of multiple-loop control strategies to industrial process control systems. The lesson also explains the operation of several types of digital process control systems. After completing the lesson, the apprentice will be able to: identify the benefits of advanced process control strategies, compare feedback and feedforward control, explain the principles and applications of a feedforward control system, explain the principles and identify the benefits of cascade control, discriminate between wild and controlled flows in a ratio control system, explain the principles and applications for ratio control, explain the principles and application of adaptive and selective control and identify the method of process.

Interpreting Process Control Diagrams (ICS ITPC03) 6 hours
This comprehensive INVOLVE® interactive multimedia training program was produced in association with the Instrument Society of America. (ISA). This one lesson program trains apprentices how to interpret process and instrument diagrams. This lesson introduces the common instrument and line symbols and notations used on process control and loop diagrams. The interpretation of process control and loop diagrams is presented as well. Emphasis is placed on identifying the functions of components within the process control system. After completing the lesson, the apprentice will be able to: identify the function, measured variable, location and accessibility, and loop identification of an instrument given its symbol and tag number, identify the type of connection between an instrument and the process to which it is connected when given a tag number, identify signal line types (pneumatic, electrical, capillary, or internal software link), identify the type of valve actuator (diaphragm, motor, solenoid, or piston) when given a symbol, describe the information available in a typical process control diagram, title block, revision list, materials list, and notes block, describe the functional operation of the systems represented in typical process control diagrams, understand the function of loop diagrams and their relationship to process control diagrams, understand the purpose of each of the four areas of a typical loop diagram, identify the location and type of each instrument port connection, junction box, and power source as well as the controller action for the instruments in a loop diagram and describe the functional operation of the systems represented in a typical loop diagram.

Total Hours Seventh Sixth Months 167 hours

Eighth Sixth Months:
Voltage and Frequency Controllers (ICS B1501) 7 hours
This unit describes an AC voltage control: gives an overview of suitable active devices; explains the ON-OFF control; discusses how to use phase control. The unit describes a DC voltage control including both the AC to DC approach and the DC to AC approach, discusses frequency control including the motor-alternator approach and static frequency

conversion, describes motor control circuits; discusses how to control DC motors, AC motors and universal motors; and describes power circuits.

Nondestructive Test Equipment (ICS B1502) 7 hours

This unit provides an overview of nondestructive testing, lists the various types of nondestructive test methods including the magnetic particle method, the filtered particle method, the electrified particle method, the penetrant method, the ultrasonic method, the radiographic method, the eddy current method, and the stress method. The unit describes the principle of operation, procedure, and chemical and/or hardware requirements of each method and cites the common precautions to be taken when working with nondestructive test equipment.

Advanced Troubleshooting Techniques (ICS B16) 42 hours

Approach to Troubleshooting (B1601)

This unit explains the importance of the block diagram approach to troubleshooting, how to classify equipment functions by section, how to locate which stage in a section is the trouble source, how to narrow the trouble to a circuit, how to pinpoint the faulty component, troubleshoot to board level, plan to reduce downtime and explains good safety habits.

Analysis of Systems (B1602)

This unit discusses the importance of understanding the operation before troubleshooting, tells the use of a logical approach to troubleshooting, how to determine the exact trouble before tracking down its cause, shows how to use manufacturers' service manuals, how to use troubleshooting flowcharts, how to measure supply and power-source voltages and how to check input and output voltages.

Test Equipment Applications (B1603)

This unit lists the test instruments considered essential for troubleshooting, names some special instruments for industrial troubleshooting, demonstrates how to use digital multimeters, Vows, and oscilloscopes, explains the use of frequency meters and counters, shows how to use a logic probe and a logic analyzer, names the four types of precision instruments used in industry, and explains their use.

Safe Troubleshooting Practices (B1604)

This unit explains the importance of working safely. Tells how to form safe working habits around electricity, lists precautions to observe when using tools, discusses why faulty equipment is sometimes a safety hazard, shows how faulty grounds present special hazards, describes special safety considerations in medical and hospital equipment and describes first aid for electric shock using CPR.

Troubleshooting Industrial Systems 1 and 2 (B1605 & 1606)

Part 1 - This unit discusses checkout of power sources and supply voltages, states case histories of typical problems and how they were solved, explains approaches to troubleshooting signal-level circuitry, explains approaches to troubleshooting power-level circuitry and tells how to handle "tough dogs" and intermittents.

Part 2 - This unit discusses an approach to troubleshooting numerical control systems, explains the major approach to troubleshooting programmable controllers, describes ways to isolate problems in a chemical process control system, lists important considerations in troubleshooting in hazardous locations, reviews troubleshooting problems in the petro-chemical field and discusses electronic equipment problems in the paper manufacturing industry.

Electronic Instrumentation and Control (ICS B13) 63 Hours
Physical Properties and Their Measurement and 2 (B1301 &1302)
Part 1 -This unit shows the apprentice how to determine the slope of a line and the direction of acceleration vectors, how to calculate centripetal force and angular acceleration, and how to solve problems involving power, work, efficiency, and mechanical advantage.

Part 2 -This unit describes how the properties of a liquid determine a liquid's viscosity, how to convert temperature readings from the English to the SI system. Solve problems involving heat, light, and sound.

Measuring Instruments and Signal Processing (B1303)
This unit teaches the apprentice when given a particular schematic, how to identify the correct circuit function, explains the principle upon which a permanent-magnet meter movement works, how to distinguish between indicating, recording, and integrating instruments, how to correlate the proper logic gate with a typical logic statement and how to select certain working parts, given a particular meter movement construction.

Transducers (B1304)
This unit identifies basic types of transducers and similar sending devices, explains the operating principles of transducers, discusses the characteristics and applications of various types of transducers and shows the apprentice how to select the proper type of transducer for any particular industrial application.

Introduction to Control Systems (B1305)
This unit discusses the types and functions of the components in a closed-loop system, teaches the apprentice to recognize the effect of deviation and duration on control response, explains the functions of the various types of synchro systems, how to calculate signal responses from scaling transducers and describes the function of the microprocessor parts.

Controllers (B1306)
This unit relates the role of the controller in a process control system, identifies the various terms and response characteristics of controller systems, shows the apprentice how to recognize symbols and nomenclature used for controller circuits and how to select the correct module symbol for desired controller action.

Control System Methods (B1307)
This unit describes how the various solid-state logic systems are used in industrial control applications, explains the role of memory units in a control system, discusses the various functions of a microprocessor as applied to control equipment and names the use of programmable controllers.

Data Logging, Transmission and Display (B1308)
This unit relates the nature and kinds of data required for instrumentation and control systems, distinguish between the various methods and types of data collection systems, explain the function of a master control center for industrial applications, discuss the various items of peripheral equipment used.

Control Applications, Maintenance and Troubleshooting (B1309)
This unit discusses maintenance and troubleshooting procedures, relates installation considerations for instrumentation and control systems and works with block diagrams in troubleshooting.

Local Area Networks Fundamentals (ICS X48) 10 hours
This course provides students with the fundamental knowledge to select configure and implement Local Area Networks (LANs). LANs are an essential part of networking in companies today. What are the characteristics of LANs? What kind of hardware and software is needed? What benefits are derived from a LAN? How do server-based LANs and peer-to-peer LANs differ? This course provides answers to these questions and others. Apprentices will learn about topologies, transmission media, the OSI model and IEEE specifications, and resource sharing. Apprentices will learn how to: understand basic LAN terminology, technology, protocols and standards, choose between server and peer LANs, configure LANs for your applications, select appropriate wiring and cables, depict the fundamental hardware and software components necessary to adapt the PC to the network environment, compare Ethernet and Token Ring. Compare 10Base-T, 100BaseX and 100BaseVG, differentiate between FDDI and Fast Ethernet, identify the differences between bus, tree, token ring and star topologies, understand the characteristics of CSMA/CD and token ring access methods and how to identify the role of each layer in the seven layer OSI model and list the IEEE 802.X specifications.

Total Hours Eighth Six Months 129 hours

Total Related Instruction Hours 1,367 hours