Apprenticeship and Industry Training

Instrumentation and Control Technician

Curriculum Guide

031 (2022)

Alberta

Apprenticeship and Industry Training

ALBERTA ADVANCED EDUCATION

Instrumentation and Control Technician: apprenticeship education program curriculum guide

ISBN 978-1-4601-5201-0

Instrumentation and Control Technician
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CURRICULUM GUIDE

Apprenticeship

Apprenticeship is post-secondary education with a difference. Apprenticeship begins with finding a sponsor. Sponsors guide apprentices, and support on-the-job learning through provision of mentorship. Approximately 80 per cent of an apprentice's time is spent on the job under the supervision of a certified journeyperson or qualified tradesperson. The other 20 per cent involves technical training provided at, or through, a post-secondary institution (PSI) – usually a college or technical institute.

To receive their post-secondary credential, apprentices must learn theory and skills, and they must pass examinations. Criteria for the program—including the content and delivery of technical training—are developed and updated by the Registrar.

The graduate of the Instrumentation and Control Technician apprenticeship education program is an individual who will be able to:

- Have an understanding of operating processes as it relates to instrumentation.
- Have a thorough knowledge of precision measurement and calibration.
- Service and repair electronic equipment.
- Apply the principles of Electronics, Pneumatics, Hydraulics, Mechanics and Chemistry.
- Understand the monitoring processes involved in process quality control.
- Service, repair, fabricate and assemble trade related electronic, mechanical, pneumatic, hydraulic, components and process connections.
- Maintain and apply Occupational Health and Safety codes and standards
- Perform assigned tasks in accordance with quality and production standards required by industry.

Apprenticeship and Industry Training System

Alberta's apprenticeship programs are supported by industry stakeholders that ensures a highly skilled, internationally competitive workforce in the province. The Registrar establishes the educational standards and provides direction to the system supported by industry and the PSI's. The Ministry of Advanced Education provides the legislative framework and administrative support for the apprenticeship and industry training system.

Special thanks are offered to the following industry members who contributed to the development of the standard:

Mr. Ken Adams.....Red Deer
Mr. Shannon Lozinski.....Edmonton
Mr. David MacLean .....Drayton Valley
Mr. Robert Matfin .....Edmonton
Mr. Bruce Carson .....Edmonton
Mr. Carl Jarvis .....Grande Prairie
Mr. Wade McNenly.....Fort Saskatchewan
Mr. Shawn Fortier.....Calgary

Alberta Government

Alberta Advanced Education works with industry, sponsor and employee organizations and technical training providers to:

- facilitate industry's development and maintenance of training and certification standards
- provide registration and counselling services to apprentices and sponsors
- coordinate technical training in collaboration with training providers
- certify apprentices and others who meet industry standards

Apprenticeship Safety

Safe working procedures and conditions, incident/injury prevention, and the preservation of health are of primary importance in apprenticeship programs in Alberta. These responsibilities are shared and require the joint efforts of government, sponsors, employees, apprentices and the public. Therefore, it is imperative that all parties are aware of circumstances that may lead to injury or harm.

Safe learning experiences and healthy environments can be created by controlling the variables and behaviours that may contribute to or cause an incident or injury. By practicing a safe and healthy attitude, everyone can enjoy the benefit of an incident and injury free environment.

Occupational Health and Safety

Persons engaged in, or supporting an individual in an experiential learning environment are often exposed to more worksite hazards than in other forms of traditional post-secondary education and therefore should be familiar with and apply the Occupational Health and Safety Act, Regulations and Code when dealing with personal safety and the special safety rules that apply to all daily tasks.

Occupational Health and Safety-OHS (a division of Alberta Labour and Immigration) conducts periodic inspections of workplaces to ensure that safety regulations for industry are being observed.

Additional information is available at www.alberta.ca/occupational-health-safety.aspx

Technical Training

Apprenticeship technical training is delivered by the PSI's throughout Alberta. The PSI's are committed to delivering the technical training component of Alberta apprenticeship education programs in a safe, efficient and effective manner. All PSI's place a strong emphasis on safety that complements safe workplace practices towards the development of a culture of safety for all professions.

The PSI's work with industry and Alberta Advanced Education to enhance access and responsiveness to industry needs through the delivery of the technical training component of apprenticeship programs across the province. They develop curriculum from the curriculum guides established by the Registrar in consultation with the PSI's and industry and provide the technical training to apprentices.

The following PSI's deliver Instrumentation and Control Technician trade apprenticeship technical training:

Grande Prairie Regional College	First Period
Lakeland College	First Period, Second Period, Third Period
Northern Alberta Institute of Technology	All Periods
Red Deer College	All Periods
Southern Alberta Institute of Technology	All Periods

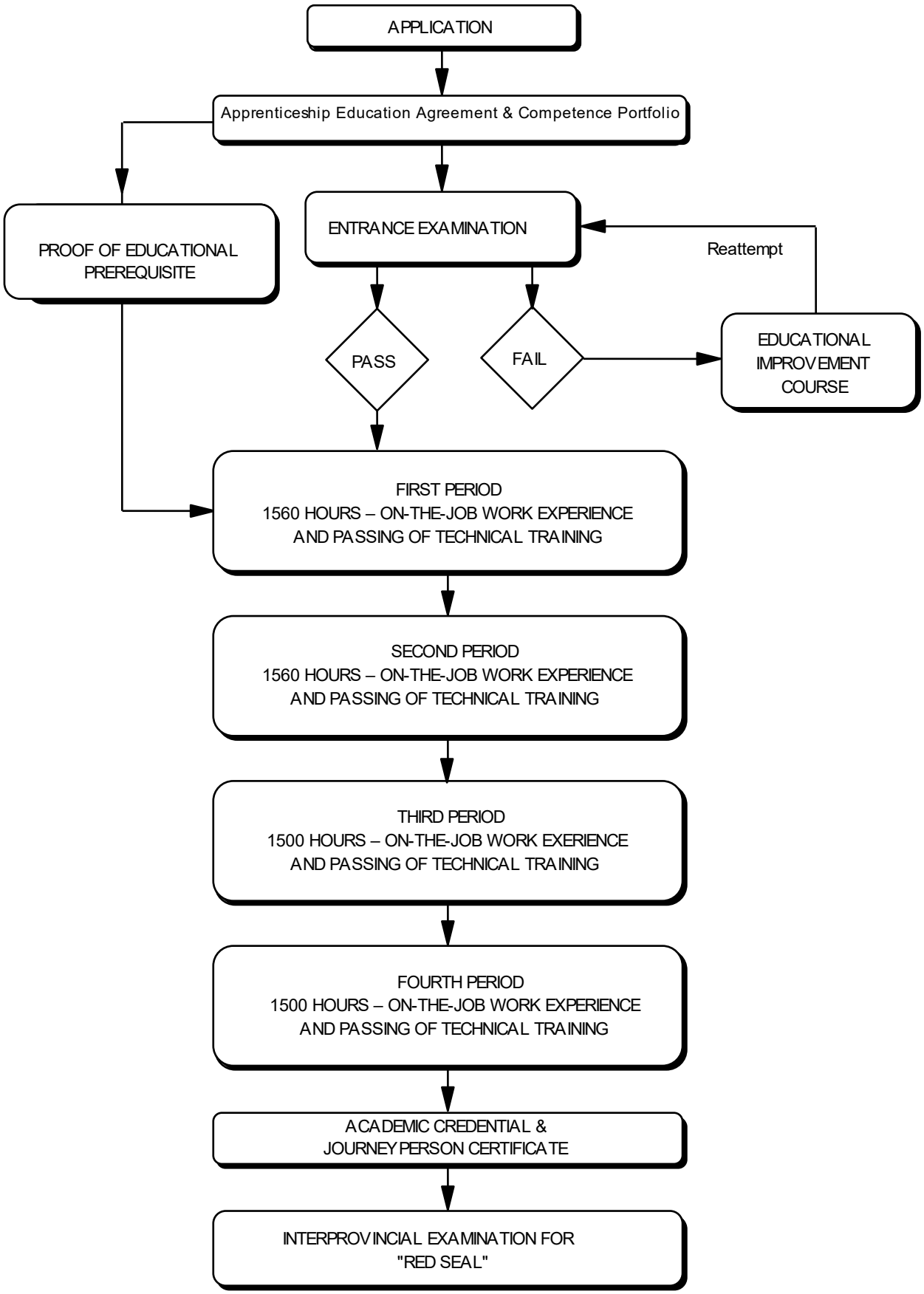
Procedures for Recommending Revisions to the Curriculum Guide

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

Registrar of Apprenticeship Education Programs
c/o Apprenticeship Delivery and Industry Support Services
Apprenticeship Delivery and Industry Support
Advanced Education
19th floor, Commerce Place
10155 102 Street NW
Edmonton AB T5J 4L5

It is requested that recommendations for change refer to specific areas and state references used.

Apprenticeship Route toward Academic Credential



Instrumentation and Control Technician Training Profile
FIRST PERIOD
(8 Weeks 30 Hours per Week – Total of 240 Hours)

SECTION ONE

SAFETY, SHOP PRACTICES, THEORY AND LABORATORY **21%**

A	B	C
Safety Legislation, Regulations & Industry Policy in the Trades 4%	Climbing, Lifting, Rigging and Hoisting 4%	Hazardous Materials & Fire Protection 6%
D	**E**	**F**
Apprenticeship Training Program 4%	Tools and Equipment 8%	Tube Bending and Joining 32%
G	**H**	**I**
Pipe Threading and Joints 18%	Mounting and Support Hardware 12%	Precision Measurement 4%
J		
Electrical and Electronic Connections 8%		

SECTION TWO

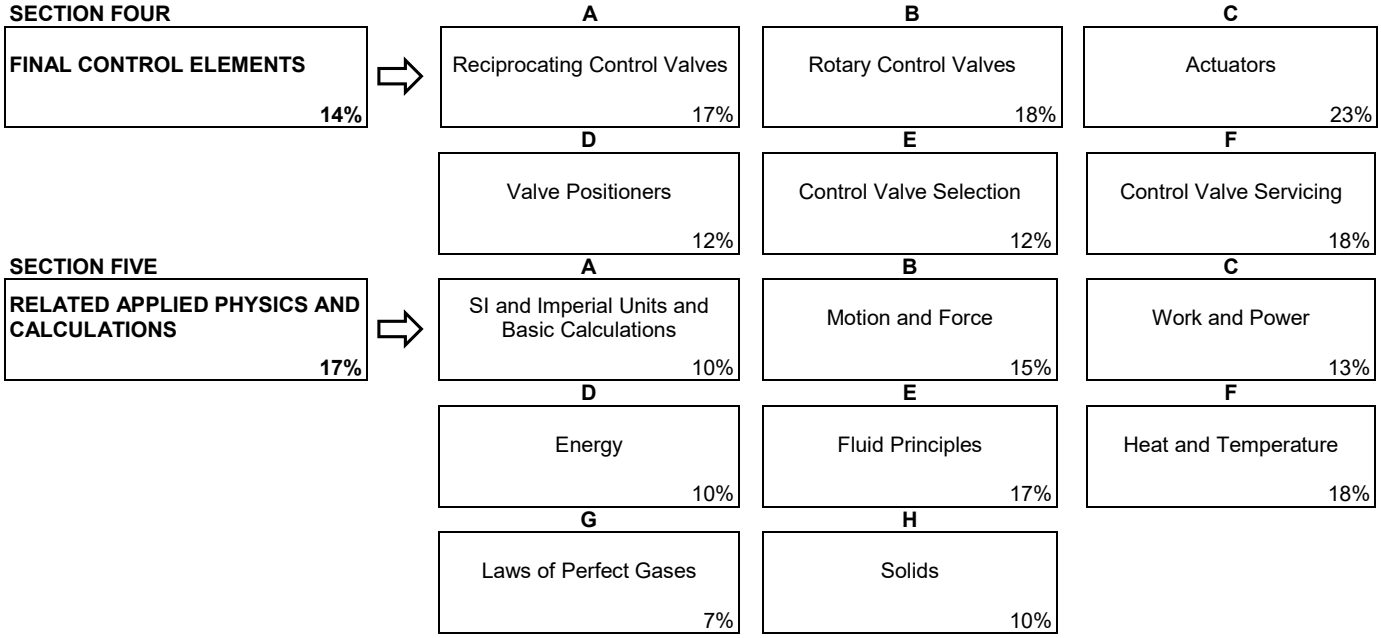
ELECTRICAL THEORY AND SAFETY **35%**

A	B	C
Resistors 5%	Current, Voltage, Resistance and Power 9%	Characteristics of Conductors 2%
D	**E**	**F**
Series Resistive Circuits 7%	Parallel Resistive Circuits 7%	Series-Parallel Resistive Circuits 7%
G	**H**	**I**
Cells and Batteries 5%	Magnetism, Electromagnetism and Electromagnetic Induction 6%	Fundamentals of Alternating Current (ac) 4%
J	**K**	**L**
Inductance and Capacitance 6%	Time Constants 5%	Inductive Reactance and Capacitive Reactance 6%
M	**N**	**O**
Alternating Current (ac) Circuit Properties 4%	Regulations 4%	Area Classifications 7%
P		
Electrical Equipment in Hazardous Locations 16%		

SECTION THREE

BASIC MEASUREMENTS AND CALIBRATION **13%**

A	B	C
Pressure Measurement 15%	Link and Lever Systems 13%	Pressure Gauges 9%
D	**E**	**F**
Pneumatic Components and Feedback Systems 16%	Pressure Regulators 16%	Pressure Transmitters 19%
G		
Chart Recorders 12%		



SECOND PERIOD
(8 Weeks/30 Hours Per Week –Total Of 240 Hours)

SECTION ONE

MEASUREMENT INSTRUMENTS **28%**

A	B	C
Temperature Measurement 12%	Thermometers and Filled Thermal Systems 6%	Thermocouples 12%
D	**E**	**F**
Resistance Temperature Detector (RTD's) 12%	Non-Contact Temperature Measurement 6%	Flow Measurement Fundamentals 4%
G	**H**	**I**
Analog Differential Pressure Measurement 6%	Analog Differential Pressure Flow Measurement 13%	Variable Area Meters / Weirs / Flumes / Flow Switches 6%
J	**K**	
Level Measurement 13%	Analog Differential Pressure Level Measurement 10%	

SECTION TWO

CONTROL INSTRUMENTS **15%**

A	B	C
Introduction to Automatic Control 17%	On-Off Controllers 11%	Proportional Integral Derivative Control (PID) 39%
D		
Pneumatic Controller Tuning 33%		

SECTION THREE

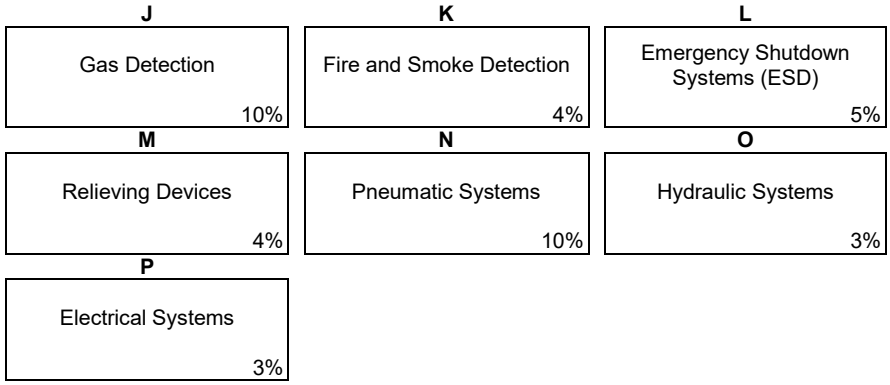
ELECTRICAL AND DIGITAL FUNDAMENTALS **25%**

A	B	C
Electrical Theory 12%	Power Supplies 10%	Introduction to Digital 9%
D	**E**	**F**
Logic Gates 5%	Microprocessor and Memory 3%	Introduction to Programmable Logic Controllers (PLC) 34%
G	**H**	
Introduction to Data Communications 17%	Introduction to Personal Computers and Software Applications 10%	

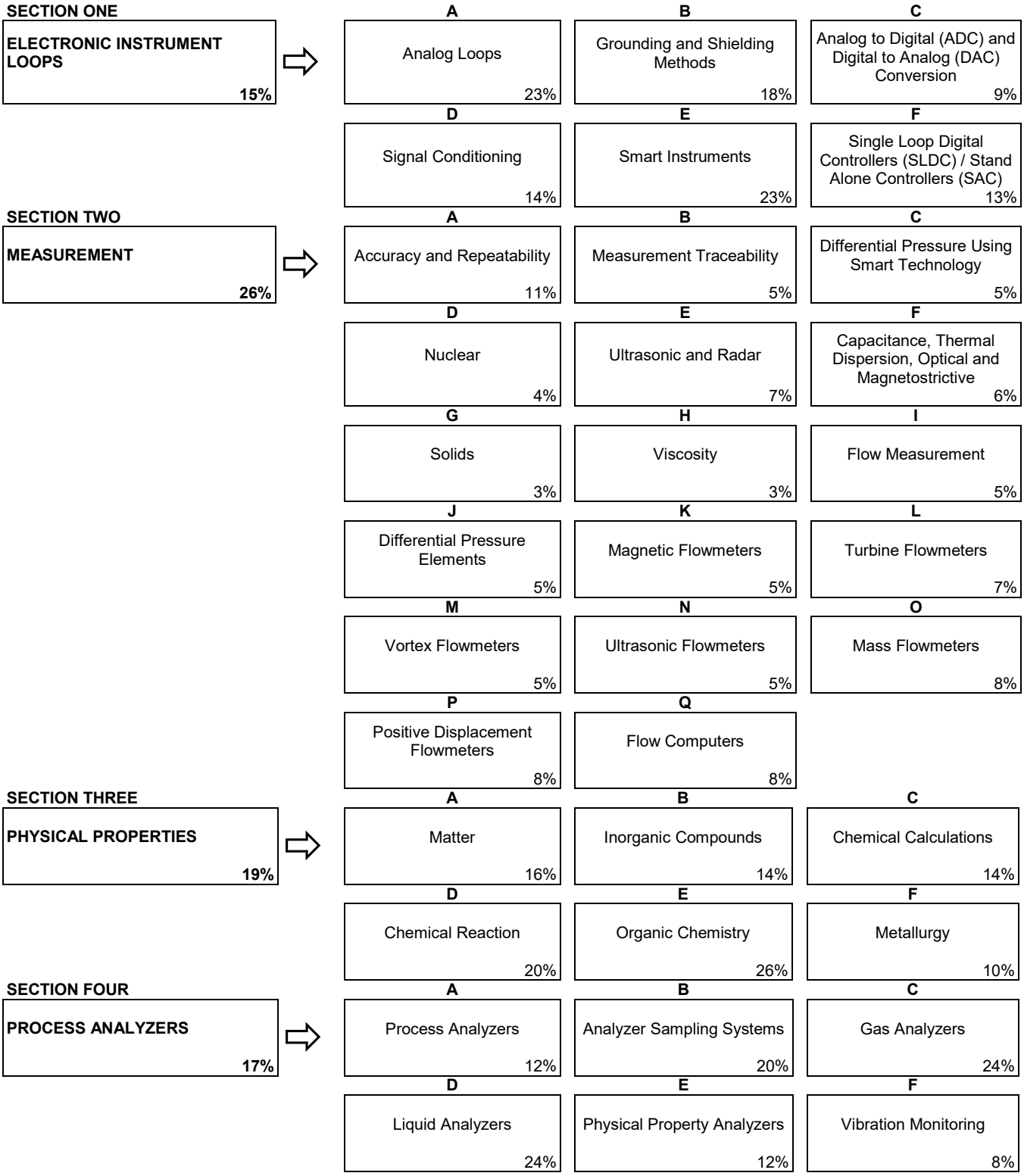
SECTION FOUR

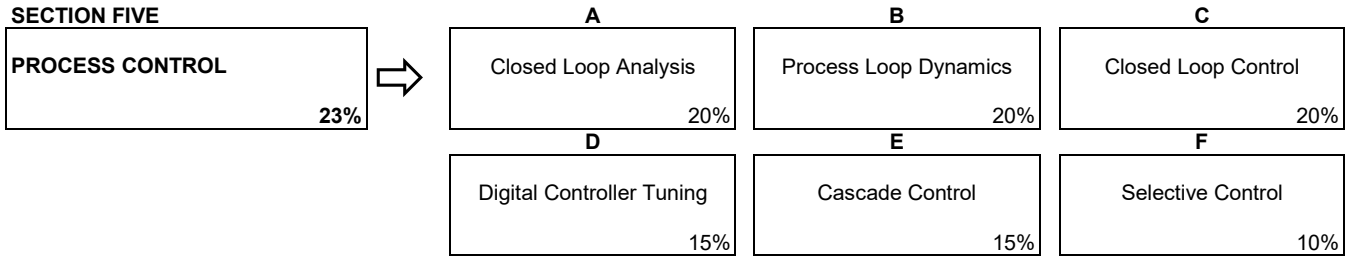
PROCESS EQUIPMENT AND ENERGY SYSTEMS **32%**

A	B	C
Drawings and Symbols 10%	Gas Compression 10%	Liquid Pumping 6%
D	**E**	**F**
Solids and Liquids 6%	Heat Transfer and Evaporation 6%	Drying, Humidification and Dehumidification 6%
G	**H**	**I**
Distillation and Fractionation 4%	Boilers and Direct Fired Heaters 4%	Production and Processing Plants 9%

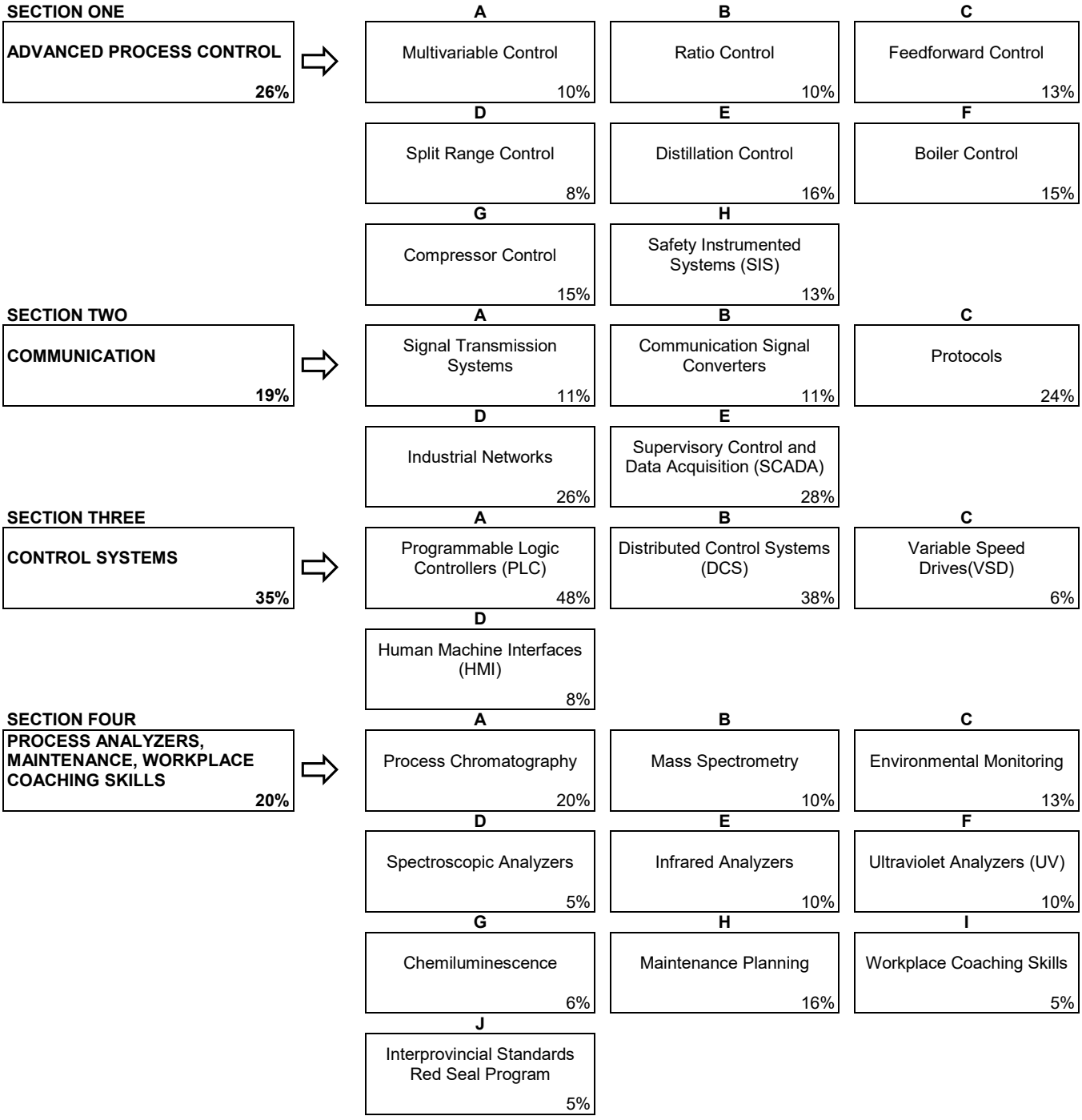


THIRD PERIOD
(10 Weeks 30 Hours per Week – Total of 300 Hours)





FOURTH PERIOD
(10 Weeks/30 Hours Per Week –Total Of 300 Hours)



FIRST PERIOD TECHNICAL TRAINING
INSTRUMENTATION AND CONTROL TECHNICIAN TRADE
CURRICULUM GUIDE

UPON SUCCESSFUL COMPLETION OF THIS PROGRAM THE APPRENTICE SHOULD BE ABLE TO PERFORM THE FOLLOWING OUTCOMES AND OBJECTIVES.

SECTION ONE:..... SAFETY, SHOP PRACTICES,THEORY AND LABORATORY..... 21%

A. Safety Legislation, Regulations & Industry Policy in the Trades..... 4%

Outcome: ***Apply legislation, regulations and practices ensuring safe work in this trade.***

1. Demonstrate the application of the Occupational Health and Safety Act, Regulation and Code.
2. Describe the sponsor's and employee's role with Occupational Health and Safety (OH&S) regulations, Worksite Hazardous Materials Information Systems (WHMIS), fire regulations, Workers Compensation Board regulations and related advisory bodies and agencies.
3. Describe industry practices for hazard assessment and control procedures.
4. Describe the responsibilities of workers and sponsors to apply emergency procedures.
5. Describe tradesperson attitudes with respect to housekeeping, personal protective equipment and emergency procedures.
6. Describe the roles and responsibilities of sponsors and employees with the selection and use of personal protective equipment (PPE).
7. Maintain required PPE for tasks.
8. Use required PPE for tasks.

B. Climbing, Lifting, Rigging and Hoisting..... 4%

Outcome: ***Use industry standard practices for climbing, lifting, rigging and hoisting in this trade.***

1. Describe manual lift procedures.
2. Describe rigging hardware and associated safety factors.
3. Select equipment for rigging loads.
4. Describe hoisting and load moving procedures.
5. Maintain personal protective equipment (PPE) for climbing, lifting and load moving equipment.
6. Use PPE for climbing, lifting and load moving equipment.

C. Hazardous Materials and Fire Protection..... 6%

Outcome: ***Apply industry standard practices for hazardous materials and fire protection in this trade.***

1. Describe roles, responsibilities, features and practices related to the Workplace Hazardous Materials Information System (WHMIS) program.
2. Describe three key elements of WHMIS.
3. Describe handling, storing and transporting procedures for hazardous material.
4. Describe venting procedures when working with hazardous materials.
5. Describe hazards, classes, procedures and equipment related to fire protection.

D. Apprenticeship Training Program 4%

Outcome: ***Manage an apprenticeship to earn journeyman certification.***

1. Describe the apprentice education agreement responsibilities of the apprentice, sponsor and Alberta Apprenticeship and Industry Training.
2. Describe the purpose of the apprentice competency portfolio.
3. Describe the procedure for changing employers during an active apprenticeship.
4. Describe the purpose of the curriculum guide.
5. Describe the procedure for progressing through an apprenticeship.
6. Describe advancement opportunities in this trade.

E. Tools and Equipment 8%

Outcome: ***Use trade related tools and equipment.***

1. Describe various energy isolation procedures and applications to establish zero energy.
2. Describe and apply safe techniques for using various workshop hand tools and power tools.
3. Demonstrate the safe use of hand tools and equipment related to the Instrumentation and Control Technician trade.
4. Demonstrate the safe use of power and specialty tools related to the Instrumentation and Control Technician trade.
5. Maintains and documents calibration, configuration and test equipment.

F. Tube Bending and Joining 32%

Outcome: ***Perform tube joining and bending.***

1. Identify types and sizes of tube and tube fittings.
2. Identify tools and techniques used in tube joining.
3. Identify tools and techniques used in tube bending.
4. Calculate tube bending lengths for various tube configurations and angles.
5. Identify hazards associated with tube and fitting selection and installation.
6. Demonstrate tube bending for instrument installations.
7. Design and install raceway to support tubing.
8. Install tubing and tube fittings.
9. Demonstrate the use of tube joining tools.
10. Demonstrate soft soldering techniques for joining copper tube.

G. Pipe Threading and Joints..... 18%

Outcome: ***Perform pipe threading and joining.***

1. Identify types and sizes of pipe, fittings and flanges.
2. Explain tools used in pipe joining.
3. Explain how to achieve a pipe installation emphasising threaded pipe joints.
4. Identify hazards associated with pipe and fitting selection and installation.
5. Demonstrate threading of steel pipe with the use of power threaders and hand threaders.

6. Install threaded pipe and fittings for a safe leak tight installation.
7. Install flange connections for a safe leak tight installation.

H. Mounting and Support Hardware 12%

Outcome: Install mounting and support hardware.

1. Describe location considerations and limitations of mounting and support hardware.
2. Identify fasteners used in mounting and support hardware.
3. Identify tools used in mounting and support hardware.
4. Fabricate mounting and support hardware.
5. Install mounting and support hardware.

I. Precision Measurement 4%

Outcome: Use precision measuring instruments.

1. Describe precision measurement used in dimensional measurement.
2. Describe measuring instruments used for precision measurement.
3. Demonstrate techniques for using precision measuring instruments.

J. Electrical and Electronic Connections 8%

Outcome: Assemble electrical and electronic connections.

1. Describe the tools, materials, and techniques used for soldering electronic circuits.
2. Describe static and anti-static devices.
3. Describe methods used in electrical connections.
4. Demonstrate electrical connection techniques.
5. Desolder and remove components from printed circuit boards.
6. Install and solder electronic components onto a printed circuit board.

SECTION TWO: ..... ELECTRICAL THEORY AND SAFETY 35%

A. Resistors 5%

Outcome: Identify types of resistors.

1. List two categories of resistors.
2. Describe resistor construction.
3. Explain methods used to determine the ratings of fixed resistors.
4. Use colour codes to determine the resistance of a resistor.

B. Current, Voltage, Resistance and Power 9%

Outcome: Apply knowledge of voltage, current, resistance and power.

1. Describe an electric current.
2. Describe the difference between electron current flow and conventional current flow.
3. Describe voltage.
4. Describe resistance and state and apply Ohm’s law.

5. Describe work, energy and power as it relates to current, voltage and resistance.
6. Connect and verify the relationship between voltage, current and resistance according to Ohm's law.
7. Connect an electrical circuit and verify the power formulae.

C. Characteristics of Conductors 2%

Outcome: ***Use conductors, semiconductors and insulators.***

1. Describe the factors affecting resistance.
2. Calculate the resistance of a conductor of specific dimensions.
3. Describe the electrical properties of materials.

D. Series Resistive Circuits..... 7%

Outcome: ***Analyze series resistive circuits.***

1. Define a series circuit.
2. Calculate current in a series circuit.
3. Calculate resistance in a series circuit.
4. Apply Kirchhoff's voltage law to a series circuit.
5. Perform calculations using ratio and direct proportion.
6. State the relationship between the resistive values of components and their voltage drops.
7. Solve problems using the voltage divider rule.
8. Determine the voltage drop across a closed or open-circuit component in a series circuit.
9. Connect and verify Kirchhoff’s current and voltage laws in a series resistive circuit.

E. Parallel Resistive Circuits..... 7%

Outcome: ***Analyze parallel circuits.***

1. Define a parallel circuit.
2. Calculate the total resistance of a parallel circuit.
3. Apply Kirchhoff’s current law to a parallel circuit.
4. Describe the effects of open circuits on a parallel circuit.
5. Use the current divider principle to calculate branch currents.
6. Connect and verify Kirchhoff’s current laws in a parallel resistive circuit.

F. Series-Parallel Resistive Circuits 7%

Outcome: ***Analyze series-parallel resistive circuits.***

1. Identify resistors that are in series.
2. Identify resistors that are in parallel.
3. Calculate the total resistance of a series-parallel circuit.
4. Apply Kirchhoff's current law.
5. Apply Kirchhoff's voltage law.
6. Solve problems involving series-parallel circuits.
7. Connect and verify the relationship of current, voltage and resistance in each part of a series/parallel circuit.

G. Cells and Batteries 5%

Outcome: ***Describe cells and batteries.***

1. Define terminology of cells.
2. Describe construction and operation of a basic primary cell.
3. Describe construction and operation of types of lead-acid batteries.
4. Describe construction and operation of a nickel-cadmium battery.
5. Describe construction and operation of a lithium battery.
6. Describe hazards when charging, handling and disposing of batteries.
7. Describe battery performance ratings.
8. Determine the effects of battery internal resistance.

H. Magnetism, Electromagnetism and Electromagnetic Induction..... 6%

Outcome: ***Describe magnetism, electromagnetism and electromagnetic induction.***

1. Describe the properties of magnetic materials.
2. Define terminology related to magnetism.
3. Describe electromagnetism and basic design considerations for electromagnetic devices.
4. Describe how an induced voltage is generated.

I. Fundamentals of Alternating Current (ac) 4%

Outcome: ***Describe the fundamental characteristics of ac circuits.***

1. Explain the generation of an ac sine wave.
2. Determine the output frequency of an ac generator.
3. Calculate standard ac sine wave values.

J. Inductance and Capacitance..... 6%

Outcome: ***Apply the concepts of inductance and capacitance and their use in dc circuits.***

1. Describe an inductor.
2. Describe inductance and the factors which affect it.
3. Describe induction and its effects.
4. Define capacitance.
5. Describe the construction of a basic capacitor.
6. Describe dielectric strength and state the unit of measurement for electric charge.
7. Describe capacitor types and applications.

K. Time Constants..... 5%

Outcome: ***Apply concepts of circuit time constants.***

1. Describe resistor-capacitor circuit time constants and the relationship to the characteristic charge and discharge waveforms.
2. Describe time effects in selected resistor-capacitor circuits.

3. Calculate instantaneous and steady state voltages in resistor-capacitor circuits.
4. Describe time effects of an inductor in a dc circuit.

L. Inductive Reactance and Capacitive Reactance 6%

Outcome: ***Analyze ac inductive and capacitive circuits.***

1. Describe effects of an inductor in an ac circuit.
2. Describe power relationships in an inductive circuit.
3. Describe effects of a capacitor in an ac circuit.
4. Describe power relationships in a capacitive circuit.
5. Analyze an ac inductive circuit.
6. Analyze an ac capacitive circuit.

M. Alternating Current (ac) Circuit Properties 4%

Outcome: ***Apply the properties of ac circuits.***

1. Describe the factors affecting impedance in an ac circuit.
2. Describe the power relationships in an ac circuit.
3. Demonstrate the relationship between sine waves and phasor diagrams.

N. Regulations 4%

Outcome: ***Apply electrical codes and regulations.***

1. Describe the Instrumentation and Control Technician's area of electrical work/responsibility.
2. Describe the role of Safety Codes Act and the Canadian Electrical Code Part 1 and how they relate to the instrumentation field.
3. Describe the role of CSA, NEMA and CUL and how they relate to the instrumentation field.

O. Area Classifications 7%

Outcome: ***Describe the classification of hazardous locations and the general rules that apply to these locations.***

1. Define the specific terms from Section 18 of the Canadian Electrical Code Part 1 that apply to area classifications.
2. Apply general rules regarding installation and maintenance in hazardous locations.
3. Describe an area classification drawing.

P. Electrical Equipment in Hazardous Locations 16%

Outcome: ***Apply protection methods for electrical equipment in hazardous areas.***

1. Define the purpose of explosion proof equipment.
2. Define installation requirements for conduit, seals, fixtures and appliances.
3. Describe maintenance procedures for explosion proof enclosures.
4. Describe non-incendive equipment.
5. Describe an intrinsically safe loop.
6. Describe an intrinsically safe loop drawing.
7. Describe the grounding requirements of an intrinsically safe system.

8. Define the relationship between explosion proof and intrinsically safe systems.
9. Describe maintenance procedures for intrinsically safe systems.
10. Describe the role of purging under the CSA and ISA definition.
11. Describe the role of sealing, potting and encapsulating for electrical safety.
12. Describe arc flash.
13. Demonstrate how to install a secondary seal.
14. Select and install an intrinsically safe barrier.

SECTION THREE: ..... BASIC MEASUREMENTS AND CALIBRATION 13%

A. Pressure Measurement 15%

Outcome: Apply the principles of pressure and the standards used to measure pressure.

1. Perform calculations for pressure and pressure units.
2. Apply the principles of pressure standards to pressure measurement techniques.
3. Perform pressure calculations for pressure scales and reference points.

B. Link and Lever Systems 13%

Outcome: Calibrate link and lever systems.

1. Define span, angularity, zero, hysteresis, and deadband as they relate to mechanical systems.
2. Perform calibrations of link and lever systems.

C. Pressure Gauges 9%

Outcome: Select, calibrate, and install pressure gauges.

1. Describe the construction, applications and limitations of pressure gauges.
2. Describe the installation and protection methods for pressure gauges.
3. Demonstrate the methods and standards used to calibrate pressure gauges.
4. Demonstrate a method to protect pressure gauges.

D. Pneumatic Components and Feedback Systems 16%

Outcome: Select, install, and maintain pneumatic components and feedback systems.

1. Describe the operation and construction of flapper nozzles.
2. Describe the operation and construction of pneumatic pilots.
3. Describe the operation and construction of pneumatic relays.
4. Describe the applications for pneumatic relays.
5. Explain different types of negative feedback systems used in pneumatic instruments.
6. Describe safety considerations of pneumatic instruments.
7. Describe specifications of pneumatic instruments.
8. Describe benefits and disadvantages of pneumatic instruments.
9. Describe alternate gas supplies used in pneumatic instruments and related hazards.
10. Demonstrate the calibration of a feedback system.

E. Pressure Regulators 16%

Outcome: Select, install, and maintain pressure regulators.

1. Describe the operating principles and applications of regulators.
2. Illustrate the design and differences between: spring-loaded, weight- loaded, and pilot operated regulators.
3. Identify hazards associated with pressure regulator selection and installation.
4. Describe maintenance procedures for pressure regulators.
5. Service a pressure regulator.

F. Pressure Transmitters 19%

Outcome: Select, install, and maintain pressure transmitters.

1. Describe the function and construction of pressure transmitters.
2. Describe the applications and installation requirements for pressure transmitters.
3. Describe analog signal standards.
4. Describe the calibration process and the application of input/output calculations for pressure transmitters.
5. Calibrate pressure transmitters.

G. Chart Recorders 12%

Outcome: Select, install, and maintain chart recorders.

1. Describe the function and construction of chart recorders.
2. Describe applications and installation requirements for chart recorders.
3. Describe calibration procedures used on chart recorders.
4. Describe and interpret charts and recording methods for chart recorders.
5. Calibrate chart recorders.

SECTION FOUR: ..... FINAL CONTROL ELEMENTS 14%

A. Reciprocating Control Valves 17%

Outcome: Install and service reciprocating control valves.

1. Describe applications and construction of reciprocating control valves.
2. Identify hazards associated with reciprocating control valves.
3. Describe servicing procedures used on reciprocating control valves.
4. Install a reciprocating control valve.
5. Service a reciprocating control valve.

B. Rotary Control Valves 18%

Outcome: Install and service rotary control valves.

1. Describe rotary control valves applications and construction.
2. Identify rotary control valves hazards.
3. Describe rotary control valves servicing.

4. Install a rotary control valve.
5. Service a rotary control valve.

C. Actuators 23%

Outcome: Install and service valve actuators.

1. Describe applications and selection of actuators and accessories.
2. Identify hazards associated with servicing valve actuators.
3. Describe servicing procedures used on valve actuators.
4. Demonstrate how to service and setup various valve actuators.

D. Valve Positioners 12%

Outcome: Install and service valve positioners.

1. Describe the applications and selection of valve positioners.
2. Describe the features of positioners.
3. Describe valve positioner servicing procedures.
4. Demonstrate the operation and calibration of pneumatic valve positioners.

E. Control Valve Selection 12%

Outcome: Explain the variables used in selecting and maintaining control valves.

1. Describe the principles of friction, and the coefficient of friction, associated with fluids in motion.
2. Describe flow characteristics, valve C_V, cavitation, flashing, erosion, corrosion, and specialized trim.
3. Describe procedures and considerations when determining valve sizes and construction materials.
4. Identify the required “Fail Safe” mode and flow direction when selecting valves for a given application.
5. Describe valve packing materials and applications.

F. Control Valve Servicing 18%

Outcome: Prepare control valves for installation and maintenance.

1. Describe the OH&S requirements for energy isolation.
2. Identify hazards associated with removing a control valve from service.
3. Describe methods used in isolating control valves for maintenance.
4. Demonstrate how to isolate a control valve for maintenance.
5. Install actuator, perform bench set and adjust valve stroke.

SECTION FIVE: .....RELATED APPLIED PHYSICS AND CALCULATIONS 17%

A. SI and Imperial Units and Basic Calculations 10%

Outcome: Solve trade related calculations.

1. Describe SI units, prefixes, and conversions between the SI system and the imperial system.
2. Transpose and solve equations involving: fractions, ratios, proportions, percentages, exponents, algebra, trigonometry and logarithms.

3. Describe units of angular measurement, right angles, obtuse angles, isosceles triangles, equilateral triangles, and the application of Pythagoras Theorem to right angled triangles.
4. Calculate the perimeter, area, and volume of various objects.

B. Motion and Force 15%

Outcome: Solve problems related to motion and force.

1. Describe velocity, acceleration, displacement, average velocity, average acceleration, momentum, gravitational acceleration, scalar vector quantities, force, and mass.
2. Describe Newton's three laws of motion, and the law of conservation of motion or momentum.
3. Solve problems related to force, mass and acceleration.
4. Describe moment of force, moment of torque, balancing of forces on a beam, equilibrium of a lever system, effort, and mechanical advantage.
5. Solve problems related to force balance about a point, and the mechanical advantage of a beam.
6. Describe the mechanical advantage or velocity ratio in terms of diameter or radius of wheels, axles, pulleys, and gears.
7. Solve problems related to speed or rotation of pulleys and gears based on diameter or radius as well as the mechanical advantage of a block and tackle system.

C. Work and Power 13%

Outcome: Solve problems related to work and power.

1. Describe the terms work, power and efficiency and their associated units.
2. Express efficiency in terms of output versus input work and power.
3. Solve problems related to work done based on force and distance data.
4. Solve problems related to power based on force, distance, and time data.

D. Energy 10%

Outcome: Solve problems related to energy.

1. Describe energy, potential energy, kinetic energy, and the units of energy.
2. Describe the forms of energy and their formulae.
3. Describe the relationship between potential and kinetic energy and the laws of conservation of energy.
4. Solve problems related to potential energy based on force and height data, and kinetic energy based on mass and velocity data.

E. Fluid Principles 17%

Outcome: Solve problems related to fluids and the flow of fluids.

1. Describe atom, molecule, element, molecular attraction, cohesion, adhesion, capillary action, compressibility, thermal expansion, density, relative density, and specific volume.
2. Solve problems related to the mass, density, and relative density of liquids and solids.
3. Describe Pascal's Law and pressure head.
4. Solve problems related to pressure, density, and height of a liquid column.
5. Describe Archimedes principle and concept of buoyancy.
6. Solve problems related to objects submerged in liquids.

7. Describe turbulent flow, laminar flow, and the continuity equation.
8. Describe Bernoulli's equation, resistance to flow, and flow turbulence.

F. Heat and Temperature..... 18%

Outcome: Solve problems related to heat and temperature.

1. Describe the relationship between temperature scales.
2. Describe temperature, heat, sources of heat energy, specific heat, and the laws of thermodynamics.
3. Describe the molecular theory of heat and heat transfer, and its significance on the change of state of a substance.
4. Describe the coefficient of linear expansion, volumetric expansion, and surface expansion of liquids and solids.
5. Solve problems related to expansion of solids, expansion of liquids, and the changes in heat content of liquids.
6. Describe the laws related to heat, conductors, insulators, and the process of heat transfer through: conduction, convection, and radiation.
7. Describe the steam tables and the following properties: sensible heat, latent heat of fusion, latent heat of evaporation, saturation temperature, and superheat.
8. Solve problems related to heat and heat transfer.

G. Laws of Ideal Gases 7%

Outcome: Solve problems related to ideal gases.

1. Describe Boyle's Law, Charles' Law and the general gas law, in relation to pressure, temperature, and volume.
2. Solve problems involving gas laws.
3. Describe the principles of gas compressibility and volumetric expansion.

H. Solids 10%

Outcome: Solve problems related to solids.

1. Define elasticity, stress, strain, Hooke's Law, and Young's Modulus of Elasticity.
2. Define the relationship between elastic limit, yield point, ultimate strength, breaking strength, safe working stress, and factor of safety.
3. Define tensile, compressive, and shear stresses.
4. Solve problems related to stress, force area, and strain.

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UPON SUCCESSFUL COMPLETION OF THIS PROGRAM THE APPRENTICE SHOULD BE ABLE TO PERFORM THE FOLLOWING OUTCOMES AND OBJECTIVES.

SECTION ONE:.....MEASUREMENT INSTRUMENTS..... 28%

A. Temperature Measurement..... 12%

Outcome: Describe temperature measurement.

1. Explain why and where temperature measurement is used in industry.
2. Define terms that apply to temperature measurement.
3. Convert temperature readings between scales.
4. Define coefficient of linear, coefficient of area and coefficient of volume expansion.
5. Solve problems involving linear and volumetric expansion of materials.
6. Describe thermal contact and its effect on accuracy and response time.
7. Describe thermowell requirements and applications.
8. Describe direct and indirect temperature measurement.
9. Describe thermal time constants.

B. Thermometers and Filled Thermal Systems..... 6%

Outcome: Install, and maintain thermometers and filled thermal systems.

1. Describe the operation and characteristics of thermometers and filled thermal systems.
2. Describe the construction and operating principle of a bimetallic thermometer.
3. Describe a filled thermal system as it relates to temperature measurement.
4. Define full compensation and case compensation.
5. List advantages and disadvantages of Scientific Apparatus Makers Association (SAMA) classifications.
6. Describe applications using case and full compensation.
7. Describe installation effects, including head elevation, thermowells and transmission lag.

C. Thermocouples..... 12%

Outcome: Install, and maintain thermocouples.

1. Explain the principle of operation of a thermocouple element.
2. Identify thermocouples and state the materials used for each type and the colour codes used for identification.
3. Perform calculations required to measure the temperature at the thermocouple using a meter and the temperature versus thermocouple referenced tables.
4. Describe the operation of a thermocouple circuit with reference junction compensation, using the battery equivalent for each point of emf generation.
5. Perform the calculations required to calibrate a reference junction compensated transmitter using a mV source and the table referenced to 0°C.

6. State the characteristics of each type of thermocouple including their advantages, limitations and application.
7. Describe methods of thermocouple fabrication.
8. Describe effects of grounded and ungrounded junctions.
9. Describe methods and components used for thermocouple installation.
10. Demonstrate the fabrication and installation of a thermocouple.
11. Calibrate and verify the accuracy of an analog thermocouple temperature transmitter.

D. Resistance Temperature Detector (RTD's) 12%

Outcome: Install, and maintain Resistance Temperature Detectors (RTD's) and thermistors.

1. Explain the principle of operation of an RTD.
2. Describe characteristics of each type of RTD's including their advantages, limitations and application.
3. Calculate the measured temperature given the resistance of an RTD.
4. Describe two, three and four wire RTD measuring circuits.
5. Describe the principle of operation of thermistors.
6. Compare positive and negative temperature coefficients.
7. Describe the characteristics of each type of thermistor including their advantages, limitations and application.
8. Describe the calibration procedure for an RTD transmitter.
9. Configure and verify the accuracy of an analog RTD temperature transmitter.

E. Non-Contact Temperature Measurement 6%

Outcome: Install and maintain non-contact temperature measurement devices.

1. Describe the principle of operation of a diode used as a temperature detecting device.
2. Describe applications of transistors in temperature measurement.
3. Explain the purpose of non-contact temperature measuring devices.
4. Define terms used in radiation pyrometers.
5. Describe the operating principle of non-contact pyrometers.
6. List advantages and limitations of non-contact temperature measuring devices.
7. Determine emissivity of various surfaces.

F. Flow Measurement Fundamentals 4%

Outcome: Describe flow measurement.

1. Describe the application of flow measurement.
2. Describe measurement units and terms used in flow measurement.
3. Explain the difference between laminar and turbulent flow.
4. Explain the significance of the Reynolds number used to describe flow.
5. Explain the effect of pulsating flow and dampening.

G. Analog Differential Pressure Measurement 6%

Outcome: ***Apply analog differential pressure measurement.***

1. Describe the theory and application of differential pressure measurement.
2. Describe devices used for differential pressure measurement.
3. Calibrate a differential pressure device.

H. Analog Differential Pressure Flow Measurement 13%

Outcome: ***Install, and maintain differential pressure flow measurement devices on orifice plates.***

1. Describe the relationship between differential pressure and flow measurement.
2. Define the terms velocity head, pressure head, elevation head and discharge coefficient.
3. Calculate flow using a continuity equation and Bernoulli's equation.
4. Describe the principle of operation, application, and installation of differential pressure flow elements.
5. Describe the requirements for square root extraction and integration.
6. Calculate the flow coefficient for an orifice plate.
7. Remove, inspect and reinstall an orifice plate in an online orifice fitting installation.

I. Variable Area Meters / Weirs / Flumes / Flow Switches 6%

Outcome: ***Install, and maintain variable area meters, weirs, flumes and flow switches.***

1. Describe the application and principle of operation of variable area meters.
2. Describe the installation requirements.
3. Describe useful range and accuracy with comparison to fixed area orifice meters.
4. Describe the application and principle of operation of weirs and flumes.
5. Describe the application and principle of operation of flow switches.

J. Level Measurement 13%

Outcome: ***Install, and maintain level measurement devices.***

1. Describe the application of level measurement.
2. Differentiate between point level and continuous level detection.
3. Differentiate between direct and inferential methods of level measurement.
4. Describe types, limitations and applications of level gauges.
5. Describe principles and differences between floats and displacers.
6. State Archimedes' principle as applied to floats and displacers.
7. Calculate buoyancy of a float.
8. Describe the application of a float used for point and continuous level measurement.
9. Calculate buoyant force of a displacer.
10. Describe the principle of a torque tube.
11. Describe the operation of a displacer element for detecting liquid level and interfaces.
12. Describe the application of a displacer used for point and continuous level measurement.
13. List advantages and disadvantages of float and displacer type level devices.

14. Connect and calibrate a displacer type instrument for continuous level measurement.

K. Analog Differential Pressure Level Measurement..... 10%

Outcome: Install, and maintain differential pressure level measurement devices.

1. Calculate hydrostatic head pressure.
2. Describe characteristics of purge fluids and seal fluids.
3. Compare methods of measuring level in atmospheric and pressurized vessels.
4. Define the terms zero elevation and zero suppression and range elevation and range suppression.
5. Describe a calibration procedure for a zero elevation application and calculate span and elevation settings.
6. Describe a calibration procedure of a zero suppression application and calculate span and elevation settings.
7. Describe a bubbler level system including the required supply pressure settings.
8. Describe purge systems used in bubbler level measurement.
9. Connect and calibrate a pneumatic differential pressure transmitter in atmospheric and pressurized vessels.

SECTION TWO: ..... CONTROL INSTRUMENTS 15%

A. Introduction to Automatic Control..... 17%

Outcome: Describe the fundamentals of automatic control and control terminology.

1. Explain why automatic control is necessary in process industries.
2. Define the terms used in automatic control.
3. Illustrate and describe feedback control and controller action selection.
4. Describe the methodology of transferring between auto and manual control.
5. Describe the application of auto/manual stations and bumpless transfer.
6. Demonstrate the effect of controller action.

B. On-Off Controllers 11%

Outcome: Install, and maintain on-off control.

1. Describe an on-off controller.
2. Describe the applications of on-off control.
3. Describe the operation of a differential gap controller.
4. Construct and commission an on-off control application.

C. Proportional Integral Derivative (PID) Control..... 39%

Outcome: Install and maintain PID controllers.

1. Define the terms used in PID control.
2. Perform controller output calculations for a proportional only controller.
3. Describe the operation of a pure proportional controller.
4. Describe bias and offset as applied to proportional control.
5. Explain the effect of gain on offset.

6. Perform controller output calculations for a PI controller.
7. State the purpose and application of integral in a controller.
8. Describe the effect of integral in a controller.
9. Explain reset wind-up on a controller.
10. Explain anti-reset wind-up and where it must be incorporated.
11. Perform controller output calculations for a PD and PID controller.
12. State the purpose and applications of derivative in a controller.
13. Perform controller output calculations for direct acting and reverse acting controllers.
14. State the guidelines to select the correct PID mode.

D. Pneumatic Controller Tuning 33%

Outcome: Tune pneumatic controllers.

1. Explain the term quarter amplitude decay.
2. Describe open loop methods used for controller tuning.
3. Describe the closed loop methods used for controller tuning.
4. Explain critically damped tunings.
5. Describe controller modes used on typical processes.
6. Describe pneumatic controller alignment.
7. Determine controller action and settings for a proportional only controller.
8. Perform a pneumatic controller alignment.
9. Determine controller action and settings for a PI controller and perform a bumpless transfer.

SECTION THREE: ..... ELECTRICAL AND DIGITAL FUNDAMENTALS 25%

A. Electrical Theory 12%

Outcome: Apply electrical concepts to circuit analysis.

1. Describe the relationship between resistance, current and voltage.
2. Determine the value of various components using color codes and numerical identifiers.
3. Calculate the resistances, voltages, and currents in both series and parallel ac and dc circuits using Ohm's Law, voltage divider and Kirchoff's Laws.
4. Perform power calculations for a circuit, given any three of the following: resistance, current, voltage or power.
5. Determine the frequency, period, and voltages of various waveforms from both graphical representations and an oscilloscope display.
6. Evaluate and solve series/parallel circuits containing ac sources, dc sources, resistors, capacitors, and inductors.
7. Describe the characteristics and operation of conductors, insulators, semiconductors, and PN junctions.
8. Describe characteristics of forward and reverse biased Zener diodes in various circuit configurations.
9. Describe transistors as used for digital I/O sensing and switching.

B. Power Supplies 10%

Outcome: Install and maintain power supplies.

1. Explain the load vs. voltage characteristics of a transformer and how it applies to power supply sizing.
2. Define and illustrate the components of an UPS system.
3. Define the operation and applications of various power supplies and uninterruptable power supplies (UPS).
4. Define power supply output quality and quantity.
5. Troubleshoot power supply output qualities.

C. Introduction to Digital 9%

Outcome: Apply the fundamentals of digital electronics.

1. Describe the application of digital circuitry in measurement and control instrumentation, and how they differ from analog devices.
2. Describe the implications of electrostatic protection when servicing electronic devices.
3. Describe the application, similarities and the base conversion methods for decimal, binary, binary coded decimal (BCD), and hexadecimal number systems.
4. Solve basic arithmetic operations on decimal, binary, BCD, and hexadecimal number systems.

D. Logic Gates 5%

Outcome: Describe digital logic gates, their schematic symbols, and their Boolean functions.

1. Describe the purpose of digital logic gates.
2. Show the truth tables for various logic gates.
3. Explain the Boolean equations and the truth tables for various logic gates.

E. Microprocessors and Memory 3%

Outcome: Describe the basic elements of a microprocessor and application of memory devices.

1. Explain memory addressing and device selection/enabling methods.
2. Describe Random Access Memory (RAM) and Read Only Memory (ROM) and their applications.
3. Describe the components of a microprocessor.
4. Describe types of mass storage devices.
5. Describe different microprocessor peripheral Input / Output (I/O) devices.
6. Describe types of memory.

F. Introduction to Programmable Logic Controllers (PLC) 34%

Outcome: Explain the operation of a PLC running a ladder logic program.

1. Describe the symbols and conventions used in relay ladder logic diagrams.
2. Describe the components of a modular PLC.
3. Describe discrete and analog I/O card types and addressing used by modular PLC's.
4. Derive a PLC ladder logic program from a relay ladder logic diagram or a Boolean logic diagram.
5. Describe troubleshooting techniques and safety considerations when working on PLC's.

6. Commission a PLC that uses discrete and analog I/O.
7. Connect and program a PLC using ladder logic and discrete I/O.
8. Connect and program a PLC using ladder logic and analog I/O.

G. Introduction to Data Communications 17%

Outcome: ***Verify data communication between devices.***

1. Describe terms used in data communication.
2. Explain serial data stream frame structure.
3. Explain the characteristics and applications of various protocols.
4. Explain the characteristics and applications of various transmission media.
5. Describe the purpose and application of modems.
6. Describe NULL modem and straight through cabling.
7. Connect two data communication devices and verify communication between them.

H. Introduction to Personal Computers and Software Applications 10%

Outcome: ***Use software applications of a personal computer including office and industrial software.***

1. Identify the hardware components of a computer.
2. Explain the purpose of data communication hardware.
3. Describe office and industrial software.
4. Describe software used in maintenance and reliability management.
5. Describe security measures as they apply to industrial instrumentation.
6. Demonstrate the ability to copy files, view and organize directories and backup data.
7. Demonstrate the use of word processing package applications.
8. Demonstrate the use of spread sheet package applications.
9. Demonstrate the use of data base package applications.
10. Demonstrate the use of the internet to research technical information.
11. Demonstrate the installation, upgrading and removal of industrial software.

SECTION FOUR: .....PROCESS EQUIPMENT AND ENERGY SYSTEMS..... 32%

A. Drawing and Symbols 10%

Outcome: ***Develop a Piping and Instrument Diagram (P&ID) drawing.***

1. Define symbols used by International Society of Automation (ISA).
2. Describe the ISA identification system used in instrument drawings.
3. Define SAMA symbols.
4. Describe the SAMA identification system used for boiler control drawings.
5. Interpret P&ID drawings.
6. Interpret Process Flow Diagram (PFD) drawings.
7. Develop a P&ID drawing.

B. Gas Compression 10%

Outcome: ***Develop P&ID drawing of a compressor and process equipment.***

1. Describe the components of a reciprocating gas compressor.
2. Describe the components of other positive displacement compressors.
3. Describe the components of centrifugal gas compressors.
4. Describe applications of gas compressors.
5. Describe types of drivers used to drive compressors and pumps.
6. Develop and sketch a P&ID of a compressor and the related process equipment.
7. Identify hazards associated with gas compression equipment.

C. Liquid Pumping 6%

Outcome: ***Develop a P&ID of a pump and the related process equipment.***

1. Describe the components of positive displacement pumps.
2. Describe the components of centrifugal pumps.
3. Describe applications of pumps.
4. Describe the use of Variable Speed Drives (VSD) for liquid pumping.
5. Identify hazards associated with pumping equipment.
6. Develop and sketch a P&ID of a pump and the related process equipment.

D. Solids and Liquids 6%

Outcome: ***Describe the basic principles and equipment used for solids size reduction, solids enlargement, solids and liquids separation or mixing.***

1. Define size reduction in regards to crushing, grinding and pulverizing.
2. Explain the process of size enlargement of material.
3. Describe size separation and screening for process materials.
4. Describe the principles and operation of two and three phase separators.
5. Explain auxiliary support equipment/processes.
6. Describe equipment used to maintain material consistency.

E. Heat Transfer and Evaporation 6%

Outcome: ***Describe the principles and application of heat transfer and evaporation.***

1. Describe the terms of heat transfer.
2. Describe heat exchangers.
3. Describe cooling methods.
4. Describe process evaporators.
5. Describe the operation of a multiple effect evaporator.
6. Describe the separation of solids and liquids by crystallization.

F. Drying, Humidification and Dehumidification 6%

Outcome: ***Describe the principle and application used in the processes of gas humidification, gas drying, and solids drying.***

1. Define drying, humidification and dehumidification.
2. Describe the processes of solids drying.
3. Describe humidification of process gases.
4. Describe dehumidification of process gases.
5. Describe the principles and applications of absorption, desorption and adsorption.
6. Describe the principles of operation of desiccant and chemical dehydration processes.

G. Distillation and Fractionation 4%

Outcome: ***Describe the principles and application used in the process of fractionation and distillation.***

1. Define the terms used in distillation and fractionation processes.
2. Describe the distillation process.
3. Describe the fractionation process.

H. Boilers and Direct Fired Heaters 4%

Outcome: ***Describe the principle and application of boilers and fired heaters.***

1. Describe boilers and auxiliary equipment.
2. Describe boiler operation.
3. Describe burner management.
4. Describe direct fired heaters.
5. Describe current standards and regulations as they apply to gas fired equipment.

I. Production and Processing Plants 9%

Outcome: ***Explain the major components and processes of process facilities using process flow diagrams (PFD).***

1. Use a PFD to explain the major processes, flows and unit operations for gas sweetening and sulphur recovery.
2. Use a PFD to explain the major processes, flows and unit operations for NGL/LPG recovery and fractionation.
3. Use a PFD to explain the major processes, flows and unit operations for a Kraft pulp and paper mill.
4. Use a PFD to explain the major processes, flows and unit operations for an oil upgrading facility.
5. Use a PFD to explain the major processes, flows and unit operations for an oil refinery.
6. Use a PFD to explain the major processes, flows and unit operations for an oil recovery unit.
7. Use a PFD to explain the major processes, flows and unit operations for a water treatment facility.

J. Gas Detection 10%

Outcome: ***Install, and maintain gas detection devices.***

1. Describe applications of personal, portable and fixed gas detectors.
2. Describe applications of toxic gas detectors.

3. Describe applications of combustible gas detectors.
4. Describe the selection of calibration gas for an application.
5. Describe the placement of portable and fixed gas detectors.
6. Calibrate a combustible gas detector selecting calibration gases.
7. Calibrate a H_2S gas detector selecting calibration gases.
8. Perform and document a bump test and calibration of a personal multi-gas monitor.

K. Fire and Smoke Detection 4%

Outcome: ***Install, and maintain fire and smoke detection devices.***

1. Describe applications of fire and smoke detectors.
2. Describe types of fire detectors stating their operating characteristics, advantages and limitations.
3. Describe types of smoke detectors stating their operating characteristics, advantages and limitations.
4. Test a smoke and fire detector.

L. Emergency Shutdown Systems (ESD) 5%

Outcome: ***Describe Emergency Shutdown Systems (ESD).***

1. Explain the need for ESD systems.
2. Describe the components and logic of an ESD System.
3. Explain the applications of ESD systems.
4. Describe the individual responsibility after the activation of an ESD system.

M. Relieving Devices 4%

Outcome: ***Install and maintain relieving devices.***

1. Explain the need for relieving devices.
2. Describe types of relieving devices stating their operating characteristics, advantages and limitations.
3. Describe the documentation and governing body/certification requirements for relieving devices.

N. Pneumatic Systems 10%

Outcome: ***Install and maintain pneumatic supplied systems.***

1. Describe and illustrate types of air compressors and their applications.
2. Describe and illustrate air dryers, air receivers and air distribution piping as part of the overall instrument air system.
3. Describe alternate gas supplies used in pneumatic systems and related hazards.
4. Describe quality, specifications and sizing of an instrument air system.
5. Describe safety considerations of pneumatic systems.
6. Describe benefits and disadvantages of pneumatic systems compared to alternate energy systems.

O. Hydraulic Systems 3%

Outcome: ***Install and maintain hydraulic systems.***

1. Describe and illustrate the specifications and components of a hydraulic system.
2. Describe alternate fluids used in hydraulic systems and related hazards.
3. Describe the benefits and disadvantages of hydraulic systems compared to other energy systems.
4. Describe safety and environmental considerations of hydraulic systems.

P. Electrical Systems 3%

Outcome: ***Install and maintain electrical systems.***

1. Describe safety considerations of electrical energy system.
2. Describe the components of alternate/multiple power sources and associated hazards.
3. Describe benefits and disadvantages of electrical systems compared to other energy systems.

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UPON SUCCESSFUL COMPLETION OF THIS PROGRAM THE APPRENTICE SHOULD BE ABLE TO PERFORM THE FOLLOWING OUTCOMES AND OBJECTIVES.

SECTION ONE: ..... ELECTRONIC INSTRUMENT LOOPS..... 15%

A. Analog Loops 23%

Outcome: Calibrate analog loops.

1. Describe the standard signal levels used in industrial measurement and control loops.
2. Calculate loop output between various standards.
3. Describe why current rather than voltage is primarily used for signal transmission.
4. Illustrate an instrument loop using a 2 wire transmitter.
5. Illustrate an instrument loop using a 4 wire transmitter.
6. Describe the circuits used to test the output of a transmitter without interrupting the current flow.
7. Describe the current to voltage relationships of an analog control loop.
8. Calculate maximum loop resistance for a current loop.
9. Describe test procedures used to calibrate and/or troubleshoot analog loops.
10. Predict how the loop could be affected by common circuit faults.
11. Calibrate an analog loop.

B. Grounding and Shielding Methods 18%

Outcome: Install grounding and shielding on equipment.

1. Describe the importance of grounding and shielding electronic equipment.
2. Describe the difference between grounding and shielding.
3. Describe methods for grounding electronic equipment.
4. Describe methods for shielding electronic equipment.
5. Install an analog instrument, demonstrate shielding methods and compare unshielded and shielded wiring methods using an oscilloscope.
6. Install an analog instrument, demonstrate grounding methods and compare ungrounded and grounded wiring methods using an oscilloscope and multimeter.

C. Analog to Digital (ADC) and Digital to Analog Conversion (DAC) 9%

Outcome: Install and maintain analog to digital (ADC) and digital to analog converters (DAC).

1. Describe the purpose and application for both ADC's and DAC's.
2. Describe resolution and calculate the resolution based on the number bits of binary data.
3. Describe multiplexer applications.
4. Explain terms and specifications for both ADC's and DAC's.
5. Perform output calculations of an ADC and DAC for a given input value.

D. Signal Conditioning 14%

Outcome: Install and maintain signal conditioners.

1. Describe the functions and applications of signal transducers.
2. Describe the components, function and application of a current to pressure (I/P) transducer.
3. Identify signal transducers.
4. Install and calibrate an I/P signal transducer.

E. Smart Instruments..... 23%

Outcome: Install and maintain smart instruments.

1. Describe the hardware architecture, features and operation of smart instruments.
2. List the digital communications standards and protocols used with smart instruments.
3. Describe the operation of hand-held and personal computer interfaces used with smart instruments.
4. Describe the advantages of smart instruments in measurement and control loops.
5. Demonstrate a digital waveform imposing an analog signal using an oscilloscope and hand held communicator.
6. Install and configure a smart positioner and capture a valve signature.
7. Configure and verify the accuracy of a smart thermocouple temperature transmitter.
8. Configure and verify the accuracy of a smart RTD temperature transmitter.

F. Single Loop Digital Controllers (SLDC) / Stand Alone Controllers (SAC)..... 13%

Outcome: Install and maintain single loop digital controller (SLDC) / stand alone controllers (SAC).

1. Describe the operation of SLDC/SAC.
2. Describe the functions and applications of SLDC/SAC.
3. Sketch a control loop diagram illustrating controller type, action and valve fail position.
4. Connect and configure a SLDC and / or a SAC for a level control application.

SECTION TWO: ..... MEASUREMENT 26%

A. Accuracy and Repeatability 11%

Outcome: Verify the accuracy of a measurement system.

1. Describe accuracy and its importance in measurement.
2. Describe repeatability and its importance in measurement.
3. State accuracy statements for analog and digital instruments and calculate their possible range of errors.
4. Describe the correlation of accuracy and repeatability as they relate to measurement uncertainty.
5. Demonstrate the accuracy and repeatability of a given instrument/component from the values measured and then compared to the manufacturer's specifications.
6. Measure and calculate the possible and probable range of errors for a measurement system consisting of several instruments.
7. Verify and compare the accuracy of a thermocouple and a RTD at three points.

B. Measurement Traceability 5%

Outcome: ***Apply regulations on measurement accuracy and traceability.***

1. Describe traceability and its importance in measurement and related certification.
2. Describe the regulatory standards and the governing bodies responsible for measurement accuracy and traceability.
3. Describe how measurement traceability relates to regulatory standards.
4. Apply current regulations on measurement accuracy and traceability.

C. Differential Pressure Using Smart Technology 5%

Outcome: ***Install and maintain differential pressure level and density measurement equipment.***

1. Describe differential pressure methods used in level measurement.
2. Describe differential pressure methods used in density measurement.
3. Describe wet and dry leg level transmitter installations.
4. Describe remote seal level transmitter installations.
5. Calculate the expected zero and span in a wet leg level application, install and configure a smart differential pressure transmitter for a suppressed zero application and verify the calculations.
6. Connect and configure a smart differential pressure transmitter in a wet leg suppressed zero application and determine the density.

D. Nuclear 4%

Outcome: ***Install and maintain nuclear instruments used in density and level measurement.***

1. Describe principles and applications used in nuclear instruments.
2. Describe installation requirements for nuclear instruments.
3. Describe methods used to calibrate nuclear instruments.
4. Describe required safety considerations when working with and around radioactive sources.
5. Describe the regulatory bodies for nuclear sources.

E. Ultrasonic and Radar 7%

Outcome: ***Install and maintain ultrasonic and radar level instruments.***

1. Describe principles and application of ultrasonic level instruments.
2. Describe installation requirements for ultrasonic level instruments.
3. Describe principles and applications of radar level instruments.
4. Describe installation requirements for radar level instruments.
5. Connect and calibrate an ultrasonic or radar level instrument.

F. Capacitance, Thermal Dispersion, Optical and Magnetostrictive 6%

Outcome: ***Install, and maintain capacitance, thermal, optical, and magnetostrictive level instruments.***

1. Describe principles, applications and installation requirements of capacitance level instruments.
2. Describe principles, applications and installation requirements of thermal level instruments.

3. Describe principles, applications and installation requirements of optical level instruments.
4. Describe principles, applications and installation requirements of magnetostrictive level instruments
5. Connect and calibrate a capacitance level instrument.

G. Solids 3%

Outcome: Install and maintain solids level instruments.

1. Describe the principles and application of solids level instruments.
2. Describe the installation requirements for solids level instruments.

H. Viscosity 3%

Outcome: Describe viscosity.

1. Describe absolute viscosity and kinematic viscosity.
2. Describe Newtonian and non-Newtonian liquids.
3. Describe the effect of viscosity on flow measurement.

I. Flow Measurement 5%

Outcome: Describe flow measurement.

1. State the purposes for flow measurement.
2. Compare mass flow and volumetric flow.
3. Describe the regulatory standards and the governing bodies responsible for flow measurement.
4. Describe principles and application of meter proving.
5. Sketch a loop diagram illustrating basic components of a proving measurement system.

J. Differential Pressure Elements 5%

Outcome: Install and maintain differential pressure elements focusing on elements other than orifice plates.

1. Describe principles and applications of differential pressure elements.
2. Describe components of differential pressure elements.
3. Describe installation requirements for differential pressure elements.
4. Describe maintenance and calibration of differential pressure elements.
5. Describe advantages and limitations of differential pressure elements.

K. Magnetic Flowmeters 5%

Outcome: Install and maintain magnetic flowmeters.

1. Describe the principles and applications of magnetic flowmeters.
2. Describe components of a magnetic flowmeter.
3. Describe installation requirements for magnetic flowmeters.
4. Describe maintenance and calibration of magnetic flowmeters.
5. Describe advantages and limitations of magnetic flowmeters.

L. Turbine Flowmeters 7%

Outcome: Install and maintain turbine flowmeters.

1. Describe principles and applications of turbine flowmeters.
2. Describe components of a turbine flowmeter.
3. Describe installation requirements for turbine flowmeters.
4. Describe maintenance and calibration of turbine flowmeters.
5. Describe advantages and limitations of turbine flowmeters.
6. Perform a volumetric prove of a turbine flowmeter calculating the K-factor and configure the totalizer.

M. Vortex Flowmeters 5%

Outcome: Install and maintain vortex flowmeters.

1. Describe the principles and applications of vortex flowmeters.
2. Describe components of a vortex flowmeter.
3. Describe installation requirements for vortex flowmeters.
4. Describe the maintenance and calibration of vortex flowmeters.
5. Describe advantages and limitations of vortex flowmeters

N. Ultrasonic Flowmeters 5%

Outcome: Install and maintain ultrasonic flowmeters.

1. Describe the principles and applications of ultrasonic flowmeters.
2. Describe components of an ultrasonic flowmeter.
3. Describe installation requirements for ultrasonic flowmeters.
4. Describe the maintenance and calibration of ultrasonic flowmeters.
5. Describe advantages and limitations of ultrasonic flowmeters.

O. Mass Flowmeters 8%

Outcome: Install and maintain mass flowmeters.

1. Describe the principles and applications of mass flowmeters.
2. Describe the components of a mass flowmeter.
3. Describe installation requirements for mass flowmeters.
4. Describe maintenance and calibration of mass flowmeters.
5. Describe advantages and limitations of mass flowmeters.
6. Configure a mass flowmeter, perform a master meter prove and calculate the meter factor.

P. Positive Displacement Flowmeters 8%

Outcome: Install and maintain positive displacement flowmeters.

1. Describe principles and applications of positive displacement flowmeters.
2. Describe components of a positive displacement flowmeter.
3. Describe installation requirements for positive displacement flowmeters.

4. Describe maintenance and calibration of positive displacement flowmeters.
5. Describe advantages and limitations of positive displacement flowmeters.
6. Connect and determine meter factor for a positive displacement flowmeter.

Q. Flow Computers 8%

Outcome: Install and maintain flow computers.

1. Describe parameters of a flow computer.
2. Describe principles and applications of flow computers.
3. Describe components of flow computers.
4. Describe advantages and limitations of flow computers.
5. Connect a flow computer for a liquid application to an ultrasonic meter and configure.
6. Install end devices on a gas orifice meter run, connect to a flow computer, configure and calibrate measurement system.

SECTION THREE: ..... PHYSICAL PROPERTIES 19%

A. Matter 16%

Outcome: Describe the relationship between atomic structure and electron flow.

1. Describe the basic composition of matter.
2. Describe physical and chemical changes to matter.
3. Describe the basic structure of the atom.
4. Describe the periodic table as it applies to properties of matter.
5. Describe nuclear fission and fusion.

B. Inorganic Compounds 14%

Outcome: Describe inorganic compounds.

1. Describe the formation of compounds.
2. Describe oxidation.
3. Describe simple and complex ions.
4. Describe cation/anion combinations.
5. Describe the classifications of compounds.

C. Chemical Calculations 14%

Outcome: Perform chemical calculations.

1. Describe molar mass, mass, number of molecules and number of atoms for a given number of moles in any compound.
2. Calculate the volume of moles of any gas at standard conditions.
3. Calculate the percent mass composition of each element in a compound.
4. Describe concentration of solutions.
5. Balance formulas for chemical reactions.

D. Chemical Reaction 20%

Outcome: Describe chemical reaction.

1. Describe classification of chemical reactions.
2. Describe chemical reactions involving metal and a metal ion.
3. Describe factors that influence rate of chemical reaction.
4. Describe exothermic and endothermic reaction.
5. Describe activation energy and reaction rate.
6. Describe electrical properties of water solutions.
7. Define pH, hydrogen ion concentration, and ionic activity.
8. Describe acids and bases as related to the pH scale.
9. Describe acid/base titration.
10. Describe oxidization and reduction in a chemical reaction.
11. Describe electrochemical cells.

E. Organic Chemistry 26%

Outcome: Describe organic chemistry.

1. Describe carbon bonding.
2. Describe carbon compounds and their molecular formula.
3. Describe organic families.
4. Describe the hydrocarbon chain.
5. Describe the chemical reactions used to refine the hydrocarbon chain.
6. Apply the stoichiometric equation to combustion of hydrocarbons.

F. Metallurgy 10%

Outcome: Select a metal or alloy for a required application.

1. Describe physical and mechanical properties of metals.
2. Describe effects of expansion and contraction.
3. Describe factors that change the properties of metals and alloys.
4. Identify effects of heat treatment on metals.
5. Describe applications and mechanical properties of alloying elements used in steel.
6. Interpret charts and tables to select a metal or alloy for an application.
7. Describe techniques of conditioning and coating of metals and alloys.
8. Describe methods of destructive and non-destructive testing of metals.
9. Describe hydrostatic tests.
10. Describe hardness testing.

SECTION FOUR: ..... PROCESS ANALYZERS 17%

A. Process Analyzers..... 12%

Outcome: Explain the terminology, technology, and applications of analytical measurements.

1. Describe process analytical measurement and terminology.
2. Describe applications of process analyzers.
3. Describe analyzer technologies.
4. Describe analyzer tolerances and limitations.
5. Describe environmental considerations for analyzer installations.
6. Describe calibration and calibration interaction of process analyzers.
7. Describe qualitative and quantitative data analysis.
8. Interpret block diagrams used in analyzer documentation.

B. Analyzer Sampling Systems..... 20%

Outcome: Explain analyzer sampling systems, including the system components and materials specifications.

1. Describe the purpose of a sample system.
2. Define in-situ and extractive sampling, used by continuous analyzers.
3. Describe the purpose and methods of sample conditioning.
4. Define clean and dirty service sample systems.
5. Describe the importance of sample loop time.
6. Describe components, design and limitations of sample systems.
7. Describe common troubleshooting techniques of various sample systems.
8. Describe representative grab sampling and the techniques utilized in grab sampling.

C. Gas Analyzers 24%

Outcome: Install and maintain gas analyzers.

1. Describe applications of gas analyzers.
2. Describe safety concerns when dealing with gas analyzers.
3. Describe principles of analysis and application of relative humidity analyzers.
4. Perform relative humidity calculations using psychrometric charts and tables.
5. Describe operation and calibration for dew point sensors.
6. Describe principles of analysis and application of dew point analyzers.
7. Describe principles of analysis and application of moisture analyzers.
8. Describe combustible chemical reactions.
9. Describe principles of analysis and application of oxygen analyzers.
10. Describe principles of analysis and application of combustion analyzers.
11. Describe combustion parameters measured to determine air to fuel ratio.
12. Describe the relationship between energy conservation, pollution emissions and combustion efficiency.
13. Connect / calibrate a combustion analyzer and demonstrate the effect of changing air / fuel ratios.

D. Liquid Analyzers 24%

Outcome: ***Install and maintain liquid analyzers.***

1. Describe applications of liquid analyzers.
2. Describe safety concerns when dealing with liquid analyzers.
3. Describe principles of analysis and application of pH analyzers.
4. Describe electrochemical process, measurement and reference half-cell reactions.
5. Apply the Nernst equation to pH measurements and determine why temperature correction is required.
6. Describe pH sensor limitations and control problems.
7. Describe similarities and differences between pH, specific ion and ORP measurements.
8. Describe buffer solutions for pH standards.
9. Describe principles of analysis and application of conductivity analyzers.
10. Describe the operation of conductivity cells.
11. Describe principles of analysis and application of turbidity analyzers.
12. Describe the operation of turbidity analyzers.
13. Describe principles of analysis and application of dissolved oxygen analyzers.
14. Describe the operation of dissolved oxygen analyzers.
15. Connect / calibrate a pH analyzer using 3 points and demonstrate the effects of buffer temperature on calibration.

E. Physical Property Analyzers 12%

Outcome: ***Install and maintain physical property analyzers.***

1. Describe principles of analysis and application of distillation (boiling point) analyzers.
2. Describe principles of analysis and application of vapour pressure analyzers.
3. Describe principles of analysis and application of viscosity analyzers.
4. Describe principles of analysis and application of density analyzers.
5. Demonstrate the effect of temperature on vapour pressure.

F. Vibration Monitoring 8%

Outcome: ***Install and maintain vibration monitoring equipment.***

1. Describe vibration as it relates to force and motion.
2. Describe units of measurement related to vibration monitoring.
3. Describe components of vibration monitoring equipment.
4. Describe where vibration monitoring is commonly used.
5. Assemble a probe, cable and amplifier, and use them to determine critical speed.

SECTION FIVE: ..... PROCESS CONTROL 23%

A. Closed Loop Analysis 20%

Outcome: Analyze loop characteristics.

1. Describe block diagrams and output/input equations for open loop control.
2. Describe the difference between linear and non-linear static gains.
3. Describe the characteristics of an integrating process.
4. Describe the characteristics of a first order process.
5. Describe the characteristics of a dead time process.
6. Describe the characteristics of a multi-capacity process.
7. Perform an open loop test to determine the characteristics of the above processes.

B. Process Loop Dynamics 20%

Outcome: Explain the dynamics of process control loops.

1. Describe the behaviour of an open loop system to a frequency input.
2. Describe the open loop frequency response of a dead time process.
3. Describe the open loop frequency response of an integrating process.
4. Describe the open loop frequency response of a first order.
5. Describe the open loop frequency response of a multi-capacity process.
6. Determine the effect of a frequency input on the gain and phase of a process.

C. Closed Loop Control 20%

Outcome: Explain the principles and applications of closed loop control for process control.

1. Describe the behaviour of a closed loop system to a disturbance.
2. Describe the closed loop response of a first order process.
3. Describe the closed loop response of an integrating process.
4. Describe the closed loop response of a dead time process.
5. Describe the closed loop response of a multi-capacity process.
6. Describe control strategies for non-linear processes.
7. Implement control strategies for the above non-linear processes.

D. Digital Controller Tuning 15%

Outcome: Commission and tune digital controllers.

1. Describe features and functionality of digital controllers versus pneumatic controllers.
2. Calculate the controller settings of a control loop.
3. Determine controller mode selection and initial settings for various process control loops.
4. Verify results of the self-tuning feature of a digital controller.
5. Connect, configure and tune a single loop digital controller in a gas pressure process.
6. Connect, configure and tune a single loop digital controller in a liquid pressure process.

7. Connect, configure and tune a controller in a flow application.
8. Connect, configure and tune a controller in a level application.

E. Cascade Control 15%

Outcome: ***Develop cascade control loop for process control.***

1. Describe advantages and applications for cascade control.
2. Describe failure mode considerations and control action for cascade control loops.
3. Explain how the effective time constant of the inner loop is reduced under cascade control.
4. Describe methods for tuning cascade control systems.
5. Draw a block diagram of a cascade control system.
6. Connect and tune a cascade control loop for a level/flow application.

F. Selective Control 10%

Outcome: ***Develop a selective control loop for process control.***

1. Describe advantages and applications for selective control.
2. Explain how to prevent reset windup on selective control.
3. Describe the methods for tuning selective control systems.
4. Draw a block diagram of a selective control system.
5. Configure and tune a selective control loop.

FOURTH PERIOD TECHNICAL TRAINING
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CURRICULUM GUIDE

UPON SUCCESSFUL COMPLETION OF THIS PROGRAM THE APPRENTICE SHOULD BE ABLE TO PERFORM THE FOLLOWING OUTCOMES AND OBJECTIVES.

SECTION ONE: ..... ADVANCED PROCESS CONTROL..... 26%

A. Multivariable Control 10%

Outcome: Develop a multivariable control loop.

1. Describe advantages and applications for multivariable control.
2. Draw a block diagram of a multivariable control system.
3. Describe methods for tuning multivariable control systems.
4. Configure and tune a multivariable control loop.

B. Ratio Control 10%

Outcome: Develop a ratio control loop.

1. Describe advantages and applications for ratio control.
2. Draw a block diagram of a ratio control system.
3. Describe methods for tuning ratio control systems.
4. Configure and tune a ratio control using hot and cold streams.

C. Feedforward Control 13%

Outcome: Develop a feedforward control loop.

1. Describe the differences between a feedforward control loop and a feedback control loop.
2. Describe the advantages and applications for feedforward control.
3. Draw a block diagram of a feedforward control system.
4. Describe the methods for tuning feedforward control systems.
5. Configure and tune a feedforward control loop.

D. Split Range Control 8%

Outcome: Develop a split range control loop.

1. Describe the advantages and applications for split range control.
2. Draw a block diagram of a split range control system.
3. Describe the methods for tuning split range control systems.
4. Configure and tune a split range control loop.

E. Distillation Control 16%

Outcome: Develop a control strategy for distillation processes.

1. Define the terms related to distillation process control.
2. Describe control strategies used in the distillation process.

3. Describe problems associated with distillation process control.
4. Demonstrate distillation process control.

F. Boiler Control 15%

Outcome: Develop a control strategy for boiler control.

1. Define terms related to boiler process control.
2. Describe control strategies used in the boiler process.
3. Describe problems associated with boiler process control.
4. Demonstrate boiler process control.

G. Compressor Control 15%

Outcome: Develop a control strategy for compressor control.

1. Define terms related to centrifugal compressor control.
2. Describe control strategies used in centrifugal compressor control.
3. Describe problems associated with centrifugal compressor control.
4. Define terms related to reciprocating compressor control.
5. Describe control strategies used in reciprocating compressor control.
6. Describe problems associated with reciprocating compressor control.
7. Demonstrate reciprocating and centrifugal compressor control applications.

H. Safety Instrumented Systems (SIS) 13%

Outcome: Develop a control strategy for safety instrumented systems (SIS).

1. Describe safety instrumented systems (SIS) and it's difference from basic process control systems (BPCS).
2. Describe safety integrity level (SIL) ratings.
3. Describe redundancy as it relates to SIS.
4. Select, configure and verify a SIS system for a specific SIL rating.

SECTION TWO: ..... COMMUNICATION 19%

A. Signal Transmission Systems 11%

Outcome: Install and maintain signal transmission systems.

1. Describe signal transmission systems used for communication.
2. Describe components of signal transmission systems.
3. Describe applications of signal transmission systems.
4. Connect and configure a signal transmission system.

B. Communication Signal Converters 11%

Outcome: Install and maintain communication signal converters.

1. Describe communication signal converters used for signal transmission.
2. Describe components of signal converters.

3. Describe applications of signal converters.
4. Configure a signal converter.

C. Protocols 24%

Outcome: ***Apply protocols between devices as used in industrial communication systems.***

1. Describe and compare the capabilities of digital field devices to that of analog devices.
2. Compare open and proprietary communication protocols.
3. Describe communication devices and application software.
4. Connect, configure and analyze several different protocol signals between devices.

D. Industrial Networks 26%

Outcome: ***Install and maintain industrial networks.***

1. Describe the different area networks and their applications.
2. Describe network components and characteristics.
3. Describe different transmission techniques of both wired and wireless.
4. Describe the different network topologies.
5. Describe methods of networking PLC's and DCS's.
6. Connect and network PLC's and or DCS's to implement industrial applications.
7. Assemble and configure a wireless network.

E. Supervisory Control and Data Acquisition (SCADA)..... 28%

Outcome: ***Perform configuration and maintenance of supervisory control and data acquisition systems.***

1. Describe SCADA applications.
2. Describe components and installation considerations of SCADA systems.
3. Describe standards, codes and licenses associated with SCADA systems.
4. Assemble, configure and test a single point to point SCADA system.
5. Assemble, configure and test a SCADA host to multiple remote terminal units (RTU).

SECTION THREE:..... CONTROL SYSTEMS..... 35%

A. Programmable Logic Controllers (PLC)..... 48%

Outcome: ***Select, configure, troubleshoot and maintain programmable logic controllers (PLC).***

1. Describe PLC ladder logic programs that use timers and counters.
2. Describe PLC ladder logic programs that use math instructions and PID control.
3. Describe PLC function block, sequential logic and structured text programs.
4. Describe PLC programs that use subroutines.
5. Describe PLC mixed language programs.
6. Describe PLC integration to various fieldbus devices.
7. Describe redundancy as it applies to PLC's.
8. Describe safety considerations when making changes online, forcing, disabling and bypassing I/O's.

9. Describe change management as it applies to PLC program changes.
10. Select all components, assemble and configure a PLC for a process control application.
11. Connect and program a PLC using ladder logic for a process control application.
12. Connect and program a PLC using function blocks for a process control application.
13. Connect and program a PLC that uses mixed programming.
14. Add I/O to a PLC; perform a program change and perform a backup.
15. Integrate various fieldbus devices to a PLC.
16. Use a configuration compare tool and update PLC change documentation.

B. Distributed Control Systems (DCS) 38%

Outcome: Select, configure and maintain distributed control systems (DCS).

1. Describe the hardware components and the buses of a DCS
2. Describe the different software programs of a DCS.
3. Describe data flow, scan cycle and databases of a DCS.
4. Evaluate DCS function block programs and communication between blocks.
5. Describe alarm management and history management concepts for a DCS.
6. Describe security and access privileges for a DCS.
7. Describe redundancy as it applies to DCS.
8. Describe change management and audit trail as they apply to a DCS.
9. Describe safety considerations as it applies to a DCS when making changes online, forcing, disabling and bypassing I/O's
10. Perform software configuration for a DCS.
11. Download and commission an analog process control strategy for a DCS.
12. Download and commission a discrete process control strategy for a DCS.
13. Add a smart field device to a DCS.
14. Add I/O to a DCS, perform a program change and perform a backup.
15. Troubleshoot a fault on a DCS using error codes.
16. Use historical logs, error logs and diagnostic tools to verify changes and troubleshoot a DCS.

C. Variable Speed Drives (VSD) 6%

Outcome: Perform configuration and maintenance of variable speed drives (VSD) used in process control.

1. Describe the principles and applications of VSDs.
2. Describe components of VSDs.
3. Describe software versions and updates.
4. Connect and configure a VSD to a PLC to control a process.

D. Human Machine Interfaces (HMI) 8%

Outcome: Perform configuration and maintenance of human machine interfaces (HMI).

1. Describe HMI components and their applications.
2. Describe programming/configuration software used for HMIs.

3. Describe methods of networking HMIs.
4. Describe software versions and updates.
5. Describe change management as it applies to HMI program changes.
6. Connect and program a HMI in a process control application.
7. Configure an HMI for VSD flow control.
8. Perform a program change and perform a backup.

SECTION FOUR:PROCESS ANALYZERS / MAINTENANCE PLANNING / WORKPLACE SKILLS 20%

A. Process Chromatography..... 20%

Outcome: Install and maintain chromatographs.

1. Explain the principle of analysis utilized by chromatography.
2. Define the terminology used in chromatography.
3. Describe components of a gas chromatograph.
4. Describe detectors used in gas chromatography.
5. Describe components of a liquid chromatograph.
6. Describe detectors used in liquid chromatography.
7. Describe sample systems and sample conditioning as they apply to chromatography.
8. Explain multi stream sample switching techniques.
9. Describe hazards and safe work practises related to chromatography and their sample systems.
10. Perform a manufacturer's periodic maintenance routine on a gas chromatograph unit.
11. Select a column and assemble sample system components for a given sample stream for a gas chromatograph, run analysis and interpret results.

B. Mass Spectrometry 10%

Outcome: Describe the principles, terminology, and applications of mass spectrometry.

1. Describe the principles of mass spectrometry.
2. Describe the application of mass spectrometry.

C. Environmental Monitoring..... 13%

Outcome: Install and maintain environmental monitoring devices.

1. Describe environmental monitoring and list pollutants that must be monitored and controlled.
2. Describe environmental monitoring with regards to health and safety.
3. Describe the role of government regulatory agencies.
4. Describe regulatory compliance with regard to environmental monitoring and the consequences of noncompliance.
5. Select and assemble sample system and sample conditioning components for a given sample stream for an environmental monitoring system, run analysis and interpret results.

D. Spectroscopic Analyzers..... 5%

Outcome: Install and maintain spectroscopic analyzers.

1. Describe the electromagnetic spectrum and electromagnetic radiation.

2. Describe absorption and emission spectrums.
3. Describe the principles of analysis and application of spectroscopic analyzers.
4. Describe the use of Beer-Lambert absorption laws for infrared (IR) and ultraviolet (UV) absorption analyzers.
5. Describe fluorescence.

E. Infrared Analyzers (IR) 10%

Outcome: Install and maintain infrared analyzers.

1. Describe the difference between dispersive infrared (DIR) and non-dispersive infrared (NDIR) analyzers.
2. Describe the sources, cells and detectors utilized by NDIR analyzers.
3. Describe negative and positive filtering techniques as applied in industry.
4. Describe process applications for IR analyzers.
5. Demonstrate the operation and calibration of a NDIR analyzer.

F. Ultraviolet Analyzers (UV)..... 10%

Outcome: Install and maintain ultraviolet analyzers.

1. Describe the principles of analysis and application of ultraviolet analyzers (UV).
2. Describe the components of UV analyzers.
3. Describe UV precautions and hazards.
4. Explain the differences between UV absorption and UV emission (fluorescence) analysis.
5. Demonstrate the operation and calibration of an ultraviolet analyzer.

G. Chemiluminescence..... 6%

Outcome: Install and maintain chemiluminescent analyzers.

1. Describe the chemical reactions related to chemiluminescence analysis.
2. Describe the components of a chemiluminescence nitric oxide (NO) analyzer.
3. Describe the principles of analysis and application of chemiluminescence analyzers.
4. Demonstrate the operation of a gas sample system for a chemiluminescence analyzer.
5. Demonstrate the operation and calibration of a chemiluminescence analyzer.

H. Maintenance Planning..... 16%

Outcome: Perform maintenance planning.

1. Describe reactive, preventative and predictive methods of maintenance planning.
2. Describe key performance indicators (KPI) as it relates to reliability.
3. Describe the equipment criticality decision process as it relates to maintenance planning.
4. Describe the inventory control process.
5. Describe estimating, justification and purchasing procedures.
6. Describe maintenance scheduling and record keeping.
7. Describe management of change (MOC) processes and their purpose.

I. Workplace Coaching Skills 5%

Outcome: ***Use coaching skills when training an apprentice.***

1. Describe the process for coaching an apprentice.

J. Interprovincial Standards Red Seal Program 5%

Outcome: ***Use Red Seal products to challenge an Interprovincial examination.***

1. Identify Red Seal products used to develop Interprovincial examinations.
2. Use Red Seal products to prepare for an Interprovincial examination.

Apprenticeship and Industry Training

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