Apprenticeship and Industry Training

Instrument Technician

Apprenticeship Course Outline

3102.2 (2002)

Alberta

Apprenticeship and Industry Training

Instrument Technician
Table of Contents

Course Outline

Apprenticeship

Apprenticeship is post-secondary education with a difference. Apprenticeship begins with finding an employer. Employers hire apprentices, pay their wages and provide on-the-job training and work experience. 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 – usually a college or technical institute.

To become certified journeypersons, apprentices must learn theory and skills, and they must pass examinations. Requirements for certification—including the content and delivery of technical training—are developed and updated by the Alberta Apprenticeship and Industry Training Board on the recommendation of Instrument Technician Provincial Apprenticeship Committee.

The graduate of the Instrument Technician apprenticeship program is a certified journeyperson who will be able to:

- have a thorough appreciation of the operating processes and their interrelation-ship with instrumentation
- have a thorough knowledge of precision measurement and calibration
- have a comprehensive understanding of basic ac and dc electrical components and circuits in order to do adjustments and repairs of electronic equipment
- be familiar with the technologies of Electronics, Pneumatics, Hydraulics, Mechanics and Chemistry
- use the correct and safe method of connecting and disconnecting low voltage signal lines from electronic instruments
- understand the monitoring processes involved in process quality control
- master the basic knowledge for the repair, fabrication and assembly of electronic and mechanical assemblies; with complete ability in making pneumatic, hydraulic and process joints and seals
- exercise good judgement and resourcefulness in construction, maintenance and Occupational Health and Safety
- perform assigned tasks in accordance with quality and production standards required by industry

Apprenticeship and Industry Training System

Industry-Driven

Alberta's apprenticeship and industry training system is an industry-driven system that ensures a highly skilled, internationally competitive workforce in more than 50 designated trades and occupations. This workforce supports the economic progress of Alberta and its competitive role in the global market. Industry (employers and employees) establishes training and certification standards and provides direction to the system through an industry committee network and the Alberta Apprenticeship and Industry Training Board. The Alberta government provides the legislative framework and administrative support for the apprenticeship and industry training system.

Alberta Apprenticeship and Industry Training Board

The Alberta Apprenticeship and Industry Training Board provides a leadership role in developing Alberta's highly skilled and trained workforce. The board's primary responsibility is to establish the standards and requirements for training and certification in programs under the Apprenticeship and Industry Training Act. The board also provides advice to the Minister of Advanced Education and Technology on the needs of Alberta's labour market for skilled and trained workers, and the designation of trades and occupations.

The thirteen-member board consists of a chair, eight members representing trades and four members representing other industries. There are equal numbers of employer and employee representatives.

Industry Committee Network

Alberta's apprenticeship and industry training system relies on a network of industry committees, including local and provincial apprenticeship committees in the designated trades, and occupational committees in the designated occupations. The network also includes other committees such as provisional committees that are established before the designation of a new trade or occupation comes into effect. All trade committees are composed of equal numbers of employer and employee representatives. The industry committee network is the foundation of Alberta's apprenticeship and industry training system.

Local Apprenticeship Committees (LAC)

Wherever there is activity in a trade, the board can set up a local apprenticeship committee. The board appoints equal numbers of employee and employer representatives for terms of up to three years. The committee appoints a member as presiding officer. Local apprenticeship committees:

- monitor apprenticeship programs and the progress of apprentices in their trade, at the local level
- make recommendations to their trade's provincial apprenticeship committee (PAC) about apprenticeship and certification in their trade
- promote apprenticeship programs and training and the pursuit of careers in their trade
- make recommendations to the board about the appointment of members to their trade's PAC
- help settle certain kinds of disagreements between apprentices and their employers
- carry out functions assigned by their trade's PAC or the board

Provincial Apprenticeship Committees (PAC)

The board establishes a provincial apprenticeship committee for each trade. It appoints an equal number of employer and employee representatives, and, on the PAC's recommendation, a presiding officer - each for a maximum of two terms of up to three years. Most PACs have nine members but can have as many as twenty-one. Provincial apprenticeship committees:

- Make recommendations to the board about:
    - standards and requirements for training and certification in their trade
    - courses and examinations in their trade
    - apprenticeship and certification
    - designation of trades and occupations
    - regulations and orders under the Apprenticeship and Industry Training Act
- monitor the activities of local apprenticeship committees in their trade
- determine whether training of various kinds is equivalent to training provided in an apprenticeship program in their trade
- promote apprenticeship programs and training and the pursuit of careers in their trade
- consult with other committees under the Apprenticeship and Industry Training Act about apprenticeship programs, training and certification and facilitate cooperation between different trades and occupations
- consult with organizations, associations and people who have an interest in their trade and with employers and employees in their trade
- may participate in resolving certain disagreements between employers and employees
- carry out functions assigned by the board

Instrument Technician PAC Members at the Time of Publication

Mr. G. Peterson	Edmonton	Presiding Officer
Mr. C. Hand	Fort McMurray	Employer
Mr. D. Lock	Grande Prairie	Employer
Mr. J. Both	Edmonton	Employer
Mr. J. Boyd	Calgary	Employee
Mr. G. Reynolds	Fort McMurray	Employee
Mr. G. Johnston	Vermilion	Employee

Alberta Government

Alberta Advanced Education and Technology works with industry, employer 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 employers
- coordinate technical training in collaboration with training providers
- certify apprentices and others who meet industry standards

Technical Institutes and Colleges

The technical institutes and colleges are key participants in Alberta's apprenticeship and industry training system. They work with the board, industry committees and Alberta Advanced Education and Technology to enhance access and responsiveness to industry needs through the delivery of the technical training component of apprenticeship programs. They develop lesson plans from the course outlines established by industry and provide technical training to apprentices.

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, employers, 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.

Alberta Apprenticeship and Industry Training Board Safety Policy

The Alberta Apprenticeship and Industry Training Board fully supports safe learning and working environments and encourages the teaching of proper safety procedures both within trade specific training and in the workplace.

Trade specific safety training is an integral component of technical training, while ongoing or general non-trade specific safety training remains the responsibility of the employer and the employee as required under workplace health and safety legislation.

Workplace Responsibilities

The employer is responsible for:

- training employees and apprentices in the safe use and operation of equipment
- providing and maintaining safety equipment, protective devices and clothing
- enforcing safe working procedures
- providing safeguards for machinery, equipment and tools
- observing all accident prevention regulations

The employee and apprentice are responsible for:

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

Workplace Health and Safety

A tradesperson is often exposed to more hazards than any other person in the work force 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.

Workplace Health and Safety (Alberta Employment, Immigration and Industry) conducts periodic inspections of workplaces to ensure that safety regulations for industry are being observed.

Additional information is available at www.worksafely.org

Technical Training

Apprenticeship technical training is delivered by the technical institutes and many colleges in the public post-secondary system throughout Alberta. The colleges and institutes are committed to delivering the technical training component of Alberta apprenticeship programs in a safe, efficient and effective manner. All training providers place great emphasis on safe technical practices that complement safe workplace practices and help to develop a skilled, safe workforce.

The following institutions deliver Instrument Technician apprenticeship technical training:

Northern Alberta Institute of Technology

Southern Alberta Institute of Technology

Procedures for Recommending Revisions to the Course Outline

Advanced Education and Technology has prepared this course outline in partnership with the Instrument Technician Provincial Apprenticeship Committee.

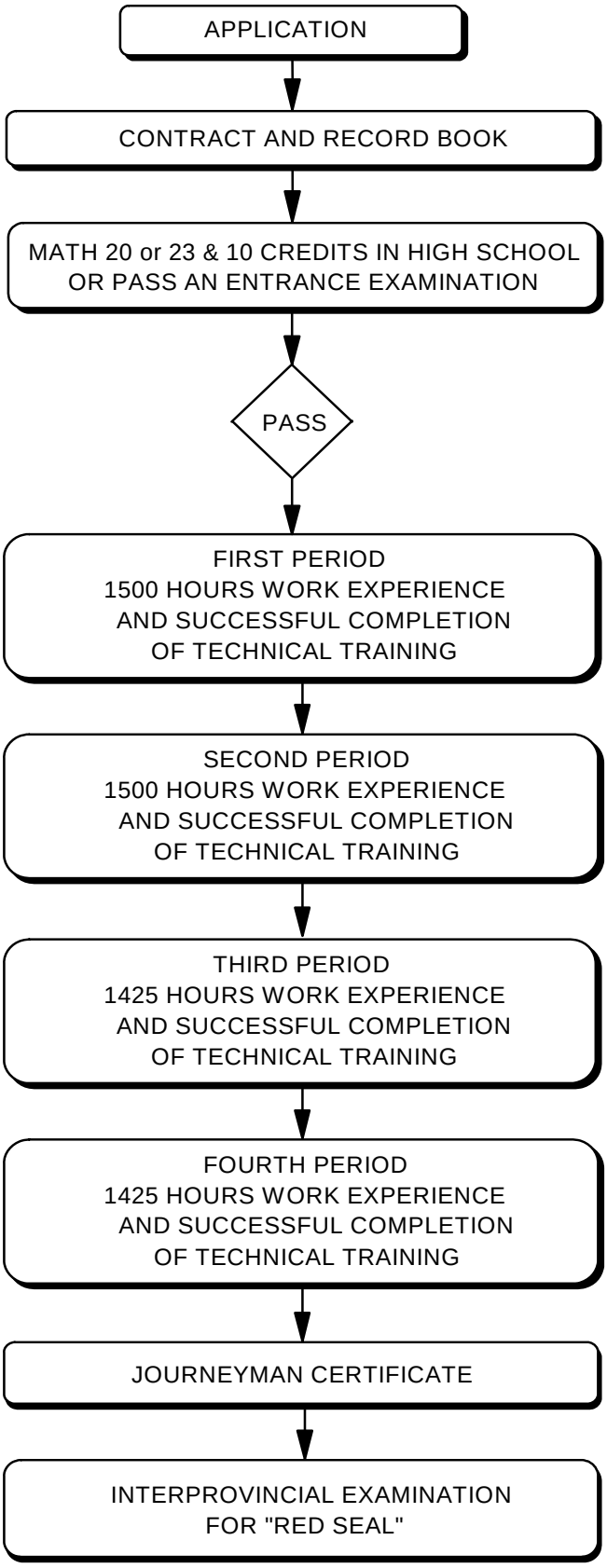
This course outline was approved on September 27, 2002 by the Alberta Apprenticeship and Industry Training Board on a recommendation from the Provincial Apprenticeship Committee. The valuable input provided by representatives of industry and the institutions that provide the technical training is acknowledged.

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

Instrument Technician Provincial Apprenticeship Committee
c/o Industry Programs and Standards
Apprenticeship and Industry Training
Advanced Education and Technology
10th 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. Recommendations for change will be placed on the agenda for regular meetings of the Instrument Technician Provincial Apprenticeship Committee.

Apprenticeship Route toward Certification



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

SECTION ONE

SHOP PRACTICES THEORY AND LABORATORY

40 HOURS

A	B	C
Safety, WHMIS and The Advisory Network 2 Hours	Tube Bending 9 Hours	Thermocouple Installation 1 Hour
D	**E**	**F**
Precision Measurement 4 Hours	Control Valve Servicing 5 Hours	Metal Fabrication 8 Hours
G	**H**	**I**
Pipe Threading 2 Hours	Electronic Soldering 4 Hours	Tube Joining Methods 5 Hours

SECTION TWO

ELECTRICAL THEORY AND LAB

88 HOURS

A	B	C
Electricity 4 Hours	Resistance 6 Hours	Ohm's Law 2 Hours
D	**E**	**F**
Series Circuit 2 Hours	Parallel Circuit 4 Hours	Series/Parallel Circuit 3 Hours
G	**H**	**I**
Kirchoff's Laws 2 Hours	Measurement of Current 2 Hours	Measurement of Voltage 2 Hours
J	**K**	**L**
Measurement of Resistance 3 Hours	Circuit Analysis 3 Hours	Batteries 4 Hours
M	**N**	**O**
Magnetism 3 Hours	Magnetic Circuits 4 Hours	Alternating Current Fundamental 28 Hours
P	**Q**	**R**
Inductance 4 Hours	Capacitance 4 Hours	Time Constants 4 Hours
S		
Reactance and Impedance 4 Hours		

SECTION THREE

PNEUMATIC INSTRUMENTS

64 HOURS

A	B	C
Pressure Standards 4 Hours	Pressure Measurement 1 Hour	Gauge Installation 1 Hour
D	**E**	**F**
Gauge Calibration 1 Hour	Pressure Regulators 3 Hours	Air Supplies 2 Hours
G	**H**	**I**
Pneumatic Components 4 Hours	Link and Lever Systems 2 Hours	Feedback Systems 1 Hour

	J Computing Relays 2 Hours	K Pressure Transmitters 2 Hours	L Plug Type Control Valves 2 Hours
	M Rotary and Other Valves 2 Hours	N Valve Actuators 3 Hours	O Valve Positioners 2 Hours
	P Control Valve Selection 3 Hours	Q Valve Maintenance 2 Hours	R Recorders 3 Hours
	S Laboratory 24 Hours		
SECTION FOUR **RELATED APPLIED PHYSICS AND MATH** **40 HOURS**	A SI and Imperial Units 1 Hour	B Basic Mathematics Review 1 Hour	C Mensuration 2 Hours
	D Motion 3 Hours	E Force 2 Hours	F Pressure 2 Hours
	G Work and Power 4 Hours	H Energy 4 Hours	I Fluid Principles 7 Hours
	J Heat and Temperature 7 Hours	K Laws of Perfect Gases 3 Hours	L Solids 4 Hours
SECTION FIVE **ELECTRICAL HAZARDS AND SAFETY I** **8 HOURS**	A Regulations 1 Hour	B Area Classifications 2 Hours	C Explosion Proof Equipment 2 Hours
	D Instrinsic Safety 2 Hours	E Other Methods 1 Hour	

Second Period
(8 Weeks/30 Hours Per Week –Total Of 240 Hours)

SECTION ONE

BASIC ELECTRONICS
42 HOURS

A	B	C
Review 4 Hours	Diodes 2 Hours	Power Supplies 8 Hours
D	**E**	**F**
Bipolar Transistors 3 Hours	Field Effect Transistors 2 Hours	Other Semiconductor Devices 5 Hours
G	**H**	
Oscillators 1 Hour	Laboratory 17 Hours	

SECTION TWO

MEASUREMENT AND CONTROL INSTRUMENTS
96 HOURS

A	B	C
Flow Measurement Terms and Industrial Applications 2 Hours	Head Type Primary Elements 3 Hours	Head Type Secondary Elements 2 Hours
D	**E**	**F**
Flowmeter Installation Practices 2 Hours	Flow Measurement Calculation 2 Hours	Variable Area Meters (Rotameters) 2 Hours
G	**H**	**I**
Weirs and Flumes 1 Hour	Flow Switches 1 Hour	Introduction to Level Measurement 1 Hour
J	**K**	**L**
Gauge Glasses 1 Hour	Floats 1 Hour	Displacers 3 Hours
M	**N**	**O**
Hydrostatic Head Level Measurement and Bubbler Systems 1 Hour	Differential Pressure Level Measurement 3 Hours	Introduction to Temperature Measurement 2 Hours
P	**Q**	**R**
Temperature Scales 1 Hour	Coefficient of Expansion 1 Hour	Glass Thermometers 1 Hour
S	**T**	**U**
Bimetallic Thermometers 1 Hour	Filled System Thermometers 2 Hours	Introduction to Thermocouples 3 Hours
V	**W**	**X**
Introduction to Automatic Control 2 Hours	On-Off Controllers 2 Hours	Proportional Control 2 Hours
Y	**Z**	**AA**
Proportional Plus Reset Control 2 Hours	PD Controllers 2 Hours	Introduction to Controller Tuning 2 Hours
AB		
Laboratory 48 Hours		

SECTION THREE

DIGITAL ELECTRONICS

40 HOURS

A	B	C
Introduction to Digital 1 Hour	Number Systems 3 Hours	Digital Signals 2 Hours
D	**E**	**F**
Logic Gates 10 Hours	Relay Ladder Logic 3 Hours	Storage Register Elements 3 Hours
G	**H**	**I**
Sequential Logic 2 Hours	Display Circuits 1 Hour	Logic Gate Specifications 1 Hour
J	**K**	**L**
Memory 2 Hours	Microcomputers 2 Hours	Point to Point Data Communications 10 Hours

SECTION FOUR

INTRODUCTION TO PROCESS EQUIPMENT

32 HOURS

A	B	C
ISA Symbols (S5-1, S5-2, S5-3 and Latest Revision) 2 Hours	Product Movement 5 Hours	Solids/Size Reduction or Enlargement 1 Hour
D	**E**	**F**
Solids/Separation 3 Hours	Fluid Separation 1 Hour	Mixing 1 Hour
G	**H**	**I**
Heat Transfer 3 Hours	Evaporation 3 Hours	Drying 1 Hour
J	**K**	**L**
Humidification and Dehumidification 2 Hours	Distillation and Fractionation 3 Hours	Gas Absorption, Desorption and Adsorption 1 Hour
M	**N**	**O**
Dehydrator 1 Hour	Boilers and Direct Fired Heaters 3 Hours	Natural Gas Processing Plants 1 Hour
P		
Pulp and Paper Mills 1 Hour		

SECTION FIVE

PERSONAL COMPUTER APPLICATIONS

30 HOURS

A	B	C
Hardware 2 Hours	Software 2 Hours	Operating Systems 6 Hours
D	**E**	**F**
Word Processors 2 Hours	Spreadsheets 6 Hours	Computer Aided Design (CAD) 3 Hours
G	**H**	
Data Base 6 Hours	Internet Access 3 Hours	

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

SECTION ONE

APPLIED ELECTRONICS

90 HOURS

A	B	C
Operational Amplifier Basics 4 Hours	Op Amp Circuit Configurations 11 Hours	Analog Circuits 7 Hours
D	**E**	**F**
Analog to Digital and Digital to Analog Conversion 7 Hours	The Instrument Loop 22 Hours	Power Control 4 Hours
G		
Laboratory 35 Hours		

SECTION TWO

MEASUREMENT INSTRUMENTS

100 HOURS

A	B	C
Introduction 4 Hours	Flow Measurement 23 Hours	Level Measurement 13 Hours
D	**E**	**F**
Density Measurement 5 Hours	Viscosity 1 Hour	Temperature Measurement 17 Hours
G		
Laboratory 37 Hours		

SECTION THREE

PROCESS ANALYZERS

60 HOURS

A	B	C
Introduction to Continuous Measurements for Process 2 Hours	Analyzer Sampling Systems 4 Hours	Relative Humidity, Dew Point and Moisture Measurement 4 Hours
D	**E**	**F**
Oxygen Measurement 4 Hours	Combustion Measurement 3 Hours	Explosive Measurements 3 Hours
G	**H**	**I**
Toxic Measurements 2 Hours	Specific Ion, pH and ORP Measurement 6 Hours	Conductivity Measurement 4 Hours
J	**K**	**L**
Turbidity Measurements 1 Hour	Dissolved Oxygen 1 Hour	Physical Properties Analyzers 3 Hours
M	**N**	
Vibration Measurement 3 Hours	Laboratory 20 Hours	

SECTION FOUR

CHEMISTRY

50 HOURS

A	B	C
Matter 9 Hours	Nomenclature of Inorganic Compounds 8 Hours	Chemical Calculations 8 Hours
D	**E**	
Chemical Reaction 10 Hours	Organic Chemistry 15 Hours	

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

SECTION ONE

PROCESS CONTROL

131 HOURS

A	B	C
Terminology and Definitions 3 Hours	The Open Loop Controller 4 Hours	Closed Loop Controller Tuning 6 Hours
D	**E**	**F**
General Single Loop Analysis 10 Hours	Process Loop Elements 7 Hours	Unique Single Loops 6 Hours
G	**H**	**I**
Control Strategies 32 Hours	Advanced Control Strategies 8 Hours	Process Units and Control 15 Hours
J		
Laboratory 40 Hours		

SECTION TWO

ADVANCED DIGITAL SYSTEMS

102 HOURS

A	B	C
Digital Controllers 8 Hours	Programmable Logic Controllers 25 Hours	Supervisory Control and Data Acquisition (SCADA) 15 Hours
D	**E**	**F**
Industrial Local Area Networks (ILAN) 6 Hours	Fieldbus Protocols 8 Hours	Laboratory 40 Hours

SECTION THREE

PROCESS ANALYZERS

63 HOURS

A	B	C
Introduction to Spectrophotometry 5 Hours	Infrared Analysis 3 Hours	Ultraviolet Analysis 3 Hours
D	**E**	**F**
Chemiluminescence 2 Hours	Process Chromatography 14 Hours	Mass Spectroscopy Measurement 4 Hours
G	**H**	**I**
Environmental Monitoring 3 Hours	Analyzer Calibrations 3 Hours	Sampling Systems 6 Hours
J		
Laboratory 20 Hours		

SECTION FOUR

WORKPLACE COACHING SKILLS

4 HOURS

A
Workplace Coaching Skills 4 Hours

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

FIRST PERIOD TECHNICAL TRAINING
INSTRUMENT TECHNICIAN TRADE
COURSE OUTLINE

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

Due to the nature of the work of the Instrument Technician trade, it is imperative that safety be taught on a continuous basis throughout the entirety of this course.

Special emphasis should be placed on weak areas of theory and shop that are evident from progressive tests and examinations administered throughout the course. The time required for such examinations and testing shall be allowed for in each area of instruction.

SECTION ONE: ..... SHOP PRACTICES THEORY AND LABORATORY ..... 40 HOURS

A. Safety, WHMIS and The Advisory Network .....2 Hours

1. Provide an awareness of OH&S.
2. Describe workplace safety program requirements.
3. Provide an awareness of WHIMIS.
4. Describe the role and purpose of the advisory network and the Provincial Apprenticeship Committee for the Instrument Technician trade.

B. Tube Bending .....9 Hours

1. Sketch and dimension common tube installations.
2. Calculate tube bending lengths for various tube configurations and angles.
3. Bend tube as needed for common instrument installations.
4. Install tubing and tube fittings for safe leak proof installations.

C. Thermocouple Installation .....1 Hour

1. Explain bare wire thermocouples by the use of hard solder joining.
2. Install bare wire thermocouples with and without the use of insulators, terminal blocks and extension wire.

D. Precision Measurement.....4 Hours

1. Take accurate measurements with the use of:
   a) rules
   b) calipers
   c) Vernier calipers
   d) micrometers

E. Control Valve Servicing.....5 Hours

1. Isolate and remove a control valve from service.
2. Dismantle, inspect and replace O-rings, gaskets, diaphragms and packing on conventional control valves.
3. Install a valve positioner and associated hardware on a control valve.
4. Measure, cut and install gaskets for flange end connections on control valves.
5. Properly install and tighten flange connections for safe leak proof service.

F. Metal Fabrication .....8 Hours

1. Effectively use metal tools such as layout instruments, hacksaw, files, drills and thread taps, in practical metal fabrication.
2. Hard solder simple metal brackets and supports using oxyacetylene equipment.

G. Pipe Threading .....2 Hours

1. Thread steel pipe with the use of power threaders and hand threaders.
2. Install threaded pipe and fittings for a safe leak tight installation.

H. Electronic Soldering .....4 Hours

1. Install and solder electronic components onto a printed circuit board.
2. Desolder and remove components from printed circuit boards.
3. Understand static and anti-static devices.

I. Tube Joining Methods.....5 Hours

1. Join tube using: soft soldering, flaring and compression fittings.

SECTION TWO: .....ELECTRICAL THEORY AND LAB.....88 HOURS

A. Electricity.....4 Hours

1. Name the components of the atom and identify their relationship.
2. Explain the theory of charge conduction.
3. Define electrical units of measurement.
4. Define direct and alternating current.
5. Identify ac and dc sources.

B. Resistance .....6 Hours

1. Define electrical resistance.
2. Explain the relationship between conductor parameters and resistance.
3. Define temperature coefficients.
4. Calculate resistance of wires using resistivity or wire tables.
5. Calculate the change in conductor resistance due to changes in conductor temperature.
6. Identify NTC and PTC resistors from their characteristics.

7. Describe when each type of resistor may be used.
8. Identify resistors from their physical characteristics and colour coding.
9. Describe superconductivity.
10. Describe applications of NTC and PTC resistors.

C. Ohm's Law ..... 2 Hours

1. Define Ohm's law.
2. Explain relationship between electromotive force, current and resistance.
3. Calculate potential, current and resistance.
4. State formulae and solve problems for power determination.

D. Series Circuit ..... 2 Hours

1. Describe current flow in a series circuit.
2. Explain polarity.
3. Calculate and verify potentials, power dissipation, polarity and current at specified points using Ohm's law.

E. Parallel Circuit ..... 4 Hours

1. Describe current flow in a parallel circuit.
2. Calculate equivalent series resistance for two or more resistances in parallel.
3. Calculate and verify potentials, power dissipation, polarity and current at specified points using Ohm's law.

F. Series/Parallel Circuit ..... 3 Hours

1. Describe current flow in a series/parallel circuit.
2. Calculate equivalent resistance of a series/parallel circuit.
3. Calculate and verify potentials, power dissipation, polarity and current, at specified points using Ohm's law.

G. Kirchoff's Laws ..... 2 Hours

1. Define and be able to verify Kirchoff's first and second laws.
2. Explain conventions and notations used with Kirchoff's laws.
3. Apply Kirchoff's laws for circuit analysis.

H. Measurement of Current ..... 2 Hours

1. Use digital ammeters to measure current.
2. Understand appropriate meter applications and safety procedures.

I. Measurement of Voltage .....2 Hours

1. Define voltmeter accuracy and explain/demonstrate its significance.
2. Explain the theory of operation of multi-range voltmeters.
3. Use digital voltmeters to measure voltage.
4. Understand appropriate meter applications and safety procedures.

J. Measurement of Resistance .....3 Hours

1. Explain the theory of operation of resistance bridges.
2. Compare analog and digital ohmmeters.
3. Use digital meters for resistance measurement.

K. Circuit Analysis .....3 Hours

1. Explain the effects of open circuits and short circuits.
2. Use digital multi-meters to troubleshoot circuits.
3. Explain the effects of faulty components in a circuit.
4. Apply superposition theorem to circuits to calculate currents or voltages.
5. Briefly compare analog and digital meters.

L. Batteries .....4 Hours

1. Define the voltage, current capacity and ratings applicable to various types of batteries.
2. Describe the hazards associated with the checking and charging various types of batteries.
3. Explain voltage and current changes when batteries are interconnected.
4. Describe the proper care and maintenance of various types of batteries.
5. Explain how batteries relate to UPS systems.
6. Compare equalization and float voltages.
7. Describe characteristics and handling precautions of Lithium and Mercury cells.

M. Magnetism .....3 Hours

1. Explain the theory of magnetism.
2. Describe the characteristic pattern of a magnetic field.
3. Define the units used for measurement.

N. Magnetic Circuits .....4 Hours

1. Identify the characteristic magnetization curve and explain the hysteresis effect.
2. Explain the theory of operation of the motor effect.
3. Explain the theory of electromagnetic induction.
4. Define Faraday's and Lenz's laws.
5. Describe mutual induction and transformer effect.

O. Alternating Current Fundamental .....28 Hours

1. Explain the relationship of voltage and time.
2. Describe a sinusoidal waveform.
3. Explain the voltage and current relationship with a resistive load.
4. Calculate average and effective values for a sine wave.
5. Describe the characteristic pattern of specified non-sinusoidal waveforms.
6. Graph phase relationships in an ac circuit.
7. Define phase angle, RMS, peak-to-peak and average voltage for a sine wave.
8. Calculate RMS, peak-to-peak and average voltage for a given sine wave.
9. Explain the resonance effect.

P. Inductance .....4 Hours

1. Define the terms inductor, induction and inductance and explain the differences.
2. Explain mutual inductance.
3. Calculate effective inductance of inductors in series or parallel.
4. Explain the basic operation of a transformer.
5. Define the terms ratio, step-up, step-down, multi-winding, isolating and polarity marks as they refer to basic transformers.
6. Calculate the output of transformers with a specified input and turns ratio.

Q. Capacitance .....4 Hours

1. Explain the electrical operation and theory of a capacitor.
2. Graph the characteristic charge/discharge curve and list the factors which modify the curve.
3. Explain charge units and describe the parameters which affect capacitance.
4. Calculate the effective capacitance of capacitors in series or parallel.

R. Time Constants .....4 Hours

1. Explain the time effects in selected R-C circuit types.
2. Graph the characteristic waveforms.
3. Define time constants and explain the effects of long and short time constants on waveforms.

S. Reactance and Impedance .....4 Hours

1. Define inductive and capacitive reactance.
2. Calculate reactance of specified components for given waveforms.
3. Define impedance.
4. Calculate impedance, current flow and phase angle for series or parallel combinations of resistors, capacitors and inductors.

SECTION THREE: .....PNEUMATIC INSTRUMENTS.....64 HOURS

A. Pressure Standards .....4 Hours

1. Describe different pressure standards.
2. Apply the standards to pressure measurement.
3. Define absolute, effective and barometric pressure.
4. Perform head pressure calculations.

B. Pressure Measurement .....1 Hour

1. Describe different pressure gauges (ΔP, absolute, receiver).
2. Describe applications/limitations of different pressure gauges.

C. Gauge Installation.....1 Hour

1. Describe and illustrate installation designs.
2. Describe protection methods.

D. Gauge Calibration .....1 Hour

1. Describe calibration procedure.
2. Describe calibration devices and their use.

E. Pressure Regulators.....3 Hours

1. Describe principle of operation of self-actuated regulators.
2. Describe details and differences between spring-loaded, weight loaded and pilot-operated regulators.
3. Specify applications including back pressure and pressure reduction.

F. Air Supplies .....2 Hours

1. Describe air dryers and their fittings.
2. Describe air receivers and their fittings.
3. Describe all types of air compressors.

G. Pneumatic Components.....4 Hours

1. Describe and explain the various operation of displacement detectors.
2. Describe and explain the operation of the air relay.

H. Link and Lever Systems.....2 Hours

1. Define gain angularity and zero.
2. Calibrate link and lever systems.

I. Feedback Systems.....1 Hour

1. Describe and recognize different types of feedback systems.

J. Computing Relays ..... 2 Hours

1. List types of computing relays.
2. Demonstrate the principle of operation of computing relays.
3. Explain typical applications.

K. Pressure Transmitters ..... 2 Hours

1. Describe operation.
2. Describe calibration procedure.
3. Describe installation arrangements.

L. Plug Type Control Valves ..... 2 Hours

1. Describe types of valve bodies.
2. Explain factors for choice of one type over another.
3. Explain service procedures.

M. Rotary and Other Valves ..... 2 Hours

1. Describe types of valve bodies.
2. Explain factors for choice of one type over another.
3. Explain service procedures.

N. Valve Actuators ..... 3 Hours

1. Describe various types of actuators.
2. Explain applications of actuators.
3. Describe service procedures.
4. List and explain accessories.

O. Valve Positioners ..... 2 Hours

1. Demonstrate principle of operation of various positioners.
2. Explain applications of positioners.
3. Describe the control features of the smart positioners.
4. Calibrate I/P transducers.

P. Control Valve Selection ..... 3 Hours

1. Define characteristics and CV factor.
2. Define corrosion, cavitation and flashing with respect to trim selection.
3. Determine fail safe mode selection.
4. Describe considerations when determining valve sizes.

Q. Valve Maintenance ..... 2 Hours

1. Describe valve packing materials and procedures.
2. Define valve stroking.
3. Describe methods of grinding seats.
4. Describe friction as applied to fluids and motion.
5. Define static and kinetic friction, coefficient of friction.

R. Recorders ..... 3 Hours

1. Describe the principle of operation of various types.
2. Describe calibration procedures of types listed above.
3. Describe different charts and recording methods (e.g. timebases).

S. Laboratory ..... 24 Hours

1. Use of pressure standards (primary and secondary).
2. Pressure gauge calibration.
3. Pressure transmitter calibration.
4. Process recorder calibration.
5. Set up a smart valve positioner.
6. Strip/re-build a pneumatic DP cell to within manufacturers' specifications.
7. Bench set and stroke (with positioner) control valves.
8. Set up valve/positioner for split range and characterize.
9. Strip/re-build various computing relays.

SECTION FOUR: ..... RELATED APPLIED PHYSICS AND MATH ..... 40 HOURS

A. SI and Imperial Units ..... 1 Hour

1. SI Units:
   a) list the basic SI units of length, mass, time and temperature with their symbols
   b) define the prefixes used to indicate large and small quantities
   c) list the derived SI units and their symbols
   d) convert Imperial units to SI and vice versa using conversion factors
2. Imperial Units:
   a) conversions and equivalents

B. Basic Mathematics Review ..... 1 Hour

1. Solve problems involving fractions and exponents.
2. Solve problems involving percentage.
3. Solve problems involving ratio and proportion.
4. Solve problems involving equations.
5. Describe the concept of equal sides of an equation.
6. Transpose and solve equation for an unknown.

7. Explain basic mathematical properties of communitation and association properties.
8. Solve problems involving basic trigonometry (SIN, COS, TAN).

C. Mensuration.....2 Hours

1. Define degrees, right angle, obtuse angle, adjacent side and opposite side of a triangle.
2. Define isosceles and equilateral triangles.
3. Apply the Pythagoras theorem to a right angled triangle.
4. Calculate the perimeter of a triangle, square, rectangle and circle.
5. Calculate the area of a triangle, square, rectangle and a circle.
6. Calculate the volume of a cylinder, cube and rectangular solid.

D. Motion .....3 Hours

1. Define velocity, speed, acceleration, displacement, average velocity, average acceleration and momentum.
2. Define gravitational acceleration, scalar vector quantities, force, and mass.
3. Solve problems related to force, mass and acceleration.
4. Describe Newton's three laws of motion.
5. Describe the law of conservation of motion or momentum.

E. Force .....2 Hours

1. Define moment of force and torque.
2. Describe balancing of forces on a beam.
3. Calculate basic problems related to force balance about a point.
4. State the condition for equilibrium of a lever system.
5. Define effort and a mechanical advantage.
6. Calculate the mechanical advantage of a beam.
7. State the mechanical advantage or velocity ratio in terms of diameters of radius of wheel and axle, pulleys and gears.
8. Calculate the size of driven gears or pulleys required to obtain the necessary speed or rotation.
9. Calculate the mechanical advantage of a block and tackle system.

F. Pressure.....2 Hours

1. Define static pressure and atmosphere pressure.
2. Calculate force and pressure on a given area.
3. State the equation relating absolute pressure, gauge pressure and atmosphere pressure (Imperial) and effective, ambient, gauge in SI.

G. Work and Power ..... 4 Hours

1. Define work, power and efficiency.
2. Derive the units of work.
3. Calculate the work done from force and distance data.
4. Calculate power from force, distance and time data.
5. Express efficiency in terms of input and output work and power.

H. Energy ..... 4 Hours

1. Define energy, potential energy and kinetic energy.
2. Derive units of energy.
3. Describe the forms of energy and their formulae.
4. Calculate potential energy from force and height data.
5. Calculate kinetic energy from mass and velocity data.
6. Describe the relationship between potential and kinetic energy.
7. Describe the laws of energy conservation.

I. Fluid Principles ..... 7 Hours

1. Define an atom, molecules, element.
2. Describe the molecular attraction of fluids and solids.
3. Discuss cohesion, adhesion, capillary action, compressibility and expansion related to liquids.
4. Define density, relative density and specific volume of fluids and solids.
5. Perform basic calculations related to mass, density and relative density of liquids and solids.
6. Describe Pascal's law and pressure head.
7. Perform calculations related to pressure, density and height of liquid.
8. Define and discuss buoyancy, Archimedes principle.
9. Solve basic problems related to objects submerged in liquids.
10. Define laminar and turbulent flow.
11. Define the continuity equation.
12. Explain resistance and turbulence and its effect on flow.
13. Explain Bernoulli's equation and its relation to fluid flow.

J. Heat and Temperature ..... 7 Hours

1. Describe the sources of heat energy.
2. Define temperature, heat, the laws of thermodynamics and specified heat.
3. Describe the molecular theory of heat and its significance on the change of state of a substance.
4. Describe the relationship between Celsius and Kelvin temperature scales and Fahrenheit and Rankine temperature scales.
5. Define coefficient of linear expansion, volumetric and surface expansion of solids.
6. Describe the expansion of liquids.

7. Solve basic problems related to expansion of solids and change in heat content of liquids.
8. Define sensible heat, latent heat of fusion, latent heat of evaporation, saturation temperature, superheat.
9. Describe heat transfer by conduction, convection and radiation and discuss conductors and insulators.
10. Perform basic calculation of heat quantities.
11. Describe the laws related to heat.
12. Provide an awareness of steam tables.

K. Laws of Perfect Gases.....3 Hours

1. Define Boyle's, Charles' and the general gas laws in relation to pressure, temperature and volume.
2. Perform basic calculations involving gas laws.
3. Discuss compressibility and expansion.

L. Solids .....4 Hours

1. Define elasticity, stress, strain and Hooke's law.
2. Discuss Young's modulus of elasticity.
3. Discuss the relationship between elastic limit, yield point, ultimate and breaking strength, safe working stress and factor of safety.
4. Define tensile, compressive and shear stresses.
5. Perform basic calculations related to stress, force area and strain.

SECTION FIVE:..... ELECTRICAL HAZARDS AND SAFETY .....8 HOURS

A. Regulations.....1 Hour

1. Define the area of electrical work for an Instrument Technician.
2. Describe the role of CSA NEMA, and Safety Codes Act.

B. Area Classifications.....2 Hours

1. Differentiate between Class I, Class II and Class III hazardous locations including their divisions/zones.
2. Define the groups A through G.
3. Describe temperature codes for electrical equipment.

C. Explosion Proof Equipment.....2 Hours

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.

D. Intrinsic Safety .....2 Hours

1. Describe an intrinsically safe loop.
2. Describe an intrinsically safe loop drawing.
3. Describe the grounding requirements of an intrinsically safe system.
4. Observe results of tests on sample loop shorts, grounds and overload.

E. Other Methods.....1 Hour

1. Describe the role of purging under the CSA and ISA definition.
2. Describe the role of sealing, potting and encapsulating for electrical safety.
3. Define the relationship between explosion proof and intrinsically safe systems.

SECOND PERIOD TECHNICAL TRAINING
INSTRUMENT TECHNICIAN TRADE
COURSE OUTLINE

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

Due to the nature of the work of the Instrument Technician trade, it is imperative that safety be taught on a continuous basis throughout the entirety of this course.

Special emphasis should be placed on weak areas of theory and shop that are evident from progressive tests and examinations administered throughout the course. The time required for such examinations and testing shall be allowed for in each area of instruction.

SECTION ONE:..... BASIC ELECTRONICS..... 42 HOURS

A. Review .....4 Hours

1. Identify resistor values using their colour codes.
2. Calculate resistance, voltage and current in dc and ac circuits using Ohm's Law.
3. Perform dc and ac calculations using the voltage divider formula.
4. Be able to analyze and calculate selected series and parallel circuits.
5. Evaluate frequency, period and instantaneous voltages of given signals.
6. Analyze and calculate series/parallel circuits that contain both dc and ac voltage sources and capacitors.
7. Calculate frequency and voltage information by interpretation of an oscilloscope display.

B. Diodes.....2 Hours

1. Define and list characteristics of conductors, insulators and semiconductors.
2. Explain the basic operation of a PN junction.
3. Identify silicon and germanium forward voltages.
4. Solve simple problems with a voltage source, resistor and a forward/reversed biased diode.
5. Test the electrical characteristics of a zener diode.
6. Reproduce the symbols and ideal characteristics for zener and signal diodes.
7. Explain the purpose of heat sinking.
8. Differentiate between power, signal, selenium-stack and puk diodes.

C. Power Supplies.....8 Hours

1. Sketch a representative block diagram of a linear power supply and a switching power supply.
2. Explain the load vs. voltage characteristics of a transformer.
3. Sketch the three rectification circuits (half-wave, bi-phase, bridge).
4. Describe the operation and relative advantages of half and full wave rectifier circuits.
5. Calculate diode and load Vavg for rectifier circuits.
6. Draw the load waveforms for the three rectifier circuit, given a reference input waveform.
7. Draw the circuit diagram for any one of four filter types.

8. Reproduce a zener regulator circuit.
9. Describe the input and output parameters of voltage regulators.
10. Determine the effect on loads caused by failed rectifiers and/or capacitors.

D. Bipolar Transistors ..... 3 Hours

1. Explain the theory of operation of PNP and NPN types.
2. Identify the base-emitter voltage of Silicon as 0.7V and Germanium as 0.3V.
3. Sketch PNP and NPN types and identify their terminals.
4. Define the relationships between base, emitter and collector currents.
5. Define the terms Beta, Saturation and Cutoff.
6. Calculate the current gain of a transistor.
7. Identify transistor casing types and their terminals.
8. Sketch a circuit showing a Darlington pair and describe its application.

E. Field Effect Transistors ..... 2 Hours

1. Define the terms depletion and enhancement.
2. Draw the symbols for both N and P channel FET's and identify their terminals.
3. Describe the operation of MOSFET and JFET and their relative advantages.
4. Identify the required gate voltage change to increase or decrease IDS.
5. Sketch a basic FET circuit showing input, output and correct biasing.
6. Describe applications of FET’s.

F. Other Semiconductor Devices ..... 5 Hours

1. Draw the symbols for SCR's, Triac's, Diac's and identify their terminals.
2. Label the SCR as a dc device and the Triac as an ac device.
3. Identify the required voltages to trigger an SCR or Triac.
4. Explain the difference between "holding" and "latching" currents.
5. Describe how to turn-off an SCR or Triac.
6. Explain the basic operation and use of photo-transistors and photo-sensitive devices.

G. Oscillators ..... 1 Hour

1. Draw the block diagram for an oscillator.
2. Describe the principle of oscillation.
3. Explain the relative advantages and list applications of these three types of oscillators:
   a) crystal controlled
   b) multi-vibrator
   c) I.C. timer

H. Laboratory ..... 17 Hours

The laboratory portion of this course is designed to reinforce the classroom theory and, at the same time, increase the students' hands-on skills by connecting typical lab equipment, predicting circuit performance, taking measurements and making adjustments.

1. Lab familiarization and oscilloscope review.
2. Diodes, half-wave rectifier.
3. Power supplies, bi-phase rectifier with capacitor.
4. Power supplies, full-wave bridge rectifier.
5. Regulators, zeners and I.C.'s.
6. Transistors switch.
7. Transistors amplifier.
8. Field effect transistors.
9. Power control devices.
10. Oscillators.

SECTION TWO: ..... MEASUREMENT AND CONTROL INSTRUMENTS ..... 96 HOURS

A. Flow Measurement Terms and Industrial Applications ..... 2 Hours

1. Explain why flow measurement is required in industry.
2. Define the terms:
   a) head
   b) differential pressure
   c) range
   d) span
   e) accuracy
   f) rangeability
   g) primary element
   h) secondary element
   i) quantity meter
   j) rate meter
   k) direct/inferential flow
   l) chart integration/planimeters
3. List the common units of flow measurement used in the SI and Imperial system.
4. Explain the difference between laminar and turbulent flow.
5. Explain the significance of the Reynold's number used to describe flow.
6. Explain the effect of pulsating flow and dampening.

B. Head Type Primary Elements ..... 3 Hours

1. Sketch and describe the following:
   a) orifice plate
   b) venturi
   c) flow nozzle
   d) pitot tube
   e) annubar
   f) integral orifice
   g) target meter
   h) elbow type flowmeters
   i) wedge type flowmeters
2. Compare the advantages and disadvantages of the above primary elements.
3. Describe with the aid of sketches the following orifice plates and their applications:
   a) segmental
   b) concentric
   c) eccentric
4. Explain the purpose of weep hole, vent hole, tab or tang on orifice plates.
5. Describe the operation of orifice plate changers.

C. Head Type Secondary Elements ..... 2 Hours

1. With the aid of a sketch describe the operation of the following flowmeter devices:
   a) wet meters (Mercury)
   b) dry meters (Bellows)
   c) differential pressure transmitters
2. Compare the above flowmeter devices by listing the advantages and disadvantages of each unit.
3. Explain the use and operation of square root extractors.
4. Explain the use and operation of integrators.

D. Flowmeter Installation Practices ..... 2 Hours

1. Sketch and describe different pipe connections and lay-outs for liquid, steam and gas service.
2. Sketch and describe:
   a) pipe taps
   b) flange taps
   c) vena contracta taps
   d) dcorner taps
   e) D and D/2 taps
3. Explain the need for upstream and downstream piping requirements in compliance with AGA and ISA standards.
4. Explain the purpose of straightening vanes.
5. Describe with the aid of sketches the purpose of installation requirements for seal pots and condensate pots.
6. Describe the desirable characteristics of a seal fluid and list common seal fluids.
7. With the aid of a sketch describe how an annubar is removed from a pressurized line.

E. Flow Measurement Calculation ..... 2 Hours

1. Calculate flow using:
   a) continuity equation
   b) Bernoulli's equation
2. Define the terms:
   a) velocity head
   b) pressure head
   c) elevation head
   d) discharge coefficient

F. Variable Area Meters (Rotameters) ..... 2 Hours

1. List the different types and typical application of each rotameter.
2. With the aid of a sketch explain the principle of operation of a rotameter.
3. With the aid of a sketch describe the installation requirements.
4. List the advantages and disadvantages of the rotameter as compared to other flow measurement devices.
5. Describe useful range and accuracy with comparison to fixed area orifice meters.

G. Weirs and Flumes ..... 1 Hour

1. List the different types of weirs, flumes and typical applications where they are used to measure flow.
2. Describe the principle of operation of weirs and flumes.
3. State the type of instrument used to detect flow.

H. Flow Switches ..... 1 Hour

1. List types and purposes.

I. Introduction to Level Measurement ..... 1 Hour

1. Describe the necessity for level measurement in industry.
2. Differentiate between point level and continuous level detection.
3. Differentiate between direct and inferential methods of level measurement.

J. Gauge Glasses ..... 1 Hour

1. With the aid of a sketch describe the operation of:
   a) tubular
   b) reflex
   c) see-through gauge glasses
   d) integral
   e) frost plug
   f) remote level gauges
2. Sketch and describe a typical gauge glass installation including all auxiliary equipment and state the function of each item.
3. Describe the limitations of gauge glass installations.

K. Floats ..... 1 Hour

1. State Archimedes' principle as applied to floats.
2. Calculate the mass of a float.
3. Sketch and describe a float and tape level instrument, include design of vapour seal and preventive maintenance techniques.
4. Describe float type level switches.

L. Displacers ..... 3 Hours

1. State Archimedes' principle as applied to displacers.
2. Differentiate between a float and a displacer.
3. Calculate the buoyant force of a displacer.
4. Describe the operation of a displacer element for detecting liquid-liquid interfaces.
5. With the aid of a sketch describe the operating principle of a torque tube.
6. Sketch and describe an installation using a stilling well and describe the purpose of all components.
7. Explain the need for heat tracing and purging.
8. Describe the use of a displacer in a level control application.
9. List the advantages and disadvantages of displacer type level devices.
10. Describe the operation of a displacer level switch.

M. Hydrostatic Head Level Measurement and Bubbler Systems ..... 1 Hour

1. Calculate the hydrostatic head pressure using the SI and Imperial formulas.
2. Sketch and describe a bubbler level system including the required supply pressure settings.
3. Describe various purge systems used in bubbler level measurement.
4. Describe the characteristics of purge fluids commonly used.

N. Differential Pressure Level Measurement ..... 3 Hours

1. Describe the force balance method of measuring differential pressure.
2. Describe the motion balance method of measuring differential pressure.
3. Compare methods of measuring level in atmospheric and pressurized vessels.
4. Explain the purpose and characteristics of seal fluids.
5. Define the terms zero elevation and suppression and range elevation and suppression.
6. Sketch a zero elevation and a zero suppression application.
7. With the aid of a sketch describe a calibration procedure for an elevation application and calculate span and elevation settings.
8. With the aid of a sketch describe a calibration procedure of a suppression application and calculate span and elevation settings.
9. List the advantages and disadvantages of differential pressure cells.

O. Introduction to Temperature Measurement ..... 2 Hours

1. Explain why temperature measurement is used in industry. List examples in industry.
2. Explain differences between the terms heat and temperature.
3. Define the terms:
   a) boiling point
   b) latent heat of vaporization
   c) triple point
   d) absolute zero
   e) condensation
   f) freezing point
   g) Charles' Law
   h) Boyle's Law

P. Temperature Scales ..... 1 Hour

1. Convert temperature readings between the most commonly used scales:
   a) Kelvin
   b) Rankine
   c) Celsius
   d) Fahrenheit

Q. Coefficient of Expansion ..... 1 Hour

1. Define the following terms:
   a) coefficient of linear expansion
   b) coefficient of area expansion
   c) coefficient of volume expansion
2. Solve problems involving linear and volumetric expansion of materials.

R. Glass Thermometers ..... 1 Hour

1. Describe the operation of a glass thermometer.
2. List the liquids used and describe the desirable characteristics.

S. Bimetallic Thermometers ..... 1 Hour

1. With the aid of a sketch, describe the construction and operating principle of a bimetallic thermometer.

T. Filled System Thermometers ..... 2 Hours

1. Sketch and describe filled systems thermometers.
2. Define full compensation and case compensation (Invar).
3. List advantages and disadvantages of various SAMA classifications.
4. Describe applications using case and full compensation.
5. Describe installation, including head elevation effects, thermowells and transmission lag.

U. Introduction to Thermocouples ..... 3 Hours

1. Explain, with the aid of a diagram, the principle operation of a thermocouple with reference to:
   a) seebeck effect
   b) Thompson effect
   c) peltier effect
   d) measuring junction
   e) reference junction
   f) emf read-out or output
2. Describe the operation of a thermocouple circuit with reference junction compensation, using the battery equivalent for each point of emf generation.
3. State and explain with diagrams the following:
   a) Law of Intermediate Metals
   b) Law of Intermediate Temperatures
   c) Law of the Homogeneous Circuit
4. List the various types of thermocouple and state the materials used for each type and the colour codes used for identification.
5. State the characteristics of each type of thermocouple including their advantages, limitations and temperature range.
6. Describe the most common methods of thermocouple fabrication.
7. Describe the methods used for thermocouple installation with reference to:
   a) terminal blocks, connection heads, protection tubes
   b) extension wires (same metals or compatible)
   c) junction boxes
   d) thermowells and their orientation

V. Introduction to Automatic Control ..... 2 Hours

1. Explain why automatic control is necessary in process industries.
2. Define the terms:
   a) feedback
   b) automatic control
   c) measured variable and process variable
   d) controlled variable
   e) manipulated variable
   f) direct acting
   g) reverse acting
   h) open loop
   i) closed loop
   j) manual control
   k) bias, manual reset
3. Describe the application of auto/manual stations.

W. On-Off Controller ..... 2 Hours

1. Sketch and describe an on-off controller.
2. Describe the limitations of on-off control.
3. Describe the operation of a differential gap controller.

X. Proportional Control ..... 2 Hours

1. Sketch and describe the operation of a pure proportional controller.
2. Differentiate between gain and proportional band.
3. Perform conversions from percent proportional band to gain and vice versa.
4. Describe bias as applied to proportional control.
5. Describe offset as applied to proportional control.
6. Explain the effect of gain on offset.
7. Perform controller output calculations.
8. State the limitations of a proportional controller.

Y. Proportional Plus Reset Control ..... 2 Hours

1. Sketch and describe the operation of a proportional plus reset controller.
2. State the purpose of reset in a controller.
3. Equate the terms reset and integral action.
4. Describe the reset units of repeats per minute and minutes per repeat.
5. Describe the effect of reset on gain of the controller.
6. Perform controller output calculations.
7. Explain reset wind-up of a proportional plus reset controller.
8. Explain anti-reset wind-up and where it must be incorporated.

Z. PD Controllers ..... 2 Hours

1. State the purpose of rate in a controller.
2. Describe the other common terms used; derivative and pre-act.
3. Describe the process applications where rate action is advantageous.
4. Sketch and describe a direct acting and reverse acting PD controller.
5. Explain the purpose of bumpless transfer.

AA. Introduction to Controller Tuning ..... 2 Hours

1. Explain the term quarter amplitude decay.
2. Describe the reaction curve method used for controller tuning.
3. Determine suitable control settings.
4. Describe the Ziegler-Nichols method used for controller tuning.
5. Describe controller modes used on typical processes.

BB. Laboratory ..... 48 Hours

1. Flow measurement devices:
    a) calibration
        i) square root extractors
        ii) bellows meter recorder
        iii) pneumatic integrator
        iv) flow recorder and totalizer
        v) integral orifice meter
    b) lab on liquid flow run to establish orifice meter constant
2. Level measurement devices:
    a) use of bubbler system to measure liquid level
    b) calibration of a D/P transmitter with elevation and suppression
    c) floats and displacers
        i) calibration
        ii) verification of results
    d) control loop experiments
        i) displacer type level controllers
3. Temperature devices:
    a) filled systems
    b) thermocouple basics
4. Align and verify the operation of:
    a) proportional
    b) proportional + reset controller
    c) proportional + rate controller

SECTION THREE: ..... DIGITAL ELECTRONICS ..... 40 HOURS

A. Introduction to Digital ..... 1 Hour

1. Describe selected applications of digital machines.
2. Compare digital to analog devices.
3. Name devices, equipment that are digital in nature.
4. Describe electrostatic protection as applied to installing and servicing equipment.

B. Number Systems ..... 3 Hours

1. Describe the common underlying principles of different number systems.
2. Describe binary, hexadecimal and BCD systems.
3. Convert from one number system to another.
4. Perform simple arithmetic operations on selected number systems.

C. Digital Signals ..... 2 Hours

1. Describe the two binary states in terms of voltage levels, Boolean operators and binary symbols.
2. Describe digital signals as they would appear on an oscilloscope or logic analyzer.
3. Recognize and interpret serial digital signals and parallel digital signals.
4. Explain the timing relationship between clock reference source and digital signals.

D. Logic Gates ..... 10 Hours

1. Explain the purpose of logic gates.
2. Show the truth tables for the common logic gates AND, OR, NOT, NAND, NOR, XOR, XNOR.
3. State the Boolean logic equation for the above logic gates.
4. Describe the enable and/or inhibit functions of logic gates.
5. Draw logic circuits given logic equations and vice-versa.
6. Show the truth table for a logic circuit and/or logic equation.
7. Explain and use deMorgan's Theorem.
8. Be able to simplify circuits and equations.
9. Be able to use Karnaugh Maps as a quick problem-solving technique.
10. Solve combinational logic problems using the above Boolean techniques.

E. Relay Ladder Logic ..... 3 Hours

1. Describe the basic form of a ladder logic diagram.
2. Draw the ladder logic diagram equivalents for each of the basic gates.
3. Be able to draw the relay equivalents of simple logic expressions, such as Z=(A+B) (Ã+C).
4. Given simple relay ladder logic circuits, derive the logic expressions.

F. Storage Register Elements ..... 3 Hours

1. Explain the purpose of memory devices.
2. Describe and verify the operation of, and complete simple timing diagrams for R/S latches.
3. Identify edge triggered inputs and identify same as rising or falling edge triggered.
4. Describe, verify the operation of, and complete simple timing diagrams of edge-triggered D type flip-flops.

G. Sequential Logic ..... 2 Hours

1. Explain the purpose and application of shift registers.
2. Explain how parallel to serial conversion and vice versa could be accomplished using MSI devices.

H. Display Circuits ..... 1 Hour

1. Describe various types of light displays and their applications.

I. Logic Gate Specifications.....1 Hour

1. Define the terms TTL, CMOS and ECL.
2. Describe advantages and disadvantages of popular logic families such as TTL, CMOS, and ECL.

J. Memory.....2 Hours

1. Describe various types of read-only memories and their applications.
2. Explain how memory devices are selected by addressing.
3. Describe various types of read-write memories and their applications.
4. Discuss attributes or differences between static (SRAM) and dynamic (DRAM) read-write memory devices.
5. Describe various types of current mass storage devices.
6. Describe various attributes of memory devices to allow proper selection in a particular application.

K. Microcomputers.....2 Hours

1. Draw a block diagram of a microcomputer (5 items).
2. Define the terms ALU, CPU.
3. Identify three buses.
4. List at least four peripheral I/O devices.
5. Identify and define the common internal registers.

L. Point to Point Data Communications.....10 Hours

1. Link elements:
   a) define data terminal equipment; data communications equipment; transmission medium
2. Units of data communication speed and modes of operation:
   a) define baud; bits/sec; character/sec
   b) define half duplex; full duplex; simplex
3. The asynchronous frame:
   a) define the structure of an asynchronous serial frame (start; stop; data; parity bits)
   b) describe how the frame is transmitted and detected by the receiver
4. Transmission media characteristics:
   a) describe copper wire characteristics and how these characteristics limit bandwidth in twisted pair and coaxial cable
   b) describe the propagation of light down a fibre optic cable and factors that limit bandwidth
   c) discuss some of the elements of radio transmission such as bands (VHF, UHF, microwave), distance vs frequency, role of CRTC, antennas

5. RS-232C DTE/DCE and RS-485 interface standard:
   a) describe the mechanical, electrical and functional characteristics of the modern protocol (using 3 wires)
   b) describe speed and distance limitations
   c) describe the NULL MODEM connection
   d) describe the RS-485 standard
6. Modems:
   a) describe why a modem is used to convert digital to analog signals and vise versa
   b) define AM; FM; PM; FSK; PSK
   c) describe the term smart modem (Hayes compatible) and use the command vocabulary
   d) describe modem communication standards

SECTION FOUR: ..... INTRODUCTION TO PROCESS EQUIPMENT ..... 32 HOURS

A. ISA Symbols (S5-1, S5-2, S5-3 and Latest Revision) ..... 2 Hours

1. Provide definitions from ISA.
2. Describe the identification system:
   a) general
   b) functional identification
   c) loop identification
   d) P and ID symbols and drawings
3. Identify symbols which include:
   a) instrument line symbols
   b) general instrument symbols-balloons
   c) control valve body symbols
   d) actuator and positioner symbols
   e) symbols for self-actuator regulators, valves and other devices
   f) symbols for actuator action in event of actuator power failure
   g) primary and secondary element symbols
   h) function symbols
   i) DCS, shared display/control symbols
   j) PLC symbols
   k) miscellaneous symbols and systems
   l) process equipment

B. Product Movement ..... 5 Hours

1. Liquids:
    a) explain the principle of liquid pumping as a means of producing flow
    b) describe the basic parts of the following centrifugal pumps
    c) explain the principle of the following displacement pumps
        i) rotary
        ii) reciprocating
    d) explain the principle of the following special pumps
        i) turbine
        ii) eductor
        iii) compressed air
    e) compare operation characteristics of PD vs centrifugal pumps
        i) pump curves
        ii) safety
        iii) operating issues
2. Gases:
    a) describe the principle of operation of fans and blowers
    b) describe the operational principle of the following compressors
        i) rotary

C. Solids/Size Reduction or Enlargement ..... 1 Hour

1. Define size reduction in regards to:
    a) crushing
    b) grinding
    c) pulverizing
2. Explain the process of size enlargement of material.

D. Solids/Separation ..... 3 Hours

1. Describe size separation and screening for process materials.
2. Explain and sketch the operation of the following filters:
    a) gravity filters
    b) pressure sand filters
    c) plate and frame filter presses
    d) rotary drum vacuum filters
    e) centrifuges
    f) electrostatic precipator
3. Describe differential flotation.

E. Fluid Separation..... 1 Hour

1. Explain and describe the operation of two and three phase separators.
2. Explain auxiliary support equipment/processes:
    a) line heaters
    b) demulsifiers
    c) descalers

F. Mixing ..... 1 Hour

1. Describe equipment and process alarms to maintain material agitation using:
    a) paddle
    b) propeller
    c) turbine
    d) circulating pumps
    e) air agitators
    f) static

G. Heat Transfer ..... 3 Hours

1. Define the terms of heat transfer.
2. Explain the common types of heat exchangers:
    a) conduction
    b) convection
    c) radiation
3. Describe cooling by humidity change using:
    a) spray ponds
    b) cooling towers

H. Evaporation ..... 3 Hours

1. Describe common process evaporators as used in industry.
2. Explain the operation of a multiple effect evaporator.
3. Describe the separation of solids and liquids by crystallization.

I. Drying ..... 1 Hour

1. Explain the process of solids drying by:
    a) direct drying using
    b) indirect drying using
    c) vacuum freeze drying

J. Humidification and Dehumidification ..... 2 Hours

1. Define the following terms:
    a) relative humidity
    b) dew point
    c) humidifying
    d) dehumidifying
    e) HVAC
2. Explain humification of process gases.
3. Explain dehumidification or drying of gases by:
    a) direct or mechanical methods
    b) chemical absorption

K. Distillation and Fractionation ..... 3 Hours

1. Explain the distillation process and define the following terms:
   a) feed
   b) reflux (internal and external)
   c) products
      i) light (tops)
      ii) heavy (bottoms)
   d) distillate
   e) trays
   f) packed towers
2. Describe simple distillation tower control for optimum product.
3. Explain the operation of a fractionation tower.

L. Gas Absorption, Desorption and Adsorption ..... 1 Hour

1. Explain the principles of absorption, desorption and adsorption.
2. Describe examples of each in the natural gas processing and refining industries.

M. Dehydrator ..... 1 Hour

1. Explain the operation of a dehydrator.

N. Boilers and Direct Fired Heaters ..... 3 Hours

1. Explain and describe briefly boilers and auxillary equipment.
2. Describe and compare the following boiler types:
   a) firetube
   b) watertube
3. Explain the main circuits for the control of boilers:
   a) feedwater
   b) combustion/steam
   c) burner management
   d) steam pressure

O. Natural Gas Processing Plants ..... 1 Hour

1. Use a PFD (Process Flow Diagram) to briefly outline the major processes, flows and unit operations found within:
   a) a gas processing plant with sulphur recovery
   b) a gas scrubbing plant with NGL/LPG recovery and fractionation

P. Pulp and Paper Mills ..... 1 Hour

1. Use a PFD to briefly outline the major processes, flows and unit operations found within a modern pulp and paper mill.

SECTION FIVE: ..... PERSONAL COMPUTER APPLICATIONS..... 30 HOURS

A. Hardware ..... 2 Hours

1. Distinguish between computer and dedicated applications such as a calculator.
2. State the basic function of a computer.
3. Identify the essential hardware components of a modern computer.
4. Explain the purpose of a data communication hardware, such as modem, NIC and routing hubs.

B. Software..... 2 Hours

1. State a working definition for software.
2. State what is meant by a program.
3. Describe what is meant by application software.
4. Describe the meaning of communications software.
5. Name several commonly used programming languages.
6. Describe the meaning of the term "Computer Graphics".

C. Operating Systems ..... 6 Hours

1. Define the term "Operating System" as a resource manager.
2. Define the term "DOS".
3. Explain the history of operating systems.
4. Be able to use current operating systems to format disks, copy files, view directories and run programs.

D. Word Processors ..... 2 Hours

1. Generally describe the meaning of "Word Processing" and "Word Processing System".
2. Be able to use a current word processing package utilizing real world instrumentation applications.

E. Spreadsheets ..... 6 Hours

1. Be able to use a current spreadsheet package utilizing real world instrumentation applications.

F. Computer Aided Design (CAD) ..... 3 Hours

1. Describe the purpose of a Computer Aided Design (CAD) simulation application.
2. Be able to use a current Computer Aided Design package utilizing real world instrumentation applications.

G. Data Base ..... 6 Hours

1. Be able to use a current data base package utilizing real world instrumentation applications.

H. Internet Access ..... 3 Hours

1. Be able to access various internet sites utilizing real world instrumentation applications.

THIRD PERIOD TECHNICAL TRAINING
INSTRUMENT TECHNICIAN TRADE
COURSE OUTLINE

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

Due to the nature of the work of the Instrument Technician trade, it is imperative that safety be taught on a continuous basis throughout the entirety of this course.

Special emphasis should be placed on weak areas of theory and shop that are evident from progressive tests and examinations administered throughout the course. The time required for such examinations and testing shall be allowed for in each area of instruction.

SECTION ONE:..... APPLIED ELECTRONICS ..... 90 HOURS

A. Operational Amplifier Basics .....4 Hours

1. Explain the circuit operation of an op amp's differential input stage.
2. Explain the basic input/output characteristics of an operational amplifier.
3. Explain meaning and significance of open loop operational amplifier specifications.

B. Op Amp Circuit Configurations.....11 Hours

1. For each of the following op amp circuit configurations:
   a) inverting
   b) non-inverting
   c) summing
   d) difference
   e) buffer
   f) potentiometric
   g) comparator
   h) integrator
   i) differentiator
2. Draw the circuit schematic.
3. Describe the circuit operation.
4. State the formula which describes the gain and/or output voltage.
5. Predict the circuit output for any given input.
6. Predict how the circuit is affected by typical component faults.
7. Sketch the output waveforms expected, given specified input waveforms.

C. Analog Circuits .....7 Hours

1. Describe the operation and predict the circuit voltages and currents associated with the following current source circuits:
   a) non-inverting
   b) inverting
   c) potentiometric

2. Describe the operation and predict the circuit voltages and currents associated with typical millivoltage to current converter circuits:
   a) predict overall and individual stage gains necessary to obtain the required conversion
   b) determine the maximum current loop resistance
   c) describe test procedures used to calibrate and/or troubleshoot the circuit
   d) predict how the circuit is affected by typical circuit faults

D. Analog to Digital and Digital to Analog Conversion ..... 7 Hours

1. Describe the purpose and application for both ADC's and DAC's.
2. List and explain the operation of common types.
3. Explain associated terms and specifications.
4. Describe associated circuitry:
   a) sample and hold
   b) multiplexers
   c) multiplexer applications
5. Identify features which affect the choice of particular types and applications.
6. Calculate the resolution based on the number bits of binary data.
7. Calculate the output of a DAC given a binary input value.

E. The Instrument Loop ..... 22 Hours

1. Describe how typical instrumentation is used in current loops.
2. Intrinsically safe systems:
   a) identify the three main techniques used to reduce electrical hazards in explosive locations
   b) describe the classification system for hazardous locations
   c) define intrinsically safe
   d) describe the requirements of intrinsically safe systems
   e) explain the operation and application of associated intrinsically safe equipment (intrinsic safety barriers)
      i) Zener barriers
      ii) isolation barriers
      iii) specifications:
         - types of barriers
         - operating and safety specifications in terms of voltages
         - current and resistance
         - other specifications
      iv) applications
   f) describe the approval procedures associated with intrinsically safe loops and entities
3. Smart transmitters:
   a) describe the hardware architecture, features and operation of typical smart transmitters
   b) describe the digital communications standards and protocols used with typical smart transmitters
   c) describe the operation of typical hand-held interfaces used with smart transmitters
   d) list the advantages of smart transmitters in instrument loops

4. Single Loop Digital Controllers (SLDC):
   a) describe the operation of typical SLDC
   b) list and describe typical functions of SLDC including:
      i) open loop responses of PID control
5. Smart recorders:
   a) describe the hardware architecture, features and operation of typical smart recorders
   b) list the advantages of smart recorders in instrument loops
6. Smart valves:
   a) describe the hardware architecture, features and operation of smart valves
   b) list the advantages of smart valves in instrument loops
7. Networked control:
   a) sketch the block diagram and describe in general terms, the operation of a typical networked control system
   b) explain the operation of typical analog and digital input and output circuits used in networked control systems
   c) describe test procedures used to troubleshoot input/output circuits in networked control systems
8. Instrument loop diagrams:
   a) sketch typical loop drawings to current ISA standards (S5.4)
   b) using loop drawings, describe how typical loops operate
   c) describe typical test procedures and predict voltages and currents expected at various points on the loop diagram

F. Power Control ..... 4 Hours

1. List and explain the operation and application of special power control devices such as:
   a) thyristors
      i) SCRs
      ii) triacs
      iii) diacs
   b) UJTs and PUTs
   c) opto-couplers
   d) solid state relays
   e) varistors
2. Describe the operation of typical switch mode control techniques for:
   a) dc circuits
      i) switch mode power control
      ii) uninterruptible power supplies
   b) ac circuits
      i) phase control
      ii) zero crossing detection and switching
3. Describe the problems, solutions and measurement techniques associated with transients, noise suppression and power conditioning including ground, bonding and prevention of ground loops.
4. Describe the operation, maintenance and functional characteristics of uninterruptible power supplies.

G. Laboratory ..... 35 Hours

1. Operational amplifier basics:
   a) breadboard typical operational amplifier configurations
   b) predict and measure to confirm output voltages based on specified input voltages
   c) build a proportional amplifier using operational amplifiers
2. Millivoltage to current converters:
   a) connect, test and calibrate a 0-10 mV to 4-20 mA converter module
   b) predict and measure voltages at various points in the circuit
3. Alarm circuits:
   a) connect, test and calibrate a typical analog alarm module
   b) predict and measure voltages at various points in the circuit
4. Analog to digital and digital to analog converters:
   a) connect, test and calibrate typical ADC and DAC circuits used in instrument applications
5. Smart transmitters:
   a) connect and test typical smart temperature and pressure transmitters using a hand-held interface
6. SLDC controllers:
   a) connect, test and configure a single loop digital controller in open loop
   b) predict and observe open loop control responses
   c) test and tune the SLDC in closed loop
7. Power control:
   a) connect, test and calibrate typical dc and ac power control circuitry
   b) use test equipment to observe typical waveforms and voltages in power control circuitry

SECTION TWO: ..... MEASUREMENT INSTRUMENTS ..... 100 HOURS

A. Introduction ..... 4 Hours

1. Explain traceability and its importance in measurements.
2. State accuracy statements for analog and digital instruments and calculate their possible range of errors.
3. Calculate the accuracy of a given instrument/component from the values measured and then compared to the manufacturer's specifications.
4. Calculate the possible and probable range of errors for a measurement system consisting of several instruments.
5. Sketch a loop diagram illustrating basic components of a process measurement system.
6. Explain the difference between a 2-wire and 4-wire transmitter.
7. Explain why current rather than voltage is mostly used for signal transmission and state what the limitations are.
8. Calculate maximum loop resistance for proper current loop operation.
9. Explain the circuits used to test the output of a transmitter without interrupting the current flow.
10. Explain the difference between conventional, smart and digital transmitters.

B. Flow Measurement ..... 23 Hours

1. Introduction:
   - a) state three reasons for flow measurement in process measurement and control applications
   - b) state the names of the two basic equations used to derive the flow equation used for measuring flow rates using head type primary elements
   - c) compare mass flow and volumetric flow
   - d) calculate gas flow at standard conditions from flowing condition data
   - e) calculate orifice meter flow rates for liquids and gases
2. Magnetic flowmeters:
   - a) state Faraday's Law and use it to explain operation of a magnetic flowmeter
   - b) with the aid of a diagram, explain the function of all parts of a magnetic flowmeter
   - c) list the methods employed to keep the electrodes free of deposits
   - d) list three methods of magnetic field excitation and state the advantages and limitations of each
   - e) describe the installation practice for magnetic flowmeters, paying attention to the lining protection and proper grounding procedures
   - f) describe typical industrial applications for the use of magnetic flowmeters
   - g) explain the advantages and limitations of magnetic flowmeters
3. Turbine flowmeters:
   - a) describe the principle of operation of a turbine flowmeter
   - b) explain the principle of operation of the three types of pick-ups used to detect turbine rotation and give a feature of each
   - c) with the aid of a turbine flowmeter calibration curve, explain the terms "K" factor, linearity, accuracy and rangeability
   - d) calculate the flow rate, given the "K" factor and the frequency of the output signal
   - e) describe, with the aid of a sketch, the proper installation practice for a turbine flowmeter
   - f) state the advantages and limitations of a turbine flowmeter
   - g) describe typical industrial applications for a turbine flowmeter
4. Vortex flowmeters:
   - a) describe, with the aid of a sketch, the construction and operation of a Vortex shedding flowmeter showing the Bluff body, the Vortices and the sensors
   - b) state and describe the various types of sensors/detectors used in the Vortex meters and state the principles of operation
   - c) calculate flow rate given the K-factor and output frequency
   - d) calculate K-factor from given dimensions and Strouhal's number
   - e) explain the proper installation practices and the piping requirements for a Vortex meter
   - f) list several industrial applications for Vortex flowmeters
   - g) state the advantages and limitations of a Vortex flowmeter
5. Ultrasoinic flowmeters:
   - a) describe the principle of operation of a Transit Time flowmeter
   - b) describe the principle of operation of a Doppler flowmeter
   - c) describe the method of installation
   - d) explain the advantages and limitations of an ultrasonic flowmeter

6. Mass flowmeters:
    a) explain the Coriolis effect
    b) state Newton's second law
    c) describe the principle of operation of a dual tube mass flowmeter
    d) describe the method of signal pick-up used in the mass flowmeter
    e) describe the installation procedure
    f) list the limitations of the mass flowmeter
    g) list industrial applications of mass flowmeters
    h) describe the operation of thermal mass flowmeters
7. Positive displacement meters:
    a) list the different types and their service
    b) describe the principle of operation of a four (4) chamber gas meter
    c) describe the principle of operation of a nutating disc liquid meter
    d) describe the operation of rotary lobe and sliding vane meters
    e) list the advantages and disadvantages of positive displacement meters compare to other flow measurement devices
    f) explain the purpose of a meter prover and why it is used in conjunction with positive displacement meters
    g) list industrial applications for positive displacement meters

C. Level Measurement ..... 13 Hours

1. Introduction:
    a) list four reasons for level measurements as used in industry
    b) explain the difference and need for point level detection and continuous level measurements
2. Capacitance level detectors:
    a) relate the effect of dielectric constant, plate area and plate distance to capacitance
    b) describe the application of bare, sheathed and insulated probes
    c) describe the advantages and limitations of capacitance probes
    d) explain the installation practice for capacitance type level detectors
3. Ultrasonic level detectors:
    a) describe the principle of operation of an ultrasonic level detector
    b) state the specific uses for ultrasonic level detectors in industry
    c) list and explain the advantages and limitations of the ultrasonic type level detector
4. Radar level detectors:
    a) describe the principle of operation of an ultrasonic level detector
    b) state the specific uses for ultrasonic level detectors in industry
    c) list and explain the advantages and limitations of the ultrasonic type level detector

5. Optical level switches:
   a) list and describe with sketches, the principal operation of the following optical level switches
      i) non-contacting level sensor
      ii) optical sludge level detector
      iii) contacting level sensor
      iv) laser type level detector
      v) fibre optics level detector
   b) state the advantages and limitations of optical level detectors
   c) list the typical industrial applications of optical level detectors
6. Nuclear radiation level detectors:
   a) explain the basic theory of nuclear radiation phenomenon and define the terms used in nuclear radiation instrumentation
   b) list the radioactive materials used in industrial applications and state their activity rate and half life values
   c) describe the units of radioactivity and compare them to the units used in the SI system
   d) state and explain the units and the safe limits of radioactive exposure
   e) explain the required safety features involved when working with and around radioactive sources with respect to clothing, distance, shielding, monitoring devices for the individual and area/record-keeping of exposure rate and duration
   f) explain the purpose for the license and the responsibility of the operator for normal and abnormal working conditions
   g) calculate the value of radioactive intensity given the source type and intensity value, distance from the source and intervening media
   h) describe the principle of operation and the advantages of the following nuclear radiation detectors
      i) geiger tube/converter
      ii) scintillation/photomultiplier
      iii) solid state detectors
   i) describe the methods used to calibrate nuclear radiation detecting instruments
   j) describe the uses of nuclear level detectors in industry
   k) describe the installation requirements for nuclear radiation level detectors
7. Solids level detectors:
   a) describe the operation of the following solid level detectors
      i) rotating paddle
      ii) weight detection
      iii) resistance tape
      iv) capacitance types
      v) ultrasonic types
      vi) radioactive types

D. Density Measurement ..... 5 Hours

1. Introduction:
   a) define the term "density" as applied to liquids and gases
   b) calculate the density of various liquids and gases
   c) list and explain the following density scales used in industry
      i) specific gravity or relative density
      ii) Baumé
      iii) degree API
   d) calculate the density in one scale given the density values in any other scale

2. Liquid density:

   a) explain the principle of operation, advantages and limitations of the following types of density measuring instruments used in liquid service
      i) hydrometer
      ii) bubbler system/hydrostatic head
      iii) optical
      iv) nuclear
      v) vibrating spool
      vi) coriolis/gyroscopic

3. Gas density:

   a) define the terms "densitometer" and "gravitometer" with respect to gas density measurement
   b) describe the methods used to measure the density and the relative density of a gas

E. Viscosity ..... 1 Hour

1. Introduction:

   a) define the terms "absolute viscosity" and "kinematic viscosity"
   b) define the terms "Newtonian" and "Non-Newtonian" liquids
   c) explain the effect of viscosity on flow measurement

F. Temperature Measurement ..... 17 Hours

1. Introduction:

   a) state the four types of temperature measuring devices or primary elements used in industrial applications
      i) thermocouples
      ii) resistance thermometers
      iii) radiation pyrometers
   b) state the difference between direct and indirect temperature measurement and explain the terms as used with temperature measurement
   c) state and explain the level of standards calibration for temperature measuring devices
   d) explain thermal time constants

2. Thermocouples:

   a) explain and perform the calculations required to measure the temperature at the thermocouple using a meter and the temperature versus emf referenced tables; Eo = Em - Er
   b) explain and perform the calculations required to calibrate a reference junction compensated transmitter using a m.v. source and the table referenced to 0°C
   c) explain, with the aid of sketches, the formulae for and the operation of the following
      i) series thermocouples
      ii) parallel thermocouples with swamping resistors
   d) describe the industrial application, advantages and limitations of thermocouples
   e) describe the various calibration procedures for thermocouple transmitters

3. Resistance Temperature Detectors (RTD):
   a) explain the principle of operation of an RTD
   b) compare the characteristics of the metals commonly used for RTD manufacture
   c) calculate the temperature measured given the resistance of an RTD
   d) describe how the Wheatstone bridge is used as measurement circuit of the RTD
   e) compare and describe the following RTD measuring circuits
      i) two wire
      ii) three wire
      iii) four wire
   f) describe the calibration procedure for an RTD
   g) describe typical applications for RTDs
   h) list the advantages and limitations of RTDs
4. Thermistors:
   a) describe the principle of operation of thermistors
   b) compare positive and negative temperature coefficients
   c) describe the measurement circuit
   d) describe the industrial applications
   e) list the advantages and disadvantages of thermistors
5. Solid state sensors:
   a) describe the principle of operation of a diode used as a temperature detecting device
   b) describe selected applications of transistors in temperature measurement
6. Pyrometers:
   a) explain the purpose of non-contact temperature measuring devices
   b) describe the operating principle of the following non-contact pyrometers
      i) optical
      ii) infrared
      iii) radiation (total)
   c) define the following terms used in radiation pyrometry
      i) absorbance
      ii) black body
      iii) emittance
      iv) micron
      v) reflectance
      vi) emissivity
      vii) transmittance
   d) list the advantages and limitations of non-contact pyrometers
7. Flame detectors:
   a) describe the various types of flame detectors stating their operating characteristics, advantages and limitations
   b) explain the need for, and typical applications of flame detectors

G. Laboratory.....37 Hours

1. Electrical measurement and accuracy.
2. Pressure measurements.
3. Differential pressure level measurements.
4. Level control loop using the bubbler.
5. Electrical temperature sensors.

6. Densitometer.
7. Turbine flowmeter.
8. Vortex shedding flowmeter.
9. Liquid flow measurement and control.
10. Magnetic flowmeter.
11. Gas flow measurement.
12. Capacitance level measurement and control.
13. Displacer type level measurement and control.
14. RTD type temperature measurement with standard and smart transmitters.
15. Thermocouple type temperature measurement with standard and smart transmitters.
16. Pyrometers.
17. Use and compare digital and smart transmitters.

SECTION THREE: ..... PROCESS ANALYZERS ..... 60 HOURS

A. Introduction to Continuous Measurements for Process ..... 2 Hours

1. Explain process analytical measurement and list processes that utilize analyzers and analytical techniques.

B. Analyzer Sampling Systems ..... 4 Hours

1. Define in-situ and extractive sampling, used by continuous analyzers.
2. Sketch in block form and explain the components used in a continuous sampling system.
3. Describe "grab" sampling and the techniques utilized in "grab" sampling.
4. Identify specific materials to be used for common samples.

GAS ANALYSES

C. Relative Humidity, Dew Point and Moisture Measurement ..... 4 Hours

1. Outline the principles of analysis for the following relative humidity sensors:
   a) wet and dry bulb systems
2. Perform relative humidity calculations using psychrometric charts and tables.
3. State the operation and calibration of the above relative humidity sensors.
4. Explain the principles of analysis, and sketch the components for the following dew point sensors:
   a) dewcell
   b) chilled mirror
5. Describe the operation and calibration for the above dew point sensors.
6. Describe the principles of analysis used by the following direct moisture sensors using current technology, such as:
   a) aluminum oxide
   b) lithium chloride
7. Describe operation and applications for the above moisture sensors.

D. Oxygen Measurement ..... 4 Hours

1. Using simple sketches, describe the principles of analysis of the following oxygen sensors:
   a) paramagnetic sensors
   b) catalytic combustion sensors
   c) electro-chemical sensors (ZrO and fuel cells)
2. Describe the operation and calibration for the above sensors.
3. List applications, advantages and disadvantages of the above sensors.

E. Combustion Measurement ..... 3 Hours

1. Explain combustible chemical reactions.
2. List combustion applications.
3. List and explain combustion parameters measured to determine combustion efficiency.
4. Outline the relationship between energy conservation, pollution emissions and combustion efficiency.
5. Perform A/F ratio and combustion efficiency calculations.
6. List sensors used to measure combustion gases.
7. Correlate flue gas analysis to A/F ratio.

F. Explosive Measurements ..... 3 Hours

1. Interpret the difference between "continuous" and "spot" explosive measurements.
2. List and explain the operation of on-line and portable explosimeters.
3. Name the applications and limitations for common sensors, including:
   a) catalytic bead sensor
   b) I.R. sensor

G. Toxic Measurements ..... 2 Hours

1. Interpret the difference between "continuous" and "spot" toxic measurements.
2. Explain the operation, applications and limitations of:
   a) absorption and chemical reaction sensors
   b) electrochemical sensors
   c) solid state detectors
   d) compare conventional and smart detectors

LIQUID ANALYSES

H. Specific Ion, pH and ORP Measurement ..... 6 Hours

1. Define pH, "hydrogen ion concentration", and ionic activity.
2. Explain acids and bases as related to the pH scale.
3. Describe the electrochemical process, measurement and reference half-cell reactions.
4. Apply the Nernst equation to pH measurements and determine why temperature correction is required.
5. Discuss pH control problems.

6. Describe specific ion measurement systems and ORP measurement systems.
7. List similarities and differences between pH, specific ion and ORP measurements.

I. Conductivity Measurement.....4 Hours

1. Define conductivity and relate it to solution conductance and resistance.
2. Explain the operation of conductivity cells and "electrodeless" cells.
3. Describe applications of conductivity.

J. Turbidity Measurements.....1 Hour

1. Define turbidity, nephelometry and opacity.
2. List, sketch and explain the principles of analysis for turbidity and nephelometry.

K. Dissolved Oxygen .....1 Hour

1. List, sketch and describe the operation of dissolved oxygen sensors.
2. Describe applications of dissolved oxygen measurement.

L. Physical Properties Analyzers .....3 Hours

1. Explain the operation of the following physical property analyzers:
   a) on-line distillation (boiling point)
   b) on-line vapour pressure
   c) on-line pour point

M. Vibration Measurement.....3 Hours

1. Describe vibration and unbalance.
2. List sources of vibration.
3. Name and describe vector quantities which determine the "mechanical health" of machinery.
4. List and describe the following vibration transducers:
   a) velocity probe
   b) accelerometer
   c) proximity probe
5. Describe the relationships between vibration and frequency including resonance and critical speed.
6. Explain how vibration analysis is used to determine the “mechanical health” of a machine.

N. Laboratory.....20 Hours

1. Moisture:
   a) operate and calibrate analyzers used to measure RH, DP and moisture
2. Vibration measurement:
   a) operate and perform vibration measurements
   b) analyze and evaluate vibration signatures
   c) proper installation of vibration measuring equipment

3. Toxic monitors:
   a) operate and calibrate toxic meters and leak detectors
   b) analyze and evaluate toxic data
4. Explosimeters:
   a) operate and calibrate explosimeters
   b) analyze and evaluate explosimeter data
5. pH:
   a) operate and calibrate pH measuring devices
6. Conductivity:
   a) operate and calibrate liquid conductivity using liquid sensors
7. Oxygen:
   a) operate and calibrate oxygen analyzer

SECTION FOUR: .....CHEMISTRY ..... 50 HOURS

A. Matter .....9 Hours

1. Discuss the forms and occurrence of matter.
2. Sketch the model of an atom showing its three fundamental particles.
3. State the relative mass and charge of each of the fundamental particles.
4. Discuss how the atomic weight figures in the periodic table have been determined.
5. For any given isotope, be able to find information missing from among:
   a) number of protons
   b) neutrons
   c) electrons
   d) atomic number
   e) mass number
6. Draw electron dot formula for any of the first eighteen elements.
7. Determine the maximum number of electrons found in any principle energy level.
8. For any element, find its symbol, atomic weight, atomic number and electron configuration (from table).
9. List three (3) properties of the alkali metal elements.
10. List three (3) properties of the halogen elements.
11. Classify any element as to being a metal, a non-metal or a metalloid.
12. For a given change in matter, determine if the change is physical or chemical.
13. Write the symbols for the following particles:
    a) alpha
    b) beta
    c) gamma
    d) positron
    e) neutron
    f) proton
14. Be able to balance a given nuclear reaction (fill in missing information).

15. Describe nuclear fission.
16. Describe nuclear fusion.
17. Define the following:
    a) matter
    b) element
    c) atom
    d) molecule
    e) isotope
    f) mixture
    g) solution
    h) compound
    i) atomic number
    j) mass number
    k) atomic mass unit
    l) atomic weight

B. Nomenclature of Inorganic Compounds ..... 8 Hours

1. Discuss what happens when two atoms join to form a compound.
2. Predict the oxidation number of the Group I A to VII B elements.
3. Distinguish between single ions and complex ions.
4. Write the correct chemical formula for any cation/anion combination.
5. Name the compound when the formula is given.
6. Write the formula for a given compound.
7. Classify compounds as to being acids, bases, oxides or salts.
8. Define the following:
    a) valence electrons
    b) oxidation number
    c) cation
    d) anion
    e) complex ions

C. Chemical Calculations ..... 8 Hours

1. Determine: molar mass, mass, number of molecules and number of atoms for a given number of moles of any compound.
2. State the volume for a given number of moles of any gas at S.T.P.
3. Calculate the percent mass composition of each element in any given compound.
4. Solve problems related to percent composition.
5. Express concentration of solutions using mole fraction, normality and PPM relevant to industrial units.
6. Solve problems related to concentration of solution.
7. Balance formulas for chemical reactions.

8. Define the following:
    a) Avogadro's number
    b) mole
    c) molar mass
    d) concentration
    e) Avogadro's hypothesis
    f) solute
    g) solvent
    h) solution

D. Chemical Reaction .....10 Hours

1. Classify a reaction as being combination, decomposition, single, or double replacement.
2. Predict occurrence of a reaction when a metal and a metal ion are involved (using the Electrochemical Series).
3. State the four main factors that can influence rate of chemical reaction.
4. Predict what effect making changes to a reaction will have on its rate of reacting.
5. Explain the extra energy required to get an endothermic reaction started (activation energy).
6. Explain how lowering this activation energy barrier, by use of catalysts, will increase reaction rate.
7. Explain the electrical properties of water solutions.
8. Perform relevant pH calculations.
9. Explain acid/base titration.
10. State the need for using buffer solutions for pH standards.
11. Describe in simple terms the make up of a buffer solution.
12. Will state three (3) common pH indicators.
13. Recognize which elements are oxidized and which elements are reduced in a chemical reaction.
14. State the two (2) types of electrochemical cells.
15. Label and describe a given electrochemical cell.
16. Define the following terms:
    a) endothermic
    b) exothermic
    c) reactants
    d) products
    e) activation energy
    f) catalysts
    g) electrolytes
    h) non-electrolyte
    i) acid
    j) base
    k) oxidation
    l) reduction
    m) anode
    n) cathode

E. Organic Chemistry ..... 15 Hours

1. Explain carbon bonding.
2. State the main sources of carbon compounds for industry.
3. Write the molecular formula, name and structural formula for relevant industrial compounds.
4. For a given compound, state which organic family it belongs to.
5. Give some common properties for specific organic families.
6. List main components of crude oil.
7. Describe how the components in the crude oil mixture are separated.
8. Briefly describe the following reactions:
   a) combustion
   b) hydrogenation
   c) halogenation
   d) polymerization
9. Define the following:
   a) aromatic
   b) saturated
   c) straight chain
   d) cyclo-chain
   e) coal
   f) petroleum
   g) paraffin
   h) naphthene
   i) sour gas
   j) amines
   k) crude distillation
   l) vacuum distillation
   m) cracking
   n) reforming
   o) monomer
   p) polymer
   q) isomer

FOURTH PERIOD TECHNICAL TRAINING
INSTRUMENT TECHNICIAN TRADE
COURSE OUTLINE

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

Due to the nature of the work of the Instrument Technician trade, it is imperative that safety be taught on a continuous basis throughout the entirety of this course.

Special emphasis should be placed on weak areas of theory and shop that are evident from progressive tests and examinations administered throughout the course. The time required for such examinations and testing shall be allowed for in each area of instruction.

SECTION ONE:..... PROCESS CONTROL ..... 131 HOURS

A. Terminology and Definitions ..... 3 Hours

1. Definition of process control:
   a) form a definition of process control and identify process variables
2. Transmitter terms:
   a) define the measurement terms
      i) span
      ii) range
      iii) zero
      iv) accuracy
      v) error
      vi) linearity
      vii) safe input value
3. Controller terms:
   a) define the terms
      i) proportional
      ii) reset
      iii) rate
      iv) setpoint engineering units
      v) bias
      vi) derivative gain
      vii) setpoint ramping
      viii) output limiting
      ix) offset
4. Loop terms:
   a) define feedback control
   b) define feedforward control
   c) transient response
   d) steady state
5. SAMA symbols:
   a) explain SAMA symbols

B. The Open Loop Controller ..... 4 Hours

1. Define common types of automatic controller response:
   a) on-off
   b) proportional
   c) proportional + reset
   d) proportional + derivative
2. Develop block diagrams and output/input equations for controllers having these responses.
3. Sketch the limitations of each controller type.
4. Explain the limitations of each controller type.
5. Explain direct and reverse acting controllers and develop a method for setting controller action correctly.
6. Define the reset windup problem.
7. Explain the relation between gain and offset.
8. Explain how reset action works.
9. Explain the open loop test of a P+I controller.
10. Explain the concept of automatic bias/adj.
11. Explain how P+D controllers function.

C. Closed Loop Controller Tuning ..... 6 Hours

1. Controller tuning:
   a) define the basis for tuning automatic controllers
   b) describe two methods of determining optimum controller settings
      i) closed-loop test
      ii) open loop test
   c) define the circumstances under which each of the two methods should be used
   d) calculate the optimum controller gain, reset and derivative settings

D. General Single Loop Analysis ..... 10 Hours

1. Loop characteristics:
   a) explain the relationship between system responses to mode selection
   b) explain what type of controllers should be used for common single-loop control
   c) review 1/4 amplitude decay
   d) explain the difference between setpoint and load change to system response
   e) explain the open and closed loop gains for a system
   f) explain the difference between linear and non-linear system gains
   g) explain control strategies for non-linear system gains
   h) form the loop statics diagram for a temperature and flow loop and compute static gains
   i) develop a general equation for closed loop steady state

E. Process Loop Elements ..... 7 Hours

1. Dead time element:
   a) explain the ways in which dead time affects the performance of a feedback control system
   b) plot recovery curves for proportional controller controlling a dead time process
   c) establish the period of oscillation for a control system having a dead time process
2. Time constants:
   a) list the characteristics of a step input to a capacity element
   b) list the characteristics of gain and phase for a single capacity system
   c) explain the relationship between a multicapacity system and the equivalent dead time and capacity system
   d) explain the method of reducing a general multicapacity system to equivalent dead time and capacity system
3. The integrating process:
   a) explain self regulation and its significance in process control
   b) explain the static gain characteristics of an integrating process
   c) explain the phase relationship for an integrating process
   d) describe the concept of offset for an integrating process
   e) explain control of a selected integrating process

F. Unique Single Loops ..... 6 Hours

1. Flow control:
   a) identify the type of controller required for flow loops
   b) describe static combinations for flow elements, valve, and line resistance installations
2. Liquid pressure:
   a) identify the type of controller required for liquid pressure control with approximate settings
3. Gas pressure:
   a) identify the type of controller required for gas pressure control with approximate settings
4. Level:
   a) identify the type of controller required for level loops with approximate settings
   b) describe two level control strategies and the type of controller required
5. Temperature:
   a) identify the type of controller required for temperature control including approximate settings

G. Control Strategies ..... 32 Hours

1. Cascade control:
   a) draw a block diagram of a cascade system
   b) list 4 advantages or uses for cascade control
   c) explain how the effective time constant of the inner loop is reduced under cascade control
   d) describe the most common forms of secondary control loops
   e) describe the correct method for tuning cascade control systems

2. Selective control:
   a) describe selective control
   b) sketch a block diagram of selective control
   c) define and describe four areas of application
   d) choose the correct controller and selector action
   e) explain why and how to prevent reset windup on selective control
3. Multivariable:
   a) define multivariable control, various related terms and sketch a block diagram
   b) illustrate one good and one bad case of multivariable control
   c) explain solutions required to make multivariable systems work
4. Ratio control:
   a) define a ratio control system
   b) calculate loop values for a common flow ratio system
   c) explain the difference between a linear and square root station
   d) explain the range of ratio station settings
   e) explain remote ratio trim
   f) explain digital blending operations
   g) identify blending errors in digital systems
5. Feedforward control:
   a) define feedforward control
   b) draw a general block diagram of a feedforward control system
   c) list and describe problems of feedback control
   d) describe the reasons for feedback trim on a feedforward system
   e) sketch a feedforward control loop with feedback trim
6. Split range:
   a) explain split range control

H. Advanced Control Strategies ..... 8 Hours

1. Fuzzy logic:
   a) explain fuzzy logic
   b) explain advanced multivariable control
   c) explain the use of VFDs as a trim element

I. Process Units and Control ..... 15 Hours

1. Distillation:
   a) describe the Unit Operations of a tower
   b) explain and describe the functions of the internals of a tower
   c) describe three types of condensers
   d) describe two types of reboilers
   e) define the terms “Rectifying Section” and “Stripping Section”
   f) define the term Reflux Ratio”
   g) describe problems with top temperature control
   h) describe problems with feed control
   i) describe reflux flow and effects
   j) describe reboiler temperature control problems
   k) describe the relationship between reflux and product quality

l) explain dry and flooded trays
m) describe the effects of reboiler temperature on product quality

2. Boiler control:

a) use SAMA symbols related to boiler control
b) explain the main control systems required to control a boiler
c) describe 1-element, 2-element and 3-element boiler feedwater control systems
d) distinguish between pressure controlled and base loaded boilers
e) explain the purpose and function of the plant master and the boiler master
f) describe series and parallel firing
g) explain cross limiting and its purpose
h) describe methods of providing the correct amount of air by
  i) O2 trim
  ii) CO trim
i) explain natural, forced, induced and balanced draft
j) describe methods of controlling steam temperature
k) describe methods of recovering heat from flue gas

J. Laboratory ..... 40 Hours

1. Temperature control:

a) develop loop statics
b) obtain process reaction curve and develop controller settings
c) use ultimate gain tuning methods

2. Level control:

a) distinguish between tight level and surge level control
b) develop settings and design controller blocks

3. Multi-capacity system:

a) static analysis of loop interaction
b) develop settings and design controller blocks

4. Dead time systems:

a) analyze a dead time system
b) verify To = 2 Td
c) develop PI settings for control

5. Cascade control:

a) configure a cascade system
b) correctly tune and commission a cascade system

6. Ratio control:

a) study a flow ratio system
b) configure a controller for ratio control

7. Selective control:

a) configure a selective control system
b) tune a selective control system

8. Feedforward control:

a) configure a feedforward control system
b) develop static valves for feedforward control
c) operate a feedforward control system

9. Distributed controllers:
   a) configure a simple single loop on a distributed system
   b) operate a multiloop distributed system
   c) develop trends and tune loops for a multiloop system
10. Advanced Control Strategies:
   a) develop fuzzy logic

SECTION TWO: ..... ADVANCED DIGITAL SYSTEMS ..... 102 HOURS

A. Digital Controllers ..... 8 Hours

1. Configuration design:
   a) given a piping and instrument diagram of an industrial digital controller application, formulate an instrument loop diagram
   b) using the piping and instrument diagram and the instrument loop diagram formulate a function diagram for a digital controller
   c) given a function block diagram for a digital controller fill out a configuration chart for the controller
2. Configuration implementation:
   a) given a configuration chart for a digital controller be able to configure the controller in both local and console modes
3. Tuning:
   a) be able to tune the controller to operate a process within specified limits
4. Internal structure:
   a) describe a digital controllers internal structure
5. Manufacture comparison:
   a) compare different manufactures: Moore; Bailey; Foxboro

B. Programmable Logic Controllers..... 25 Hours

1. Physical components:
   a) define chassis; processor module; and I/O modules
   b) describe opto-couplers and Scr/Triac switching circuits as they apply to descrete I/O modules
   c) describe A/D and D/A conversion as it applies to analog modules
2. Logical components:
   a) define group; rack; terminal and relate these terms to the physical components by describing addressing modes
3. Data tables:
   a) describe the various data storage locations and how they relate to logical and physical components
4. Discrete functions:
   a) program the PLC using ladder logic with the following function: N.O. and N.C. contacts normal, latching and unlatching coils; timers, counters; sequencers
   b) develop programs for application in manufacturing, emergency shut down and alarm systems

5. Analog functions:
   a) program the PLC using ladder logic with the following functions, math; logical; decision; PID control
   b) develop programs for application in industrial controls
6. Modular programming:
   a) use modular programming methods to write PLC programs: graph sets; sequencial function charts (SFC)
7. High level language programming:
   a) program the PLC using high level third party software
   b) list PLC communication protocols
8. 3rd Party Software:
   a) use 3rd party software to extract and manipulate data

C. Supervisory Control and Data Acquisition (SCADA) ..... 15 Hours

1. SCADA and DAS functions:
   a) describe some typical applications: oil/gas; electric power; water distribution; waste water management
2. Hardware components:
   a) describe devices used for supervisory functions
   b) describe remote or distributed l/O devices

D. Industrial Local Area Networks (ILAN) ..... 6 Hours

1. Local area network concepts:
   a) define wide area networks; local area networks
   b) describe LAN applications, components and characteristics
   c) describe different transmission techniques: baseband; carrierband; broadband
   d) discuss different topologies: star; ring; bus
2. The OSI model:
   a) describe the OSI model as it applies to industrial applications
3. Network access methods:
   a) describe master/slave; CSMA/CD; token passing
4. Standards:
   a) describe the TCP/IP protocol

E. Fieldbus Protocols ..... 8 Hours

1. Describe the common protocols.
2. Describe and contrast the capabilities of digital field devices to that of analog devices.
3. Describe the different techniques that digital field devices use to communicate.
4. Describe the physical architecture:
   a) installation and wiring
   b) device powering
   c) implications for intrinsic safety

5. Describe communication devices and application software:
   a) use of handheld communicators
   b) device addressing
   c) significance of device descriptors
   d) device programming/configuring
6. Describe how these protocols relate to the ISO/OSI layer model.
7. Example protocol:
   a) describe at least one popular protocol (Rosemount HART; Honeywell; SP-50)

F. Laboratory ..... 40 Hours

1. The laboratory component of the course gives the student practical exercises to reinforce the theory component. The student will interconnect hardware, design and implement software and finally test the system as a whole:
   a) Digital controller configuration (simple PID)
   b) Digital controller configuration (advanced control strategy)
   c) PLC programming (software introduction and discrete)
   d) PLC programming (emergency shut down)
   e) PLC programming (alarms)
   f) PLC programming (boiler simulation)
   g) PLC programming (sequential function chart)
   h) PLC programming (analog; block transfer)
   i) PLC programming (simple PID)
   j) PLC programming (advanced control strategy)
   k) PLC programming (high level language)
   l) SCADA RTU programming (discrete and analog)
   m) SCADA RTU programming (PID)
   n) Asynchronous communications (RS-232)
   o) Hayes compatible moderns
   p) Digital controller peer to peer communications
   q) SCADA communications
   r) PLC, DCS controller, trouble shooting
   s) Field Bus

SECTION THREE: ..... PROCESS ANALYZERS ..... 63 HOURS

A. Introduction to Spectrophotometry ..... 5 Hours

1. Describe the electromagnetic spectrum and electro-magnetic radiation.
2. Explain the purpose of the following analyzer components:
   a) sources
   b) cells (reference and sample)
   c) detectors
   d) choppers
   e) filters
   f) monochromators (prisms and diffraction gratings)
3. Explain absorption and emission spectrums.
4. Explain and apply the Beer-Lambert absorption laws to I.R. and U.V. absorption analyzers.

5. Explain fluorescence and phosphorescence.

B. Infrared Analysis ..... 3 Hours

1. Explain the difference between DIR and NDIR analyzers.
2. List and describe the sources, cells and detectors utilized by NDIR analyzers.
3. Explain negative and positive filtering techniques as applied in industry.
4. Describe process applications for IR analyzers.

C. Ultraviolet Analysis ..... 3 Hours

1. Explain the differences between UV absorption and UV emission (fluorescence) analysis.
2. List and describe the sources, cells, detectors and filters utilized by UV analyzers.
3. With the aid of a diagram, explain the principle of analysis for the following UV designs:
   a) opposed beam
   b) dual beam, single detector
   c) dual beam, dual detector
   d) split beam
   e) flicker
   f) pulsed and chopped fluorescence
4. Describe process applications for UV analyzers.
5. List and explain UV precautions and hazards.

D. Chemiluminescence ..... 2 Hours

1. Describe and explain the chemiluminescent reaction.
2. With the aid of a diagram, list and explain the components of a chemiluminescent NO analyzer.
3. Explain the principle of analysis and applications of a chemiluminescent analyzer.

E. Process Chromatography ..... 14 Hours

1. Explain the principle of analysis utilized by chromatography.
2. Define:
   a) chromatography
   b) gas chromatography
   c) liquid chromatography
   d) laboratory chromatography
   e) process chromatography
   f) carrier gas
   g) mobile phase
   h) stationary phase
   i) GSC, GLC, LSC, LLC
   j) solid support (substrate)
   k) elution time, retention time
   l) number of theoretical plates and HETP
   m) peak resolution
   n) column efficiency

3. Describe and explain the following gas chromatograph components:
    a) injection port
    b) sample valve
    c) sample loop
    d) column
    e) detector
        i) TCD (thermal conductivity detector)
        ii) FID (flame ionization detector)
        iii) PID (photo ionization detector)
        iv) FPD (flame photometric detector)
4. Explain switching techniques.
5. Describe and explain the following liquid chromatograph components:
    a) analysis section
    b) control section
    c) carrier supply
    d) valves
    e) column types
    f) detectors
6. Explain qualitative and quantitative data analysis.

F. Mass Spectroscopy Measurement.....4 Hours

1. Describe the principles of operation of mass spectrometers.
2. List and describe the parts required for the operation of the following mass spectrometers:
    a) magnetic sector (both fixed and variable fields)
    b) quadrapole filter
3. Describe the handling of the data output from mass spectrometers.
4. List and describe typical applications of mass spectroscopy.

G. Environmental Monitoring.....3 Hours

1. Explain environmental (ambient and workplace) measurement and list pollutants that must be measured and controlled.
2. Provide an awareness of various government regulatory agencies.
3. Discuss process operating licenses and parameters that must be measured.
4. Review air monitoring directives and identify parameters that must be measured.
5. List and explain the operation of equipment required for monitoring pollutants.
6. Describe the auxiliary equipment required to measure:
    a) wind, speed and direction
    b) fog and moisture
    c) particulate samples

H. Analyzer Calibrations ..... 3 Hours

1. Calibration procedures:
   a) describe what an analyzer calibration is
   b) list the components required for an analyzer calibration
   c) describe the procedure required to perform a government/industry approved calibration
2. Calibration systems:
   a) list and describe three calibration systems
   b) identify, from tables, calibration and sampling materials required for various pollutants
   c) describe a sample manifold
3. Calibration data analysis:
   a) label and describe an analyzer calibration chart
   b) draw, label and describe an analyzer calibration graph

I. Sampling Systems ..... 6 Hours

1. Apply the general principles of sampling systems to continuous process analyzers.
2. Describe and calculate lag time and determine how to minimize it.
3. Discuss typical sampling system applications.

J. Laboratory ..... 20 Hours

1. Operate and calibrate a NDIR analyzer.
2. Operate and calibrate a chemiluminescence analyzer.
3. Operate and calibrate a SO2 analyzer.
4. Operate a gas chromatograph to determine valve timings for column switching.
5. Operate a gas chromatograph to determine peak elution times and calibration factors for data analysis.
6. Operate, calibrate and evaluate stack emission data (example: from a CSEM system).
7. Operate and calibrate and evaluate process data (example: a mass spectrometer).

SECTION FOUR: ..... WORKPLACE COACHING SKILLS ..... 4 HOURS

A. WORKPLACE COACHING SKILLS ..... 4 hours

1. Describe the following coaching skills used for training apprentices:
   a) identify the point of the lesson
   b) link the lesson
   c) demonstrate a skill
   d) provide opportunity to practice a skill
   e) give feedback to learner
   f) assess the learner's progress

Excellence through training and experience

3102.2