REPUBLIC OF KENYA

COMPETENCY BASED MODULAR CURRICULUM
FOR
INDUSTRIAL MECHATRONICS TECHNOLOGY

KNQF LEVEL 6

CYCLE 3

ISCED PROGRAMME CODE: 0715 554 A

TVET CDACC
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FOREWORD

Provision of quality education and training is fundamental to the Government's overall strategy for socio-economic development. Quality education and training contribute to achievement focused on Kenya's development blueprint and sustainable development goals.

Reforms in the education and training sector are necessary for achievement of Kenya Vision 2030 and meeting the provisions the Constitution of Kenya. The education sector had to be aligned to the Constitution and this resulted in formulation of the Policy Framework for Reforming Education and Training (Sessional Paper No. 1 of 2019). A key feature of this policy is the change in the design and delivery of TVET training. This policy document requires that training in TVET be competency based, curriculum development be industry led, certification be based on demonstration of competence and mode of delivery that allows for multiple entry and exit in TVET programs.

These reforms demand that Industry takes a leading role in curriculum development to ensure the curriculum addresses its competence needs. It is against this background that this Curriculum has been developed.

It is my conviction that this curriculum will play a great role towards development of competent human resource for the Industrial Mechatronics sector's growth and sustainable development.

PRINCIPAL SECRETARY

STATE DEPARTMENT FOR TVET

MINISTRY OF EDUCATION

PREFACE

Kenya Vision 2030 aims to transform Kenya into a newly industrializing middle-income country, providing high-quality life to all its citizens by the year 2030. Kenya intends to create globally competitive and adaptive human resource base to meet the requirements of a rapidly industrializing economy through lifelong education and training. TVET has a responsibility to facilitate the process of inculcating knowledge, skills, and worker behaviour necessary for catapulting the nation to a globally competitive country, hence the paradigm shift to embrace Competency-Based Education and Training (CBET).

TVET Act CAP 210A and Sessional Paper No. 1 of 2019 on Reforming Education and Training in Kenya for Sustainable Development emphasized the need to reform curriculum development, assessment, and certification. This called for a shift to CBET to address the mismatch between skills acquired through training and skills needed by industry, as well as increase the global competitiveness of the Kenyan labour force.

This curriculum has been developed in adherence to the Kenya National Qualifications Framework and CBETA standards and guidelines. The curriculum is designed and organized into Units of Learning with Learning Outcomes, suggested delivery methods, learning resources, and methods of assessing the trainee's achievement. In addition, the units of learning have been grouped in modules to concretize the skills acquisition process and streamline upskilling.

I am grateful to all expert trainers and everyone who played a role in translating the Occupational Standards into this competency-based modular curriculum

CHAIRMAN
TVET CDACC

ACKNOWLEDGEMENT

This curriculum has been designed for competency-based training and has independent units of learning that allow the trainee flexibility in entry and exit. In developing the curriculum, significant involvement and support was received from industry and various organizations.

I appreciate National Industrial Mechatronics Sector Skills Committee who enabled the development of this curriculum. I recognize with appreciation the role of the SSC in ensuring that competencies required by the industry are addressed in this curriculum.

I also thank all stakeholders in the Industrial Mechatronics sector for their valuable input and all those who participated in the process of developing this curriculum.

I am convinced that this curriculum will go a long way in ensuring that workers in Industrial Mechatronics sector will acquire competencies that will enable them perform their work more efficiently.

COUNCIL SECRETARY/CEO

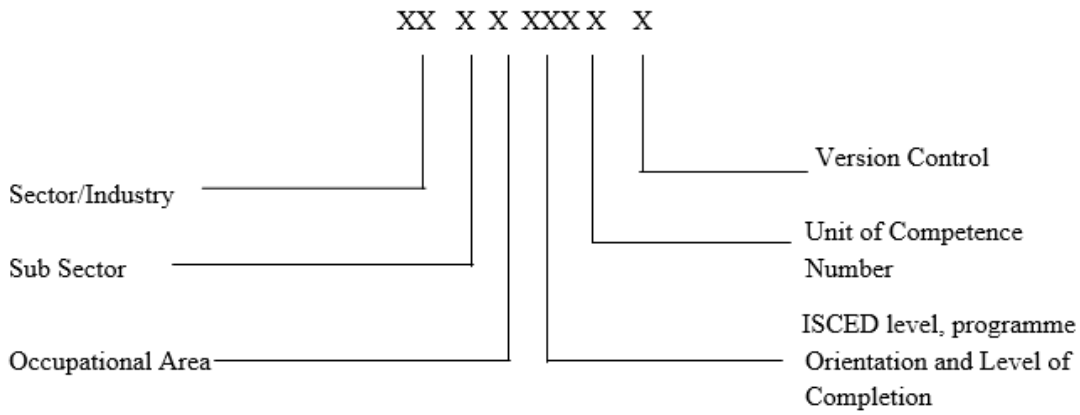
TVET CDACC

TABLE OF CONTENTS

ABBREVIATIONS AND ACRONYMS

CAP	Chapter
CBET	Competency Based Education and Training
DCS	Distributed Control System
IEEE	Institute of Electrical and electronics Engineers
KCE	Kenya Certificate of Education
KCSE	Kenya Certificate of Secondary Education
KNQF	Kenya National Qualification Framework
PID	Proportional Integral Derivative
PLC	Programmable Logic Controllers
PPE	Personal Protective Equipment
SCADA	Supervisory Control and Data Acquisition
TVET	Technical and Vocational Education and Training

KEY TO ISCED UNIT CODE



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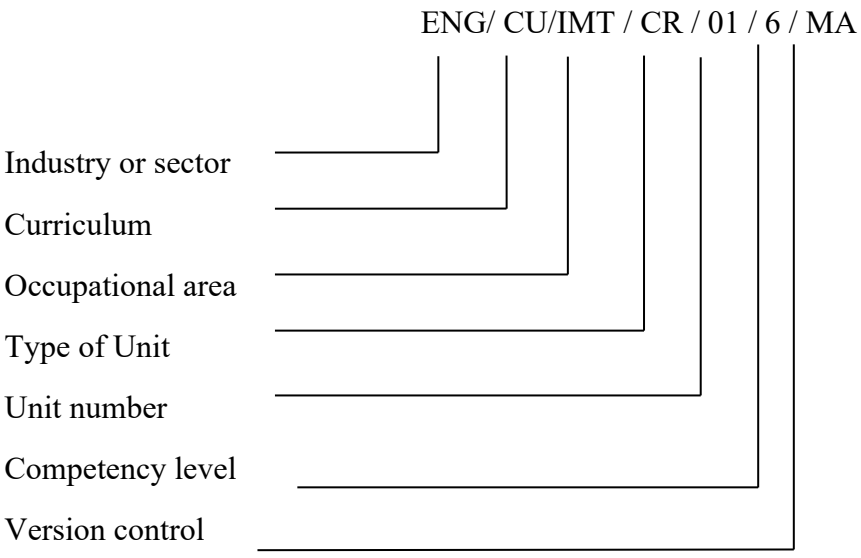

COURSE OVERVIEW

Industrial Mechatronics Technology Level 6 curriculum consists of competencies that an individual must achieve to perform Industrial Mechatronics activities. It involves designing electromechanical systems, installing electromechanical systems, maintaining electromechanical systems, designing hydraulic and pneumatic systems, installing hydraulic and pneumatic systems, maintaining hydraulic and pneumatic systems, installing robotic systems, maintaining robotic systems, managing industrial resources, programming PLC systems, maintaining PLC systems, maintaining SCADA systems and operating fabrication machinery.

UNIT CATEGORY	UNIT CODE	UNIT NAME	DURATN(Hours	CREDIT FACTOR
MODULE I				
ENG/CU/IMT/CC/01/6/MA	0541 541 05A	Engineering mathematics	**150**	**15.0**
ENG/CU/IMT/CC/02/6/MA	0715 541 06A	Thermodynamics and fluid mechanics principles	**150**	**15.0**
ENG/CU/IMT/CR/01/6/MA	0715 551 10A	Electromechanical systems design	**200**	**20.0**
TOTAL			**500**	**50.0**
MODULE II				
ENG/CU/IMT/CC/03/6/MA	0732 551 09A	Computer aided drawing	180	18.0
ENG/CU/IMT/CR/02/6/MA	0715 551 11A	Electromechanical systems installation and maintenance	200	20.0
ENG/CU/IMT/BC/02/6/MA	0031 541 02A	Communication skills	40	4.0
TOTAL			**420**	**42.0**
MODULE III				
ENG/CU/IMT/CR/03/6/MA	0715 551 12A	Hydraulic and pneumatic systems installation and maintenance	280	28.0
ENG/CU/IMT/CC/04/6/MA	0713 541 08A	Electrical and Electronics Principles	180	18.0
TOTAL			**460**	**46.0**
MODULE IV				
ENG/CU/IMT/CR/04/6/MA	0715 551 13A	Stand-alone controllers' installation and maintenance	200	20.0
ENG/CU/IMT/CR/05/6/MA	0715 551 14A	PLC systems installation and maintenance	240	24.0
TOTAL			**440**	**44.0**
MODULE V				
ENG/CU/IMT/CR/06/6/MA	0715 551 15A	Robotic systems installation and maintenance	240	24.0
ENG/CU/IMT/CR/07/6/MA	0715 551 16A	Supervisory control and data acquisition (SCADA) systems installation and maintenance	**200**	**20.0**

TOTAL			**440**	**44.0**
MODULE VI				
ENG/CU/IMT/CC/05/6/MA	0715 541 07A	engineering mechanics	150	15.0
ENG/CU/IMT/CR/08/6/MA	0715 551 17A	Electrical machines and mechanical drives installation	220	22.0
ENG/CU/IMT/BC/01/6/MA	0611 551 01A	Digital Literacy	40	4.0
TOTAL			**410**	**41.0**
MODULE VII				
ENG/CU/IMT/CR/09/6/MA	0715 551 18A	Fabrication machinery operation	300	30.0
ENG/CU/IMT/BC/03/6/MA	0417 541 03A	Work Ethics and Practices	40	4.0
ENG/CU/IMT/BC/04/6/MA	0413 541 04A	Entrepreneurial skills	40	4.0
TOTAL			**380**	**38.0**
		Industry Training	**480**	**48.0**
		COURSE DURATION	**3530**	**353.0**

The total duration for this course is 3530 hrs

Entry Requirements

An individual entering this course should have any of the following minimum requirements:

a) Kenya certificate of secondary education (K.C.S.E.) with Grade C- (minus)

Or

b) Certificate in Industrial Mechatronics Technology or related course level 5

Or

c) Equivalent qualifications as determined by TVETA.

Trainer Qualification

Qualifications of a trainer for this course include:

a) Have a minimum of Industrial Mechatronics Technology KNQF Level 7 qualification or its equivalent in a related trade area.
b) Be licensed by TVETA.

c) Registered by Engineer Board of Kenya (E.B.K) or Kenya Engineering Technology Registration Board (KETRB).

Industry Training

An individual enrolled in this course will be required to undergo Industry training for a minimum period of 480 hours in Industrial Mechatronics sector. The industrial training may be taken after completion of all units for those pursuing the full qualification or be distributed equally in each unit for those pursuing part qualification. In the case of dual training model, industrial training shall be as guided by the dual training policy.

Assessment

The course shall be assessed formatively and summatively:

a) During formative assessment all performance criteria shall be assessed based on performance criteria weighting.
b) During summative assessment basic and common units shall be integrated in the core units.
c) Summative assessment shall involve practical assessment focusing more on critical aspects of the respective unit of competency.
d) Theoretical and practical weight shall be 40:60 respectively for each unit of learning;
e) Theoretical (written/oral) assessment shall have formative and summative assessments weighted at 60% and 40% respectively in the overall unit of learning score
f) Assessment performance rating for each unit of competency shall be as follows

MARKS	COMPETENCE RATING
80 -100	Attained Mastery
65 - 79	Proficient
50 - 64	Competent
49 and below	Not Yet Competent
Y	Assessment Malpractice/irregularities

g) Assessment for Recognition of Prior Learning (RPL) may lead to award of part and/or full qualification.

Certification

A candidate will be issued with a Certificate of Competency upon demonstration of competence in a unit of competency. To be issued with Kenya National TVET Certificate in Industrial Mechatronics Technology Level 6, the candidate must demonstrate competence in all the units of competency as given in qualification pack. Statement of Attainment certificate may be awarded upon demonstration of competence in certifiable element within a unit

These certificates will be issued by TVETCDACC

MODULE I

ENGINEERING MATHEMATICS

ISCED Unit code: 0541 541 05A

TVETCDACC UNIT CODE: ENG/CU/IMT/CC/01/6/MA

Unit duration: 150 Hours

Relationship to occupational standards

This unit addresses the unit of competency: apply engineering mathematics

Unit description

This unit describes the competences required in order to apply engineering mathematics. It involves: applying algebra, trigonometry and hyperbolic functions, complex numbers, performing coordinates geometry, carrying out binomial expansion, applying calculus, carrying out mensuration, applying statistics and probability, vector theorem, and matrices.

Summary of Learning outcomes

By the end of this unit of learning, the trainee will be able to:

S/No	Learning Outcome	Duration (Hrs)
1	Apply algebra	15
2	Apply trigonometric and hyperbolic functions	15
3	Apply complex numbers	15
4	Perform coordinate geometry	15
5	Carry out binomial expansion	15
6	Apply calculus	15
7	Carry out mensuration	15
8	Apply statistics and probability	15
9	Apply vector theorem	15
10	Apply matrices	15
	TOTAL	**150**

Learning outcomes, content and suggested assessment methods

Learning outcome	Content	Suggested assessment methods
1. Apply algebra	1.1 Indices 1.1.1 Power zero 1.1.2 Negative powers 1.1.3 Fractional powers 1.1.4 Laws of indices 1.1.4.1 Addition 1.1.4.2 Subtraction 1.1.4.3 Division 1.1.4.4 Multiplication 1.2 BODMAS 1.3 Roots 1.3.1 Square roots 1.3.2 Cube roots 1.3.3 n^{th} roots 1.4 Logarithms 1.4.1 Laws of logarithms 1.4.1.1 Product law 1.4.1.2 Quotient law 1.4.1.3 Power law 1.5 Use of scientific calculator 1.5.1 Power ON/OFF 1.5.2 Mode 1.5.2.1 Degree 1.5.2.2 Radian 1.5.2.3 Gradient 1.5.2.4 SD 1.5.3 Clear 1.5.4 Save	• Written tests

	1.5.5 Shift 1.6 Simultaneous equations (up to 3 equations) 1.6.1 Elimination 1.6.2 Substitution 1.6.3 Reduction 1.6.4 Graphical 1.7 Quadratic equations 1.7.1 Factorization 1.7.2 Quadratic formula 1.7.3 Completing the square 1.7.4 Graphical	
2. Apply trigonometric and hyperbolic functions	2.1 Angles 2.1.1 Acute 2.1.2 Obtuse 2.1.3 Reflex 2.1.4 Right angle 2.2 Triangles 2.2.1 Isosceles 2.2.2 Equilateral 2.2.3 Right angled 2.2.4 Scalene 2.3 Trigonometric ratios 2.3.1 Sine 2.3.2 Cosine 2.3.3 Tangent 2.3.4 Cosecant 2.3.5 Secant 2.3.6 Cotangent 2.4 Trigonometric Identities 2.4.1 Proof of identities	• Written tests

	2.4.2 Pythagorean identities 2.5 Trigonometric equations 2.6 Hyperbolic functions 2.6.1 Sinh x 2.6.2 Cosh x 2.6.3 Cosech x 2.6.4 Tanh x 2.6.5 Sech x	
3. Apply complex numbers	3.1 Complex geometry 3.1.1 Real part 3.1.2 Imaginary part 3.1.3 Argand diagram 3.1.4 Modulus/magnitude 3.1.5 Argument /angle 3.1.6 Conjugate 3.2 Operations 3.2.1 Addition 3.2.2 Subtraction 3.2.3 Multiplication 3.2.4 Division 3.2.5 Conversions 3.2.5.1 Polar form to rectangular form 3.2.5.2 Rectangular form to polar form 3.3 De Moivre's theorem 3.3.1 Expansion of complex numbers 3.3.2 Roots of complex numbers	• Written tests

	3.3.3 Trigonometric identities using complex numbers	
4. Perform coordinate geometry	4.1 Cartesian geometry 4.1.1 Cartesian plane 4.1.1.1 x and y axes 4.1.1.2 Positive and negative coordinates 4.1.2 Gradient 4.1.2.1 Positive 4.1.2.2 Negative 4.1.2.3 Zero 4.1.2.4 Infinite 4.1.2.5 Gradients of parallel line 4.1.2.6 Gradients of perpendicular lines 4.1.3 y-intercept 4.2 Linear equations 4.2.1 Straight line 4.2.2 Parallel lines 4.2.3 Perpendicular lines 4.3 Graphs of linear equations 4.3.1 Straight lines 4.4 Polar geometry 4.4.1 Magnitude 4.4.2 Direction 4.4.3 Graphs 4.5 Conversions 4.5.1 Linear to polar 4.5.2 Polar to linear	• Written tests

	4.6 Solving polar equations	
5. Carry out binomial expansion	5.1 Binomial series 5.1.1 Powers 5.1.2 Coefficients 5.1.3 Pascals triangle 5.1.4 Expansion 5.2 Binomial theorem 5.2.1 Positive powers of n 5.2.2 Negative powers of n 5.2.3 Fractional powers of n (roots) 5.2.4 Estimation of errors of small changes	• Written tests
6. Apply calculus	6.1 Differentiation up to third order 6.1.1 Functions 6.1.1.1 Linear 6.1.1.2 Trigonometric 6.1.1.3 Logarithmic 6.1.1.4 Exponential 6.1.2 Rules 6.1.2.1 Power 6.1.2.2 Product 6.1.2.3 Chain 6.1.2.4 Quotient 6.1.3 Applications 6.1.3.1 Stationary points 6.1.3.2 Rates of change 6.2 Integration 6.2.1 Standard integral 6.2.2 Definite integral	• Written tests

	6.2.3 Techniques 6.2.3.1 By parts 6.2.3.2 Substitution 6.2.3.3 Partial fractions 6.2.4 Applications 6.2.4.1 Area between and under curves 6.2.4.2 Volume	
7. Carry out mensuration	7.1 Units and symbols of measurement 7.1.1 Mass 7.1.2 Distance 7.1.3 Speed 7.1.4 Temperature 7.1.5 Time 7.2 Imperial and metric units 7.2.1 Conversions 7.3 Perimeter 7.3.1 Regular shapes 7.3.2 Irregular shapes 7.4 Area 7.4.1 Regular shapes 7.4.2 Irregular shapes 7.4.3 Surface area 7.5 Volume 7.5.1 Regularly shaped objects	• Written tests
8. Apply statistics and probability	8.1 Data presentation 8.1.1 Continuous variables 8.1.1.1 Histogram 8.1.1.2 Line 8.1.2 Discrete variable	• Written tests

	8.1.2.1 Bar graph 8.1.2.2 Pie graph 8.1.3 Grouped data 8.1.3.1 Histogram 8.1.3.2 Bar 8.1.3.3 Cumulative frequency 8.1.3.4 ogive 8.1.4 Ungrouped data 8.1.4.1 Line 8.1.4.2 Cumulative frequency 8.2 Measures of central tendency 8.2.1 Mean 8.2.1.1 Grouped data 8.2.1.2 Ungrouped data 8.2.2 Mode 8.2.2.1 Grouped data 8.2.2.2 Ungrouped data 8.2.3 Medium 8.2.3.1 Grouped data 8.2.3.2 Ungrouped data 8.3 Measures of dispersion 8.3.1 Standard deviation 8.3.2 Variance 8.3.3 Range. 8.3.4 Quartile deviation. 8.3.5 Mean deviation 8.4 Probability types 8.4.1 With replacement 8.4.2 Without replacement	

	8.5 Probability distribution functions 8.5.1 Binomial distribution 8.5.2 Poisson distribution 8.5.3 Normal distribution	
9. Apply vector theorem	9.1 Differentiate between vector and scalar quantities 9.1.1 Magnitude 9.1.2 Direction 9.1.2.1 Positive 9.1.2.2 Negative 9.2 Operation on vectors 9.2.1 Addition 9.2.2 Subtraction 9.2.3 Dot product 9.2.4 Cross product 9.3 Resolution of vectors 9.3.1 Analysis 9.3.2 Graphical methods 9.3.2.1 Triangle theorem 9.3.2.2 Parallel theorem 9.3.2.3 Polygon theorem	• Written tests
10. Apply matrices	10.1 Matrices 10.1.1 Types 10.1.1.1 Row 10.1.1.2 Column 10.1.1.3 Square 10.1.1.4 Zero 10.1.1.5 Identity 10.1.1.6 Diagonal 10.2 Matrices operations (up to 3 x 3)	• Written tests

	10.2.1 Addition 10.2.2 Subtraction 10.2.3 Multiplication 10.3 Inverse of matrices (up to 3 x 3) 10.3.1 Determinant 10.3.2 Transpose 10.3.3 Adjoint 10.3.4 Inverse 10.4 Simultaneous equations (up to 3 equations) 10.4.1 Inverse method 10.4.2 Crammers rule 10.4.3 Row reduction	

Suggested delivery methods

- Demonstration
- Group discussions
- Online materials
- Direct instructions
- Simulation

Recommended resources for 30 trainees

S/No.	Category/item	Description/specifications	Quantity	Recommended ratio (item: trainee)
A	**Learning materials**			
1.	Textbooks	Comprehensive textbooks on engineering mathematics	30	1:1

2.	Graph books	For graphical representation of solutions	30	1:1
3.	Projector	Functional projector for displaying content during presentations	1	1:30
4.	Computer	Functional desktop computer with online instructional content	1	1:30
5.	White board	Quality whiteboard of approximately 6 ft by 3 ft for writing during theory instruction	1	1:30
6.	Printer	An ink-jet, laser-jet or toner-cartridge printer for printing notes, instructions and working drawings	1	1:30
B	**Learning facilities & infrastructure**			
7.	Lecture/theory room	Spacious room with seats for 25 trainees, approximately 60 sqm	1	1:30
C	**Materials and supplies**			
8.	First aid kit	Fully equipped first aid kit for use in case of accidents	1	1:30
D	**Tools and equipment**			
9.	Set of mathematical instruments	For constructions and measurements	30	1:1
10.	Firefighting extinguishers	Water, carbon dioxide and chemical powder fire	1	1:30

		extinguishers for fire fighting		
F	**Reference materials**			
11.	Standard Mathematical Tables	For reference on formulae, identities, laws and principles	30	1:1

THERMODYNAMICS AND FLUID MECHANICS

UNIT CODE: 0715 541 06A

TVETCDACC UNIT CODE: ENG/CU/IMT/CC/02/6/MA

Relationship to occupational standards

This unit addresses the unit of competency: apply mechanical technology principles

Duration of unit: 150 hours

Unit description

This unit describes the competences required in order to apply thermodynamics and fluid mechanics in their work. It includes applying steady flow processes, perfect gas, steam cycles, fuel and combustion. It also includes applying heat transfers and exchangers, fluid mechanics concepts and operating of air compressors and fluid pumps.

Summary of learning outcomes

By the end of the unit of learning, the trainee will be able to;

S/No	Learning Outcomes	Duration (Hrs)
1	To Apply thermodynamic processes	15
2	To Apply knowledge of perfect gases	15
3	To Apply knowledge of steam cycle	15
4	To Apply knowledge of fuel combustion	15
5	To Apply heat transfer and heat exchangers in fluid	15
6	To Operate air compressors	15
7	To Apply the knowledge of the flow of fluids	15
8	To Apply the knowledge of viscous flow of fluids	15
9	To Apply dimensional and models analysis fluids	15
10	To Operate fluid pumps	15
	TOTAL	150

Learning outcomes, content and suggested assessment methods

Learning outcome	Content	Suggested assessment methods
1. Apply thermodynamic processes	1.1 Basic thermodynamics terms definition 1.1.1 work, 1.1.2 Power 1.1.3 Internal energy 1.1.4 Heat 1.1.5 Temperature 1.2 Laws of thermodynamics 1.2.1 First law of thermodynamics 1.2.2 Second law of thermodynamics 1.2.3 Zeroth law of thermodynamics 1.3 Thermodynamic processes 1.3.1 Non-flow process. 1.3.2 Constant volume process 1.3.3 Constant pressure process 1.3.4 Hyperbolic process. 1.3.5 Constant temperature process 1.3.6 Adiabatic process 1.3.7 Polytropic process. 1.4 Thermodynamics systems 1.4.1 Boundary and surrounding 1.4.2 Closed systems 1.4.3 Open systems	• Written tests

	1.4.4 Isolated systems 1.4.5 Adiabatic system 1.4.6 Homogeneous systems 1.4.7 Heterogeneous systems 1.5 Heating and expansions of gases 1.5.1 Determine work done 1.5.2 Application of First Law of Thermodynamics 1.5.3 Reversible non-flow processes. 1.5.4 Irreversible non-flow processes 1.6 General laws for expansion and compression 1.6.1 Define the terms: 1.6.1.1 Expansion 1.6.1.2 compression 1.6.2 Apply PV^n = Constant for various values of n 1.6.3 Curves of pressure against volume for various values of n (index) 1.7 Application of steady flow energy equation to: 1.7.1 boilers 1.7.2 condensers 1.7.3 nozzles 1.7.4 diffusers 1.7.5 compressors 1.7.6 turbines	

2. Apply knowledge of perfect gases	2.1 Laws of perfect gases 2.1.1 Boyle's law 2.1.2 Charles' law 2.1.3 Gay-Lussac law 2.1.4 Joule's law 2.1.5 Avogadro's law 2.2 General gas equation 2.2.1 Derive and apply general gas equation PV=mRT 2.3 Characteristic equation of gas 2.3.1 Application in engineering calculations 2.4 Universal gas constant 2.4.1 Define universal gas constant 2.4.2 Apply universal gas constant equation in engineering calculation 2.5 Specific heat 2.5.1 Constant volume 2.5.2 Constant pressure	• Written tests
3. Apply knowledge of steam cycle	3.1 Steam cycles 3.1.1 Rankine 3.1.1.1 Schematic diagram of a steam engine or turbine plant. 3.1.1.2 Determine Rankine efficiency 3.1.1.3 T-S and h-s graphs 3.1.1.4 Modified Rankine cycle 3.1.1.5 Work-done using	• Written tests

	Rankine equations 3.1.1.6 Efficiency of modified Rankine Cycle 3.1.1.7 Theoretical loss of work per kg of steam due to incomplete expansion 3.1.1.8 Loss in Rankine efficiency due to restricted expansion of steam 3.1.1.9 Enthalpy- entropy chart 3.1.2 Carnot 3.1.2.1 Draw schematic diagrams of Carnot engine 3.1.2.2 Carnot cycle with steam as working substance 3.1.2.3 Performance criteria for carnot cycle 3.1.3 Reheat 3.1.3.1 T-S diagram of reheat steam cycle 3.1.3.2 Determine work-done using reheat equations 3.1.3.3 Determine efficiency of reheat cycles 3.1.4 Regenerative 3.1.4.1 Ideal regenerative cycle diagram 3.1.4.2 Regenerative cycle with single feed water heater	

	3.1.4.3 Regenerative cycle with single feed water heater diagram 3.1.4.4 Determine work-done by regenerative cycle 3.1.4.5 Determine regenerative cycle efficiency 3.1.4.6 Regenerative cycle with two feed water heaters and its efficiency 3.2 Thermodynamics steam turbines 3.2.1 Characteristics of steam turbines 3.2.2 classification of Steam Turbines 3.2.3 Pressure and velocity of steam in an impulse turbine 3.2.4 Velocity triangles for moving blade of an impulse turbine 3.2.5 Combined velocity triangle for moving blades 3.2.6 Power produced by an impulse turbine	
4. Apply knowledge of fuel combustion	4.1 Elements and compounds of fuel 4.1.1 Define of terms 4.1.1.1 Element 4.1.1.2 Compound 4.1.1.3 Atoms 4.1.1.4 Molecules 4.1.1.5 Atomic Mass	• Written tests

	4.1.1.6 Molecular Mass 4.1.2 Element and symbols table sketches 4.2 Combustion equations of fuels and calculations 4.2.1 Balanced combustion equations of solid fuels 4.2.2 Write a balanced Combustion Equations of gaseous fuels 4.3 Conversion analysis of fuels 4.3.1 Theoretical or minimum volume of air required for complete combustion 4.3.2 Conversion of volumetric analysis into mass analysis or gravimetric analysis 4.3.3 Conversion of mass analysis into volumetric analysis 4.4 Mass of carbon in flue gases 4.4.1 Calculation of mass of carbon, contained in 1 kg of flue or exhaust gases 4.5 Mass of flue gases per kg of fuel burnt 4.5.1 Calculate the mass of dry flue gases by comparing the mass of carbon present in the flue gases with the mass of carbon in the fuel. 4.6 Excess air supplied calculations	

	4.6.1 Mass of excess air supplied by the mass of unused oxygen, found in the flue gases. 4.6.2 Total mass of air supplied 4.7 Flue gas analysis by ors at apparatus 4.7.1 Components 4.7.2 Use of the apparatus 4.7.3 Operation 4.7.4 Diagram sketches	
5. Apply heat transfer and heat exchangers in fluid	5.1 Heat transfer media 5.1.1 Heat transfer methods: 5.1.1.1 Conduction 5.1.1.2 Convection 5.1.1.3 Radiation 5.1.2 Newton's law of Cooling 5.1.3 Derivation and application of Fourier's* law of heat conduction equation $Q \propto A \times \frac{dT}{dx} = kA \times \frac{dT}{dx}$ 5.2 Heat transfer by conduction through 5.2.1 Slab 5.2.1.1 Thermal conductivity 5.2.1.2 Temperature gradient 5.2.2 Composite wall 5.2.3 Thick cylinder 5.2.4 Thick cphere 5.3 Overall coefficient of heat transfer	• Written tests

	5.3.1 Heat exchangers	
6. Operate air compressors	6.1 Classification of air compressors 6.1.1 According to working 6.1.2 According to action 6.1.3 According to number of stages 6.2 Single stage reciprocating air compressor 6.2.1 Work done by a single stage reciprocating air compressor without clearance volume 6.3 Work done during 6.3.1 isothermal compression 6.3.2 polytropic compression (PV^n = Constant) 6.3.3 isentropic compression 6.4 Power required to drive a single-stage reciprocating air compressor 6.4.1 Calculations 6.5 Work-done by reciprocating air compressor with clearance volume 6.5.1 Calculations 6.5.2 Determine multistage compression 6.6 Power required to drive a two-stage reciprocating air compressor 6.7 Minimum work required for a two-stage reciprocating air compressor	• Written tests

7. Apply knowledge of flow of fluids	7.1 Types of fluid flow 7.1.1 Steady and unsteady flows 7.1.2 Uniform and non-uniform flows 7.1.3 Rotational and irrotational flows 7.1.4 Laminar and turbulent flows 7.1.5 Compressible and incompressible flows 7.2 Loss of energy (or Head) in Pipes 7.2.1 Darcy-weisbach formula 7.2.2 Chezy's formula for loss of head due to friction 7.2.3 Loss of head due to sudden enlargement 7.2.4 Loss of head due to sudden contraction 7.2.5 Loss of head due to obstruction in pipe 7.2.6 Loss of head at the entrance to pipe 7.2.7 Loss of head at the exit of a pipe 7.2.8 Loss of head due to bend in the pipe 7.3 Hydraulic gradient and total energy lines 7.3.1 Pipes in series or compound pipes 7.3.2 Pipes in parallel 7.3.3 Power transmission through	• Written tests

	Pipes	
8. Apply knowledge of viscous flow of fluids	8.1 Flow of viscous flow 8.1.1 Flow of viscous fluid in circular pipes 8.1.2 Flow of viscous fluid through an annulus 8.1.3 Flow of viscous fluid between two parallel plates 8.1.3.1 One plate moving and other at rest 8.1.3.2 Both plates at rest 8.1.3.3 Both plates moving in opposite directions 8.1.4 Kinetic energy correction and momentum 8.1.5 Power absorbed in viscous flow 8.1.6 Viscous resistance of journal bearings 8.1.7 Viscous resistance of foot-step 8.1.8 Viscous resistance of collar bearing	• Written tests
9. Apply dimensional and models analysis fluids	9.1 Definition of terms 9.1.1 Dimensional homogeneity 9.1.2 Methods of solving dimensional analysis 9.1.2.1 Rayleigh's theorem 9.1.2.2 Buckingham π theorem 9.2 Dimensional analysis similitude 9.2.1 Geometric	• Written tests

	9.2.2 Kinematic 9.2.3 Dynamic 9.3 Dimensionless Numbers 9.3.1 Reynold's number (Re) 9.3.2 Froude's number (Fe) 9.3.3 Euler's number (Eu) 9.3.4 Weber's number (We) 9.3.5 Mach's number (M) 9.4 Model test analysis and calculations 9.4.1 Classification of Models 9.4.1.1 Undistorted Models 9.4.1.2 Distorted models 9.4.1.3 Scale ratios for distorted models	
10. Operate fluid pumps	10.1 Principles of operation of: 10.1.1 Reciprocating pumps 10.1.2 Centrifugal pumps 10.2 Derivation of equations for a reciprocating pump 10.2.1 Coefficient of discharge 10.2.2 percentage slip 10.2.3 Work done 10.2.4 Acceleration head 10.2.5 Friction head 10.2.6 Pressure head in the cylinder 10.3 Application of reciprocating pumps equations to solve problems 10.4 Derivation of equations for a centrifugal pump	• Written tests

	10.4.1 Effective head 10.4.2 Manometric head 10.4.3 efficiency 10.4.4 Mechanical efficiency 10.4.5 Discharge 10.4.6 Torque 10.4.7 Work done unit weight 10.4.8 Specific speed 10.5 Application of centrifugal pumps equations to solve problems	

Suggested delivery methods

- Group discussions
- Demonstration by trainer
- Online videos
- Power point presentation

Recommended resources for 30 trainees

S/No.	Category/item	Description/specifications	Quantity	Recommended ratio (item: trainee)
A	**Learning materials**			
1.	Textbooks	1. Applied thermodynamics for engineering technology (fifth edition) by T.D. Eastop and A. McConkey 2. Engineering thermodynamics by R.K.Rajput	5 each	1:6

		3. A textbook of fluid mechanics and hydraulic machines by R.K.Rajput 4. A textbook of fluid mechanics and hydraulic machines by R.K Bansal		
2.	Projector	Functional projector for displaying content during presentations	1	1:30
3.	Computer	Functional desktop computer with online instructional content	1	1:30
4.	White board	Quality whiteboard of approximately 6 ft by 3 ft for writing during theory instruction	1	1:30
5.	Printer	An ink-jet, laser-jet or toner-cartridge printer for printing notes, instructions and working drawings	1	1:30
B	**Learning facilities & infrastructure**			
6.	Lecture/Theory Room	Spacious room with seats for 30 trainees, approximately 60 sqm	1	1:30
C	**Materials and supplies**			
7.	Dust coat/ overall	Shields skin and regular clothes from sparks	30	1:1
8.	Fire extinguishers	Fighting fire	1	1:30

9.	First aid kit	Fully equipped first aid kit for use in case of accidents	1	1:30

ELECTROMECHANICAL SYSTEMS DESIGN

UNIT CODE: 0715 551 10A

TVETCDACC UNIT CODE: ENG/CU/IMT/CR/01/6/MA

Relationship to occupational standards

This unit addresses the unit of competency: design electromechanical systems.

Duration of unit: 200 hours.

Unit description

This unit covers the competencies required by an industrial mechatronic technician to design electromechanical systems. It prepares the technician to perform need analysis, develop conceptual design, build electromechanical system prototype, and test electromechanical system prototype.

Summary of learning outcomes

By the end of the unit of learning, the trainee will be able to;

S/No	Learning outcomes	Duration (Hrs)
1	Perform electromechanical system need analysis	50
2	Develop electromechanical systems conceptual design	50
3	Build electromechanical system conceptual design	50
4	Test electromechanical system prototype	50
	TOTAL	**200**

Learning outcomes, content and suggested assessment methods

Learning outcome	Content	Suggested assessment methods
1. Perform electromechanical system need analysis	1.1 Introduction 1.1.1 Importance of electromechanical systems in various industries 1.2 Electromechanical system specifications 1.2.1 Electromechanical design function 1.2.2 Electromechanical design output 1.2.3 Project name 1.2.4 Customer's name 1.2.5 Project scope 1.2.6 Project objective 1.3 Objectives of the needs analysis 1.3.1 Purpose of needs analysis for design and implementation 1.3.2 Identify requirements 1.3.3 Define performance criteria 1.3.4 Assess constraints 1.3.5 Evaluate existing systems 1.3.6 Future-proofing 1.4 Needs analysis 1.4.1 Stakeholder engagement 1.4.2 Requirements gathering 1.4.3 Performance metrics definition 1.4.4 Constraint analysis 1.4.5 Current system evaluation 1.4.6 Future needs assessment	• Observation • Oral assessment • Projects • Trainee presentation • Written assessments

Learning outcome	Content	Suggested assessment methods
	1.5 Documentation and reporting 1.6 Review and validation	
2. Develop electromechanical systems conceptual design	2.1 Introduction 2.1.1 Definition of terms 2.1.2 Importance of conceptual design 2.1.3 Translation of user requirements into design concepts 2.2 Objectives of conceptual design 2.2.1 Translate requirements into design 2.2.2 Establish design parameters 2.2.3 Identify system architecture 2.3 Electromechanical system design 2.3.1 Requirements analysis 2.3.2 Preliminary design sketching 2.3.3 Simulation and modelling 2.3.4 Feasibility assessment 2.3.4.1 Design ergonomics 2.3.4.2 Architecture 2.3.4.3 Design cost 2.3.4.4 Design context 2.3.4.5 Design speed 2.3.5 Iterative refinement 2.3.6 Documentation and reporting	• Observation • Oral assessment • Projects (self, team-based, work-based) • Trainee presentation • Written assessments • Trainer/supervisor report
3. Build electromechanical system prototype	3.1 Health and safety 3.1.1 PPEs	• Observation • Oral assessment

Learning outcome	Content	Suggested assessment methods
	3.1.2 Work permits 3.1.3 Waste management 3.1.4 Electrical wiring colour coding 3.1.5 Danger warning signage 3.1.6 Barricades 3.1.7 High voltage signage 3.1.8 Health policy 3.2 Electromechanical system prototype components 3.2.1 Circuit board 3.2.2 Variable frequency drive 3.2.3 Programmable logic controller 3.2.4 2 bar linkage 3.2.5 3 bar linkage 3.2.6 Bearings (ball bearing, rolling-element bearing etc.) 3.2.7 Electric motors (AC, DC, Stepper, Servo, Linear etc.) 3.2.8 Pulleys (fixed, block and tackle, movable etc.) 3.2.9 Chain drive 3.2.10 Clamp lever 3.2.11 Spring 3.2.12 Damper 3.2.13 Mechanical seal 3.3 Introduction to subsystems 3.3.1 Block diagram showing component interaction	• Projects (self, team-based, work-based) • Trainee presentation • Written assessments • Trainer/supervisor report

Learning outcome	Content	Suggested assessment methods
	3.3.2 Input-output relationships and data flow 3.3.3 Mechanical design 3.3.3.1 Actuators (motors, hydraulics, pneumatics) 3.3.3.2 Motion requirements (degrees of freedom, precision) 3.3.4 Electrical design 3.3.4.1 Power supply and distribution 3.3.4.2 Sensor selection and feedback mechanisms 3.3.5 Control system design-control strategies (open-loop, closed-loop, PID) 3.3.5.1 Distributed control systems 3.3.5.2 SCADA 3.3.5.3 Stand alone controllers (PID, microprocessors, microcontrollers etc 3.3.5.4 Relay 3.3.5.5 PLC 3.3.5.6 Software and algorithm design	

Learning outcome	Content	Suggested assessment methods
	3.3.5.7 Communication protocols and interfaces 3.3.6 Integration of Systems 3.3.6.1 Mechanical-electrical interface (mounting, coupling) 3.3.6.2 User interface design (buttons, touchscreens, software) 3.4 Safety and reliability 3.4.1 Safety mechanisms (emergency stops, fail-safes) 3.5 Reliability and maintenance considerations 3.6 Testing 3.6.1 Testing methodology for performance, reliability, and safety 3.7 Cost and feasibility 3.7.1 Cost estimation of components and development	
4. Test electromechanical system prototype	4.1 Mechanical testing 4.1.1 Motion testing: validate movements, degrees of freedom, speed, and range 4.1.2 Load testing 4.1.3 Durability testing 4.2 Electrical testing	• Observation • Oral assessment • Projects (self, team-based, work-based) • Trainee presentation

Learning outcome	Content	Suggested assessment methods
	4.2.1 Power consumption 4.2.2 Sensor accuracy 4.2.3 Signal integrity 4.3 Control System testing 4.3.1 Control algorithm performance 4.3.2 Feedback loop testing 4.3.3 User interface testing 4.4 Safety testing 4.4.1 Emergency shutdown 4.4.2 Failure mode testing 4.4.3 Compliance testing 4.5 Reliability testing 4.5.1 Long-term performance 4.5.2 Environmental stress testing 4.5.3 Redundancy testing 4.6 Data Collection and analysis 4.6.1 Methods for collecting test data (real-time monitoring, logging software) 4.6.2 Analysis of test results against expected performance metrics 4.6.3 Identifying issues and potential design improvements 4.7 Functionality test 4.8 Test Reporting 4.8.1 Summary of test outcomes	• Written assessments • Trainer/supervisor report

Learning outcome	Content	Suggested assessment methods
	4.8.2 Pass/fail criteria for each aspect of the system 4.8.3 Recommendations for modifications or enhancements	

Suggested delivery methods

- Group discussions
- Demonstration by trainer
- Online videos
- Power point presentation

Recommended resources for 25 trainees

S/No.	Category/Item	Description/Specifications	Quantity	Recommended Ratio (Item: Trainee)
A	**Tools**			
1.	Set of pliers	For gripping	2 sets	2:25
2.	Clamps	For holding	2 sets	2:25
3.	Set of Allen keys	For fastening	13 pcs	13:25
B	**Materials and Supplies**			
4.	Standalone controllers (PID, microprocessors, microcontrollers)	For programming	5 pcs	2:5
5.	25 Microcontroller development boards (e.g., Arduino, Raspberry Pi)	For programming	2 pcs	2:25

6.	Relays	For actuation	25 pcs	1:1
7.	PLCs	For programmable logic control setups	5 pcs	2:5
8.	Electric cables and conductors	For electrical connections	10 pcs	10:25
9.	Breadboards	For prototype circuit assembly	25 pcs	1:1
10.	Trunking	For organizing and protecting cables	Sufficient	
11.	Fuses	For protecting circuits	10 pcs	10:25
12.	Electrical accessories	Connectors, sockets, and other components	10 pcs	10:25
C	**Equipment**			
13.	Projectors	For visual presentations	1	1:25
14.	Whiteboards	For writing instructional content	1	1:25
15.	Drills	Various types for assembly and installation	13 pcs	13:25
16.	Pneumatic systems	For demonstrating fluid control systems	5 pcs	1:5
17.	PLC modules	For electromechanical control exercises	13 pcs	13:25
18.	Control linkage	For demonstrating mechanical linkages	5 pcs	1:5
19.	Laptops/PCs and appropriate software for electromechanical system design.	For designing	25pcs	1:1
20.	AC/DC electronics training modules	Training modules for AC/DC electronics	1 pc	1:25

21.	AC/DC machines control training modules	Modules for controlling AC/DC machines	1 pc	1:25
D	**Reference materials**			
22.	Component and equipment manuals	Manuals for reference on component use and specifications	Adequate	
23.	Health and safety manuals	For workplace safety instructions	Adequate	
24.	Electromechanical reference books	Comprehensive guides on electromechanical systems	Adequate	
E	**Softwares**			
25.	Electrical circuit design software	Software for designing electrical circuits	1 license	
26.	AUTOCAD	For creating and modifying digital schematics	1 license	
F	**Trainee requirements**			
27.	Protective clothing	Dust coats, gloves, safety boots, goggles	25 sets	1:1

MODULE II

COMPUTER AIDED DRAWING

ISCED UNIT CODE: 0732 541 09A
TVETCDACC UNIT CODE: ENG/CU/IMT/CC/03/6/MA

UNIT DURATION: 150 HOURS

Relationship to occupational standards

This unit addresses the unit of competency: perform computer aided drawing.

Unit description

This unit covers the competences required to perform computer aided drawing. It involves: navigating CAD software, producing geometric, pictorial, orthographic and assembly drawings, and designing mechanical components.

Summary of learning outcomes

By the end of the unit of learning, the trainee will be able to;

S/No	Learning Outcomes	Duration (Hrs)
1	Operate computer devices	20
2	Navigate CAD software	20
3	Produce geometric drawings	20
4	Produce pictorial drawings	20
5	Produce orthographic drawings.	30
6	Produce assembly drawings	20
7	Design mechanical components	20
	TOTAL	**150**

Learning outcomes, content and suggested assessment methods

Learning outcome	Content	Suggested assessment methods
1. Navigate CAD software	1.1 Overview of CAD 1.1.1 Definition and significance of CAD in engineering and design. 1.1.2 Historical development of CAD technologies. 1.2 Computing equipment and Software 1.2.1 Identify hardware requirements for CAD operations. 1.2.2 List popular CAD software options (e.g., AutoCAD, SolidWorks, Inventor). 1.3 Drawing CAD Software 1.3.1 Overview of the software interface. 1.3.2 Functions and capabilities of CAD tools. 1.4 CAD software templates 1.4.1 Explore various templates available for different drawing requirements. 1.5 Importing CAD Files	1 Written tests 2 Oral Questioning 3 Portfolio of evidence

	1.5.1 Process of importing files (DWG, STL, DXF, STEP) into the working space. 1.6 User interface navigation 1.6.1 Familiarization with the CAD software interface. 1.6.2 Understanding toolbars, menus, and command lines. 1.7 Setting up the drawing environment 1.7.1 Units and measurement settings. 1.7.2 Creating a new drawing and saving files. 1.8 Symbols, codes, and standards 1.8.1 Identify relevant symbols and codes according to software functionality. 1.9 Understand and utilize drawing elements 1.9.1 Points 1.9.2 Line angles 1.9.3 Circles and arcs 1.9.4 Planes (horizontal, vertical) 1.9.5 Figures and solids 1.9.6 Shapes	

	1.9.7 Objects snapping settings 1.9.8 Polar tracking settings. 1.9.9 Orthomode utilization 1.10 Use editing commands editing tools 1.10.1 Delete, undo and redo commands 1.10.2 Fillet and chamfer commands 1.10.3 Trim, extend and break commands 1.10.4 Zoom and pan commands 1.10.5 Move, copy, and paste commands 1.10.6 Rotate and mirror commands 1.10.7 Object snapping and grouping commands 1.10.8 Dimension and scaling commands	
2. Produce geometric drawings	2.1 Setting drawing lines 2.1.1 Recognize standard drawing line conventions • Dimension lines • Hidden detail lines • Extension lines • Section lines • Break lines	

	• Chain 2.2 Using drawing lines 2.3 Constructing types of angles 2.3.1 Use trigonometry principles to construct acute, obtuse, and right angles. 2.4 Constructing geometrical forms 2.4.1 Create circles, rectangles, triangles, and polygons according to standards. 2.5 Developing geometric drawings 2.5.1 2-Dimensional 2.5.2 Orthographic 2.5.3 Isometric	
3. Produce pictorial drawings	3.1 Drawing symbols and abbreviations 3.1.1 Apply standard drawing symbols and abbreviations in pictorial drawings. 3.2 Producing pictorial drawings 3.2.1 Techniques for creating isometric, oblique, cabinet, and cavalier drawings. 3.3 Saving pictorial drawings 3.3.1 Procedures for saving drawings in appropriate formats.	

4. Produce orthographic drawings.	4.1 Fundamentals of orthographic projection 4.1.1 Definition and importance of orthographic drawing. 4.1.2 Differences between orthographic and other drawing types (isometric, perspective). 4.2 Types of orthographic projections 4.2.1 First-angle projection. 4.2.2 Third-angle projection. 4.3 Understanding views 4.3.1 Front, top, and side views. 4.3.2 Additional views (sectional, auxiliary). 4.4 First angle orthographic drawings 4.4.1 Develop first-angle drawings adhering to standard conventions. 4.5 Third angle orthographic drawings 4.5.1 Create third-angle drawings based on standard practices. 4.6 Saving orthographic drawings 4.6.1 Techniques for properly saving orthographic drawings. 4.7 Dimensioning orthographic views	

	4.8 Printing orthographic views 4.9 Creating isometric drawing 4.9.1 Choosing isometric cursor 4.9.2 Dimensioning isometric drawing 4.9.3 Printing isometric drawing 4.10 Creating 3D model 4.10.1 Choosing 3D workspace 4.10.2 3D workspace modifying tool (3D orbit, 3D mirrors, union, extrude, press pull, e.t.c) 4.10.3 Rendering 4.10.4 Printing 3D models	
5. Produce assembly drawings	5.1 Overview of assembly drawings 5.1.1 Definition and purpose of assembly drawings. 5.1.2 Importance in manufacturing and engineering. 5.2 Types of assembly drawings 5.2.1 General assembly drawings vs. detailed assembly drawings. 5.2.2 Exploded view vs. isometric assembly drawings. 5.3 Exploding orthographic views	

	5.3.1 Techniques for exploding views in accordance with standard conventions. 5.4 Exploding pictorial views 5.4.1 Create exploded pictorial views based on drawing specifications. 5.5 Assembling views 5.5.1 Assemble orthographic and pictorial views accurately. 5.6 Producing sectional views 5.6.1 Generate sectional views according to drawing standards. 5.7 Developing parts list 5.7.1 Creating a parts list based on the drawing schematic.	
6. Design mechanical components	1.1 Designing mechanical components 1.1.1 Apply CAD principles to design mechanical components per work requirements. 1.2 Applying CAE in simulation 1.2.1 Use computer-aided engineering tools for simulating mechanical designs.	

	1.3 Determining improvements 1.3.1 Analyze design results to identify efficiency improvements. 1.4 Creating a manufacturing database 1.4.1 Develop a database to support the manufacturing process. 1.5 Improving design documents 1.5.1 Make enhancements to design documents based on manufacturing feedback.	

Suggested Delivery Methods

- Demonstration
- Group discussions
- Online training
- Direct instructions
- Simulation

Recommended resources for 30 trainees

S/No.	Category/item	Description/specifications	Quantity	Recommended ratio (item)
A	**Learning materials**			
1.	Textbooks	Comprehensive texts on CAD basics, history, and hardware requirements.	5 pcs	1:5
2.	Charts	Visual aids covering CAD software evolution and industry applications.	10 pcs	1:2.5

3.	PowerPoint Presentations	For trainer's use, covering CAD definitions, history, and hardware requirements.	1	1:25
B	**Learning Facilities & Infrastructure**			
4.	Lecture/Theory Room	Equipped with projector, seating for 25 trainees, ~60 sqm.	1	1:25
5.	Computer Laboratory	Equipped with 25 computers installed with CAD software, ~80 sqm.	25	1:1
6.	Printer/plotter	For printing CAD drawings	2	1:13
7.	3D printer	For printing 3D models	2	1:13
8.	3D printer filament	3D printing material	2 rolls	1:13
C	**Consumable Materials**			
9.	USB Drives	For storing and transferring CAD project files.	25 pcs	1:1
10.	Notebooks	For trainees to take notes during CAD sessions.	25 pcs	1:1
D	**Tools and Equipment**			
11.	Computers	Equipped with CAD software and compatible hardware (e.g., high RAM, graphics support).	25 pcs	1:1
12.	Projector	For displaying CAD software demonstrations and presentations in lecture room.	1	1:25
13.	External Hard Drives	For backing up CAD files and course materials.	5 pcs	1:5
14.	Drawing Tablets	For CAD software use, supporting stylus input for design precision.	5 pcs	1:5

E	**Reference Materials**			
15.	CAD Software Manuals	Documentation detailing CAD software functionalities and hardware requirements.	25 pcs	1:1
16.	CAD Industry Case Studies	Case studies showcasing CAD applications in engineering and design.	5 pcs	1:5
17.	Practical Assessment Guides	Worksheets for practical assessments on CAD navigation and hardware requirements.	25 pcs	1:1
18.	Training Presentations/Slides	Digital format for shared access among trainees covering CAD course content.	1	1:25

ELECTROMECHANICAL SYSTEM INSTALLATION AND MAINTANANCE

ISCED UNIT CODE: 0715 551 11A

TVETCDACC UNIT CODE: ENG/CU/IMT/CR/02/6/MA

Relationship to occupational standards

This unit addresses the unit of competency: install and maintain electromechanical system

Duration of unit: 200 Hours

Unit description

This unit describes the competencies required by an industrial mechatronic technician to prepare electromechanical system installation site, mount electromechanical system components, and maintain electromechanical system.

Summary of learning outcomes

By the end of Unit of learning, the trainee will be able to;

S/No	Learning outcomes	Duration (Hrs)
1	Prepare electromechanical system installation site	60
2	Mount electromechanical system components	70
3	Maintain electromechanical system.	70
	TOTAL	**200**

Learning outcomes, content and suggested assessment methods

Learning outcome	Content	Suggested assessment methods
1. Prepare electromechanical system installation site	1.1 Workplace health and safety standards 1.1.1 PPEs 1.1.2 Work permits 1.1.3 Waste management	• Oral assessment • Portfolio of evidence

Learning outcome	Content	Suggested assessment methods
	1.1.4 Electrical wiring colour coding 1.1.5 Danger warning signage 1.1.6 Barricades 1.1.7 High voltage signage 1.1.8 Health policy 1.2 Safety measures in electrical installations 1.2.1 Electrical wiring color codes 1.2.2 High voltage and danger warning signage 1.2.3 Barricades and safety barriers 1.3 Waste management protocols 1.3.1 Disposal of electrical and mechanical waste 1.3.2 Environmental policies and regulations 1.4 Health policy compliance 1.4.1 Company and industry-specific health policies 1.5 Electromechanical system installation site survey 1.5.1 Site analysis techniques 1.5.2 Equipment and environmental considerations 1.5.2.1 Load-bearing capacity 1.5.2.2 Space 1.5.2.3 Accessibility 1.5.3 Documentation and Site Mapping 1.5.3.1 Survey reports 1.5.3.2 Hazard identification 1.6 Electromechanical installation schedule 1.6.1 Scheduling procedures 1.6.1.1 Timeline creation based on manufacturer's guidelines 1.6.2 Task prioritization and resource allocation	• Interviews • Third party report • Written assessment • Practical assessment • Projects

Learning outcome	Content	Suggested assessment methods
	1.6.2.1 Coordinating materials and human resources 1.7 Installation area set up 1.7.1 Preparing physical space 1.7.1.1 Equipment layout and setup 1.7.2 Compliance with manufacturer requirements 1.7.3 Initial safety checks and signage	
2. Mount electromechanical system components	2.1 Health and safety procedures 2.1.1 Safety procedures during component mounting 2.2 Electromechanical system components 2.2.1 Circuit board 2.2.2 Variable frequency drive 2.2.3 Programmable logic controller 2.2.4 2 bar linkage 2.2.5 3 bar linkage 2.2.6 Bearings (ball bearing, rolling-element bearing etc.) 2.2.7 Electric motors (AC, DC, Stepper, Servo, Linear etc.) 2.2.8 Pulleys (fixed, block and tackle, movable etc.) 2.2.9 Chain drive 2.2.10 Clamp lever 2.2.11 Spring 2.2.12 Damper 2.2.13 Mechanical seal 2.3 Mechanical component mounting techniques 2.3.1 Pulleys, chain drives, clamps, springs, dampers, and mechanical seals 2.4 Documentation for assembly 2.4.1 Creating assembly records as per workplace guidelines	• Oral assessment • Portfolio of evidence • Interviews • Third party report • Written assessment • Practical assessment • Projects

Learning outcome	Content	Suggested assessment methods
	2.5 Configure electromechanical control systems 2.5.1 Control system overview 2.5.1.1 Introduction to SCADA, PLCs, distributed control systems 2.5.2 Configuration process 2.5.2.1 Programming stand-alone controllers, relay configurations 2.6 Verification of system settings 2.6.1 Testing to ensure configurations meet specifications 2.7 Electromechanical system tests 2.7.1 Types of system testing 2.7.1.1 Electrical, 2.7.1.2 Mechanical, 2.7.1.3 Functionality, 2.7.1.4 Safety tests 2.7.2 Test procedures and documentation 2.7.2.1 Creating and recording test data as per requirements 2.8 Installation report 2.8.1 Reporting standards and structure 2.8.1.1 Workplace guidelines for documenting the installation process 2.8.2 Key elements of installation report 2.8.2.1 Safety checks, component logs, configuration settings, testing results	
3. Maintain electromechanical system.	3.1 Health and safety procedures 3.1.1 Safety protocols during maintenance 3.2 Develop electromechanical system maintenance schedule	• Oral assessment • Portfolio of evidence

Learning outcome	Content	Suggested assessment methods
	3.2.1 Maintenance scheduling techniques 3.2.1.1 Preventive vs. corrective maintenance strategies 3.2.2 Resource planning for maintenance 3.2.2.1 Allocating time, materials, and workforce 3.3 Electromechanical system maintenance 3.3.1 Routine maintenance procedures 3.3.1.1 Cleaning, inspecting, and testing components 3.3.2 Replacing faulty components 3.3.2.1 Guidelines for replacing and reinstalling worn-out parts 3.3.3 Lubrication and adjustment of moving parts 3.3.3.1 Maintenance best practices for mechanical longevity 3.4 Troubleshoot electromechanical system 3.4.1 Identifying common issues 3.4.1.1 Electrical faults, mechanical malfunctions 3.4.2 Troubleshooting techniques and tools 3.4.2.1 Using diagnostic tools and reference to manufacturer guidelines	• Interviews • Third party report • Written assessment • Practical assessment • Projects

Learning outcome	Content	Suggested assessment methods
	3.4.3 Documentation of troubleshooting processes 3.4.3.1 Logs for issue identification, resolution steps, and outcomes 3.5 Generate maintenance report 3.5.1 Report structure and essential elements 3.5.1.1 Faults identification 3.5.1.2 Corrective actions 3.5.1.3 Future maintenance suggestions 3.5.2 Filing and documentation standards 3.5.2.1 Workplace standards for recording and storing maintenance data	

Suggested delivery methods

- Group discussions
- Demonstration by trainer
- Online videos
- Power point presentation

Recommended resources for 25 trainees

S/No.	Category/item	Description/specifications	Quantity	Recommended ratio (item: trainee)
A	**Tools**			
1.	Screwdriver sets	Various sizes for different screw types	2 sets	2:25
2.	Wrench sets	For tightening bolts and nuts in various sizes	2 sets	2:25
3.	Pliers Sets	For gripping and cutting wires and components	2 sets	2:25

4.	Clamps	For holding components securely during assembly	13 pcs	13:25
5.	Allen key sets	For hexagonal bolts and nuts	2 sets	2:25
6.	Digital multi-meters	For measuring voltage, current, and resistance	5 pcs	1:5
7.	Digital tachometers	For measuring rotational speed of motors	5 pcs	1:5
B	**Materials and supplies**			
8.	Whiteboard markers	For writing on whiteboards during instruction	Adequate	
9.	PCB boards	For circuit assembly and testing	25 pcs	1:1
10.	Switches	Mechanical and electronic types for circuit control	10 pcs	2:5
11.	Bolts, nuts, and washers	For securing components	Adequate	
12.	Fasteners	Used in assembly	5 pcs	1:5
13.	Bearings, gears, and rollers	Components for rotational systems	5 sets	1:5
14.	Electric cables and conductors	For electrical connections	10 pcs	2:5
15.	Breadboards	For prototype circuit assembly	25 pcs	1:1
16.	Trunking	For organizing and protecting cables	adequate	
17.	Fuses	For protecting circuits	10 pcs	2:5
18.	Electrical accessories	Connectors, sockets, and other components	10 pcs	2:5
19.	Oils and lubricants	For machinery maintenance	adequate	
20.	Oil seals and gaskets	For sealing components	5 pcs	1:5

21.	Assorted drive belts	For power transmission in machinery	2 pcs	2:25
22.	PLC modules	For programmable logic control setups	2 pcs	2:25
23.	Variable speed/frequency drives (VSD/VFD)	For motor control	2 pcs	1:25
C	**Equipment**			
24.	Projectors	For visual presentations	1	1:25
25.	Whiteboards	For writing instructional content	1	1:25
26.	Drills	Various types for assembly and installation	5 pcs	1:5
27.	Servomechanisms	For automation and control demonstrations	5 pcs	1:5
28.	Compressor systems	For pneumatic operations	5 pcs	1:5
29.	Pneumatic systems	For demonstrating fluid control systems	5 pcs	1:5
30.	PLC Modules	For electromechanical control exercises	5 pcs	1:5
31.	Gyroscopes	For rotational motion study	5 pcs	1:5
32.	Dynamometers	For measuring torque and rotational force	5 pcs	1:5
33.	Magnetic drums	For magnetic field and storage studies	5 pcs	1:5
34.	Brakes	For studying braking mechanisms	5 pcs	1:5
35.	Control linkage	For demonstrating mechanical linkages	5 pcs	1:5

36.	Actuators	For demonstrating movement control	5 pcs	1:5
D	**Equipment**			
37.	AC/DC electronics training modules	Training modules for AC/DC electronics	1 pc	1:25
38.	AC/DC machines control training modules	Modules for controlling AC/DC machines	1 pc	1:25
E	**Reference Materials**			
39.	Component and Equipment Manuals	Manuals for reference on component use and specifications	Sufficient	
40.	Health and Safety Manuals	For workplace safety instructions	Sufficient	
41.	Electromechanical Reference Books	Comprehensive guides on electromechanical systems	Sufficient	
F	**Software**			
42.	Electrical Circuit Design Software	Software for designing electrical circuits	1 license	
43.	AUTOCAD	For creating and modifying digital schematics	1 license	
G	**Trainee Requirements**			
44.	Computing Devices	Desktops, laptops, or tablets for individual use	25 pcs	1:1
45.	Protective Clothing	Dust coats, gloves, safety boots, goggles	25 sets	1:1

COMMUNICATION SKILLS

ISCED UNIT CODE: 0031 541 02A

TVETCDACC UNIT CODE: ENG/CU/IMT/BC/02/6/MA

Relationship with occupational standards

This unit addresses the unit of competency: Apply Communication Skills

Duration of unit: 40 Hours

Unit description

This unit covers the competencies required to apply communication skills. It involves applying communication channels, written, non-verbal, oral, and group communication skills.

Summary of learning outcomes

By the end of Unit of learning, the trainee will be able to;

S/No.	Learning outcome	Duration (Hours)
1	Apply communication channels.	10
2	Apply written communication skills.	12
3	Apply non-verbal skills.	4
4	Apply oral communication skills.	4
5	Apply group communication skills.	10
	TOTAL HOURS	**40**

Learning outcomes, content, and suggested assessment methods

Learning outcome	Content	Suggested assessment methods
1. Apply communication channels	1.1 Communication process 1.2 Principles of effective communication 1.3 Channels/medium/modes of communication	• Oral questions • Written assessment • Observation • Portfolio of evidence • Practical assessment

Learning outcome	Content	Suggested assessment methods
	1.4 Factors to consider when selecting a channel of communication 1.5 Barriers to effective communication 1.6 Flow/patterns of communication 1.7 Sources of information 1.8 Organizational policies	• Third party report
2. Apply written communication skills	2.1 Types of written communication 2.2 Elements of communication 2.3 Organization requirements for written communication	• Oral assessment • Written assessment • Observation • Portfolio of evidence • Practical assessment • Third party report
3. Apply non-verbal communication skills	3.1 Utilize body language and gestures 3.2 Apply body posture 3.3 Apply workplace dressing code	• Oral assessment • Written assessment • Observation • Portfolio of evidence • Practical assessment • Third party report
4. Apply oral communication skills	4.1 Types of oral communication pathways 4.2 Effective questioning techniques 4.3 Workplace etiquette 4.4 Active listening	• Oral assessment • Written assessment • Observation • Portfolio of evidence • Practical assessment • Third party report

Learning outcome	Content	Suggested assessment methods
5. Apply group communication skills	5.1 Establishing rapport 5.1.1 Facilitating resolution of issues 5.1.2 Developing action plans 5.1.3 Group organization techniques 5.1.4 Turn-taking techniques 5.1.5 Conflict resolution techniques 5.1.6 Team-work	• Oral assessment • Written assessment • Observation • Portfolio of evidence • Practical assessment

Suggested methods of instruction

- Discussion
- Roleplaying
- Simulation
- Direct instruction
- Demonstration
- Field trips

Recommended resources for 30 trainees

S/No.	Category/item	Description/specifications	Quantity	Recommended ratio (item: trainee)
A	**Learning materials**			
1.	Textbooks	Comprehensive texts books on communication skills	30 pcs	1:1
2.	Mobile phones	Smartphone for use by trainees	30 pcs	1:1

3.	Internet connection	Internet connection to aid communication between trainees		
4.	Powerpoint presentations	For trainer's use, covering course content and practical applications	1	1:30
5.	Projector	Functional projector for displaying content during presentations	1	1:30
6.	White board	Quality whiteboard of approximately 6 ft by 3 ft for writing during theory instruction	1	1:30
7.	Printer	An ink-jet, laser-jet or toner-cartridge printer for printing notes, instructions and working drawings	1	1:30
8.	Templates	Templates for creating various documents e.g. CV, Cover Letter, minutes, reports etc.	30	1:1
B	**Learning facilities & infrastructure**			
9.	Lecture/theory room /learning resource area	Spacious, equipped with projectors and seats for 30 trainees, approximately 45 sqm (5 m x 9 m)	1	1:30
10.	Computer laboratory	Equipped with at least 30 functional computers with internet connectivity and the following software:	30	1:1

		• Windows/ linux/ macintosh operating system • Microsoft office software • Google workspace account • Antivirus software		
C	**Consumable Materials**			
11.	Printing papers	A4 and A3 printing papers suitable for the task	Adequate	
12.	Flashcards	For carrying out various activities by trainees	Adequate	
13.	Flipcharts	Sufficient for group work activities and displaying	Adequate	
14.	Whiteboard marker pens	Dry-erase markers for trainers use. Assorted colors	Adequate	

MODULE III

HYDRAULIC AND PNEUMATIC SYSTEMS INSTALLATION AND MAINTANANCE

ISCED UNIT CODE: 0715 551 12A

TVETCDACC UNIT CODE: ENG/CU/IMT/CR/03/6/MA

Relationship to occupational standards

This unit addresses the unit of competency: install and maintain hydraulic and pneumatic systems

Duration of unit: 240 hours.

Unit description

This unit covers the competencies required by an industrial mechatronic technician to prepare hydraulic and pneumatic systems installation site, mount hydraulic and pneumatic system components, and maintain hydraulic and pneumatic system.

Summary of learning outcomes

By the end of the unit of learning, the trainee will be able to;

S/No.	Learning outcome	Duration (Hrs)
1	Prepare hydraulic and pneumatic system installation site	80
2	Mount hydraulic and pneumatic system components	100
3	Maintain hydraulic and pneumatic system	100
	TOTAL	**280**

Learning outcomes, content and suggested assessment methods

Learning outcome	Content	Suggested assessment methods
1. Prepare hydraulic and pneumatic system installation site	1.1 Health and safety in installation sites 1.1.1 Overview of health and safety standards for hydraulic and pneumatic installations 1.1.2 Personal protective equipment (PPE) requirements 1.1.3 Emergency procedures and first aid basics 1.1.4 Hazard identification and risk assessment techniques 1.1.5 Safe handling and storage of tools and equipment 1.2 Surveying for hydraulic and pneumatic installations 1.2.1 Purpose and process of site surveys 1.2.2 Identification of site requirements based on system specifications 1.2.3 Assessment of environmental factors and site conditions 1.2.4 Documentation of survey findings and recommendations 1.3 Installation, scheduling and documentation 1.3.1 Components of an effective installation schedule 1.3.2 Installation timelines	• Project • Practical • Third party report • Portfolio of evidence • Written tests • Oral questioning

Learning outcome	Content	Suggested assessment methods
	1.3.3 Scheduling tools and software 1.3.4 Documentation of schedule 1.4 Site Preparation in line with technical and manufacturer requirements 1.4.1 Preparation of installation sites for hydraulic and pneumatic systems 1.4.2 Site specifications 1.4.3 Workspace layout and positioning of equipment 1.4.4 Verification of tools and materials are available and in working order	
2 Mount hydraulic and pneumatic system components	2.1 Components of fluid power systems 2.1.1 Reservoirs, tanks and accumulators 2.1.2 Pumps (centrifugal, submersible, diaphragm, gear, peristaltic, piston etc.) 2.1.3 Motors (AC, DC, linear, servo, stepper etc.) 2.1.4 Actuators 2.2 Pipes and hoses (fixed, flexible) 2.2.1 Valves (pressure relief, pressure reducing etc.) 2.2.2 Switches (mechanical, electronic etc.) 2.2.3 Gauges (limit, pressure etc.) 2.2.4 Filters (pressure, oil, air etc.)	• Project • Practical • Third party report • Portfolio of evidence • Written tests • Oral questioning

Learning outcome	Content	Suggested assessment methods
	2.2.5 Cylinders 2.2.6 DCV 2.2.7 Compressors 2.3 Symbols and standard representations in fluid power systems 2.4 Hydraulic and pneumatic controllers 2.4.1 Distributed control systems 2.4.2 SCADA 2.4.3 Stand-alone controllers (PID, microprocessors, microcontrollers etc 2.4.4 Relay 2.4.5 PLC 2.5 Pneumatic principles and components 2.5.1 Working principle of pneumatic systems 2.5.2 Types of compressors and their applications 2.5.3 Air preparation units (filters, regulators, lubricators) 2.6 Pneumatic actuators and control valves 2.6.1 Types of pneumatic actuators (cylinders, motors, grippers) 2.6.2 Pneumatic valves (directional, flow control, check valves) 2.7 Pneumatic circuit design and analysis 2.7.1 Basic pneumatic circuit symbols and diagrams	

Learning outcome	Content	Suggested assessment methods
	2.7.2 Design of simple pneumatic circuits (using valves, actuators) 2.7.3 Troubleshoot common pneumatic system issues 2.8 Hydraulic principles and components 2.8.1 Fluid properties and their impact on hydraulic systems 2.8.2 Types of hydraulic pumps (gear, vane, piston) and their applications 2.9 3.2 Hydraulic actuators and control valves 2.9.1 Hydraulic cylinders, hydraulic motors 2.9.2 Types of hydraulic valves (pressure, flow, directional control) 2.10 Hydraulic circuit design and analysis 2.10.1 Basic hydraulic circuit symbols and diagrams 2.10.2 Design of hydraulic circuits for different industrial applications 2.11 Introduction to fluid power simulation software 2.11.1 Overview of simulation software (e.g., automation studio, FluidSIM) 2.12 Simulation exercises	

Learning outcome	Content	Suggested assessment methods
	2.12.1 Design and simulation of pneumatic and hydraulic circuits 2.12.2 Analysis of circuit behaviour and identification of improvements 2.13 Component assembly and safety standards 2.13.1 Interpretation of manufacturer's specifications 2.13.2 Sequence of component assembly for hydraulic and pneumatic systems 2.13.3 Safe and quality assemblies 2.14 Controller configuration procedures 2.14.1 Hydraulic and pneumatic control systems. 2.14.2 Configuration of controllers 2.14.3 Calibration of controllers to optimize performance 2.14.4 Safety checks, verification and post-configuration 2.15 System testing methods 2.15.1 Types of tests for hydraulic and pneumatic systems (pressure, leak, functionality, mechanical, electrical and safety) 2.15.2 Procedures for conducting initial and follow-up tests	

Learning outcome	Content	Suggested assessment methods
	2.15.3 Analysis of test results 2.15.4 Documentation of test outcomes. 2.16 Reporting protocols for installation processes 2.16.1 Required documentation for installation processes 2.16.2 Standard reporting formats and workplace protocols 2.16.3 Accuracy and completeness of reports 2.16.4 Communication of findings and installation status effectively 2.17 Practical exercises and assignments 2.17.1 Practice exercises in circuit building, modification, and installation	
3 Maintain hydraulic and pneumatic system	3.1 Maintenance scheduling and safety protocols 3.1.1 Development of a preventive maintenance schedule 3.1.2 Importance of routine maintenance in hydraulic and pneumatic systems 3.1.3 Integration of health and safety protocols into maintenance activities	• Project • Practical • Third party report • Portfolio of evidence • Written tests • Oral questioning

Learning outcome	Content	Suggested assessment methods
	3.1.4 Record-keeping for maintenance schedules and updates 3.2 System troubleshooting techniques 3.2.1 Common issues and faults in hydraulic and pneumatic systems 3.2.2 Diagnostic techniques for identifying and isolating problems 3.2.3 Step-by-step troubleshooting approaches 3.2.4 Use of manufacturer guidelines for effective troubleshooting 3.3 Reporting of maintenance activities for compliance and quality control 3.3.1 Importance of maintenance documentation for compliance 3.3.2 Standard maintenance report templates and guidelines 3.3.3 Detailing findings, repairs, and system status in reports 3.3.4 Reports review 3.4 Practical exercises and assignments 3.4.1 Practice exercises in troubleshooting and maintenance	

Suggested Delivery Methods

- Group discussions
- Demonstration by trainer
- Online videos
- Power point presentation

Recommended resources for 25 trainees

S/No.	Category/item	Description/specifications	Quantity	Recommended ratio (item)
A	**Tools**			
1.	Multimeters	For measuring voltage, current, and resistance	25 pcs	1:1
2.	Clamp meters	For measuring electrical current	5 pcs	1:5
3.	Power analysers	For analysing power quality and consumption	5 pcs	1:5
4.	Thermal imaging cameras	For visualizing heat patterns and identifying issues	5 pcs	1:5
5.	Assorted wrenches	For tightening and loosening fasteners	5 Sets	1:5
6.	Screwdrivers	For driving screws; various types included	5 pcs	1:5
7.	Pliers	For gripping and bending wires	5 pcs	1:5
8.	Hex keys	For hexagonal screws and bolts	5 pcs	1:5
9.	Cutters	For cutting wires and cables	5 pcs	1:5
10.	Tape measures	For measuring lengths and distances	5 pcs	1:5
11.	Callipers	For measuring internal and external dimensions	5 pcs	1:5
12.	Alignment lasers	For precise alignment of components	2 pcs	2:25

13.	Plumb bobs	For vertical alignment in installations	5 pcs	1:5
B	**Learning facilities & infrastructure**			
14.	Lecture/theory room	Approximately 60 sqm	1	1:25
15.	Workshop	Approximately 80 sqm	1	1:25
16.	Laboratory	Approximately 80 sqm	1	1:25
C	**Materials and supplies**			
17.	Pressure gauges	For measuring pressure in pneumatic systems	25 pcs	1:1
18.	Vacuum gauges	For measuring vacuum levels in systems	25 pcs	1:1
19.	Pressure regulators	For controlling and regulating pressure	25 pcs	1:1
20.	Pipes and tubes	For various pneumatic and hydraulic applications	100 pcs	4:1
21.	Connectors	For connecting pipes and tubes	100 pcs	4:1
22.	Air compressors	For supplying compressed air for pneumatic tools	25 pcs	1:1
23.	Valves	For controlling the flow of fluids in systems	25 pcs	1:1
24.	Enclosures	For housing electrical and mechanical components	25 pcs	1:1
25.	Fittings	For connecting different sections of pipes and tubes	25 pcs	1:1
26.	Safety valves	For ensuring safety in pressure systems	25 pcs	1:1
27.	Pneumatic cylinders	Single/double	10 pcs	2:5
28.	Sensors	Assorted	10 pcs	2:5

29.	Controllers	Controlling automatic pneumatic systems	5 pcs	1:5
D	**Equipment**			
30.	Safety glasses	Eye protection for all trainees	25 pcs	1:1
31.	Gloves	Hand protection during training and operations	25 pairs	1:1
32.	Hearing protection	To safeguard against loud noises	25 pcs	1:1
33.	Hard hats	Head protection while working	25 pcs	1:1
34.	Oscilloscopes	For visualizing electrical signals	2 units	2:25
35.	Megohmmeters	For testing insulation resistance	5 units	1:5
36.	Pneumatic system training kits	For training	5 units	1:5
37.	Hydraulic system training kits	For training	5 units	1:5
E	**Miscellaneous**			
38.	Lubricating Equipment	For maintaining smooth operation of mechanical components	1 unit	1:25
39.	Vacuum Pump	For creating a vacuum for testing and operations	1 unit	1:25
F	**Reference materials**			
40.	Component and Equipment Manuals	Comprehensive guides on all tools and equipment	Adequate	
41.	Pneumatic and hydraulic system installation manuals	For proper setup and maintenance of pneumatic systems	Adequate	

42.	Other reference materials	Journals, past papers, and online resources for further study	Adequate	

ELECTRICAL AND ELECTRONICS PRINCIPLES

ISCED UNIT CODE: 0713 541 08A

TVETCDACC UNIT CODE: ENG/CU/IMT/CC/04/6/MA

UNIT DURATION: 180 HOURS

Relationship to occupational standards

This unit addresses the unit of competency: apply electrical and electronics principles.

Unit description

This unit describes the competences required in order to apply electrical and electronics principles. It involves: applying safety requirements for electricity, basic electrical quantities and principles, D.C and A.C circuits in electrical installation, magnetism and electromagnetism, single and three phase power supply, sensors and transducers principles, principles of analogue electronics, and design electronic circuits

Summary of learning outcomes

By the end of the unit of learning, the trainee will be able to:

S/No.	Learning outcomes	Duration (Hrs)
1	Apply safety requirements for electricity	10
2	Apply basic electrical quantities and principles	20
3	Apply D.C and A.C circuits in electrical installation	20
4	Apply magnetism and electromagnetism	20
5	Apply single and three phase power supply	30
6	Apply sensors and transducers principles	20
7	Apply principles of analogue electronics	20
8	Apply principles of digital electronics	20
9	Design electronic circuits	20
	TOTAL	**180**

Learning outcomes, content and suggested assessment methods

Learning outcome	Content	Suggested assessment methods
1. Apply safety requirements for electricity	1.1 Personal protective equipment (PPE) 1.1.1 Types of PPE 1.1.1.1 Head protection, insulating gloves, eye protection 1.1.1.2 Usage guidelines and importance 1.2 Control of electrical hazards 1.2.1 Identification of Hazards 1.2.1.1 Shocks, explosions, electrocution, burns, fires, electric arcs 1.2.1.2 Risk assessment and management 1.3 Electric Hazard Prevention 1.3.1 Preventative measures 1.3.1.1 Lockout/tagout (LOTO) procedures 1.3.1.2 Safe work practices	• Project • Practical • Written tests • Oral Questioning • Portfolio of evidence

2. Use the concept of basic electrical quantities	2.1 Basic SI units 2.1.1 Overview of SI Units 2.1.1.1 Power (Watts, W) 2.1.1.2 Current (Amperes, A) 2.1.1.3 Resistance (Ohms, Ω) 2.1.1.4 Voltage (Volts, V) 2.2 Conductors and insulators 2.2.1 Identification and characteristics 2.2.1.1 Metals vs. non-metals 2.2.1.2 Applications in electrical circuits 2.3 Electrical quantities 2.3.1 Charge, force, work, and power 2.3.2 Definitions and units 2.3.3 Calculations involving Electrical quantities 2.4 Ohm's law 2.4.1 Understanding ohm's law 2.4.2 Practical applications and calculations 2.5 Basic electrical and electronic measurements 2.5.1 Measurement Techniques 2.5.2 Use of multimeters, oscilloscopes, and ammeters	• Project • Practical • Written tests • Oral Questioning • Portfolio of evidence

	2.5.3 Measurement accuracy and calibration	
3. Apply DC and AC circuits	3.1 Introduction to electrical circuits 3.1.1 Introduction to electricity: 3.1.2 Voltage, current, and power. 3.1.3 Overview of DC and AC circuits. 3.1.4 Basic circuit elements: resistors, capacitors, and inductors. 3.2 DC Circuit Analysis 3.2.1 Series and parallel circuits. 3.2.2 Voltage and current division principles. 3.2.3 Kirchhoff's Vvltage law (KVL) and Kirchhoff's current law (KCL). 3.2.4 Analysis of complex circuits using KVL and KCL. 3.2.5 Introduction to circuit simulation software (e.g., SPICE).	• Project • Practical • Written tests • Oral questioning • Portfolio of evidence

	3.2.6 Practical applications of DC circuit analysis. 3.2.7 Circuit design and testing using breadboards. 3.2.8 Hands-on lab: Building and testing DC circuits. 3.3 AC circuits analysis 3.3.1 Introduction to AC: Sinusoidal waveforms, frequency, and period. 3.3.2 RMS values, peak values, and average values. 3.3.3 AC voltage and current sources. 3.3.4 Phasor representation of AC quantities. 3.3.5 Impedance and admittance. 3.3.6 Series and parallel AC circuits. 3.3.7 Resonance in RLC circuits. 3.3.8 Practical analysis of AC circuits using phasors.	

	3.3.9 Power in AC Circuits 3.3.9.1 Power factor and power factor correction. 3.3.9.2 Real, reactive, and apparent power. 3.3.9.3 AC power calculations for single-phase and three-phase circuits. 3.3.9.4 Energy consumption and efficiency. 3.3.9.5 Applications of AC power in household and industrial settings. 3.4 Practical activity: 3.4.1 Connection in series and Parallel 3.4.2 Simulation	
4. Apply magnetism and electromagnetism	4.1 Magnetic circuits and devices 4.1.1 Introduction to magnetic circuits. 4.1.2 Magnetic flux, magnetic field density, magnetic field strength, Reluctance,	• Project • Practical • Written tests • Oral questioning • Portfolio of evidence

	magnetomotive force (MMF), and magnetic flux. 4.1.3 Calculations involving magnetic circuits 4.1.4 Analogies between electric and magnetic circuits. 4.1.5 Magnetic materials in electrical devices (soft and hard magnetic materials). 4.2 Electromagnetic induction 4.2.1 Faraday's law of electromagnetic induction. 4.2.2 Lenz's law: Direction of induced EMF. 4.2.3 Practical applications: Electric generators and transformers. 4.2.4 Induced EMF in different configurations (moving conductors, changing magnetic fields). 4.2.5 Self-induction and mutual induction. 4.2.6 Transformers: Working principles, construction, and applications. 4.2.7 Step up and step-down transformers 4.2.8 Power losses in transformers. 4.2.9 Calculations involving transformers	

	4.2.10 Energy stored in magnetic fields.	
5. Apply single and three phase power supply principles	5.1 Overview of electrical power systems 5.1.1 Definition and importance of power supply systems 5.1.2 Types of power systems: Single-phase vs. three-phase 5.1.3 Basic electrical concepts 5.1.3.1 Voltage, current, power, and frequency 5.1.3.2 Phase relationships and power factor 5.2 Single-phase power supply 5.2.1 Characteristics of single-phase systems 5.2.1.1 Voltage and current waveforms 5.2.1.2 Applications and limitations of single-phase power 5.2.2 Circuit design and Implementation 5.2.2.1 Basic circuit configurations: series and parallel	• Project • Practical • Written tests • Oral questioning • Portfolio of evidence

	5.2.2.2 Wiring techniques and component selection 5.2.3 Measurement Techniques 5.2.3.1 Measuring voltage, current, and power in single-phase circuits 5.2.3.2 Tools and instruments for measurements 5.3 Three-phase power supply 5.3.1 Fundamentals of three-phase systems 5.3.1.1 Characteristics of three-phase power: Star (Y) and Delta (Δ) configurations 5.3.1.2 Advantages of three-phase systems over single-phase 5.3.2 Circuit design and implementation 5.3.2.1 Wiring and connection techniques for three-phase systems	

	5.3.2.2 Component selection and configuration 5.3.3 Measurement techniques 5.3.3.1 Measuring line and phase voltages, currents, and power in three-phase circuits 5.3.3.2 Use of power analyzers and other measurement tools 5.4 Power calculations and analysis 5.4.1 Power calculations 5.4.1.1 Active, reactive, and apparent power calculations 5.4.1.2 Understanding the power triangle in both single and three-phase systems 5.4.2 Power factor correction 5.4.2.1 Importance of power factor in electrical systems	

	5.4.2.2 Techniques for improving power factor in both types of systems 5.5 Troubleshooting and maintenance 5.5.1 Common issues in power supply systems 5.5.1.1 Identifying and diagnosing faults in single and three-phase systems 5.5.1.2 Troubleshooting techniques and best practices	
6. Apply sensors and transducers principles	1.1 Introduction to sensors and transducers 1.1.1 Definitions and Concepts 1.1.2 Differences between sensors and transducers 1.1.2.1 Overview of their roles in measurement and control systems 1.2 Basic principles of operation 1.2.1 How sensors and transducers convert physical phenomena into electrical signals 1.2.2 Common physical quantities measured	• Project • Practical • Written tests • Oral questioning • Portfolio of evidence

	(e.g., temperature, pressure, moisture, position, oxygen, light) 1.3 Types of sensors 1.3.1 Temperature sensors 1.3.2 Thermocouples, thermistors, and infrared sensors 1.3.3 Principles of operations 1.3.4 Applications and selection criteria 1.4 **Pressure sensors** 1.4.1 Strain gauge, piezoelectric, and capacitive pressure sensors 1.4.2 Principles of operations 1.4.3 Measurement techniques and applications 1.5 **Proximity and displacement sensors** 1.5.1 Inductive, capacitive, and photoelectric sensors 1.5.2 Principles of operations	

	1.5.3 Use cases and installation considerations 1.6 Other **sensor types** 1.6.1 Humidity, moisture, oxygen, flow, level, and gas sensors 1.6.2 Overview of their principles and applications 1.7 Types of transducers 1.7.1 Definition **and Functionality** 1.7.1.1 Types of transducers (active vs. passive) 1.7.1.2 Examples and applications 1.8 Electrical **transducers** 1.8.1 Strain gauges, load cells, and piezoelectric transducers 1.8.2 Principles of operation and usage 1.9 Mechanical **transducers** 1.9.1 Overview of mechanical types and their applications 1.9.2 Integration into automated systems	

	1.10 Hands-on experiments on testing sensors and actuators.	
7. Apply principles of analogue electronics	7.1 Introduction to electronic components 7.1.1 Overview of electronics: What are electronic components? 7.1.2 Classification of components: passive, active, and electromechanical. 7.1.3 Introduction to circuit symbols and schematic diagrams. 7.1.4 Basic electrical quantities and units (voltage, current, resistance). 7.1.5 Understanding datasheets and component specifications. 7.1.6 Overview of testing and measurement tools (multimeters, oscilloscopes). 7.2 Passive Components 7.2.1 Resistors: types, color codes, power ratings, and applications.	• Project • Practical • Written tests • Oral questioning • Portfolio of evidence

	7.2.2 Capacitors: types (ceramic, electrolytic, film), capacitance value, and working voltage. 7.2.3 Charging and discharging of capacitors in DC circuits. 7.2.4 Applications of capacitors in filtering, timing, and energy storage. 7.2.5 Inductors: types, inductance value, and applications. 7.2.6 Inductor behavior in DC and AC circuits. 7.2.7 Introduction to filters: RC, RL, and RLC circuits. 7.3 Semiconductor devices 7.3.1 Diodes: Introduction to PN junctions, characteristics, and types (LEDs, zener diodes, Schottky diodes). 7.3.2 Applications of diodes in rectification, voltage regulation, and signal clipping.	

	7.3.3 Transistors: types (BJT and MOSFET), characteristics, and configurations. 7.3.4 Basic transistor circuits: Switches and amplifiers. 7.3.5 Hands-on lab: Building and testing simple diode and transistor circuits. 7.3.6 Special semiconductor devices: thyristors, TRIACs, and optoelectronic devices. 7.3.7 Characteristics and applications in switching and control. 7.4 Integrated Circuits (ICs) 7.4.1 Overview of integrated circuits: Analog vs. digital ICs. 7.4.2 Operational amplifiers (Op-Amps): Characteristics and basic configurations. 7.4.3 Applications of Op-Amps in signal processing.	

	7.4.4 Timers and oscillators: 555 timer IC and its applications. 7.4.5 Voltage regulators: Linear and switching regulators. 7.4.6 Introduction to data converters (ADC and DAC). 7.5 Electromechanical and Specialized components 7.5.1 Relays: types, operation, and applications in switching. 7.5.2 Switches and connectors: types and usage in electronic circuits. 7.5.3 Transformers: basic operation, step-up/step-down functions, and isolation. 7.5.4 Displays: LED, LCD, and seven-segment displays. 7.5.5 Circuit design and practical applications 7.5.6 Basic circuit design principles: bread	

	boarding, PCB layout, and soldering. 7.5.7 Introduction to circuit simulation tools (e.g., Multisim, LTSpice). 7.5.8 Testing and troubleshooting techniques. 7.5.9 Real-world applications of electronic components. 7.5.10 Building practical projects: Power supplies, audio amplifiers, and sensor-based circuits. 7.5.11 Hands-on lab: Final project assembly and testing.	
8. Apply principles of digital electronics	8.1 Basics of digital electronics 8.1.1 Introduction to digital electronics, importance, and applications 8.1.2 Introduction to binary, decimal, hexadecimal, and octal number systems 8.2 Number systems and conversions	• Project • Practical • Written tests • Oral Questioning • Portfolio of evidence

	8.2.1 Converting between binary, decimal, hexadecimal, and octal systems 8.2.2 Application of number systems in digital electronics 8.3 Digital logic gates 8.3.1 Boolean algebra 8.3.2 Types and functions of logic gates (AND, OR, NOT, NAND, NOR, XOR, XNOR) 8.3.3 Reading and interpreting logic gate symbols and truth tables 8.3.4 Construction of digital circuits using logic gates 8.4 Digital circuit construction 8.4.1 Building basic digital circuits with logic gates 8.4.2 Testing and verifying functionality according to design requirements 8.4.3 Practical exercises: simple logic gate projects	

9. Design electronic circuits	1.1 Drawing electronic circuit schematics 1.1.1 Introduction to circuit schematic symbols and layout 1.1.2 Software tools for drawing schematic diagrams 1.1.3 Practical exercises: creating schematic diagrams 1.2 Identification and selection of circuit components 1.2.1 Identifying components and understanding their roles in circuits 1.2.2 Selection of components based on design specifications and functionality 1.3 Simulation of electronic circuits 1.3.1 Introduction to circuit simulation software 1.3.2 Simulation electronic circuits for testing and troubleshooting 1.3.3 Evaluation of simulation results and identifying design adjustments	• Project • Practical • Written tests • Oral Questioning • Portfolio of evidence

	1.4 Soldering and circuit assembly 1.4.1 Techniques in soldering and desoldering components 1.4.2 Assembly of circuits as per design specifications 1.4.3 Quality checks and safety protocols in circuit assembly 1.5 Testing and troubleshooting 1.5.1 Testing circuit functionality and performance 1.5.2 Identification and rectification of faults in assembled circuits 1.5.3 Practical exercises: testing and troubleshooting projects	

Recommended resources for 25 trainees

S/No.	Category/item	Description/specifications	Quantity	Recommended ratio (item: trainee)
A	**Learning materials**			
1	Textbooks	Comprehensive texts on electrical and electronics principles.	5 pcs	1:5

2	Charts	Visual aids covering electrical theories and safety protocols	10 pcs	1:3
3	PowerPoint Presentations	For trainer's use, covering course content and practical applications	adequate	
B	**Learning facilities & infrastructure**			
1	Lecture/Theory Room	Equipped with projectors and seating for 25 trainees, ~60 sqm	1	1:25
2	Workshop	Hands-on training area with workbenches, tools, and safety equipment, ~80 sqm	1	1:25
3	Computer Laboratory	Equipped with testing setups for electrical experiments, ~50 sqm. Equipped with computers installed with Circuit simulation software.	25	1:1
C	**Consumable materials**			
1	Electrical Wires	Assorted sizes and color-coded (e.g., 1.5mm², 2.5mm², 4mm²)	5 rolls	1:5
2	Insulation Tapes	For securing connections and insulation, assorted colors	25 pcs	1:1
3	Breadboard	For prototyping and testing circuits	25 pcs	1:1
4	Sensors	Assorted types	adequate	
5	Signal generators	For generating AC signals	5pcs	1:5
6	Transducers	Assorted	adequate	
7	Electronic components	Resistors, transistors, capacitors, relays, transformers. Integrated IC, OPAM.	assorted	
D	**Tools and equipment**			
1	Screwdrivers	Assorted sets for various applications	2 sets	1:12.5
2	Side Cutters	For cutting wires and cables	4 pcs	1:7
3	Pliers	For gripping and bending wires	3 pcs	1:9

4	Stripping Knives	For stripping insulation from wires	4 pcs	1:7
5	Computers	Equipped with electrical and electronics simulation software	5 pcs	1:5
6	Multimeters	For measuring voltage, current, and resistance	5 pcs	1:5
7	Clamp Meters	For measuring current flow in circuits	5 pcs	1:5
8	Oscilloscope	For observing waveforms and signals	1	1:25
9	Voltmeter	For measuring voltage	1	1:25
10	Ammeter	For measuring current	1	1:25
11	Signal Generator	For generating electrical signals for testing	1	1:25
12	Soldering gun	For soldering	10	1:3
13	Soldering wire	For making joints in electrical circuits	10	1:3
E	**PPE (personal protective equipment)**			
1	PPE Sets	Includes helmets, gloves, safety goggles, shoes, and harnesses	25 sets	1:1
2	Safety Signs and Barriers	For simulating safety zones and hazards	10 sets	1:3
3	Earthing test Kits	For ground testing and demonstrating earthing procedures	5 pcs	1:5
4	Electrical test benches	For hands-on testing of functionality and circuit design	5 pcs	1:5
F	**Reference materials**			
1	Industrial automation manuals	Covering principles and practices in automation	25 pcs	1:1
2	Electrical standards	Reference on industry standards (e.g., IEEE guidelines)	5 pcs	1:5

3	Technical handbooks	On motors, drives, and wiring systems	25 pcs	1:1
4	Training presentations/slides	Digital format for shared access among trainees	1	1:25
5	Multimedia Learning Modules	Digital licenses for videos and tutorials	25 pcs	1:1
6	Practical assessment guides	Worksheets for practical assessments	25 pcs	1:1

MODULE IV

STAND-ALONE CONTROLLER INSTALLATION AND MAINTENANCE

ISCED UNIT CODE: 0715 551 13A

TVETCDACC UNIT CODE: ENG/CU/IMT/CR/04/6/MA

Relationship to occupational standards

This unit addresses the unit of competency: Install and Maintain Stand-Alone Controllers

Duration of unit: 200 hours.

Unit description

This unit covers the competencies required by an industrial mechatronic technician to mount stand-alone controller hardware, interface stand-alone controller I/O modules, program stand-alone controller, and maintain stand-alone controller.

Summary of learning outcomes

By the end of unit of learning, the trainee will be able to;

S/No.	Learning outcomes	Duration (Hrs)
1	Mount stand-alone controller hardware	50
2	Interface stand-alone controller i/o	50
3	Program stand-alone controller	50
4	Maintain stand-alone controller	50
	TOTAL	**200**

Learning outcomes, content and suggested assessment methods

Learning outcome	Content	Suggested assessment methods
1. Mount Stand-alone	1.1 Health and safety 1.1.1 PPEs 1.1.2 Work permits	• Oral assessment • Portfolio of evidence

Learning outcome	Content	Suggested assessment methods
controller hardware	1.1.3 Waste management 1.1.4 Electrical wiring colour coding 1.1.5 Danger warning signage 1.1.6 Barricades 1.1.7 High voltage signage 1.1.8 Health policy 1.2 Standalone controllers 1.2.1 Programmable Logic Controllers (PLCs) 1.2.2 Supervisory Control and Data Acquisition (SCADA) 1.2.3 Distributed Control System (DCS). 1.2.4 PIDs 1.2.5 Microcontroller 1.2.6 Digital signal processors 1.2.7 Motor controllers 1.2.8 Power inverters 1.3 Standalone controller Installation tools 1.3.1 Hand Tools 1.3.2 Screwdrivers, wrenches, pliers, and hex keys for securing components. 1.3.3 Power Tools 1.3.4 Impact drivers, and cordless screwdrivers for efficient assembly. 1.3.5 Measuring Tools	• Interviews • Third party report • Written assessment • Practical assessment • Projects

Learning outcome	Content	Suggested assessment methods
	Tape measures, levels, and calipers for accurate placement and alignment. 1.3.6 Cable Management Tools 1.3.6.1 Cable ties, trays, and labels for organizing and securing wiring. 1.4 Preparation of the installation cabinet for stand-alone controllers 1.4.1 Introduction to controller cabinets 1.4.2 Interpretation of manufacturer specifications for cabinet preparation (required dimensions, cooling or ventilation needs, and placement guidelines etc) 1.4.3 Environmental requirements 1.4.4 Cabinet preparation steps 1.5 Fitting stand-alone controllers in the cabinet 1.5.1 Interpretation of technical drawings 1.5.2 Controller mounting requirements 1.5.3 Step-by-step controller installation 1.5.4 Cable management 1.6 Stand-alone control system wiring 1.6.1 Power connections	

Learning outcome	Content	Suggested assessment methods
	1.6.2 Sensor wiring 1.6.3 Actuator wiring 1.6.4 Signal wiring 1.6.5 System testing 1.7 Practice: Hands-on exercises in cabinet preparation, controller fitting, and performing wiring according to IEEE standards.	
2 Interface Stand-alone controller I/O	2.1 Stand-alone controller I/O 2.1.1 Input (I) 2.1.1.1 Digital Inputs: Switches, push buttons, and various sensors (proximity, limit, photoelectric, pressure, temperature) for detecting states and conditions. Encoder inputs for position feedback. 2.1.1.2 Analog Inputs: Potentiometers, voltage and current sensors, RTDs, thermocouples, and strain gauges. 2.1.1.3 Communication Inputs: Serial ports (RS-232, RS-485), Ethernet ports, CAN bus, and USB ports. 2.1.2 Output (O)	• Oral assessment • Portfolio of evidence • Interviews • Third party report • Written assessment • Practical assessment • Projects

Learning outcome	Content	Suggested assessment methods
	2.1.2.1 Digital Outputs: Relays, transistors, indicator lights, buzzers, and LEDs for control and status indication. 2.1.2.2 Analog Outputs: PWM outputs for motor speed control, voltage, and current outputs for sending signals to devices. 2.1.2.3 Communication Outputs: Serial ports, Ethernet ports, CAN bus, and USB ports for transmitting data to other devices. 2.1.3 Power I/O 2.1.4 Power Supply	
3 Program stand-alone controller	3.1 Standalone controller programming 3.1.1 Programming software 3.1.1.1 Arduino IDE 3.1.1.2 Raspberry Pi IDE 3.1.1.3 Gx works 3.1.1.4 Rs Logix 3.1.1.5 Step 7 3.1.1.6 TIA Portal 3.1.2 Objective definition: Task identification and performance criteria. 3.1.3 System flow chart 3.1.4 Control algorithms 3.1.5 Coding.	• Oral assessment • Portfolio of evidence • Interviews • Third party report • Written assessment • Practical assessment • Projects

Learning outcome	Content	Suggested assessment methods
	3.1.6 Compiling 3.1.7 Testing and debugging program 3.1.8 System simulation 3.1.9 Field testing 3.1.10 Code, algorithm documentation, and user manuals.	
4 Maintain Stand-alone controller	4.1 Standalone controller maintenance schedule 4.1.1 Daily 4.1.1.1 Visual Inspection 4.1.1.2 Cleanliness Checks 4.1.1.3 Basic Functionality Test 4.1.2 Weekly 4.1.2.1 Lubrication 4.1.2.2 Sensor calibration 4.1.2.3 Fuse and battery check 4.1.3 Monthly 4.1.3.1 Comprehensive inspection 4.1.3.2 Software update 4.1.3.3 Detailed functional testing 4.1.4 Quarterly 4.1.4.1 Replacement of worn parts	• Oral assessment • Portfolio of evidence • Interviews • Third party report • Written assessment • Practical assessment • Projects

Learning outcome	Content	Suggested assessment methods
	4.1.4.2 Calibration: Conduct detailed calibration of sensors and actuators. 4.1.4.3 Safety system check 4.1.5 Annually 4.1.5.1 In-depth functional testing. 4.1.5.2 Data review 4.1.5.3 Comprehensive system audit 4.1.5.4 Upgrade assessment 4.2 Standalone controller system maintenance report 4.2.1 Daily 4.2.2 Weekly 4.2.3 Quarterly 4.2.4 Annual	

Suggested delivery methods

- Group discussions
- Demonstration by trainer
- Online videos
- Power point presentation

Recommended resources for 25 trainees

S/No.	Category/item	Description/specifications	Quantity	Recommended ratio (item: trainee)
A	**Tools**			

1.	Multimeters	Digital multimeters for measuring voltage, current, and resistance	25 pcs	1:1
2.	Clamp Meters	For measuring current flow in electrical systems	5 pcs	1:5
3.	Power Analyzers	For analyzing power quality and consumption	5 pcs	1:5
4.	Sensors	Assorted sensors	5 pcs	1:5
B	**Learning facilities & infrastructure**			
5.	Lecture/Theory Room	Approximately 60 sqm	1	1:25
6.	Workshop	Approximately 80 sqm	1	1:25
7.	Laboratory	Approximately 80 sqm	1	1:25
C	**Hand tools**			
10.	Wrenches	Adjustable wrenches for various sizes of nuts and bolts	4 pcs	1:6.25
11.	Screwdrivers	Phillips and flathead screwdrivers for assembly work	5 pcs	1:5
12.	Pliers	For gripping, twisting, and cutting wires	5 pcs	1:5
13.	Hex Keys	Allen wrenches for hexagonal screws and bolts	5 pcs	1:5
14.	Cutters	Wire cutters for precise cutting of electrical wires	5 pcs	1:5
D	**Measuring tools**			
15.	Tape measures	5m tape measures for accurate measurements	5 pcs	1:5
16.	Calipers	For measuring internal and external dimensions precisely	5 pcs	1:5
17.	Alignment tools	Assorted	5 pcs	1:5

E	**Materials and Supplies**			
18.	Manipulators	For robotic manipulation tasks	2 pcs	2:25
19.	Controller units	For controlling robotic systems	2 pcs	2:25
20.	Sensors	Various sensors for feedback and measurement	2 pcs	2:25
21.	Actuators	For converting electrical signals into mechanical motion	2 pcs	2:25
22.	Encoders	For position sensing in robotic systems	2 pcs	2:25
23.	Gears	For mechanical transmission in robotics	2 pcs	2:25
24.	Motors	Includes servo motors, stepper motors, and linear motors	2 pcs	2:25
F	**Equipment**			
	Safety equipment			
25.	Safety glasses	For eye protection during practical activities	25 pcs	1:1
26.	Gloves	For hand protection while working with machinery	25 pairs	1:1
27.	Hearing protection	Ear protection to prevent noise-related injuries	25 pcs	1:1
28.	Helmet	Head protection for safety during hands-on work	25 pcs	1:1
	Testing equipment			
29.	Oscilloscopes	For visualizing electrical signals	2 pcs	2:25
30.	Megaohmmeters	For insulation resistance testing	2 pcs	2:25
	Miscellaneous			

31.	Lubricating Equipment	For maintenance of mechanical systems	1 set	
32.	Vacuum pump	For testing and cooling applications	1 unit	
G	**Reference materials**			
33.	Component and equipment manuals	Detailed manuals for operation and maintenance	adequate	
34.	Robotic installation books	Texts covering the principles and practices of robotic systems	adequate	
35.	Other reference materials	Journals, past papers, and online resources for further learning	adequate	

PLC SYSTEM INSTALLATION AND MAINTANANCE

ISCED UNIT CODE: 0715 551 14A

TVETCDACC UNIT CODE: ENG/CU/IMT/CR/05/6/MA

Relationship to occupational standards

This unit addresses the unit of competency: install and maintain plc systems.

Duration of unit: 240 hours.

Unit description

This unit covers the competencies required by an industrial mechatronic technician to mount PLC hardware, interface PLC I/O modules, program PLC, and maintain PLC systems

Summary of learning outcomes

By the end of unit of learning, the trainee will be able to;

S/No.	Learning outcomes	Duration (Hrs)
1	Mount PLC hardware	60
2	Interface PLC with I/O modules	60
3	Program PLC	60
4	Maintain PLC Systems	60
	TOTAL	**240**

Learning outcomes, content and suggested assessment methods

Learning Outcome	Content	Suggested assessment methods
1. Mount PLC hardware	1.1 Health and safety; 1.1.1 Operator safety 1.1.2 PPEs 1.1.3 Work permits 1.1.4 Waste management 1.1.5 Electrical wiring colour coding 1.1.6 Danger warning signage	• Practical assessment • Oral presentations • Observations • Trainee report • Supervisor's report • Online assignments

Learning Outcome	Content	Suggested assessment methods
	1.1.7 Barricades 1.1.8 High voltage signage 1.1.9 Health policy 1.2 Selection of tools and equipment in PLC hardware mounting, 1.2.1 Clamp-meter 1.2.2 Multi-meter 1.2.3 Ethernet crimping tools 1.2.4 Set of screwdrivers 1.2.5 Set of wrenches 1.2.6 Set of Pliers 1.3 Preparation of PLC installation cabinet 1.4 Installation of PLC hardware in the cabinet 1.4.1 Power supply 1.4.2 Input module 1.4.3 Output module 1.4.4 Processor (CPU) 1.4.5 Rack or mounting assembly 1.4.6 Indicator lights 1.5 PLC wiring 1.5.1 Interpretation of PLC hardware component manuals 1.5.2 Interpretation of PLC software manuals 1.5.3 Interpretation of I/O modules installation manuals 1.5.4 Interpretation of installation drawings	• Case studies • Trainer report • Written assessments • Portfolio assessment

Learning Outcome	Content	Suggested assessment methods
	1.5.5 Interpretation of electrical wiring drawings 1.5.6 Electrical wiring standards, codes and procedures 1.6 Practice: Cabinet preparation and hardware installation	
2 Interface PLC with I/O modules	2.1 PLC network working cables 2.1.1 Ethernet cable 2.1.2 USB Cable 2.1.3 Serial Cable 2.1.4 Profinet cables 2.1.5 Profibus cables 2.1.6 Coaxial cables 2.2 Fiber optic cables PLC cable layout and cable management 2.3 Network cables termination 2.4 Network cables testing 2.4.1 Professional testers 2.4.2 Continuity testers 2.4.3 LAN cable tester 2.4.4 Phone line tester 2.5 PLC device communication protocols and channels 2.6 PLC memory addressing 2.7 Human machine interface 2.8 Configuration of network ports 2.8.1 Ethernet ports 2.8.2 USB ports 2.8.3 HDMI ports 2.8.4 Mac serial ports	• Practical assessment • Oral presentation • Observations • Trainee assessment • Supervisor's report • Online assignments

Learning Outcome	Content	Suggested assessment methods
	2.9 Practice: Network cable termination	
3 Program PLC	3.1 Installation of PLC programming software 3.1.1 RS Logix 3.1.2 Logosoft 3.1.3 Gx works 3.1.4 Step 5- Micro wins 3.1.5 Step 7- Simatic Manager 3.1.6 TIA portal 3.2 Configuration of PLC software and hardware 3.3 Flow diagrams 3.3.1 Cross functional flow diagrams 3.3.2 Swim lane flow diagrams 3.4 PLC programming languages 3.4.1 ladder logic 3.4.2 functional block diagrams 3.4.3 Structured Text 3.4.4 Sequential Flow Charts 3.4.5 Instruction Lists 3.5 Creation of PLC, I/O schedules 3.6 PLC programming 3.6.1 PLC program structure 3.6.2 PLC rungs 3.7 Simulation of PLC program 3.8 Troubleshoot PLC program faults 3.8.1 I/O module failure 3.8.2 Power supply failure 3.8.3 Corrupted memory 3.8.4 Failed voltage supply	• Practical assessment • Oral presentations • Observations • Trainee report • Supervisor's report • Online assignments • Case studies • Trainer report • Written assessments • Portfolio assessment

Learning Outcome	Content	Suggested assessment methods
	3.9 Reconfiguration of PLC programming software 3.10 PLC operation modes 3.11 Establishment of PLC communication 3.12 Clearance of PLC memory 3.13 Downloading of PLC program to PLC hardware 3.14 Practice: Developing and debugging PLC programs	
4 Maintain PLC systems	4.1 Environmental and safety standards 4.2 PLC program back-up 4.2.1 Extraction of PLC program 4.2.2 Recovery of PLC program 4.3 PLC system tag out/Lock out and routine checks 4.4 PLC network data communication 4.5 Verification of I/O modules for normal operations 4.6 Verification of PLC's CPU optimum performance 4.7 Verification of sensors for normal performance 4.8 PLC system configuration 4.9 PLC modules 4.9.1 Power supply module (PS) 4.9.2 CPU 4.9.3 Interface module (IM) 4.9.4 Signal modules (SM) 4.9.5 Function module (FM)	• Practical assessment • Oral presentations • Observations • Trainee report • Supervisor's report • Online assignments • Case studies • Trainer report • Written assessments • Portfolio assessment

Learning Outcome	Content	Suggested assessment methods
	4.9.6 Communication processor (CP) 4.10 Identification of PLC wires and cables 4.10.1 Terminal cables 4.10.2 Tag cables 4.11 Interpretation of schematic diagrams and maintenance manuals 4.12 Visual checks on PLC attachments 4.13 Cleaning of PLC systems and peripheral devices 4.14 Restoration of PLC program 4.15 Format PLC system software 4.16 Maintenance of logging activities in maintenance management systems 4.17 Maintenance documentation 4.17.1 CPU module specification sheet 4.17.2 I/O terminal block specification sheet 4.17.3 Output specification sheet 4.17.4 DeviceNET link specification sheet 4.17.5 Flow diagrams 4.17.6 I/O schedule 4.17.7 PLC program 4.18 Practice: Prepare maintenance documentation report	

Suggested delivery methods

- Group discussions

- Demonstration by trainer
- Online videos
- Power point presentation

Recommended resources for 25 trainees

S/No.	Category/item	Description/specifications	Quantity	Recommended ratio (item: trainee)
A	**Tools**			
1.	Ethernet crimping tool	For crimping jacks	5 pcs	1:5
2.	Set of screwdrivers	Flat and star-assorted sizes. For fastening screws	2 set each	-
3.	Set of wrenches	For tightening bolts and nuts in various sizes	5 pcs	1:5
4.	Clamp meter	For measuring current without connection to a circuit in series	5 pcs	1:5
5.	Continuity testers	For cable continuity testing	5 pcs	1:5
6.	LAN cable tester	For testing ethernet cables	5 pcs	1:5
7.	Phone line tester	For line fault diagnosis	5 pcs	1:5
B	**Materials and supplies**			
1.	Whiteboard markers	For writing on whiteboards during instruction	Adequate	
2.	PCB boards	For circuit assembly and testing	10 pcs	2:5

3.	Bolts, Nuts, and Washers	For securing components	Adequate	
4.	Fasteners	Used in assembly tasks	5 pcs	1:5
5.	Breadboards	For prototype circuit assembly	10 pcs	2:5
6.	Trunking	For organizing and protecting cables	Sufficient	
7.	DIN rail	For mounting components	Adequate	
8.	Sensors	Assorted-For PLC inputs	Adequate	
9.	PLC cables and wires	For PLC wiring	Adequate	
10.	Racks	For mounting PLC modules	Adequate	
c	**Equipment**			
1.	Projectors	For visual presentations	1	1:25
2.	Actuators	For demonstrating movement control	5 pcs	1:5
3.	PLC Modules	For programmable logic control setups	5 pcs	1:5
4.	HMI	For Human Machine Interface	5 pcs	1:5
5.	Power supplies	For powering PLC systems	5 pcs	1:5
6.	RCD	For electrical shock prevention	5 pcs	1:5
7.	Contactors	For PLC outputs	5 pcs	1:5
D	**Reference materials**			
1.	PLC maintenance manuals/handbooks	Manuals for reference on PLC maintenance	Adequate	

2.	Health and safety manuals	For workplace safety instructions	Adequate	
3.	PLC operation manuals	Comprehensive guides on PLC systems	Adequate	
4.	Relevant PLC textbooks	For refencing	Adequate	
5.	Relevant journals and websites	For refencing	Sufficient	N/A
E	**Software**			
1.	PLC software	For programming PLC	1 license (distributable)	N/A
	Trainee requirements			
1.	Computing Devices	Desktops, laptops, or tablets for individual use	25 pcs	1:1
2.	Personal PROTECTIVE EQUIPMENT (PPEs):	Overalls /dust coats, safety shoes, ear muffs, safety goggles, nose masks, helmets, welding ray protection shields	25 sets	1:1

MODULE V

ROBOTIC SYSTEM INSTALLATION AND MAINTENANCE

ISCED UNIT CODE: 0715 551 15A

TVETCDACC UNIT CODE: ENG/CU/IMT/CR/06/6/MA

Relationship to occupational standards

This unit addresses the unit of competency: Install and maintain robotic system

Duration of unit: 240 hours.

Unit description

This unit covers the competencies required by an industrial mechatronic technician to prepare robotic systems installation site, assemble robotic system components, program robotic system, and maintain robotic system.

Summary of learning outcomes

By the end of unit of learning, the trainee will be able to;

S/No.	Learning outcomes	Duration (Hrs)
1	Prepare robotic systems installation site	60
2	Assemble robotic system components	60
3	Program robotic system	60
4	Maintain robotic system	60
	TOTAL	**240**

Learning outcomes, content and suggested assessment methods

Learning outcome	Content	Suggested assessment methods
1. Prepare robotic	1.1 Health and safety 1.1.1 PPEs	• Oral assessment

Learning outcome	Content	Suggested assessment methods
systems installation site	1.1.2 Work permits 1.1.3 Waste management 1.1.4 Electrical wiring colour coding 1.1.5 Danger warning signage 1.1.6 Barricades 1.1.7 High voltage signage 1.1.8 Health policy 1.2 Robotic system installation site survey 1.2.1 Purpose and importance of site surveys 1.2.2 Components of a site survey 1.2.3 Environmental considerations 1.2.4 Site survey documentation 1.3 Developing a robotic system installation schedule 1.3.1 Reading and interpreting manufacturer's guidelines 1.3.2 Project planning fundamentals 1.3.3 Resource allocation 1.3.4 Creating a Gantt chart	• Portfolio of evidence • Interviews • Third party report • Written assessment • Practical assessment • Projects

Learning outcome	Content	Suggested assessment methods
	1.3.5 Contingency planning 1.4 Setting up the robotic system installation area 1.4.1 Preparing the physical space 1.4.2 Positioning equipment 1.4.3 System infrastructure setup 1.5 Documenting the robotic system site preparation 1.5.1 Importance of site preparation documentation 1.5.2 Guidelines for creating a site preparation report 1.5.3 Using documentation templates 1.5.4 Review and submission	
2 Assemble robotic system components	2.1 Types of robotic systems 2.1.1 Industrial robots 2.1.2 Mobile robots. 2.1.3 Service robots 2.1.4 Humanoid robot 2.1.5 Autonomous robots 2.1.6 Cartesian robots	• Oral assessment • Portfolio of evidence • Interviews • Third party report • Written assessment • Practical assessment • Projects

Learning outcome	Content	Suggested assessment methods
	2.1.7 Polar robot 2.1.8 Articulated robot 2.1.9 Teleoperated robots 2.1.10 Swarm robots 2.1.11 Modular robots 2.1.12 Soft robots 2.1.13 Bionic robots 2.2 Components of a robotic system 2.2.1 Sensors 2.2.2 Actuators 2.2.3 Controller 2.2.4 Manipulator 2.2.5 Encoder 2.2.6 Gears 2.2.7 Power Supply 2.2.8 Chassis and Frame 2.2.9 End Effectors 2.2.10 Motors (servo motors, stepper motors, linear motors, etc) 2.3 Robotic system tests 2.3.1 Electrical 2.3.2 Mechanical	

Learning outcome	Content	Suggested assessment methods
	2.3.3 Safety 2.3.4 Functional testing 2.3.5 Performance testing 2.3.6 Load testing 2.3.7 Durability testing 2.3.8 Safety testing 2.3.9 Integration testing 2.3.10 Usability testing 2.3.11 Reliability testing 2.3.12 Sensor Calibration testing	
3 Program robotic system	3.1 Robotic system programming 3.1.1 Software 3.1.1.1 TIA portal 3.1.1.2 STEP 7 3.1.1.3 GX works 3.1.1.4 TWINCAT 3.1.1.5 Micro-Logix 3.1.1.6 C, C++ (Arduino, Raspberry Pi, STM32 etc)	• Oral assessment • Portfolio of evidence • Interviews • Third party report • Written assessment • Practical assessment • Projects

Learning outcome	Content	Suggested assessment methods
	3.1.2 Objective definition: Task identification and performance criteria. 3.1.3 System flow chart 3.1.4 Control algorithms 3.1.5 Integration of sensor data 3.1.6 Motion planning and obstacle avoidance algorithms. 3.1.7 Testing and debugging program 3.1.8 System simulation 3.1.9 Field testing 3.1.10 Code, algorithm documentation, and user manuals. 3.2 Practice: program robotic system	
4 Maintain robotic system	4.1 Robotic system maintenance schedule 4.1.1 Daily 4.1.1.1 Visual inspection 4.1.1.2 Cleanliness checks 4.1.1.3 basic functionality test 4.1.2 Weekly 4.1.2.1 Lubrication	• Oral assessment • Portfolio of evidence • Interviews • Third party report • Written assessment • Practical assessment

Learning outcome	Content	Suggested assessment methods
	4.1.2.2 Sensor calibration 4.1.2.3 Battery check 4.1.3 Monthly 4.1.3.1 Comprehensive inspection 4.1.3.2 Software update 4.1.3.3 Detailed functional testing 4.1.4 Quarterly 4.1.4.1 Replacement of worn parts 4.1.4.2 Calibration: conduct detailed calibration of sensors and actuators. 4.1.4.3 Safety system check 4.1.5 Annually 4.1.5.1 Battery replacement 4.1.5.2 In-depth functional testing. 4.1.5.3 Data review 4.1.5.4 Comprehensive system audit 4.1.5.5 Training refresh 4.1.5.6 Upgrade assessment 4.1.6 Robotic system maintenance report	• Projects

Learning outcome	Content	Suggested assessment methods
	4.1.6.1 Daily 4.1.6.2 Weekly 4.1.6.3 Quarterly 4.1.6.4 Annual 4.2 Practice: Maintain robotics system	

Suggested delivery methods

- Group discussions
- Demonstration by trainer
- Online videos
- Power point presentation

Recommended resources for 25 trainees

S/No.	Category/item	Description/specifications	Quantity	Recommended ratio (item: trainee)
A	**Tools**			
1.	Multimeters	Digital multimeters for measuring voltage, current, and resistance	25 pcs	1:1
2.	Clamp Meters	For measuring current flow in electrical systems	5 pcs	1:5
3.	Power Analyzers	For analyzing power quality and consumption	5 pcs	1:5
B	**Learning facilities & infrastructure**			
4.	Lecture/Theory Room	Approximately 60 sqm	1	1:25

5.	Workshop	Approximately 80 sqm	1	1:25
6.	Laboratory	Approximately 80 sqm	1	1:25
C	**Hand Tools**			
7.	Wrenches	Adjustable wrenches for various sizes of nuts and bolts	4 pcs	1:6
8.	Screwdrivers	Phillips and flathead screwdrivers for assembly work	5 pcs	1:5
9.	Pliers	For gripping, twisting, and cutting wires	5 pcs	1:5
10.	Hex Keys	Allen wrenches for hexagonal screws and bolts	5 pcs	1:5
11.	Cutters	Wire cutters for precise cutting of electrical wires	5 pcs	1:5
D	**Measuring tools**			
12.	Tape measures	5m tape measures for accurate measurements	5 pcs	1:5
13.	Calipers	For measuring internal and external dimensions precisely	5 pcs	1:5
14.	Alignment Tools	Assorted	5 pcs	1:5
E	**Materials and supplies**			
15.	Manipulators	For robotic manipulation tasks	2 pcs	2:25
16.	Controller Units	For controlling robotic systems	2 pcs	2:25
17.	Sensors	Assorted sensors for feedback and measurement	Adequate	
18.	Actuators	For converting electrical signals into mechanical motion	2 pcs	2:25
19.	Encoders	For position sensing in robotic systems	2 pcs	2:25

20.	Gears	For mechanical transmission in robotics	2 pcs	2:25
21.	Motors	Includes servo motors, stepper motors, and linear motors	2 pcs	2:25
F	**Equipment**			
22.	*Safety equipment*			
23.	Safety Glasses	For eye protection during practical activities	25 pcs	1:1
24.	Gloves	For hand protection while working with machinery	25 pairs	1:1
25.	Hearing protection	Ear protection to prevent noise-related injuries	25 pcs	1:1
26.	Hard hats	Head protection for safety during hands-on work	25 pcs	1:1
27.	Robotics training kit	For training	2	2:25
G	**Testing Equipment**			
28.	Oscilloscopes	For visualizing electrical signals	2 pcs	2:25
29.	Megaohmmeters	For insulation resistance testing	2 pcs	2:25
30.	Lubricating Equipment	For maintenance of mechanical systems	1 set	
31.	Vacuum Pump	For testing and cooling applications	1 unit	
G	**Reference materials**			
32.	Component and equipment manuals	Detailed manuals for operation and maintenance	Adequate	

33.	Robotic installation books	Texts covering the principles and practices of robotic systems	Adequate	
34.	Other reference materials	Journals, past papers, and online resources for further learning	Adequate	

SUPERVISORY CONTROL AND DATA ACQUISITION (SCADA) SYSTEMS INSTALLATION AND MAINTANANCE

ISCED UNIT CODE: 0715 551 16A

TVETCDACC UNIT CODE: ENG/CU/IMT/CR/07/6/MA

Relationship to occupational standards

This unit addresses the unit of competency: Maintain SCADA systems.

Duration of unit: 200 hours.

Unit description

This unit covers the competencies required by an industrial mechatronic technician to maintain SCADA systems. It enables the learner to: prepare SCADA system installation site, mount SCADA system components, program SCADA system and maintain SCADA system.

Summary of learning outcomes

By the end of unit of learning, the trainee will be able to;

S/No.	Learning outcomes	Duration (Hrs)
1	Prepare SCADA system installation site	50
2	Mount SCADA system components	50
3	Program SCADA system	50
4	Maintain SCADA system	50
		200

Learning outcomes, content and suggested assessment methods

Learning outcome	Content	Suggested assessment methods
1. Prepare SCADA system installation site	1.1 Observe occupational health and safety 1.2 Types and usage of PPE 1.3 Industrial safety signs 1.4 SCADA installation tools and equipment 1.5 SCADA system parts and accessories	• Observation • Oral assessment • Portfolio of evidence

Learning outcome	Content	Suggested assessment methods
	1.6 Installation management 1.6.1 Initiation 1.6.2 Planning 1.6.3 Execution 1.6.4 Work distribution 1.7 Project: Prepare site preparation plan	• Interviews • Third party report • Written assessment • Practical assessment • Projects
2. Mount SCADA system components	2.1 Health and safety 2.1.1 PPEs 2.1.2 Work permits 2.1.3 Waste management 2.1.4 Electrical wiring colour coding 2.1.5 Danger warning signage 2.1.6 Barricades 2.1.7 High voltage signage 2.2 Selection of tools and equipment in SCADA hardware mounting 2.3 Preparation of SCADA installation cabinet 2.4 SCADA components 2.4.1 Data input devices such as sensors 2.4.2 Data processing devices, such as a PLC or RTU 2.4.3 Data output devices such as an HMI or monitor, relays	• Observation • Oral assessment • Portfolio of evidence • Interviews • Third party report • Written assessment • Practical assessment • Projects

Learning outcome	Content	Suggested assessment methods
	2.4.4 Communication devices 2.5 SCADA system wiring 2.5.1 Industrial communication networks 2.5.2 Industrial automation control mechanisms 2.5.3 Transmission media 2.5.3.1 Wireless: radio waves 2.5.3.2 Wired: twisted pair, coaxial cable or fiber optics 2.6 Network troubleshooting 2.7 SCADA hierarchical levels 2.7.1 Field level 2.7.2 PLCs and RTU Level 2.7.3 Communications Level 2.7.4 HMI Level 2.8 Functional classification of industrial communication networks 2.8.1 Serial Communication 2.8.2 HART (Highway Addressable Remote Transducer) 2.8.3 DeviceNet 2.8.4 Modbus 2.8.5 Profibus 2.8.6 Foundation Fieldbus 2.9 SCADA Wiring regulations	

Learning outcome	Content	Suggested assessment methods
	2.10 Project: Mount and wire a SCADA system	
3. Program SCADA system	3.1 SCADA programming software 3.1.1 WinTr 3.1.2 Siemens 3.1.3 MC Works64 3.1.4 Easy SCADA 3.2 Installation of SCADA program on SCADA system 3.3 SCADA program simulation 3.4 Downloading SCADA program 3.5 Testing SCADA program 3.6 Troubleshooting and restoration of SCADA program 3.7 Project: write and download a SCADA Program	• Observation • Oral assessment • Portfolio of evidence • Interviews • Third party report • Written assessment • Practical assessment • Projects
4. Maintain SCADA system	4.1 SCADA system 4.1.1 SCADA software 4.1.2 Firewalls 4.1.3 Security updates 4.1.4 Firmware updates 4.1.5 PLCs 4.2 Backup SCADA program 4.2.1 Establishment of SCADA system 4.2.2 Extraction of SCADA program 4.2.3 Recovery of SCADA program	• Observation • Oral assessment • Portfolio of evidence • Interviews • Third party report • Written assessment • Practical assessment

Learning outcome	Content	Suggested assessment methods
	4.2.4 Troubleshooting and restoration of SCADA program 4.3 SCADA system tagging 4.4 Diagnosis of SCADA system faults 4.4.1 Interconnections of SCADA system 4.4.2 Online diagnostics of SCADA system 4.4.3 Identification of network faults 4.5 Replacement of faulty SCADA parts 4.5.1 Preparation of requisition forms as per operational regulation 4.5.2 Removal of faulty parts from system 4.5.3 Replacement of faulty parts with new parts 4.5.4 Test replaced parts as per maintenance manual 4.6 Routine maintenance 4.6.1 Inspection of remote terminal unit condition 4.6.2 Inspection of network utilities condition 4.6.3 Servicing of sensors 4.6.4 SCADA system updating 4.7 Maintenance records documentation 4.7.1 Filling work orders as per workplace standards	• Projects

Learning outcome	Content	Suggested assessment methods
	4.7.2 Filling maintenance check sheets 4.7.3 Generation of maintenance reports 4.8 Project: Diagnose and replace SCADA faulty part.	

Suggested delivery methods

- Group discussions
- Demonstration by trainer
- Online videos
- Power point presentation

Recommended resources for 25 trainees

S/No.	Category/item	Description/specifications	Quantity	Recommended ratio (item: trainee)
A	**Tools**			
1.	Multipurpose network cable tester	For testing cables	10 pcs	2:5
2.	Ethernet crimping tool	For crimping jacks	25 pcs	1:1
3.	Soldering gun	For soldering components	25 pcs	1:1
4.	Breadboard	For experimenting electronic components	25 pcs	1:1
5.	Variable power supplies	For powering up circuits	5 pcs	1:5

6.	Oscilloscope	For waves analysis	5 pcs	1:5
7.	Greasing guns/pumps	For greasing joints and bearings	5 pcs	1:5
8.	Assorted screw drivers	Flat and star-assorted sizes. For fastening screws	adequate	
9.	Pliers	For gripping	25 pcs	1:1
10.	Bearing extraction tools	For removing bearings	5 pcs	1:5
11.	Spanners	Assorted sizes for fastening nuts.	adequate	
12.	Allen keys,	Assorted sizes for hexagonal bolts and nuts	adequate	
13.	Multi-meters	For measuring electrical quantities.	5 pcs	1:5
14.	Pipe wrenches	For tightening bolts and nuts in various sizes	5 pcs	1:5
15.	Tape measures	For linear measurements	10 pcs	2:5
16.	portable drilling machines	For drilling holes	10 pcs	2:5
17.	Square	For right angle measurement	25 pcs	1:1
18.	Scribers	For marking out	10 pcs	2:5
19.	Centre punches	For holes piloting	10 pcs	2:5
20.	Files	For filing materials	25 pcs	1:1
21.	Taps and dies	For creating threads	5 pcs	1:5
22.	Vernier calipers	For internal and external measurement	10 pcs	2:5
23.	Micrometer screw gauge	For internal and external measurement	10 pcs	2:5

24.	Assorted gauges	Measuring different objects with different dimensions	10 pcs	2:5
25.	Signal generator	For generating repeating and non-repeating waveforms	5 pcs	1:5
26.	Continuity testers	For cable continuity testing	5 pcs	1:5
27.	Phone line tester	For line fault diagnosis	5 pcs	1:5
28.	SCADA cables and wires	For SCADA networking	sufficient	
B	**Materials and supplies**			
29.	Whiteboard Markers	For writing on whiteboards during instruction	adequate	
30.	PCB boards	For circuit assembly and testing	10 pcs	2:5
31.	Bolts, nuts, and washers	For securing components	adequate	
32.	Fasteners	Used in fastening	5 pcs	1:5
33.	Breadboards	For prototype circuit assembly	10 pcs	2:5
34.	Trunking	For cable management	adequate	
C	**Equipment**			
35.	Projectors	For visual presentations	1	1:25
36.	Actuators	For demonstrating movement control	10 pcs	2:5
37.	PLC modules	For programmable logic control setups	10 pcs	2:5
38.	HMI	For human machine interface	10 pcs	2:5

39.	RTUs	For connecting hardware to a SCADA system	10 pcs	2:5
D	**Reference materials**			
40.	SCADA maintenance manuals/handbooks	Manuals for reference on SCADA maintenance	adequate	
41.	Health and safety manuals	For workplace safety instructions	adequate	
42.	SCADA operation manuals	Comprehensive guides on SCADA systems	adequate	
43.	Periphery equipment maintenance manuals	Comprehensive guides on periphery systems	adequate	
44.	Relevant SCADA textbooks	For referencing	adequate	
45.	Relevant journals and websites	For referencing	adequate	
E	**Software**			
46.	SCADA software	For programming SCADA	1 license (distributable)	
47.	PLC software	For programming PLC	1 license (distributable)	
F	**Trainee Requirements**			
48.	Computing devices	Desktops, laptops, or tablets for individual use	25 pcs	1:1
49.	Personal protective equipment (PPEs):	Overalls /dust coats, safety shoes, ear muffs, safety	25 sets	1:1

		goggles, nose masks, helmets, welding ray protection shields		

MODULE VI

ENGINEERING MECHANICS

ISCED UNIT CODE: 0715 541 07A

TVETCDACC UNIT CODE: ENG/CU/IMT/CC/05/6/MA

Relationship to occupational standards: apply engineering mechanics

Duration of unit: 150 Hours

Unit description

This unit of competency describes the competences required in order to apply engineering mechanics principles. This includes: applying forces and moments, friction principles, kinematics of motion, mechanical work-energy theorem, kinetics of motion, law of machines, determining loading conditions, applying simple mechanisms, designing belts, ropes and chain drives, designing toothed gears and gear trains, designing mechanical rotor dynamic machines, applying stress and strain concepts, applying simple bending theory, and torsion theory in mechanical systems.

Summary of learning outcomes

By the end of this unit, trainees should be able to:

S/No.	Learning outcomes	Duration (Hrs)
1	Apply forces and moments in a mechanical system	10
2	Apply friction principles in mechanical systems	10
3	Apply kinematics of motion in mechanical systems	10
4	Apply mechanical work-energy theorem	10
5	Apply kinetics of motion in mechanical systems	10
6	Apply law of machines	10
7	Determine loading conditions in mechanical systems	10
8	Apply simple mechanisms	10
9	Design belts, ropes and chain drives	20
10	Design toothed gears and gear trains	10

11	Design mechanical rotor dynamic machines	10
12	Apply stress and strain concepts in mechanical systems	10
12	Apply simple bending theory in mechanical systems	10
14	Apply torsion theory in mechanical systems	10
	TOTAL	**150**

Learning outcomes, content and suggested assessment methods

Learning outcome	**Content**	**Suggested assessment methods**
1. Apply forces and moments in a mechanical system	1.1 Force 1.1.1 Definition 1.1.2 Types 1.1.2.1 Tensional 1.1.2.2 Compressional 1.1.2.3 Shear 1.1.3 Applications 1.2 Moments 1.2.1 Definition 1.2.2 Types 1.2.2.1 Bending moments 1.2.3 Applications	• Written Tests
2. Apply friction principles in mechanical systems	2.1 Friction 2.1.1 Static 2.1.2 Dynamic 2.1.2.1 Rolling friction 2.1.2.2 Sliding friction 2.2 Coefficient of friction 2.3 Limiting friction	• Written tests

	2.4 Laws of friction 2.5 Factors affecting friction 2.6 Advantages and disadvantages of friction 2.7 Applications of friction 2.8 Lubrication 2.8.1 Types of lubricants 2.8.2 Advantages of lubricants 2.9 Analysis of Friction 2.9.1 Friction on a horizontal plane 2.9.2 Friction on an inclined plane 2.10 Applications of friction in engineering 2.10.1 Tyre traction 2.10.2 Braking systems 2.10.3 Bearing and bushings 2.10.4 Grinding of tools 2.10.5 Transmission systems 2.11 Coolants and cutting fluids 2.11.1 Categories and types 2.11.2 Functions 2.11.3 Properties of an ideal cutting fluid	
3. Apply kinematics of motion in mechanical systems	3.1 Introduction to kinematics of motion 3.1.1 Definition of kinematics 3.1.2 Linear and angular motion 3.1.2.1 Linear and angular displacement 3.1.2.2 Linear and angular velocity 3.1.2.3 Linear and angular acceleration	• Written Tests

	3.1.2.4 Relative velocity 3.1.3 Applications of kinematics of motion in mechanical systems 3.1.3.1 Cam and follower systems 3.1.3.2 Piston and engine mechanisms 3.1.3.3 Elevators and escalators 3.2 Structural supports 3.2.1 Load analysis 3.2.2 Material selection for structural supports 3.2.3 Structural support components 3.2.4 Deflection and stiffness requirements for structural supports 3.3 Displacement/time graphs 3.3.1 Body moving with uniform velocity 3.3.2 Body moving with varied velocity	
4. Apply mechanical work-energy theorem	4.1 Work 4.1.1 Definition 4.1.2 Calculations of work done 4.2 Energy 4.2.1 Definition 4.2.2 Calculations of energy requirements and efficiency 4.3 Power	• Written tests

	4.3.1 Definition 4.3.2 Calculations of power	
5. Apply kinetics of motion in mechanical systems	5.1 Definition of KINETICS 5.2 Newtons laws of motion 5.2.1 First law 5.2.2 Second law 5.2.3 Third law 5.3 Applications of kinetics in mechanical systems 5.4 Structural Supports 5.4.1 Definition and types of structural supports 5.4.2 Forces acting on structural supports 5.4.3 Loads and reactions in structural supports 5.4.4 Stress and strain in structural supports 5.4.5 Designing structural supports for motion 5.5 Kinetic linkages 5.5.1 Definition and types 5.5.2 Factors in selecting kinematic linkages	• Written tests
6. Apply law of machines	6.1 Simple machines 6.1.1 Definition 6.1.2 Working principles and applications 6.1.2.1 Lever 6.1.2.2 Wedge 6.1.2.3 Inclined plane 6.1.2.4 Pulley	• Written Tests

	6.1.2.5 Wheel and axle 6.1.2.6 Screw jack 6.1.3 Simple machine analysis 6.1.3.1 Load and load distance 6.1.3.2 Effort and effort distance 6.1.3.3 Ideal load and effort 6.1.3.4 Mechanical advantage 6.1.3.5 Velocity ratio 6.1.3.6 Efficiency 6.1.3.7 Law of machine 6.1.4 Factors affecting the efficiency of simple machines 6.2 Selection of simple machines 6.2.1 Advantages and disadvantages of each type of simple machine 6.2.2 Factors to consider when selecting a simple machine 6.3 Simple machines speed adjustment 6.3.1 Relationship between speed and mechanical advantage 6.3.2 Adjusting speed with different simple machines 6.3.3 Combining simple machines for speed and efficiency	

7. Determine loading conditions in mechanical systems	7.1 Define structure 7.2 Types of loading 7.2.1 Point load 7.2.2 Uniformly distributed load 7.2.3 Varying load 7.3 Types of beams 7.3.1 Simply supported beams 7.3.2 Cantilever beam 7.3.3 Overhanging beam	Written tests
8. Apply simple mechanisms	8.1 Define simple mechanism 8.2 Components of simple mechanism 8.2.1 Link 8.2.2 Element 8.3 Types of mechanisms 8.3.1 Single slider mechanism 8.3.2 Double slider mechanism	• Written tests
9. Design belts, ropes and chain drives	9.1 Definition 9.1.1 Belt 9.1.2 Rope 9.1.3 Chain 9.2 Belts 9.2.1 Material used for belt 9.2.1.1 Rubber 9.2.1.2 Cotton 9.2.1.3 Leather 9.2.2 Types of belts 9.2.2.1 Flat 9.2.2.2 V belt 9.2.2.3 Circular 9.2.3 Configuration of belt drive 9.2.3.1 Open 9.2.3.2 Crossed	• Written tests

		9.2.4 Design analysis of flat and V-Belts 9.2.4.1 Velocity ratio 9.2.4.2 Length of belt 9.2.4.3 Angle of contact 9.2.4.4 Power transmitted 9.3 Rope drives 9.3.1 Types of rope drives 9.4 Chain drives 9.4.1 Types of chain drives	
10	Design toothed gears and gear trains	10.1Types of gears 10.1.1 Spur 10.1.2 Helical 10.1.3 Double helical 10.2Types of gear trains 10.2.1 Simple gear train 10.2.1.1 Design calculations 10.2.2 Compound gear train 10.2.2.1 Design calculations 10.2.3 Reverted gear train 10.2.3.1 Design calculations 10.2.4 Epicyclic gear train 10.3Lubrication of gears	• Written tests
11	Design mechanical rotor dynamic machines	11.1Types of pumps and operation principle 11.1.1 Reciprocating pump 11.1.2 Centrifugal pump 11.2Derivation of equations for 11.2.1 Reciprocating pumps	• Written tests

	11.2.2 Centrifugal pumps 11.3Analysis of pumps 11.3.1 Discharge 11.3.2 Efficiency 11.3.3 Power 11.3.4 Head 11.3.5 Weight per unit 11.4Types and operation principle of rotary compressors 11.4.1 Rotary screw compressors 11.4.2 Rotary vane compressors 11.4.3 Scroll compressor 11.4.4 Rotary lobe 11.5Analysis of compressors 11.5.1 Inlet and outlet flow 11.5.2 Work done 11.5.3 Mass flow rate 11.5.4 Power requirement 11.5.5 Efficiency 11.6Compressor fans and vanes 11.6.1 Structure and functions of compressor fans and vanes 11.6.2 Operation principles of fans and vanes in rotary compressors 11.6.3 Maintenance of fans and vanes 11.7Design analysis 11.7.1 Vane efficiency 11.7.2 Fan efficiency 11.7.3 Power consumption	

12	Apply stress and strain concepts in mechanical systems	12.1Define stress and strain 12.2Types of simple stresses 12.2.1 Direct 12.2.2 Shear 12.2.3 Ultimate tensile stress 12.2.4 Yield stress 12.2.5 Breaking stress 12.2.6 True stress 12.3Analysing stress on 12.3.1 Beams 12.3.2 Thin cylinders 12.3.3 Thin shells 12.4Applications of stress and strain concepts 12.4.1 Bolts and nuts 12.4.2 Shafts	• Written tests
13	Apply simple bending theory in mechanical systems	13.1Engineers bending equation 13.2Types of Beams 13.2.1 Simply supported beams 13.2.2 Cantilever beam 13.2.3 Overhanging beam 13.3Analysis of beams 13.3.1 T-section 13.3.2 L-section 13.3.3 I-section 13.4Types of shafts 13.4.1 Solid 13.4.2 Tubular 13.4.3 stepped 13.5Analysis of shafts 13.5.1 Solid 13.5.2 Tubular	• Written tests

		13.5.3 Stepped	
14	Apply torsion theory in mechanical systems	1.1 Define torsion 1.2 Torque analysis 1.3 Analysis of shafts 1.3.1 Series arranged shafts 1.3.2 Parallel arranged shafts 1.4 Determine angle of twist 1.4.1 Engineers' torsion equation	• Written tests

Suggested delivery methods

- Group discussions
- Demonstration by the trainer
- Online video clips
- Power point presentation

Recommended resources for 30 trainees

S/No.	Category/item	Description/specifications	Quantity	Recommended ratio (item: trainee)
A	**Learning materials**			
1.	Textbooks	Comprehensive textbooks on Engineering mechanics principles	30	1:1
2.	Graph books	For graphical representation of solutions	30	1:1
3.	Projector	Functional projector for displaying content during presentations	1	1:30
4.	Computer	Functional desktop computer with online instructional content	1	1:30

5.	White board	Quality whiteboard of approximately 6 ft by 3 ft for writing during theory instruction	1	1:30
6.	Printer	An ink-jet, laser-jet or toner-cartridge printer for printing notes, instructions and working drawings	1	1:30
B	**Learning facilities & infrastructure**			
7.	Lecture/theory room	Spacious room with seats for 25 trainees, approximately 60 sqm	1	1:30
C	**Materials and supplies**			
8.	First aid kit	Fully equipped first aid kit for use in case of accidents	1	1:30
D	**Tools and equipment**			
9.	Calculators	For calculations	30	1:1
10.	Firefighting extinguishers	Water, carbon dioxide and chemical powder fire extinguishers for fire fighting	1	1:30
F	**Reference materials**			
11.	Training Presentations/Slides	Digital format for shared access among trainees	1	1:30

ELECTRICAL MACHINES AND MECHANICAL DRIVES INSTALLATION

ISCED UNIT CODE: 0715 551 17A

TVETCDACC UNIT CODE: ENG/CU/IMT/CR/08/6/MA

Relationship to occupational standards

This unit addresses the unit of competency: Install electrical machines and mechanical drives installation.

Duration of unit: 220 Hours

Unit description

This unit covers the competencies required in installation and maintenance of electrical machines and mechanical drives. The competencies covered include: analyzing electrical machines, installing electrical machines, maintaining electrical machines, analyzing mechanical drives, assembling mechanical drives, and maintaining mechanical drives.

Summary of learning outcomes

By the end of unit of learning, the trainee will be able to;

S/No.	Learning outcomes	Duration (Hrs)
1	Analyse electrical machines	30
2	Install electrical machines	40
3	Maintain electrical machines.	40
4	Analyse mechanical drives	40
5	Assemble mechanical drives	40
6	Maintain mechanical drives	30
	TOTAL	**220**

Learning outcomes, content and suggested assessment methods

Learning outcome	Content	Suggested assessment methods
1. Analyse electrical machines	1.1 Electrical principles application 1.1.1 Ohm's law and its applications 1.1.2 Kirchhoff's laws in circuit analysis 1.1.3 Fundamentals of electromagnetism in motor function 1.1.4 Electrostatics principles in machine design 1.2 Electrical machines 1.2.1 Introduction to AC and DC motors 1.2.2 Characteristics of special motors 1.2.3 Transformers and their applications 1.2.4 Distinctions between AC and DC generators 1.3 Sizing electrical machines 1.3.1 Machine capacity load requirements 1.3.2 Power rating and efficiency considerations 1.3.3 Calculation of load demands for specific applications 1.4 Power requirements identification 1.4.1 Assessment of voltage and current needs	• Project • Practical • Third party report • Portfolio of evidence • Written tests • Oral questioning

Learning outcome	Content	Suggested assessment methods
	1.4.2 Power factor and energy efficiency 1.4.3 Backup power requirements for machines 1.5 Electrical machine analysis reporting 1.5.1 Documentation of analysed results 1.5.2 Standard reporting procedures in workplace documentation	
2. Install electrical machines	2.1 Personal protective equipment (PPE) 2.1.1 Types of PPE for electrical installation 2.1.2 Safety protocols and regulations 2.2 Installation tools and equipment 2.2.1 Hand tools: 2.2.1.1 Pliers 2.2.1.2 Hammer 2.2.1.3 Spanners 2.2.1.4 Wire stripper 2.2.1.5 Crimping tool 2.2.1.6 Allen keys 2.2.1.7 Screw drivers 2.2.1.8 Multimeters 2.2.2 Specialized equipment: 2.2.2.1 Lifting gear	• Project • Practical • Third party report • Portfolio of evidence • Written tests • Oral questioning

Learning outcome	Content	Suggested assessment methods
	2.2.2.2 Scaffold 2.2.2.3 Motors 2.2.2.4 Transformers 2.2.2.5 Generators 2.2.2.6 Compressors 2.2.2.7 Pumps 2.3 Electrical machines mounting 2.3.1 Interpretation of design specifications 2.3.2 Mounting methods for different Types of machines 2.3.3 Safety considerations during mounting 2.4 Termination and connection of electrical machines 2.4.1 Wire termination techniques and standards 2.4.2 Component coupling and alignment 2.4.3 Safety checks before powering machines 2.5 Electrical machines testing 2.5.1 Functionality tests 2.5.2 Electrical tests 2.5.3 Endurance tests 2.5.4 Speed tests	
3. Maintain electrical machines	3.1 Maintenance schedule preparation 3.1.1 Routine and preventative maintenance schedules	• Project • Practical

Learning outcome	Content	Suggested assessment methods
	3.1.2 Documentation and tracking of maintenance tasks 3.2 PPE for maintenance 3.2.1 PPE requirements specific to maintenance tasks 3.2.2 Hazard prevention during maintenance 3.3 Maintenance tools, equipment, and spares 3.3.1 Tools 3.3.1.1 Pliers 3.3.1.2 Hammer 3.3.1.3 Spanners 3.3.1.4 Wire stripper 3.3.1.5 Crimping tool 3.3.1.6 Allen keys 3.3.1.7 Screw drivers 3.3.1.8 Multimeters 3.3.2 Equipment 3.3.2.1 Lifting gear 3.3.2.2 PPE 3.3.2.3 Spares 3.3.2.4 Motors 3.3.2.5 Motor parts 3.3.2.6 Bearings 3.3.2.7 Generators 3.3.2.8 Cables 3.4 Maintenance tasks	• Third party report • Portfolio of evidence • Written tests • Oral questioning

Learning outcome	Content	Suggested assessment methods
	3.4.1 Inspection 3.4.2 Testing and measurements 3.4.3 Cleaning 3.4.4 Lubrication 3.4.5 Tightening 3.4.6 Replacing consumables 3.5 Maintenance reporting 3.5.1 Maintenance records 3.5.2 Workplace documentation standards	
4. Analyse mechanical drives	4.1 Mechanical drives 4.1.1 Types of mechanical drives 4.1.1.1 Pulleys 4.1.1.2 Gears 4.1.1.3 Belts 4.1.1.4 Chains 4.1.1.5 Conveyers 4.1.2 Application and function of each drive type 4.2 Sizing mechanical drives 4.2.1 Determination of sizing based on power requirements 4.2.2 Load and torque calculations 4.3 Mechanical drive analysis reporting 4.3.1 Analysis and documentation	• Project • Practical • Third party report • Portfolio of evidence • Written tests • Oral questioning

Learning outcome	Content	Suggested assessment methods
	4.3.2 Workplace report standards	
5. Assemble mechanical drives	5.1 PPE for assembly 5.1.1 PPE for assembling mechanical components 5.1.2 Safety protocols for mechanical assembly tasks 5.2 Tools and equipment 5.2.1 Tools: hand tools, alignment lasers, pullers 5.2.2 Equipment: lifting and climbing gear 5.3 Mechanical drives assembly 5.3.1 Assembly procedures based on design specs 5.3.2 Precision alignment and fitting of components 5.4 Mechanical drive tests 5.4.1 Alignment 5.4.2 Functionality test 5.4.3 Load test and vibration tests	• Project • Practical • Third party report • Portfolio of evidence • Written tests • Oral questioning
6. Maintain mechanical drives	6.1 Maintenance schedule preparation 6.1.1 Schedules for routine drive maintenance 6.1.2 Task scheduling 6.2 PPE for maintenance 6.2.1 PPE requirements for drive maintenance tasks	• Project • Practical • Third party report • Portfolio of evidence

Learning outcome	Content	Suggested assessment methods
	6.2.2 Safety standards 6.3 Maintenance tools, equipment, and spares 6.3.1 Tools 6.3.1.1 Hand tools 6.3.1.1.1 Alignment laser 6.3.1.1.2 Cleaning tools 6.3.2 Equipment 6.3.2.1 Pullers 6.3.2.2 Lifting gear 6.3.2.3 Climbing gear 6.3.3 Spares 6.3.3.1 Chains 6.3.3.2 Sprocket 6.3.3.3 Belts 6.3.3.4 Fasteners 6.3.3.5 Gears 6.3.3.6 Pulleys 6.4 Maintenance Tasks 6.4.1 Inspection 6.4.2 Cleaning 6.4.3 Tightening procedures 6.4.4 Lubrication, 6.4.5 Replacement of worn parts, and testing 6.5 Maintenance reporting 6.5.1 Maintenance reports 6.5.2 Findings and future recommendations	• Written tests • Oral questioning

Suggested delivery methods

- Practical
- Project
- Direct instruction method
- Group discussions

Recommended resources for 25 trainees

S/No.	Category/item	Description/specifications	Quantity	Recommended ratio (item: trainee)
A	**Tools**			
1.	Screwdriver sets	assorted screw types	2 sets	2:25
2.	Wrench Sets	For tightening bolts and nuts in various sizes	2 sets	2:25
3.	Pliers Sets	For gripping and cutting wires and components	2 sets	2:25
4.	Clamps	For holding components securely during assembly	13 pcs	13:25
5.	Allen Key Sets	Assorted	2 sets	2:25
6.	Digital Multi-meters	For measuring voltage, current, and resistance	5 pcs	1:5
7.	Digital Tachometers	For measuring rotational speed of motors	5 pcs	1:5
B	**Materials and supplies**			
8.	Whiteboard Markers	For writing on whiteboards during instruction	Adequate	
9.	PCB Boards	For circuit assembly and testing	10 pcs	2:5

10.	Switches	Mechanical and electronic types for circuit control	10 pcs	2:5
11.	Fasteners	Used in fastening	Adequate	
12.	Bearings, Gears, and Rollers	Components for rotational systems	5 sets	1:5
13.	Assorted electric cables and conductors	For electrical connections	Adequate	
14.	Breadboards	For prototype circuit assembly	10 pcs	2:5
15.	Trunking	For cable management	Adequate	
16.	Fuses	For protecting circuits	Adequate	
17.	Electrical Accessories	Connectors, sockets, and other components	Adequate	
18.	Oils and lubricants	For machinery maintenance	Adequate	
19.	Oil seals and gaskets	For sealing components	5 pcs	1:5
20.	Drive belts	For power transmission in machinery	Adequate	
21.	Variable speed/frequency drives	For motor control	1 pc	1:25
C	**Equipment**			
22.	Projectors	For visual presentations	1	1:25
23.	Whiteboards	For writing instructional content	1	1:25
24.	Hand drilling machine	Various types for assembly and installation	5 pcs	1:5
25.	Servomechanisms	For automation and control demonstrations	5 pcs	1:5

26.	Compressor systems	For pneumatic operations	1 pc	1:25
27.	Gyroscopes	For rotational motion study	5 pcs	1:5
28.	Dynamometers	For measuring torque and rotational force	5 pcs	1:5
29.	Magnetic drums	For magnetic field and storage studies	5 pcs	1:5
30.	Drives brakes	For studying braking mechanisms	5 pcs	1:5
31.	Control linkage	For demonstrating mechanical linkages	5 pcs	1:5
32.	Actuators	For demonstrating movement control	Adequate	
D	**Equipment**			
33.	AC/DC electronics training modules	Training modules for AC/DC electronics	1 pc	1:25
34.	AC/DC machines control modules	Modules for controlling AC/DC machines	1 pc	1:25
E	**Reference Materials**			
35.	Component and equipment manuals	Manuals for component use and specifications	Adequate	
36.	Health and safety manuals	For workplace safety instructions	Adequate	
37.	Electromechanical reference books	Comprehensive guides on electromechanical systems	Adequate	
F	**Software**			
38.	Electrical circuit design software	For designing electrical circuits	1 license	
39.	AUTOCAD	For creating and modifying digital schematics	1 license	
G	**Trainee requirements**			

40.	Computing devices	Desktops, laptops, or tablets for individual use	25 pcs	1:1
41.	Protective clothing	Dust coats, gloves, safety boots, goggles	25 sets	1:1

DIGITAL LITERACY

ISCED UNIT CODE: 0611 551 01A

TVETCDACC UNIT CODE: ENG/CU/IMT/BC/01/6/MA

Relationship with occupational standards

This unit addresses the unit of competency: Apply digital literacy

Duration of unit: 40 Hours

Unit description

This unit covers the competencies required to demonstrate digital literacy. It involves operating computer devices, solving tasks using the office suite, managing data and information, performing online communication and collaboration, applying cybersecurity skills, performing jobs online, and applying job entry techniques.

Summary of learning outcomes

By the end of the unit of learning, the trainee will be able to;

S/No.	Learning outcome	Duration (Hrs)
1	Operate computer devices	6
2	Solve tasks using office suite	14
3	Manage data and information	6
4	Perform online communication and collaborations	4
5	Apply cybersecurity skills	4
6	Perform online jobs	4
7	Apply job entry techniques	2
	TOTAL HOURS	**40**

Learning outcomes, content, and suggested assessment methods

Learning outcome	Content	Suggested assessment methods
1. Operate computer devices	1.1 Meaning and importance of digital literacy 1.2 Functions and uses of computers 1.3 Classification of computers 1.4 Components of a computer system 1.5 Computer hardware 1.5.1 The system unit e.g. motherboard, CPU, casing 1.5.2 Input devices e.g. pointing, keying, scanning, voice/speech recognition, direct data capture devices. 1.5.3 Output devices e.g. hardcopy output and softcopy output 1.5.4 Storage devices e.g. main memory e.g. RAM, secondary storage (Solid state devices, hard drives, CDs & DVDs, memory cards, flash drives	• Observation • Written assessment • Oral assessment • Practical assessment

Learning outcome	Content	Suggested assessment methods
	1.5.5 Computer ports e.g. HDMI, DVI, VGA, USB type C etc. 1.6 Classification of computer software 1.7 Operating system functions 1.8 Procedure for turning/off a computer 1.9 Mouse use techniques 1.10 Keyboard parts and use techniques 1.11 Desktop customization 1.12 File and files management using an operating system 1.13 Computer internet connection options 1.13.1 Mobile Networks/data plans 1.13.2 Wireless hotspots 1.13.3 Cabled (Ethernet/Fiber) 1.13.4 Dial-Up 1.13.5 Satellite 1.14 Computer external devices management 1.14.1 Device connections 1.14.2 Device controls	

Learning outcome	Content	Suggested assessment methods
	(volume controls and display properties)	
2. Solve tasks using office suite	2.1 Meaning and importance of word processing 2.2 Examples of word processors 2.3 Working with word documents 2.3.1 Open and close word processor 2.3.2 Create a new document 2.3.3 Save a document 2.3.4 Switch between open documents 2.4 Enhancing productivity 2.4.1 Set basic options/preferences 2.4.2 Help resources 2.4.3 Using magnification/zoom tools 2.4.4 Display, hide built-in tool bar 2.4.5 Using navigation tools	• Observation • Portfolio of Evidence • Project • Written assessment • Practical assessment • Oral assessment

Learning outcome	Content	Suggested assessment methods
	2.5 Typing text 2.6 Document editing (copy, cut, paste commands, spelling and grammar check) 2.7 Document formatting 2.7.1 Formatting text 2.7.2 Formatting paragraph 2.7.3 Formatting styles 2.7.4 Alignment 2.7.5 Creating tables 2.7.6 Formatting tables 2.8 Graphical objects 2.8.1 Insert object (picture, drawn object) 2.8.2 Select an object 2.8.3 Edit an object 2.8.4 Format an object 2.9 Document print setup 2.9.1 Page layout, 2.9.2 Margins set up 2.9.3 Orientation. 2.10 Word document printing 2.11 Meaning & importance of electronic spreadsheets 2.12 Components of	

Learning outcome	Content	Suggested assessment methods
	spreadsheets 2.13 Application areas of spreadsheets 2.14 Using spreadsheet application 2.14.1 Parts of excel screen: ribbon, formula bar, active cell, name box, column letter,row number, quick access toolbar. 2.14.2 Cell data types 2.14.3 Block operations 2.14.4 Arithmetic operators (formula bar (-, +, *, /). 2.14.5 Cell referencing 2.15 Data manipulation 2.15.1 Using functions (Sum, average, sumif, count, max, max, if, rank, product, mode etc) 2.15.2 Using formulae 2.15.3 Sorting data 2.15.4 Filtering data	

Learning outcome	Content	Suggested assessment methods
	2.15.5 Visual representation using charts 2.16 Worksheet printing 2.17 Electronic presentations 2.18 Meaning and importance of electronic presentations 2.19 Examples of presentation software 2.20 Using the electronic presentation application 2.20.1 Parts of the powerpoint screen (slide navigation pane, slide pane, notes, the ribbon, quick access toolbar, and scroll bars). 2.20.2 Open and close presentations 2.20.3 Creating slides (insert new slides, duplicate, or reuse slides.) 2.20.4 Text management (insert, delete, copy, cut and paste, drag and	

Learning outcome	Content	Suggested assessment methods
	drop, format, and use spell check). 2.20.5 Using magnification/zoom tools 2.20.6 Apply or change a theme. 2.20.7 Saving a presentation 2.20.8 Switching between open presentations 2.21 Developing a presentation 2.21.1 Presentation views 2.21.2 Slides 2.21.3 Master slide 2.22 Text 2.22.1 Editing text 2.22.2 Formatting 2.22.3 Tables 2.23 Charts 2.23.1 Using charts 2.23.2 Organization charts 2.24 Graphical objects 2.24.1 Insert, manipulate 2.24.2 Drawings 2.25 Prepare outputs	

Learning outcome	Content	Suggested assessment methods
	2.25.1 Applying slide effects and transitions 2.25.2 Check and deliver 2.25.2.1 Spell check a presentation 2.25.2.2 Slide orientation 2.25.2.3 Slide shows, navigation 2.26 Print presentations (slides and handouts)	
3. Manage data and information	3.1 Meaning of data and information 3.2 Importance and uses of data and information 3.3 Types of internet services 3.3.1 Communication Services 3.3.2 Information retrieval services 3.3.3 File transfer 3.3.4 World wide web services 3.3.5 Web services 3.3.6 Automatic network	• Observation • Portfolio of Evidence • Project • Written assessment • Practical assessment • Oral assessment

Learning outcome	Content	Suggested assessment methods
	address configuration 3.3.7 News group 3.3.8 Ecommerce 3.4 Types of internet access applications 3.5 Web browsing concepts 3.5.1 Key concepts 3.5.2 Security and safety 3.6 Web browsing 3.6.1 Using the web browser 3.6.2 Tools and settings 3.6.3 Clearing cache and cookies 3.6.4 URIs 3.6.5 Bookmarks 3.6.6 Web outputs 3.7 Web based information 3.7.1 Search 3.7.2 Critical evaluation of information 3.7.3 Copyright, data protection 3.8 Downloads management 3.9 Performing digital data backup (Online and offline) 3.10 Emerging issues in	

Learning outcome	Content	Suggested assessment methods
	internet	
4. Perform online communication and collaboration	4.1 Netiquette principles 4.2 Communication concepts 4.2.1 Online communities 4.2.2 Communication tools 4.2.3 Email concepts 4.3 Using email 4.3.1 Sending email 4.3.2 Receiving email 4.3.3 Tools and settings 4.3.4 Organizing email 4.4 Digital content copyright and licenses 4.5 Online collaboration tools 4.5.1 Online Storage (Google Drive) 4.5.2 Online productivity applications (google docs & forms) 4.5.3 Online meetings (google meet/zoom) 4.5.4 Online learning environments 4.5.5 Online calendars (google calendars) 4.5.6 Social networks (facebook/twitter - settings & privacy)	• Observation • Portfolio of Evidence • Project • Written assessment • Practical assessment • Oral assessment

Learning outcome	Content	Suggested assessment methods
	4.6 Preparation for online collaboration 4.6.1 Common setup features 4.6.2 Setup 4.7 Mobile collaboration 4.7.1 Key concepts 4.7.2 Using mobile devices 4.7.3 Applications 4.7.4 Synchronization	
5. Apply cybersecurity skills	5.1 Data protection and privacy 5.1.1 Confidentiality of data/information 5.1.2 Integrity of data/information 5.1.3 Availability of data/information 5.2 Internet security threats 5.2.1 Malware attacks 5.2.2 Social engineering attacks 5.2.3 Distributed denial of service (DDoS) 5.2.4 Man-in-the-middle attack (MitM) 5.2.5 Password attacks 5.2.6 IoT attacks 5.2.7 Phishing attacks	• Observation • Portfolio of Evidence • Project • Written assessment • Practical assessment • Oral assessment

Learning outcome	Content	Suggested assessment methods
	5.2.8 Ransomware 5.3 Computer threats and crimes 5.4 Cybersecurity control measures 5.4.1 Physical controls 5.4.2 Technical/logical controls (passwords,PINs, biometrics) 5.4.3 Operational controls 5.5 Laws governing protection of ICT in Kenya 5.5.1 The Computer Misuse and Cybercrimes Act No. 5 of 2018 5.5.2 The data protection Act No. 24 Of 2019	
6. Perform online Jobs	6.1 Introduction to online working 6.2 Types of online jobs 6.3 Online job platforms 6.3.1 Remotask 6.3.2 Data annotation tech 6.3.3 Cloud worker	• Observation • Portfolio of Evidence • Project • Written assessment • Practical assessment • Oral assessment

Learning outcome	Content	Suggested assessment methods
	6.3.4 Upwork 6.3.5 Oneforma 6.3.6 Appen 6.4 Online account and profile management 6.5 Identifying online jobs/job bidding 6.6 Online digital identity 6.7 Executing online tasks 6.8 Management of online payment accounts.	
7. Apply job entry techniques	7.1 Types of job opportunities 7.1.1 Self-employment 7.1.2 Service provision 7.1.3 product development 7.1.4 salaried employment 7.1.4.1 Sources of job opportunities 7.2 Resume/ curriculum vitae 7.2.1 What is a CV 7.2.2 How long should a CV be 7.2.3 What to include in a CV 7.2.4 Format of CV	• Observation • Oral assessment • Portfolio of evidence • Third party report • Written assessment

Learning outcome	Content	Suggested assessment methods
	7.2.5 How to write a good CV 7.2.6 Don’ts of writing a CV 7.3 Job application letter 7.3.1 What to include 7.3.2 Addressing a cover letter 7.3.3 Signing off a cover letter 7.4 Portfolio of evidence 7.4.1 Academic credentials 7.4.2 Letters of commendations 7.4.3 Certification of participations 7.4.4 Awards and decorations 7.5 Interview skills 7.5.1 Listening skills 7.5.2 Grooming 7.5.3 Language command 7.5.4 Articulation of issues 7.5.5 Body language 7.5.6 Time management	

Learning outcome	Content	Suggested assessment methods
	7.5.7 Honesty 7.6 Generally knowledgeable in current affairs and technical area	

Suggested Methods Instruction

- Instructor-led facilitation using active learning strategies
- Demonstration by trainer
- Viewing of related videos
- Group discussions
- Role play
- Case study

Recommended resources for 30 trainees

S/No.	Category/Item	Description/specifications	Quantity	Recommended ratio (Item: trainee)
A	**Learning materials**			
1.	Textbooks	Comprehensive texts books on digital literacy	5 pcs	1:6
2.	Installation manuals	Detailed guides for equipment and software installation and troubleshooting	5 pcs	1:6
3.	Powerpoint presentations	For trainer's use, covering course content and practical applications	1	1:30
4.	Projector	Functional projector for displaying content during presentations	1	1:30

5.	White board	Quality whiteboard of approximately 6 ft by 3 ft for writing during theory instruction	1	1:30
6.	Printer	An ink-jet, laser-jet or toner-cartridge printer for printing notes, instructions and working drawings	1	1:30
7.	Templates	Templates for creating various documents e.g. CV, Cover Letter, etc.	30	1:1
B	**Learning Facilities & Infrastructure**			
8.	Lecture/theory room /learning resource Area	Spacious, equipped with projectors and Seats for 30 trainees, approximately 45 sqm (5 m x 9 m)	1	1:30
9.	Computer laboratory	Equipped with at least 30 functional computers with internet connectivity and the following software: • Windows/ linux/ macintosh operating system • Microsoft office software • Google workspace account • Antivirus software	1	1:30
C	**Consumable materials**			
10.	Printing papers	A4 and A3 printing papers suitable for the task	adequate	

11.	Whiteboard marker pens	Dry-erase markers for trainers use. Assorted colors	adequate	
12.	Storage devices	Any of the following storage devices: • USB flash drive • USB hard drive • Compact disks (CDs) • Digital versatile disks (DVDs)	adequate	

MODULE VII

FABRICATION MACHINERY OPERATION

ISCED UNIT CODE: 0715 551 18A

TVETCDACC UNIT CODE: ENG/CU/IMT/CR/09/6/MA

Relationship to occupational standards

This unit addresses the unit of competency: Operate fabrication machinery

Duration of unit: 300 hours.

Unit description

This unit describes the competencies required by an industrial mechatronics technician to operate a fabrication machinery and produce a part within the required safety rules and standards. In the context of the standard, the trainee is to demonstrate ability to: create part designs, perform machine configuration, and perform machining processes.

Summary of learning outcomes

By the end of the unit of learning, the trainee will be able to;

S/No.	Learning outcomes	Duration (Hrs)
1	Apply workshop safety	20
2	Apply material science principles	20
3	Apply workshop tools and equipment	20
4	Carry out metal joining processes	30
5	Perform workshop organization technique	30
6	Create part designs	60
7	Perform machine configuration	60
8	Perform machining processes	60
	TOTAL	**300**

1. Apply workshop safety
2. Apply material science principles
3. Apply workshop tools and equipment
4. Carry out metal joining processes
5. Perform workshop organization technique

6. Create part designs
7. Perform machine configuration
8. Perform machining processes

Learning outcomes, content and suggested assessment methods

Learning outcome	Content	Suggested assessment methods
1. Apply workshop safety	1.1 Workshop safety 1.1.1 Workshop safety definition 1.1.2 Types and uses of PPE's 1.2 Emergency responses steps 1.2.1 Common emergencies 1.2.1.1 Fire 1.2.1.2 Chemical spills 1.2.1.3 Injuries 1.3 Fire safety 1.3.1 Fire extinguishers types and uses 1.3.2 Flammable materials identification 1.3.3 Fire prevention 1.4 Safe handling and disposal of chemicals and materials 1.4.1 Chemical hazard identification 1.4.2 Safe handling procedure 1.4.3 Storage and labelling of chemicals 1.4.4 Chemical disposal procedures 1.4.5 Emergency response for chemical exposure 1.5 Identifying and marking hazardous zones	• Apply workshop safety

	1.5.1 Common hazardous zones 1.5.1.1 Flammable zones 1.5.1.2 High traffic zones 1.5.1.3 Electrical hazard zones 1.5.1.4 Chemical storage areas 1.6 Work area organization and maintenance 1.6.1 Setting up 1.6.2 Proper storage and labelling of tools and equipment 1.7 Workplace hazards 1.7.1 Physical hazards 1.7.1.1 Noises 1.7.1.2 Vibration 1.7.1.3 Heat 1.7.1.4 Sharp object 1.7.2 Chemical hazards 1.7.2.1 Fuels 1.7.2.2 Oils 1.7.2.3 Cleaning agents 1.7.3 Electric hazards 1.7.3.1 Live wires 1.7.3.2 Batteries 1.7.3.3 Electrical systems 1.8 Workshop accidents, causes and prevention 1.8.1 Near accident 1.8.2 Trivial accident 1.8.3 Minor accident	

	1.8.4 Serious accident 1.8.5 Fatal accident	
2. Apply material science principles	2.1 Material science principles 2.1.1 Definition 2.1.2 Importance of material science in engineering 2.2 Engineering materials classification and characteristics 2.2.1 Metals 2.2.2 Polymers 2.2.3 Ceramics 2.3 Properties of engineering materials 2.3.1 Mechanical properties 2.3.1.1 Strength 2.3.1.2 Hardness 2.3.1.3 Toughness 2.3.1.4 Malleability 2.3.1.5 Ductility 2.3.1.6 Rigidity 2.3.2 Thermal properties 2.3.2.1 Specific heat 2.3.2.2 Thermal expansion 2.3.3 Chemical properties 2.3.3.1 Corrosion resistance 2.3.4 Electrical properties 2.3.4.1 Electrical conductivity 2.3.4.2 Insulation properties	• Apply material science principles

	2.4 Material selection for engineering materials 2.4.1 Factors to consider 2.5 Material handling safety 2.5.1 Handling metals and alloys 2.5.2 Chemical and fuels 2.5.3 Safety measures for plastics and composites 2.5.4 Electrical safety and conductive materials	
3. Apply workshop tools and equipment	3.1 Tools and equipment safety and maintenance practices 3.1.1 Inspection 3.1.2 Safe handling techniques 3.2 Technical drawing interpretation 3.2.1 Purpose of assembly drawing 3.2.2 Bill of quantity 3.2.3 Assembly instructions 3.3 Workshop tools and equipment uses and maintenance 3.3.1 Measuring tools 3.3.1.1 Tape measure 3.3.1.2 Steel rule 3.3.1.3 Callipers 3.3.1.4 Micrometer gauge 3.3.1.5 Protractor 3.3.1.6 Spirit level 3.3.1.7 Dial indicator 3.3.1.8 Torque wrench	• Apply workshop tools and equipment

	3.3.2 Marking out tools 3.3.2.1 Scriber 3.3.2.2 Marking gauge 3.3.2.3 Combination square 3.3.3 Cutting tools 3.3.3.1 Hacksaw 3.3.3.2 Chisel 3.3.3.3 Files 3.3.3.4 Scissors 3.3.4 Fitting tools 3.3.4.1 Wrenches 3.3.4.2 Sockets 3.3.4.3 Pliers 3.3.4.4 Hammers 3.3.4.5 Punch 3.3.4.6 Tap and die 3.3.5 Forging tools 3.3.5.1 Anvil 3.3.5.2 Hammers 3.3.5.3 Tongs 3.3.5.4 Swage block 3.3.6 Sheet metal tools 3.3.6.1 Shears 3.3.6.2 Tin snips 3.3.6.3 Rivet gun 3.3.6.4 Vise 3.3.7 Workshop machine 3.3.7.1 Grinding machine	

	3.3.7.2 Arc welding machine 3.3.7.3 Gas welding machine 3.3.7.4 Drilling machine	
4. Carry out metal joining processes	4.1 Observation of safety 4.1.1 Safety gears 4.1.2 Machine operation manuals 4.2 Metal joining methods 4.2.1 Welding 4.2.1.1 Arc welding 4.2.1.2 Gas welding 4.2.2 Riveting 4.2.3 Fastening 4.3 Material preparation 4.3.1 Measuring 4.3.2 Marking out 4.4 Process of metal finishing 4.4.1 Grinding 4.4.2 Filing 4.4.3 Polishing	• Carry out metal joining processes
5. Apply workshop organisation techniques	5.1 Workshop layout 5.1.1 Types of workshop layout 5.1.1.1 Fixed layout 5.1.1.2 Process layout 5.1.1.3 Line layout 5.1.1.4 Operation layout 5.1.1.5 Combination/group layout 5.1.2 Safety signs 5.1.3 Emergency exits 5.2 Management inventory 5.2.1 Types of inventories	• Apply workshop organisation techniques

	5.2.2 Record keeping 5.2.3 Job card preparation 5.3 Maintenance schedules 5.3.1 Goals of maintenance schedule 5.3.1.1 Reactive 5.3.1.2 Equipment failure 5.3.1.3 Maintenance backlog 5.3.2 Types of maintenance 5.3.2.1 Preventive maintenance 5.3.2.2 Corrective maintenance 5.3.2.3 Condition based maintenance 5.3.2.4 Predictive maintenance 5.3.2.5 Break down maintenance 5.4 Housekeeping 5.4.1 Definition 5.4.2 importance of housekeeping 5.5 Housekeeping activities and their importance 5.5.1 Tool and equipment organization 5.5.2 Work area cleanliness 5.5.3 Safe handling and disposal of hazardous materials 5.5.4 Inspection and maintenance of equipment	

	5.5.5 Personal protective equipment management 5.5.6 Air and ventilation maintenance 5.5.7 Incident prevention and reporting 5.6 Housekeeping tools and equipment 5.6.1 Uses and maintenance 5.6.1.1 Brooms and brushes 5.6.1.2 Dustpans and squeegees 5.6.1.3 Vacuum cleaners 5.6.1.4 Mops and mop buckets 5.6.1.5 Waste bins and recycling containers 5.7 Housekeeping materials 5.7.1 Cleaning cloths and rags 5.7.2 Cleaning agents and solvents 5.7.3 Lubricants 5.7.4 Gloves and PPE's 5.7.5 Disposable bags and liners 5.8 Workshop waste sorting and disposal 5.8.1 Types of waste 5.8.1.1 General waste 5.8.1.2 Hazardous waste 5.8.1.3 Recyclable waste 5.8.1.4 Organic waste	

	5.8.1.5 e-waste 5.8.2 Waste sorting procedure 5.8.2.1 Designated bins for different types of waste 5.8.2.2 Sorting by material 5.8.2.3 Pre-sorting hazardous waste 5.8.3 Hazardous waste disposal 5.8.3.1 Chemical waste 5.8.3.2 Used oil and solvents 5.8.3.3 Paints and finishes	
6. Create part designs	6.1 Health and safety in part design 6.1.1 Overview of health and safety standards in the workshop 6.1.1.1 Work permits 6.1.1.2 Waste management 6.1.1.3 Electrical wiring colour coding 6.1.1.4 Danger warning signage 6.1.1.5 Barricades 6.1.1.6 High voltage signage 6.1.2 Personal protective equipment (PPE) for design processes 6.1.3 Hazard identification and risk mitigation in design stages	• Project • Practical • Third party report • Portfolio of evidence • Written tests • Oral questioning

	6.2 Part design drawings 6.2.1 Interpretation of technical drawings and blueprints 6.2.2 Symbols, terminology, and specifications in part designs 6.2.3 Sources for obtaining part design documentation and blueprints 6.3 Preparation of operation sequence plans 6.3.1 Importance of an operation sequence plan 6.3.2 Steps for creating a sequence plan aligned with part design specifications 6.3.3 Case studies: planning sequences for common fabrication parts 6.4 Creation of part designs based on specifications 6.4.1 Design specifications 6.4.1.1 Dimensions 6.4.1.2 Geometry 6.4.1.3 Surface finish 6.4.2 Design creation techniques (CAD software and manual drafting) 6.4.3 Translation of specifications into physical part designs 6.4.4 Design validation and verification processes 6.5 Precision in part design	

	6.5.1 Precision standards and tolerances in fabrication 6.5.2 Techniques for maintaining accuracy in part design 6.5.3 Tools and practices to verify design precision	
7. Perform machine configuration	7.1 Health and safety in machine configuration 7.1.1 Safety protocols specific to machine setup and configuration 7.1.2 Emergency procedures and equipment handling guidelines 7.1.3 PPE and environmental safety checks before machine setup 7.2 Tool setting on fabrication machinery 7.2.1 Tooling types and selection 7.2.2 Hands-on practice: securing tooling with accuracy and alignment 7.2.3 Challenges in tooling setup and troubleshooting methods 7.3 Preparation of materials for fabrication 7.3.1 Material selection criteria 7.3.2 Techniques for loading, securing, and positioning materials	• Project • Practical • Third party report • Portfolio of evidence • Written tests • Oral questioning

	7.3.3 Material compatibility with fabrication machines 7.4 Configuration of fabrication machine 7.4.1 Configuring machine parameters (speed, feed rate, pressure, etc.) 7.4.2 Practical exercises on machine configuration for different tasks 7.4.3 Configuration of machine operational requirements	
8. Perform machining processes	8.1 Health and safety in machining operations 8.1.1 Hazard prevention in machining operations 8.1.2 PPE and safe practices during machining 8.1.3 Risks reduction during machine operation and part handling 8.2 Executing Fabrication Machining Operations 8.2.1 Overview of conventional machining processes 8.2.1.1 Drilling 8.2.1.2 Turning 8.2.1.3 Milling 8.2.1.4 Grinding 8.2.2 Introduction to CNC (Computer Numerical Control) Machining	• Project • Practical • Third party report • Portfolio of evidence • Written tests • Oral questioning

	8.2.2.1 Definition and purpose of CNC machining in fabrication 8.2.2.2 Comparison of CNC machining vs. conventional machining 8.2.2.3 Overview of common CNC machines (milling, lathe, router, etc.) 8.2.3 CNC Machine Components 8.2.3.1 Major components: controller, worktable, spindle, tool holder, etc. 8.2.3.2 Role of each component in the CNC machining process 8.2.3.3 Types of CNC tooling and their applications 8.2.4 CNC Programming basics 8.2.4.1 Introduction to G-code, F-code, S-code, and M-code commands 8.2.4.2 Overview of CNC software for part design and programming 8.2.4.3 Translation of design specifications into CNC programming code 8.2.4.4 Programming exercises 8.2.5 CNC machine set up	

	8.2.5.1 Safety precautions specific to CNC operations 8.2.5.2 Loading and securing materials for CNC processes 8.2.5.3 Tools alignment 8.2.5.4 Input and verification of CNC programs on the machine 8.2.6 Executing CNC Machining Operations 8.2.6.1 Step-by-step process for running a CNC machine 8.2.6.2 Monitoring CNC operations for accuracy and quality 8.2.6.3 Adjustments and troubleshooting during the machining process 8.2.7 Techniques for executing precise machining tasks 8.2.8 Hands-on exercises with different fabrication operations 8.3 Inspection of fabrication machinery parts 8.3.1 Inspection standards and techniques (visual, dimensional, tolerance)	

	8.3.2 Quality control checkpoints during and post-machining 8.3.3 Gauges, callipers, and other inspection tools 8.4 Documentation of fabrication machinery operations 8.4.1 Importance of accurate documentation in fabrication 8.4.2 Workplace standards for machine setup and operation logs 8.4.3 Practicing accurate and complete documentation processes	

Suggested delivery methods

- Group discussions
- Demonstration by trainer
- Online videos
- Power point presentation

Recommended resources for 25 trainees

S/No.	Category/item	Description/specifications	Quantity	Recommended ratio (item)
A	**Tools**			
1.	Multimeters	For measuring voltage, current, and resistance	5 pcs	1:5
2.	Callipers	For measuring internal and external dimensions	5 pcs	1:5

3.	CAD software licenses	Licenses for CAD software (e.g., AutoCAD)	25 pcs	1:1
4.	Assorted wrenches	For tightening and loosening fasteners	5 sets	1:5
5.	Screwdrivers	Various types for driving screws	5 sets	1:5
6.	Pliers	For gripping, bending, and cutting wires	5 pcs	1:5
B	**Learning facilities & infrastructure**			
7.	Lecture/Theory Room	Approximately 60 sqm for theoretical training	1	1:25
8.	Workshop	Approximately 80 sqm for hands-on practice	1	1:25
9.	Laboratory	Approximately 80 sqm for equipment testing and practice	1	1:25
C	**Materials and Supplies**			
10.	Metal and composite blocks	Raw materials for machining exercises	adequate	
11.	Tooling sets	Various cutting and shaping tools for lathes and CNC machines	5 sets	1:5
12.	Fasteners and connectors	Nuts, bolts, and connectors for assembling parts	adequate	

13.	Safety Signs	Danger warning, barricades, and high-voltage signage for workshop safety	adequate	
14.	PPE Kits (gloves, masks, ear protection)	Full PPE for safety during machine operation	25 sets	1:1
15.	Inspection gauges	Tools for quality control and verification	5 pcs	1:5
D	**Equipment**			
16.	CNC Simulators	Simulation devices for CNC training	5 pcs	1:5
17.	CNC Tooling	Assorted tooling specifically for CNC machines	5 sets	1:5
18.	CNC programming software licenses	Software for CNC machine programming	1-distributable	1:25
19.	CNC machines	CNC milling and lathe machines for machining processes	1 pc	1:25
20.	Lathe machines	Conventional lathes for hands-on training in machining	1 pc	1:25
21.	Drill presses	For drilling holes in materials during machining	1 pc	1:25
22.	Grinding machines	For surface finishing and precision grinding	1 pc	1:25
E	**Miscellaneous**			

23.	Lubrication equipment	For maintenance of machines and smooth operation	1 unit	1:25
24.	First-aid kits	For emergency medical care	2 kits	
F	**Reference materials**			
25.	Safety manuals	Guides on health and safety protocols	adequate	
26.	CNC programming guidebooks	Manuals for codes and CNC software	adequate	
27.	Design and inspection standards manuals	Guides for design verification and precision standards	adequate	

WORK ETHICS AND PRACTICES

ISCED UNIT CODE: **0417 541 03A**

TVETCDACC UNIT CODE: ENG/CU/IMT/BC/03/6/MA

Relationship with occupational standards

This unit addresses the unit of competency: apply work ethics and practices.

Duration of unit: **40 Hours**

Unit description

This unit covers competencies required to demonstrate employability skills. It involves: applying self-management, promoting ethical work practices and values, promoting teamwork, maintaining professional and personal development, applying problem-solving, and promoting customer care.

Summary of learning outcomes

By the end of the unit of learning, the trainee will be able to;

S/No.	Learning outcomes	Duration (Hrs)
1	Apply self-management skills	10
2	Promote ethical practices and values	4
3	Promote teamwork	10
4	Maintain professional and personal development	10
5	Apply problem-solving skills	4
6	Promote customer care.	2
	TOTAL HOURS	**40**

Learning outcomes, content, and suggested assessment methods

Learning outcome	Content	Suggested assessment methods
1. Apply self-management skills	1.1 Self-awareness 1.2 Formulating personal vision, mission, and goals 1.3 Healthy lifestyle practices 1.4 Strategies for overcoming work challenges 1.5 Emotional intelligence 1.6 Coping with work stress. 1.7 Assertiveness versus aggressiveness and passiveness 1.7.1 Developing and maintaining high self-esteem 1.7.2 Developing and maintaining positive self-image 1.7.3 Time management 1.7.4 Setting performance targets 1.7.5 Monitoring and evaluating performance targets	• Observation • Written assessment • Oral assessment • Third party reports • Portfolio of evidence • Project • Practical
2. Promote ethical work practices and values	2.1 Integrity 2.2 Core Values, ethics and beliefs 2.3 Patriotism 2.4 Professionalism 2.5 Organizational codes of conduct	• Observation • Written assessment • Oral assessment • Third party reports • Portfolio of evidence • Project

Learning outcome	Content	Suggested assessment methods
	2.6 Industry policies and procedures	• Practical
3. Promote teamwork	3.1 Types of teams 3.2 Team building 3.2.1 Individual responsibilities in a team 3.2.2 Determination of team roles and objectives 3.2.3 Team parameters and relationships 3.2.4 Benefits of teamwork 3.2.5 Qualities of a team player 3.2.6 Leading a team 3.2.7 Team performance and evaluation 3.3 Conflicts and conflict resolution 3.4 Gender and diversity mainstreaming 3.5 Developing healthy workplace relationships 3.6 Adaptability and flexibility 3.7 Coaching and mentoring skills	• Observation • Written assessment • Oral assessment • Third party reports • Portfolio of evidence • Project • Practical

Learning outcome	Content	Suggested assessment methods
4. Maintain professional and personal development	4.1 Personal vs professional development and growth 4.2 Avenues for professional growth 4.3 Recognizing career advancement 4.4 Training and career opportunities 4.4.1 Assessing training needs 4.4.2 Mobilizing training resources 4.5 Licenses and certifications for professional growth and development 4.6 Pursuing personal and organizational goals 4.7 Managing work priorities and commitments 4.8 Dynamism and on-the-job learning	• Observation • Written assessment • Oral assessment • Third party reports • Portfolio of evidence • Project • Practical
5. Apply problem-solving skills	5.1 Causes of problems 5.2 Methods of solving problems 5.3 Problem-solving process 5.4 Decision making 5.5 Creative thinking and critical thinking process in development of innovative and practical	• Observation • Written assessment • Oral assessment • Third party reports • Portfolio of evidence • Project • Practical

Learning outcome	Content	Suggested assessment methods
	solutions	
6. Promote customer care	6.1 Identifying customer needs 6.2 Qualities of good customer service 6.3 Customer feedback methods 6.4 Resolving customer concerns 6.5 Customer outreach programs 6.6 Customer retention	• Observation • Written assessment • Oral assessment • Third party reports • Portfolio of evidence • Project • Practical

Suggested Methods of Instruction

- Instructor lead facilitation of theory using active learning strategies.
- Demonstrations
- Simulation/Role play
- Group Discussion
- Presentations
- Case studies

Recommended resources for 30 trainees

S/No.	Category/item	Description/specifications	Quantity	Recommended ratio (item: trainee)
A	**Learning materials**			
1.	Textbooks	Comprehensive texts books on work ethics and practices	30 pcs	1:1
2.	Powerpoint presentations	For trainer's use, covering course content and practical applications	1	1:30

3.	Projector	Functional projector for displaying content during presentations	1	1:30
4.	Media Resources	This include but are not limited to: • Video clips • Audio clips • TV sets • Radio sets	Adequate	
5.	White board	Quality whiteboard of approximately 6 ft by 3 ft for writing during theory instruction	1	1:30
B	**Learning facilities & infrastructure**			
1.	Lecture/theory room /learning resource area	Spacious, equipped with projectors and seats for 30 trainees, approximately 45 sqm (5 m x 9 m)	1	1:30
2.	Computer laboratory	Equipped with at least 30 functional computers with internet connectivity and the following software: • Windows/ linux/ macintosh operating system • microsoft office software • Google workspace account • Antivirus software	30	1:1
C	**Consumable materials**			

1.	Printing papers	A4 and A3 printing papers suitable for the task	Adequate	
2.	Flashcards	For carrying out various activities by trainees	Adequate	
3.	Charts	Sufficient for group work activities and displaying	Adequate	
4.	Whiteboard marker pens	Dry-erase markers for trainers use. Assorted colors	Adequate	

ENTREPRENEURIAL SKILLS

ISCED UNIT CODE: 0413 541 04A

TVETCDACC UNIT CODE: ENG/CU/IMT/BC/04/6/MA

Relationship with occupational standards

This unit addresses the unit of competency: Apply entrepreneurial skills.

Duration of unit: 40 Hours

Unit description:

This unit covers the competencies required to demonstrate an understanding of entrepreneurship. It involves: applying financial literacy, applying entrepreneurial concepts, identifying entrepreneurship opportunities, applying business legal aspects, innovating business strategies, and developing business plans.

Summary of learning outcomes

By the end of the unit of learning, the trainee will be able to;

S/NO.	LEARNING OUTCOMES	DURATION (HRS)
1	Apply financial literacy	6
2	Apply the entrepreneurial concept	4
3	Identify entrepreneurship opportunities	6
4	Apply business legal aspects	6
5	Innovate business strategies	6
6	Develop business plan	12
	TOTAL HOURS	**40**

Learning outcomes, content and suggested assessment methods

Learning outcome	Content	Suggested assessment methods
1. Apply financial literacy	1.1 Personal finance management 1.2 Balancing between needs and wants 1.3 Budget preparation	• Observation • Project • Written assessment • Oral assessment

Learning outcome	Content	Suggested assessment methods
	1.4 Saving management 1.5 Factors to consider when deciding where to save 1.6 Debt management 1.7 Factors to consider before taking a loan 1.8 Investment decisions 1.9 Types of investments 1.10 Factors to consider when investing money 1.11 Insurance services 1.12 insurance products available in the market 1.13 Insurable risks	• Third party report • Interviews
2. Apply entrepreneurial concept	2.1 Difference between Entrepreneurs and business persons 2.2 Types of entrepreneurs 2.3 Ways of becoming an entrepreneur 2.4 Characteristics of Entrepreneurs 2.5 salaried employment and self-employment 2.6 Requirements for entry into self-employment 2.7 Roles of an entrepreneur in an enterprise	• Observation • Project • Written assessment • Oral assessment • Third party report •

Learning outcome	Content	Suggested assessment methods
	2.8 Contributions of Entrepreneurship	
3. Identify entrepreneurship opportunities	3.1 Sources of business ideas 3.2 Factors to consider when evaluating business opportunity 3.3 Business life cycle	• Observation • Project • Written assessment • Oral assessment • Third party report
4. Apply business legal aspects	4.1 Forms of business ownership 4.2 Business registration and licensing processing 4.3 Types of contracts and agreements 4.4 Employment laws 4.5 Taxation laws	• Observation • Project • Written assessment • Oral assessment • Third party report
5. Innovate business Strategies	5.1 Creativity in business 5.2 Innovative business strategies 5.3 Entrepreneurial linkages 5.4 ICT in business growth and development	• Observation • Project • Written assessment • Oral assessment • Third party report
6. Develop business plan	6.1 Business description 6.2 Marketing plan 6.3 Organizational/management plan 6.4 Production/operation plan 6.5 Financial plan 6.6 Executive summary 6.7 Business plan presentation 6.8 Business idea incubation	• Observation • Written assessment • Project • Oral assessment • Third party report

Suggested methods of instruction

- Direct instruction with active learning strategies
- Project (Business plan)
- Case studies
- Field trips
- Group Discussions
- Demonstration
- Experiential
- Team training
- Guest speakers

Recommended resources for 30 trainees

S/No.	Category/item	Description/specifications	Quantity	Recommended ratio (item: trainee)
A	**Learning materials**			
1.	Textbooks	Comprehensive texts books on entrepreneurial skills	30 pcs	1:1
2.	Powerpoint presentations	For trainer's use, covering course content and practical applications	1	1:30
3.	Projector	Functional projector for displaying content during presentations	1	1:30
4.	Media resources	These include but are not limited to: • Video clips • Audio clips • TV sets • Radio sets	Adequate	

		• Newspapers • Business journals • Case studies		
5.	Templates	Templates for creating various documents e.g. business plan, invoices etc.	30	1:1
6.	White board	Quality whiteboard of approximately 6 ft by 3 ft for writing during theory instruction	1	1:30
B	**Learning facilities & infrastructure**			
7.	Lecture/theory room /learning resource area*	Spacious, equipped with projectors and Seats for 30 trainees, approximately 45 sqm (5 m x 9 m)	1	1:30
8.	Computer laboratory	Equipped with at least 15 functional computers with internet connectivity and the following software: • Windows/ Linux/ Macintosh operating system • Microsoft office software • Google workspace account • Antivirus software	1	1:1
C	**Consumable Materials**			
9.	Writing Materials	Writing materials for note taking	Adequate	

10.	Flashcards	For carrying out various activities by trainees	Adequate	
11.	Charts	Sufficient for group work activities and displaying	Enough	
12.	Whiteboard Marker Pens	Dry-erase markers for trainers use. Assorted colors	Enough	