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INDUSTRIAL AUTOMATION

TRAINER GUIDE

National Vocational Certificate Level 3

Version 1 - September, 2019

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Introduction

Competence-based training helps to bridge the gap between what is taught in training and what tasks will be performed on the job. Training trainees to perform actual job functions helps to ensure that future front-line workers have the skills, knowledge and abilities required to perform their jobs properly, safely and effectively. In addition to competence-based training, assessment based on the performance of actual work competencies helps to ensure that:

- trainees are performing their work tasks as safely as possible
- performance gaps are recognized prior to serious incidents
- training can be implemented to improve competence.

There are significant benefits to competence-based training:

1. **Cost effectiveness**

   Since training activities and assessments in a competence-based approach are goal-oriented, trainers focus on clearly defined areas of skills, knowledge and understanding that their own industry has defined in the competence standards. At the same time, trainees are more motivated to learn when they realize the benefits of improved performance.

2. **Efficiency**

   The transfer gap between the training environment and working on the job is reduced substantially in a competence-based approach. This is because training and assessment are relevant to what needs to be done on the job. As a result, it takes less time for trainees to become competent in the required areas. This, in turn, contributes to improved efficiency where training and assessment are concerned.

3. **Increased productivity**

   When trainees become competent in the competence standards that their own industry has defined, when they know what the performance expectations are and receive recognition for their abilities through successful assessments, they are likely to be more motivated and experience higher job satisfaction. The result is improved productivity for organizations. The communication and constructive feedback between future employers and employees will improve as a result of a competence-based approach, which can also increase productivity.

4. **Reduced risk**

   Using a competence-based approach to training, development, and assessment, employers are able to create project teams of people with complementary skills. A trainee's record of the skills, knowledge and understanding relating to the competence standards they have achieved can be used by a future employer to identify and provide further relevant training and assessment for new skills areas. Competence standards can shape employee development and promotional paths within an organization and give employees the opportunity to learn more competencies beyond their roles. It can also provide organizations with greater ability to scale and flex as needed, thereby reducing the risk they face.

5. **Increased customer satisfaction**

   Employees who have been trained and assessed using a competence-based approach are, by the definition of the relevant competence standards, able to perform the required tasks associated with a job. The knock-on effect is that, in service-related industries, they are able to provide high service levels, thereby increasing customer satisfaction. In production or manufacturing industries, they are able to work closely to industry standards in a more effective and efficient way.

Lesson Plans:

This manual provides a series of lesson plans that will guide delivery of each module for the Industrial Automation qualification. It is important for trainers to be flexible and be ready to adapt lesson plans to suit the context of the subject and the needs of their trainees.

Good teachers acknowledge that CBT means each and every trainee in the class learns at a different speed. The good teacher is prepared to throw aside the day's lesson plan and do something different (and unplanned) for the class even if it means 'writing' a lesson plan for each trainee to match their learning pace for that day or week.

Learning by doing is different from learning theory and then applying it. To learn to do something, trainees need someone looking over their shoulder saying 'it's not quite like that, it's like this', 'you do it like this because …', or even 'tell me why you chose to do it like this?'.

In this way, trainees learn that theoretical knowledge is meaningless if it is not seen in the context of what they are doing. In other words, if a trainee doesn't know why they do something, they will not do it competently (skills underpinned by knowledge = competent performer).

This is how an Industrial Automation learner acquires a practical grasp of the standards expected. It's not by learning it in theory, but because those standards are acquired through correction by people who show what the standards are, and correct the trainee where they do not meet those standards, and where they repeat it correction until they have internalized those standards.

Demonstration of a Skill:

Demonstration or modeling a skill is a powerful tool, which is used, in vocational training. The instructions for trainers for demonstration are as under:

a) Read the procedure mentioned in the Trainer Guide for the relevant Learning Unit before demonstration.
b) Arrange all tools, equipment and consumable material, which are required for demonstration of a skill.
c) Practice the skill before demonstration to trainees, if possible.
d) Introduce the skill to trainees clearly at the commencement of demonstration.
e) Explain how the skill relates to the skill(s) already acquired and describe the expected results or show the objects to trainees.
f) Carry out demonstration in a way that can be seen by all trainees.
g) Use the same tools and materials that the learner will be using.
h) Go through EACH of the steps involved in performing the skill.
i) Go SLOWLY - describe each step as it is completed.
j) Encourage the learners to move around and watch what you are doing from a number of different angles.
k) Identify critical or complex steps, or steps that involve safety precautions to be followed.
l) Explain theoretical knowledge where applicable and ask questions to trainees to test their understanding.
m) Try to involve the learners: Ask them questions about why they think the process may work that way.
n) Repeat critical steps in demonstration, if required.
o) Summarize the demonstration by asking questions to trainees.

Involvement in the process (actively seeing) is important at this stage. When you work on getting involved, getting people to participate, you make them a part of what is happening. Questions for clarification or explanation are important throughout the demonstration. It is up to the learners to ask questions about things they do not understand, but it is also important for trainers to seek out and elicit questions from learners. A trainer may need to do repeated demonstrations of difficult or complex skills.

Remember that the learner will learn a lot from your demonstration - and not just the demonstration itself. Learners will learn about how to perform the skills, but they will also learn from watching demonstrations how trainers treat the tools or materials and how they follow safety procedures.

After the demonstration, it is important to again seek out questions - be sure all questions are answered. The trainer should ask the learner if they are ready to try the skill. If not, there may be a need for recycling the demonstration (or part of it), and clarifying some of the information.

Overview of the program

Course: NVQ Certificate Level 3 in Industrial Automation	**Total Course Duration:** **Hours**
Course Overview:	
The Industrial Automation program is to engage young people with a program of development that will provide them with the knowledge, skills and understanding to start their career in Pakistan as Industrial Controls & Automation skilled person , technician or expert. The program has been developed to address specific issues, such as the national, regional and local cultures, the manpower availability within the country, and meeting and exceeding the needs and expectations of their customers.	

Module Title and Aim	Learning Units	Duration
Module 12: Perform Programmable Logic Controller (PLC) Operations **Aim:** The aim of this module to get knowledge, skills and understanding to perform programmable logic controller (PLC) operations	**LU1:** Integrate Programmable Logic Controller **LU2:** Develop Logic for Programmable Logic Controller	420
Module 13: Develop Human Machine Interface (HMI) **Aim:** The aim of this module to get knowledge, skills and understanding to develop human machine interface (HMI)	**LU1:** Configure HMI **LU2:** Develop graphical User Interface **LU3:** Develop HMI Programs & Recipes	110

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Module-12

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Trainer's Guidelines

Module 12: 071400938 Perform Programmable Logic Controller (PLC) Operations

Objective of the module: The aim of this module to get knowledge, skills and understanding to perform programmable logic controller (PLC) operations.

Learning Unit	Suggested Teaching/ Learning Activities	Delivery Context	Media
LU1: Integrate Programmable Logic Controller (PLC)	Deliver illustrated presentations which consist of following points • Study of various tools to be used for PLC integration • Comparison between PLC and tradition controllers • Main parts of PLC and their function • Study of different types of PLC w.r.t. switching. • Study of integration of discrete I/O module of PLC • Study of analog I/O module of PLC. • Identification of physical I/O modules of PLC and their addressing • Knowledge of sourcing/sinking wiring of PLC • Study of the pin configuration of PLC and extra digital I/Os modules. • Study of the pin configuration of analogue module • Differentiate between power signal and control signal. • Understanding of the integration of	Lab / Workshop	• White Board • Multimedia /Internet • Illustration of Tools and equipment video lectures and animations https://www.youtube.com/watch?v=hkkjcS5AGEs https://www.youtube.com/watch?v=PLYosK87D8E

Module 12: 071400938 Perform Programmable Logic Controller (PLC) Operations

Objective of the module: The aim of this module to get knowledge, skills and understanding to perform programmable logic controller (PLC) operations.

Learning Unit	Suggested Teaching/ Learning Activities	Delivery Context	Media
	pneumatic instruments and hydraulic instrument with PLC Show the learners • Various tools to be used for PLC integration • Main parts of PLC • Transistor type PLC, Relay type PLC and Triac type PLC • I/O modules of PLC. • Physical I/O modules of PLC and their addressing • Pins and tags of PLC and extra digital I/Os modules. • Pin and tags of analogue module Demonstrate the learners about • Use of the tools and equipment • Sourcing/sinking wiring on any conventional circuit for the learners understanding • Pin configuration of PLC and extra digital I/Os modules. • Pin configuration of analogue module		

Module 12: 071400938 Perform Programmable Logic Controller (PLC) Operations

Objective of the module: The aim of this module to get knowledge, skills and understanding to perform programmable logic controller (PLC) operations.

Learning Unit	Suggested Teaching/ Learning Activities	Delivery Context	Media
	• Integration of pneumatic instruments and hydraulic instrument with PLC Organize the following activities • Give all the learners different task and let them identify their required tools and equipment • Ask the learners to present the different parts of PLC and each learner will explain the one part of PLC • Change the tags on wires connected with PLC (wrong tagging) and let the learners trace the wrong tagging keeping in mind the real addressing mentioned on PLC hardware • Ask the learners to apply the all four wiring scheme on single push button lighting control circuit. • Study of the pin configuration of PLC and extra digital I/Os modules. • Ask the learner to draw the complete wiring diagram of PLC, modules, Inputs, Outputs, hydraulic and pneumatic attachments		
LU2: Develop logic for Programmable Logic Controller	Deliver illustrated presentations which consist of following points:	Classroom / Lab / Workshop	• White Board • Multimedia /Internet • Illustration of tools and

Module 12: 071400938 Perform Programmable Logic Controller (PLC) Operations

Objective of the module: The aim of this module to get knowledge, skills and understanding to perform programmable logic controller (PLC) operations.

Learning Unit	Suggested Teaching/ Learning Activities	Delivery Context	Media
	• Understanding of software • Identification of different software used for PLC programming; • Installation of programming software. • Basic operational & functional keys of software. • Data sheet of Built-in/software based relays and data registers • Different communication protocols of PLC • Simulation methods in PLCs • PLC programming for digital operations using hardware • Communication between PC and PLC. • Switching Instructions in PLC (NO Contact, NC Contact, Rising Edge, Falling Edge, Output Coil, Set, Reset, Alternating Instruction, Inverse Logic, Logic Gates etc) • Arithmetic Instructions in PLC (Addition, Subtraction, Multiplication, Division,		equipment video Lectures and animations https://www.youtube.com/watch?v=o0LLV5GP6Ow https://www.youtube.com/watch?v=zeYJZnGw99w

Module 12: 071400938 Perform Programmable Logic Controller (PLC) Operations

Objective of the module: The aim of this module to get knowledge, skills and understanding to perform programmable logic controller (PLC) operations.

Learning Unit	Suggested Teaching/ Learning Activities	Delivery Context	Media
	Square root, Mean etc) • Data processing instructions (Data Movement, Data Shifting and Data rotation, Comparison, Exchange, Matrix, Complement, Negation, Display etc) • Timing and counting instructions. • Special instructions.(Step Ladder, Master Control, Encoder Instructions, PWM, Reading, Writing) • Subroutine instructions (Subroutine CALL, Jump, Interrupt etc) • PLC programming for analogue operations using hardware (Analog Inputs, Analog Outputs) • Identification of analogue signals encountered with PLC (Voltage Signal, Current Signal, Pressure Signal and Temperature Signal) • Analogue configuration through software • Analogue signal processing • Thermocouple module and signal		

Module 12: 071400938 Perform Programmable Logic Controller (PLC) Operations

Objective of the module: The aim of this module to get knowledge, skills and understanding to perform programmable logic controller (PLC) operations.

Learning Unit	Suggested Teaching/ Learning Activities	Delivery Context	Media
	processing • PT module and signal processing. • Load cell module and signal processing. • PID Instruction and operation. • Pressure handling analogue devices. **Show the Learners :** • Data sheet of Built-in/software based relays and data registers • Pressure handling analogue devices. **Demonstrate the learners about :** • Installation of programming software. • Basic operational & functional keys of software. • Setting of different communication protocols of PLC • Simulation methods in PLCs • PLC programming for digital operations using hardware • Communication setting between PC and		

Module 12: 071400938 Perform Programmable Logic Controller (PLC) Operations

Objective of the module: The aim of this module to get knowledge, skills and understanding to perform programmable logic controller (PLC) operations.

Learning Unit	Suggested Teaching/ Learning Activities	Delivery Context	Media
	PLC. • Identification of analogue signals encountered with PLC (Voltage Signal, Current Signal, Pressure Signal and Temperature Signal) • Analogue configuration through software • Analogue signal processing • Thermocouple module and signal processing • PT module and signal processing. • Load cell module and signal processing. • PID Instruction and operation. • Pressure handling analogue devices. Teach the learners following PLC programming instructions and ask them to practice these instructions on simulation and hardware. • Switching Instructions in PLC (NO Contact, NC Contact, Rising Edge, Falling Edge, Output Coil, Set, Reset, Alternating Instruction, Inverse Logic, Logic Gates		

Module 12: 071400938 Perform Programmable Logic Controller (PLC) Operations

Objective of the module: The aim of this module to get knowledge, skills and understanding to perform programmable logic controller (PLC) operations.

Learning Unit	Suggested Teaching/ Learning Activities	Delivery Context	Media
	etc) • Arithmetic Instructions in PLC (Addition, Subtraction, Multiplication, Division, Square root, Mean etc) • Data processing instructions (Data Movement, Data Shifting and Data rotation, Comparison, Exchange, Matrix, Complement, Negation, Display etc) • Timing and counting instructions. • Special instructions.(Step Ladder, Master Control, Encoder Instructions, PWM, Reading, Writing) • Subroutine instructions (Subroutine CALL, Jump, Interrupt etc) • Analog Instruction for Data read and write **Organize the following activities in class** • Installation of programming software. • Setting of different communication protocols of PLC • Simulation of different programs		

Module 12: 071400938 Perform Programmable Logic Controller (PLC) Operations

Objective of the module: The aim of this module to get knowledge, skills and understanding to perform programmable logic controller (PLC) operations.

Learning Unit	Suggested Teaching/ Learning Activities	Delivery Context	Media
	• PLC programming for analogue operations using hardware (Analog Inputs, Analog Outputs) • Identification of analogue signals encountered with PLC (Voltage Signal, Current Signal, Pressure Signal and Temperature Signal) • Analogue configuration through software • Analogue signal processing • Thermocouple module and signal processing • PT module and signal processing. • Load cell module and signal processing. • Operation and working of PID instructions Direct the learner to develop the ladder logic of following real life problems and perform the operation on hardware as well. • Falling bottle detection on conveyer belt • Automatic tank filling using level switches		

Module 12: 071400938 Perform Programmable Logic Controller (PLC) Operations

Objective of the module: The aim of this module to get knowledge, skills and understanding to perform programmable logic controller (PLC) operations.

Learning Unit	Suggested Teaching/ Learning Activities	Delivery Context	Media
	and latch function • Entry / Exit control of underground car parking using Alternating Instruction • Auto blackboard cleaner using Alternating instruction • Actuator pipe flow measurement using arithmetic functions • Staircase circuit using alternating instruction • Automatic Coffee Maker using timer instruction • Single way traffic light signal system using timer instruction • Two way traffic light signal system using timer instruction • Three way traffic light signal system using timer instruction • Four way traffic light signal system using timer instruction		

Module 12: 071400938 Perform Programmable Logic Controller (PLC) Operations

Objective of the module: The aim of this module to get knowledge, skills and understanding to perform programmable logic controller (PLC) operations.

Learning Unit	Suggested Teaching/ Learning Activities	Delivery Context	Media
	• Automatic urinal flushing control system using timer instruction • Office bell timing control using timer instruction • Product amount calculation system using counter instruction • Production mass packaging system using counter instructions • Daily production record system using counter instruction • 24 hours clock using counter instruction • Multiple history data backup using data movement instructions • Defective product detection system using shifting instruction • Color light flashing using rotation instruction • Traffic control signals using step ladder instructions		

Module 12: 071400938 Perform Programmable Logic Controller (PLC) Operations

Objective of the module: The aim of this module to get knowledge, skills and understanding to perform programmable logic controller (PLC) operations.

Learning Unit	Suggested Teaching/ Learning Activities	Delivery Context	Media
	• Automatic material mixing machine using comparison instructions • Water level alarm control system using comparison instructions • Control of warehouse automatic door using comparison instructions • Fire alarm system in office using interruption instructions • Reservoir level control using call subroutine instructions • Selective execution of colors using master control instructions • Day light harvesting circuit using analog sensors and analog module • Compressor pressure regulation using Analog module • Boiler Temperature control using PT Module • Construction material mixing machine		

Module 12: 071400938 Perform Programmable Logic Controller (PLC) Operations

Objective of the module: The aim of this module to get knowledge, skills and understanding to perform programmable logic controller (PLC) operations.

Learning Unit	Suggested Teaching/ Learning Activities	Delivery Context	Media
	using load cell module • Temperature control of Generator using TC module • Pressure control system using PID Instructions (Hydraulic and pneumatic) • Temperature control system using PID Instructions		

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Module-13

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Module 13 : 071400939 Develop Human Machine Interface (HMI)

Objective of the module: The aim of this module to get knowledge, skills and understanding to develop human machine interface (HMI).

Learning Unit	Suggested Teaching/ Learning Activities	Delivery Context	Media
LU1: Configure HMI	Deliver illustrated presentations which consist of following points • Need and concept of HMI systems • Types of HMI • Types of various communication protocols (e.g. Modbus, TCP/IP, Profibus, Profinet) used for HMI • HMI communication with different controllers (e.g. PLCs, VFDs, Servo Drive, Actuators and Analyzers) **Show the Learners** • Different type of HMI • Types of various communication protocols (e.g. Modbus, TCP/IP, Profibus, Profinet) used for HMI Demonstrate the HMI communication with different controllers (e.g. PLCs, VFDs, Servo Drive, Actuators and Analyzers) Direct the learners to perform the communicationof HMI with different controllers (e.g. PLCs, VFDs, Servo Drive, Actuators and Analyzers)	Lab / Workshop	• Learner Guide • White Board • Multimedia /Internet • Illustration of tools and equipment video lectures and animations

Module 13 : 071400939 Develop Human Machine Interface (HMI)

Objective of the module: The aim of this module to get knowledge, skills and understanding to develop human machine interface (HMI).

Learning Unit	Suggested Teaching/ Learning Activities	Delivery Context	Media
LU2: Develop graphical User Interface	Deliver illustrated presentations which consist of following points • Process flow diagrams (PFDs) of a process • Process and instrumentation diagrams (P&IDs) of a process • Basic operations of software used for HMI designing • Basic simulation techniques for HMI development • Static screen development: depicting the complete plant in different screens • Dynamic linking of tags: Communications with the PLC and animation of graphic objects according to the status of the process. • Trending: viewing the X-Y plots of different parameters for analysis **Demonstrate the following to the Learners** • Process flow diagrams (PFDs) of a process • Process and instrumentation diagrams (P&IDs) of a process • Basic operations of software used for HMI designing	Classroom / Lab / Workshop	• White Board • Multimedia /Internet • Illustration of tools and equipment video lectures and animations • Learner Guide

Module 13 : 071400939 Develop Human Machine Interface (HMI)

Objective of the module: The aim of this module to get knowledge, skills and understanding to develop human machine interface (HMI).

Learning Unit	Suggested Teaching/ Learning Activities	Delivery Context	Media
	• Basic simulation techniques for HMI developmentStatic screen development: depicting the complete plant in different screens • Dynamic linking of tags: Communications with the PLC and animation of graphic objects according to the status of the process. • Trending: viewing the X-Y plots of different parameters for analysis Direct the learner to draw the P&IDs and PFDs on paper first Direct the learners to perform the installation of HMI software Organize an activity in which ask the learners to identify the different instruments symbols used in software Direct the learners to perform following operations on HMI software • Perform the communication setting • Configure tags for different elements on software • Draw the different type of buttons and perform the graphical designing on the buttons • Operate the button and verify the function		

Module 13 : 071400939 Develop Human Machine Interface (HMI)

Objective of the module: The aim of this module to get knowledge, skills and understanding to develop human machine interface (HMI).

Learning Unit	Suggested Teaching/ Learning Activities	Delivery Context	Media
	of different buttons on simulation • Draw the different type of indicators and Perform the graphical designing on the indicators • Operate the indicators and verify the function of different indicators on simulation • Draw the different type of meters and perform the graphical designing on the meters • Operate the meters and verify the function of different meters on simulation • Draw the different type of pipes and perform the graphical designing on the pipes • Operate the pipes and verify the function of different pipes on simulation • Draw the different type of entries and perform the graphical designing on the entries • Operate the entries and verify the function of different entries on simulation • Draw the different type of displays and perform the graphical designing on the displays • Operate the displays and verify the		

Module 13 : 071400939 Develop Human Machine Interface (HMI)

Objective of the module: The aim of this module to get knowledge, skills and understanding to develop human machine interface (HMI).

Learning Unit	Suggested Teaching/ Learning Activities	Delivery Context	Media
	function of different displays on simulation • Draw the moving signs and perform the graphical designing Direct the learners to design the PFDs for following real life problems on HMI software; Integrate the HMI with PLC and perform operation of the PFDs on hardware. • Single way traffic light signal system • Two way traffic light signal system • Three way traffic light signal system • Four way traffic light signal system • Flashing light system • Level determination of tanks • Temperature control of process • Pressure control of process • Pressure monitoring of a process • Temperature monitoring of a process		
LU3: Develop HMI Program & Recipes	Deliver illustrated presentations which consist of following points • Configuring Alarms, recipes and report generation. • History and Bar graph • Back screen macros in HMI	Classroom / Lab / Workshop	• White Board • Multimedia /Internet • Illustration of tools and equipment video lectures and animations • Learner Guide

Module 13 : 071400939 Develop Human Machine Interface (HMI)

Objective of the module: The aim of this module to get knowledge, skills and understanding to develop human machine interface (HMI).

Learning Unit	Suggested Teaching/ Learning Activities	Delivery Context	Media
	• Security levels and settings. • Testing of HMI • Troubleshooting the developed HMI system. **Demonstrate the Learners** • Alarm configuration HMI • Recipe making in HMIReport generation in HMI • History and bar graph drawing in HMI • Back screen macros in HMI • Security level setting • Password Setting in HMI • Testing of HMI • Troubleshooting of developed HMI system. Direct the learners to perform the following operations in HMI • Set alarm for different situations • Make recipes of different processes • Generate the reports of process • Show the process values on bar graph and make history • Use HMI as controller and develop macros for programming		

Module 13 : 071400939 Develop Human Machine Interface (HMI)

Objective of the module: The aim of this module to get knowledge, skills and understanding to develop human machine interface (HMI).

Learning Unit	Suggested Teaching/ Learning Activities	Delivery Context	Media
	• Set all level security on HMI • Set password on all level securities • Perform testing on HMI • Troubleshoot the HMI		

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