**A lion with two spears and a rooster

Description automatically generated**

**REPUBLIC OF KENYA**

**COMPETENCY BASED CURRICULUM**

**FOR**

**INDUSTRIAL MECHATRONICS TECHNOLOGY**

**KNQF LEVEL 6**

**PROGRAMME ISCEDCODE: 0715 554 A**

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**Council Secretary/CEO/Chief Principal**

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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 the country into a newly industrializing, middle-income country providing high quality life to all its citizens by the year 2030. Kenya intends to create a globally competitive and adaptive human resource base to meet requirements of a rapidly industrializing economy through life-long education and training. TVET has a responsibility of facilitating 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).

The Technical and Vocational Education and Training Act No. 29 of 2013 and the Sessional Paper No. 1 of 2019 on Reforming Education and Training in Kenya, emphasized the need toreform 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 Kenyan labour force.

This curriculum has been developed in adherence to the Kenya National Qualification Framework and CBETA standards and guidelines. The curriculum is designed and organized into Units of Learning with Learning Outcomes; suggested delivery methods, training/learning resources and methods of assessing the trainee’s achievement. The curriculum is competency-based and allows multiple entry and exit to the course.

I am grateful to the Council Members, Council Secretariat, …….. NSSC, expert workers and all those who participated in the development of this curriculum.

**Council Secretary/CEO/Chief Principal**

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# 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/Chief Principal**

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# TABLE OF CONTENTS

[FOREWORD 3](#_Toc195773971)

[ACKNOWLEDGEMENT 5](#_Toc195773972)

[TABLE OF CONTENTS 6](#_Toc195773973)

[ABBREVIATIONS AND ACRONYMS 8](#_Toc195773974)

[KEY TO ISCED UNIT CODE 9](#_Toc195773975)

[COURSE OVERVIEW 10](#_Toc195773976)

[MODULE ONE 14](#_Toc195773977)

[ENGINEERING MATHEMATICS 14](#_Toc195773978)

[THERMODYNAMICS AND FLUID MECHANICS 26](#_Toc195773979)

[ELECTROMECHANICAL SYSTEMS DESIGN 44](#_Toc195773980)

[MODULE TWO 55](#_Toc195773981)

[COMPUTER AIDED DRAWING 55](#_Toc195773982)

[ELECTROMECHANICAL SYSTEM INSTALLATION AND MAINTANANCE 66](#_Toc195773983)

[COMMUNICATION SKILLS 76](#_Toc195773984)

[MODULE THREE 81](#_Toc195773985)

[ELECTRICAL AND ELECTRONICS PRINCIPLES 93](#_Toc195773986)

[MODULE FOUR 117](#_Toc195773987)

[STAND-ALONE CONTROLLER INSTALLATION AND MAINTENANCE 117](#_Toc195773988)

[PLC SYSTEM INSTALLATION AND MAINTANANCE 127](#_Toc195773989)

[MODULE FIVE 136](#_Toc195773990)

[ROBOTIC SYSTEM INSTALLATION AND MAINTENANCE 136](#_Toc195773991)

[SUPERVISORY CONTROL AND DATA ACQUISITION (SCADA) SYSTEMS INSTALLATION AND MAINTANANCE 147](#_Toc195773992)

[MODULE SIX 157](#_Toc195773993)

[ENGINEERING MECHANICS 157](#_Toc195773994)

[ELECTRICAL MACHINES AND MECHANICAL DRIVES INSTALLATION 170](#_Toc195773995)

[DIGITAL LITERACY 182](#_Toc195773996)

[MODULE SEVEN 199](#_Toc195773997)

[FABRICATION MACHINERY OPERATION 199](#_Toc195773998)

[WORK ETHICS AND PRACTICES 223](#_Toc195773999)

[ENTREPRENEURIAL SKILLS 230](#_Toc195774000)

# 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



# COURSE OVERVIEW

This Industrial Mechatronics Technology curriculum is designed to equip an Industrial Mechatronics technician with the competencies required to: Operate industrial mechatronics systems, maintain industrial mechatronics systems and maintain product quality.

**SUMMARY OF UNITS OF COMPETENCY**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **MODULE** | **UNITS** | | | |
| **UNIT**  **CATEGORY** | **UNIT CODE** | **UNIT NAME** | **DURATION(Hours)** |
| **ONE (I)** | **COMMON** | 0541 541 05A | Apply engineering mathematics | 140 |
| **COMMON** | 0715 541 06A | Apply thermodynamics and fluid mechanics principles | 140 |
| **CORE** | 0715 551 10A | Electromechanical systems design | 200 |
| **SUB TOTAL** | | | **480** |
| **TWO (II)** | **COMMON** | 0732 551 09A | Perform computer aided drawing | 180 |
| **CORE** | 0715 551 11A | Electromechanical systems installation and maintenance | 200 |
| **BASIC** | 0031 541 02A | Apply communication skills | 40 |
| **SUB TOTAL** | | | **420** |
| **THREE(III)** | **CORE** | 0715 551 12A | Hydraulic and pneumatic systems installation and maintenance | 280 |
| **COMMON** | 0713 541 08A | Apply electrical and electronics principles | 180 |
| **SUB TOTAL** | | | **460** |
| **FOUR(IV)** | **CORE** | 0715 551 13A | Stand-alone controllers’ installation and maintenance | 200 |
| **CORE** | 0715 551 14A | PLC systems installation and maintenance | 240 |
| **SUB TOTAL** | | | **440** |
| **FIVE(V)** | **CORE** | 0715 551 15A | Robotic systems installation and maintenance | 240 |
| **CORE** | 0715 551 16A | Supervisory control and data acquisition (SCADA) systems installation and maintenance | **200** |
|  | **SUB TOTAL** | | | **440** |
| **SIX(VI)** | **COMMON** | 0715 541 07A | Apply engineering mechanics principles | 150 |
| **CORE** | 0715 551 17A | Electrical machines and mechanical drives installation | 220 |
| **BASIC** | 0611 551 01A | Apply Digital Literacy | **410** |
|  | **SUB TOTAL** | | |  |
| **SEVEN(VII)** | **CORE** | 0715 551 18A | Fabrication machinery operation | 300 |
| **BASIC** | 0417 541 03A | Apply Work Ethics and Practices | 50 |
|  | **BASIC** | 0413 541 04A | Apply entrepreneurial skills | 60 |
|  | **SUB TOTAL** | | | 370 |
|  | **INDUSTRIAL ATTACHMENT** | | | **480** |
| **COURSE DURATION** | | | | **3130HRS** |

The total duration for this course is 3130 hrs

**Entry Requirements**

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

1. Kenya certificate of secondary education (K.C.S.E.) with a minimum mean grade of D (Plain) or KCE division IV or its equivalent as determined by the regulator

**Or**

1. Industrial Mechatronics KNQF level 5 certificate or its equivalent as determined by TVETA

**Trainer Qualification**

Qualifications of a trainer for this course include:

1. Have a minimum of KNQF Level 7 qualification or its equivalent in a related trade area.
2. Be licensed by TVETA.

**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:

1. During formative assessment all performance criteria shall be assessed based on performance criteria weighting.
2. During summative assessment basic and common units shall be integrated in the core units.
3. Summative assessment shall involve practical assessment focusing more on critical aspects of the respective unit of competency.
4. Theoretical and practical weight shall be 40:60 respectively for each unit of learning;
5. Theoretical (written/oral) assessment shall have formative and summative assessments weighted at 60% and 40% respectively in the overall unit of learning score
6. 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 |

1. 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 attain a Certificate in Industrial Mechatronics KNQF 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 ……… (QAI)

# MODULE ONE

ENGINEERING MATHEMATICS

**ISCED Unit code:** 0541 541 05A

**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. Indices      1. Power zero      2. Negative powers      3. Fractional powers      4. Laws of indices         1. Addition         2. Subtraction         3. Division         4. Multiplication   2. BODMAS   3. Roots      1. Square roots      2. Cube roots      3. nth roots   4. Logarithms      1. Laws of logarithms         1. Product law         2. Quotient law         3. Power law   5. Use of scientific calculator      1. Power ON/OFF      2. Mode         1. Degree         2. Radian         3. Gradient         4. SD      3. Clear      4. Save      5. Shift   6. Simultaneous equations   (up to 3 equations)   * + 1. Elimination     2. Substitution     3. Reduction     4. Graphical   1. Quadratic equations      1. Factorization      2. Quadratic formula      3. Completing the square      4. Graphical | * Written tests |
| 1. Apply trigonometric and hyperbolic functions | * 1. Angles      1. Acute      2. Obtuse      3. Reflex      4. Right angle   2. Triangles      1. Isosceles      2. Equilateral      3. Right angled      4. Scalene   3. Trigonometric ratios      1. Sine      2. Cosine      3. Tangent      4. Cosecant      5. Secant      6. Cotangent   4. Trigonometric Identities      1. Proof of identities      2. Pythagorean identities   5. Trigonometric equations   6. Hyperbolic functions      1. Sinh x      2. Cosh x      3. Cosech x      4. Tanh x      5. Sech x | * Written tests |
| 1. Apply complex numbers | * 1. Complex geometry      1. Real part      2. Imaginary part      3. Argand diagram      4. Modulus/magnitude      5. Argument /angle      6. Conjugate   2. Operations      1. Addition      2. Subtraction      3. Multiplication      4. Division      5. Conversions         1. Polar form to rectangular form         2. Rectangular form to polar form   3. De Moivre’s theorem      1. Expansion of complex numbers      2. Roots of complex numbers      3. Trigonometric identities using complex numbers | * Written tests |
| 1. Perform coordinate geometry | * 1. Cartesian geometry      1. Cartesian plane         1. x and y axes         2. Positive and negative coordinates      2. Gradient         1. Positive         2. Negative         3. Zero         4. Infinite         5. Gradients of parallel line         6. Gradients of perpendicular lines      3. y-intercept   2. Linear equations      1. Straight line      2. Parallel lines      3. Perpendicular lines   3. Graphs of linear equations      1. Straight lines   4. Polar geometry      1. Magnitude      2. Direction      3. Graphs   5. Conversions      1. Linear to polar      2. Polar to linear   6. Solving polar equations | * Written tests |
| 1. Carry out binomial expansion | * 1. Binomial series      1. Powers      2. Coefficients      3. Pascals triangle      4. Expansion   2. Binomial theorem      1. Positive powers of n      2. Negative powers of n      3. Fractional powers of n (roots)      4. Estimation of errors of small changes | * Written tests |
| 1. Apply calculus | * 1. Differentiation up to third order      1. Functions         1. Linear         2. Trigonometric         3. Logarithmic         4. Exponential      2. Rules         1. Power         2. Product         3. Chain         4. Quotient      3. Applications         1. Stationary points         2. Rates of change   2. Integration      1. Standard integral      2. Definite integral      3. Techniques         1. By parts         2. Substitution         3. Partial fractions      4. Applications         1. Area between and under curves         2. Volume | * Written tests |
| 1. Carry out mensuration | * 1. Units and symbols of measurement      1. Mass      2. Distance      3. Speed      4. Temperature      5. Time   2. Imperial and metric units      1. Conversions   3. Perimeter      1. Regular shapes      2. Irregular shapes   4. Area      1. Regular shapes      2. Irregular shapes      3. Surface area   5. Volume      1. Regularly shaped objects | * Written tests |
| 1. Apply statistics and probability | * 1. Data presentation      1. Continuous variables         1. Histogram         2. Line      2. Discrete variable         1. Bar graph         2. Pie graph      3. Grouped data         1. Histogram         2. Bar         3. Cumulative frequency         4. ogive      4. Ungrouped data         1. Line         2. Cumulative frequency   2. Measures of central tendency      1. Mean         1. Grouped data         2. Ungrouped data      2. Mode         1. Grouped data         2. Ungrouped data      3. Medium         1. Grouped data         2. Ungrouped data   3. Measures of dispersion      1. Standard deviation      2. Variance      3. Range.      4. Quartile deviation.      5. Mean deviation   4. Probability types      1. With replacement      2. Without replacement   5. Probability distribution functions      1. Binomial distribution      2. Poisson distribution      3. Normal distribution | * Written tests |
| 1. Apply vector theorem | * 1. Differentiate between vector and scalar quantities      1. Magnitude      2. Direction         1. Positive         2. Negative   2. Operation on vectors      1. Addition      2. Subtraction      3. Dot product      4. Cross product   3. Resolution of vectors      1. Analysis      2. Graphical methods         1. Triangle theorem         2. Parallel theorem         3. Polygon theorem | * Written tests |
| 1. Apply matrices | * 1. Matrices      1. Types         1. Row         2. Column         3. Square         4. Zero         5. Identity         6. Diagonal   2. Matrices operations (up to 3 x 3)      1. Addition      2. Subtraction      3. Multiplication   3. Inverse of matrices (up to 3 x 3)      1. Determinant      2. Transpose      3. Adjoint      4. Inverse   4. Simultaneous equations   (up to 3 equations)   * + 1. Inverse method     2. Crammers rule     3. Row reduction | * Written tests |

**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** | | | |
|  | Textbooks | Comprehensive textbooks on engineering mathematics | 30 | 1:1 |
|  | Graph books | For graphical representation of solutions | 30 | 1:1 |
|  | Projector | Functional projector for displaying content during presentations | 1 | 1:30 |
|  | Computer | Functional desktop computer with online instructional content | 1 | 1:30 |
|  | White board | Quality whiteboard of approximately 6 ft by 3 ft for writing during theory instruction | 1 | 1:30 |
|  | Printer | An ink-jet, laser-jet or toner-cartridge printer for printing notes, instructions and working drawings | 1 | 1:30 |
| **B** | **Learning facilities & infrastructure** | | | |
|  | Lecture/theory room | Spacious room with seats for 25 trainees, approximately 60 sqm | 1 | 1:30 |
| **C** | **Materials and supplies** | | | |
|  | First aid kit | Fully equipped first aid kit for use in case of accidents | 1 | 1:30 |
| **D** | **Tools and equipment** | | | |
|  | Set of mathematical instruments | For constructions and measurements | 30 | 1:1 |
|  | Firefighting extinguishers | Water, carbon dioxide and chemical powder fire extinguishers for fire fighting | 1 | 1:30 |
| **F** | **Reference materials** | | | |
|  | Standard Mathematical Tables | For reference on formulae, identities, laws and principles | 30 | 1:1 |

## THERMODYNAMICS AND FLUID MECHANICS

**UNIT CODE:** 0715 541 06A

**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 | Apply thermodynamic processes | 15 |
| 2 | Apply knowledge of perfect gases | 15 |
| 3 | Apply knowledge of steam cycle | 15 |
| 4 | Apply knowledge of fuel combustion | 15 |
| 5 | Apply heat transfer and heat exchangers in fluid | 15 |
| 6 | Operate air compressors | 15 |
| 7 | Apply the knowledge of the flow of fluids | 15 |
| 8 | Apply the knowledge of viscous flow of fluids | 15 |
| 9 | Apply dimensional and models analysis fluids | 15 |
| 10 | Operate fluid pumps | 15 |
| TOTAL | | 250 |

**Learning outcomes, content and suggested assessment methods**

|  |  |  |
| --- | --- | --- |
| **Learning outcome** | **Content** | **Suggested assessment methods** |
| 1. Apply thermodynamic processes | * 1. Basic thermodynamics terms definition      1. work,      2. Power      3. Internal energy      4. Heat      5. Temperature   2. Laws of thermodynamics      1. First law of thermodynamics      2. Second law of thermodynamics      3. Zeroth law of thermodynamics   3. Thermodynamic processes      1. Non-flow process.      2. Constant volume process      3. Constant pressure process      4. Hyperbolic process.      5. Constant temperature process      6. Adiabatic process      7. Polytropic process.   4. Thermodynamics systems      1. Boundary and surrounding      2. Closed systems      3. Open systems      4. Isolated systems      5. Adiabatic system      6. Homogeneous systems      7. Heterogeneous systems   5. Heating and expansions of gases      1. Determine work done      2. Application of First Law of Thermodynamics      3. Reversible non-flow processes.      4. Irreversible non-flow processes   6. General laws for expansion and compression      1. Define the terms:         1. Expansion         2. compression      2. Apply PVn = Constant for various values of n      3. Curves of pressure against volume for various values of n (index)   7. Application of steady flow energy equation to:      1. boilers      2. condensers      3. nozzles      4. diffusers      5. compressors      6. turbines | * Written tests |
| 1. Apply knowledge of perfect gases | * 1. Laws of perfect gases      1. Boyle's law      2. Charles' law      3. Gay-Lussac law      4. Joule's law      5. Avogadro's law   2. General gas equation      1. Derive and apply general gas equation PV=mRT   3. Characteristic equation of gas      1. Application in engineering calculations   4. Universal gas constant      1. Define universal gas constant      2. Apply universal gas constant equation in engineering calculation   5. Specific heat      1. Constant volume      2. Constant pressure | * Written tests |
| 1. Apply knowledge of steam cycle | * 1. Steam cycles      1. Rankine         1. Schematic diagram of a steam engine or turbine plant.         2. Determine Rankine efficiency         3. T-S and h-s graphs         4. Modified Rankine cycle         5. Work-done using Rankine equations         6. Efficiency of modified Rankine Cycle         7. Theoretical loss of work per kg of steam due to incomplete expansion         8. Loss in Rankine efficiency due to restricted expansion of steam         9. Enthalpy- entropy chart      2. Carnot         1. Draw schematic diagrams of Carnot engine         2. Carnot cycle with steam as working substance         3. Performance criteria for carnot cycle      3. Reheat         1. T-S diagram of reheat steam cycle         2. Determine work-done using reheat equations         3. Determine efficiency of reheat cycles      4. Regenerative         1. Ideal regenerative cycle diagram         2. Regenerative cycle with single feed water heater         3. Regenerative cycle with single feed water heater diagram         4. Determine work-done by regenerative cycle         5. Determine regenerative cycle efficiency         6. Regenerative cycle with two feed water heaters and its efficiency   2. Thermodynamics steam turbines      1. Characteristics of steam turbines      2. classification of Steam Turbines      3. Pressure and velocity of steam in an impulse turbine      4. Velocity triangles for moving blade of an impulse turbine      5. Combined velocity triangle for moving blades      6. Power produced by an impulse turbine | * Written tests |
| 1. Apply knowledge of fuel combustion | * 1. Elements and compounds of fuel      1. Define of terms         1. Element         2. Compound         3. Atoms         4. Molecules         5. Atomic Mass         6. Molecular Mass      2. Element and symbols table sketches   2. Combustion equations of fuels and calculations      1. Balanced combustion equations of solid fuels      2. Write a balanced Combustion Equations of gaseous fuels   3. Conversion analysis of fuels      1. Theoretical or minimum volume of air required for complete combustion      2. Conversion of volumetric analysis into mass analysis or gravimetric analysis      3. Conversion of mass analysis into volumetric analysis   4. Mass of carbon in flue gases      1. Calculation of mass of carbon, contained in 1 kg of flue or exhaust gases   5. Mass of flue gases per kg of fuel burnt      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.   6. Excess air supplied calculations      1. Mass of excess air supplied by the mass of unused oxygen, found in the flue gases.      2. Total mass of air supplied   7. Flue gas analysis by ors at apparatus      1. Components      2. Use of the apparatus      3. Operation      4. Diagram sketches | * Written tests |
| 1. Apply heat transfer and heat exchangers in fluid | * 1. Heat transfer media      1. Heat transfer methods:         1. Conduction         2. Convection         3. Radiation      2. Newton's law of Cooling      3. Derivation and application of Fourier's\* law of heat conduction equation   2. Heat transfer by conduction   through   * + 1. Slab        1. Thermal conductivity        2. Temperature gradient     2. Composite wall     3. Thick cylinder     4. Thick cphere   1. Overall coefficient of heat transfer      1. Heat exchangers | * Written tests |
| 1. Operate air compressors | * 1. Classification of air compressors      1. According to working      2. According to action      3. According to number of stages   2. Single stage reciprocating air compressor      1. Work done by a single stage reciprocating air compressor without clearance volume   3. Work done during      1. isothermal compression      2. polytropic compression (PVn = Constant)      3. isentropic compression   4. Power required to drive a single-stage reciprocating air compressor      1. Calculations   5. Work-done by reciprocating air compressor with clearance volume      1. Calculations      2. Determine multistage compression   6. Power required to drive a two-stage reciprocating air compressor   7. Minimum work required for a two-stage reciprocating air compressor | * Written tests |
| 1. Apply knowledge of flow of fluids | * 1. Types of fluid flow      1. Steady and unsteady flows      2. Uniform and non-uniform flows      3. Rotational and irrotational flows      4. Laminar and turbulent flows      5. Compressible and incompressible flows   2. Loss of energy (or Head) in Pipes      1. Darcy-weisbach formula      2. Chezy’s formula for loss of head due to friction      3. Loss of head due to sudden enlargement      4. Loss of head due to sudden contraction      5. Loss of head due to obstruction in pipe      6. Loss of head at the entrance to pipe      7. Loss of head at the exit of a pipe      8. Loss of head due to bend in the pipe   3. Hydraulic gradient and total energy lines      1. Pipes in series or compound pipes      2. Pipes in parallel      3. Power transmission through Pipes | * Written tests |
| 1. Apply knowledge of viscous flow of fluids | * 1. Flow of viscous flow      1. Flow of viscous fluid in circular pipes      2. Flow of viscous fluid through an annulus      3. Flow of viscous fluid between two parallel plates         1. One plate moving and other at rest         2. Both plates at rest         3. Both plates moving in opposite directions      4. Kinetic energy correction and momentum      5. Power absorbed in viscous flow      6. Viscous resistance of journal bearings      7. Viscous resistance of foot-step      8. Viscous resistance of collar bearing | * Written tests |
| 1. Apply dimensional and models analysis fluids | * 1. Definition of terms      1. Dimensional homogeneity      2. Methods of solving dimensional analysis         1. Rayleigh’s theorem         2. Buckingham π theorem   2. Dimensional analysis similitude      1. Geometric      2. Kinematic      3. Dynamic   3. Dimensionless Numbers      1. Reynold’s number (Re )      2. Froude’s number (Fe )      3. Euler’s number (Eu )      4. Weber’s number (We )      5. Mach’s number ( M )   4. Model test analysis and calculations      1. Classification of Models         1. Undistorted Models         2. Distorted models         3. Scale ratios for distorted models | * Written tests |
| 1. Operate fluid pumps | * 1. Principles of operation of:      1. Reciprocating pumps      2. Centrifugal pumps   2. Derivation of equations for a reciprocating pump      1. Coefficient of discharge      2. percentage slip      3. Work done      4. Acceleration head      5. Friction head      6. Pressure head in the cylinder   3. Application of reciprocating pumps equations to solve problems   4. Derivation of equations for a centrifugal pump      1. Effective head      2. Manometric head      3. efficiency      4. Mechanical efficiency      5. Discharge      6. Torque      7. Work done unit weight      8. Specific speed   5. Application of centrifugal pumps equations to solve problems | * Written tests |

**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** | | | |
|  | Textbooks | * + - 1. Applied thermodynamics for engineering technology (fifth edition) by T.D. Eastop and A. McConkey       2. Engineering thermodynamics by R.K.Rajput       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 | 5 each | 1:6 |
|  | Projector | Functional projector for displaying content during presentations | 1 | 1:30 |
|  | Computer | Functional desktop computer with online instructional content | 1 | 1:30 |
|  | White board | Quality whiteboard of approximately 6 ft by 3 ft for writing during theory instruction | 1 | 1:30 |
|  | Printer | An ink-jet, laser-jet or toner-cartridge printer for printing notes, instructions and working drawings | 1 | 1:30 |
| **B** | **Learning facilities & infrastructure** | | | |
|  | Lecture/Theory Room | Spacious room with seats for 30 trainees, approximately 60 sqm | 1 | 1:30 |
| **C** | **Materials and supplies** | | | |
|  | Dust coat/ overall | Shields skin and regular clothes from sparks | 30 | 1:1 |
|  | Fire extinguishers | Fighting fire | 1 | 1:30 |
|  | 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

**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. Introduction      1. Importance of electromechanical systems in various industries   2. Electromechanical system specifications      1. Electromechanical design function      2. Electromechanical design output      3. Project name      4. Customer’s name      5. Project scope      6. Project objective   3. Objectives of the needs analysis      1. Purpose of needs analysis for design and implementation      2. Identify requirements      3. Define performance criteria      4. Assess constraints      5. Evaluate existing systems      6. Future-proofing   4. Needs analysis      1. Stakeholder engagement      2. Requirements gathering      3. Performance metrics definition      4. Constraint analysis      5. Current system evaluation      6. Future needs assessment   5. Documentation and reporting   6. Review and validation | * Observation * Oral assessment * Projects * Trainee presentation * Written assessments |
| 1. Develop electromechanical systems conceptual design | * 1. Introduction      1. Definition of terms      2. Importance of conceptual design      3. Translation of user requirements into design concepts   2. Objectives of conceptual design      1. Translate requirements into design      2. Establish design parameters      3. Identify system architecture   3. Electromechanical system design      1. Requirements analysis      2. Preliminary design sketching      3. Simulation and modelling      4. Feasibility assessment         1. Design ergonomics         2. Architecture         3. Design cost         4. Design context         5. Design speed      5. Iterative refinement      6. Documentation and reporting | * Observation * Oral assessment * Projects (self, team-based, work-based) * Trainee presentation * Written assessments * Trainer/supervisor report |
| 1. Build electromechanical system prototype | * 1. Health and safety      1. PPEs      2. Work permits      3. Waste management      4. Electrical wiring colour coding      5. Danger warning signage      6. Barricades      7. High voltage signage      8. Health policy   2. Electromechanical system prototype components      1. Circuit board      2. Variable frequency drive      3. Programmable logic controller      4. 2 bar linkage      5. 3 bar linkage      6. Bearings (ball bearing, rolling-element bearing etc.)      7. Electric motors (AC, DC, Stepper, Servo, Linear etc.)      8. Pulleys (fixed, block and tackle, movable etc.)      9. Chain drive      10. Clamp lever      11. Spring      12. Damper      13. Mechanical seal   3. Introduction to subsystems      1. Block diagram showing component interaction      2. Input-output relationships and data flow      3. Mechanical design         1. Actuators (motors, hydraulics, pneumatics)         2. Motion requirements (degrees of freedom, precision)      4. Electrical design         1. Power supply and distribution         2. Sensor selection and feedback mechanisms      5. Control system design- control strategies (open-loop, closed-loop, PID)         1. Distributed control systems         2. SCADA         3. Stand alone controllers (PID, microprocessors, microcontrollers etc         4. Relay         5. PLC         6. Software and algorithm design         7. Communication protocols and interfaces      6. Integration of Systems         1. Mechanical-electrical interface (mounting, coupling)         2. User interface design (buttons, touchscreens, software)   4. Safety and reliability      1. Safety mechanisms (emergency stops, fail-safes)   5. Reliability and maintenance considerations   6. Testing      1. Testing methodology for performance, reliability, and safety   7. Cost and feasibility      1. Cost estimation of components and development | * Observation * Oral assessment * Projects (self, team-based, work-based) * Trainee presentation * Written assessments * Trainer/supervisor report |
| 1. Test electromechanical system prototype | * 1. Mechanical testing      1. Motion testing: validate movements, degrees of freedom, speed, and range      2. Load testing      3. Durability testing   2. Electrical testing      1. Power consumption      2. Sensor accuracy      3. Signal integrity   3. Control System testing      1. Control algorithm performance      2. Feedback loop testing      3. User interface testing   4. Safety testing      1. Emergency shutdown      2. Failure mode testing      3. Compliance testing   5. Reliability testing      1. Long-term performance      2. Environmental stress testing      3. Redundancy testing   6. Data Collection and analysis      1. Methods for collecting test data (real-time monitoring, logging software)      2. Analysis of test results against expected performance metrics      3. Identifying issues and potential design improvements   7. Functionality test   8. Test Reporting      1. Summary of test outcomes      2. Pass/fail criteria for each aspect of the system      3. Recommendations for modifications or enhancements | * Observation * Oral assessment * Projects (self, team-based, work-based) * Trainee presentation * Written assessments * Trainer/supervisor 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** |  |  |  |
|  | Set of pliers | For gripping | 2 sets | 2:25 |
|  | Clamps | For holding | 2 sets | 2:25 |
|  | Set of Allen keys | For fastening | 13 pcs | 13:25 |
| **B** | **Materials and Supplies** | | | |
|  | Standalone controllers (PID, microprocessors, microcontrollers) | For programming | 5 pcs | 2:5 |
|  | 25 Microcontroller development boards (e.g., Arduino, Raspberry Pi) | For programming | 2 pcs | 2:25 |
|  | Relays | For actuation | 25 pcs | 1:1 |
|  | PLCs | For programmable logic control setups | 5 pcs | 2:5 |
|  | Electric cables and conductors | For electrical connections | 10 pcs | 10:25 |
|  | Breadboards | For prototype circuit assembly | 25 pcs | 1:1 |
|  | Trunking | For organizing and protecting cables | Sufficient |  |
|  | Fuses | For protecting circuits | 10 pcs | 10:25 |
|  | Electrical accessories | Connectors, sockets, and other components | 10 pcs | 10:25 |
| **C** | **Equipment** | | | |
|  | Projectors | For visual presentations | 1 | 1:25 |
|  | Whiteboards | For writing instructional content | 1 | 1:25 |
|  | Drills | Various types for assembly and installation | 13 pcs | 13:25 |
|  | Pneumatic systems | For demonstrating fluid control systems | 5 pcs | 1:5 |
|  | PLC modules | For electromechanical control exercises | 13 pcs | 13:25 |
|  | Control linkage | For demonstrating mechanical linkages | 5 pcs | 1:5 |
|  | Laptops/PCs and appropriate software for electromechanical system design. | For designing | 25pcs | 1:1 |
|  | AC/DC electronics training modules | Training modules for AC/DC electronics | 1 pc | 1:25 |
|  | AC/DC machines control training modules | Modules for controlling AC/DC machines | 1 pc | 1:25 |
| **D** | **Reference materials** | | | |
|  | Component and equipment manuals | Manuals for reference on component use and specifications | Adequate |  |
|  | Health and safety manuals | For workplace safety instructions | Adequate |  |
|  | Electromechanical reference books | Comprehensive guides on electromechanical systems | Adequate |  |
| **E** | **Softwares** | | | |
|  | Electrical circuit design software | Software for designing electrical circuits | 1 license |  |
|  | AUTOCAD | For creating and modifying digital schematics | 1 license |  |
| **F** | **Trainee requirements** | | | |
|  | Protective clothing | Dust coats, gloves, safety boots, goggles | 25 sets | 1:1 |

# MODULE TWO

## COMPUTER AIDED DRAWING

**ISCED UNIT CODE:** 0732 541 09A

**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 | 15 |
| 2 | Navigate CAD software | 15 |
| 3 | Produce geometric drawings | 25 |
| 4 | Produce pictorial drawings | 25 |
| 5 | Produce orthographic drawings. | 25 |
| 6 | Produce assembly drawings | 25 |
| 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. Overview of CAD      1. Definition and significance of CAD in engineering and design.      2. Historical development of CAD technologies.   2. Computing equipment and Software      1. Identify hardware requirements for CAD operations.      2. List popular CAD software options (e.g., AutoCAD, SolidWorks, Inventor).   3. Drawing CAD Software      1. Overview of the software interface.      2. Functions and capabilities of CAD tools.   4. CAD software templates      1. Explore various templates available for different drawing requirements.   5. Importing CAD Files      1. Process of importing files (DWG, STL, DXF, STEP) into the working space.   6. User interface navigation      1. Familiarization with the CAD software interface.      2. Understanding toolbars, menus, and command lines.   7. Setting up the drawing environment      1. Units and measurement settings.      2. Creating a new drawing and saving files.   8. Symbols, codes, and standards      1. Identify relevant symbols and codes according to software functionality.   9. Understand and utilize drawing elements      1. Points      2. Line angles      3. Circles and arcs      4. Planes (horizontal, vertical)      5. Figures and solids      6. Shapes      7. Objects snapping settings      8. Polar tracking settings.      9. Orthomode utilization   10. Use editing commands editing tools       1. Delete, undo and redo commands       2. Fillet and chamfer commands       3. Trim, extend and break commands       4. Zoom and pan commands       5. Move, copy, and paste commands       6. Rotate and mirror commands       7. Object snapping and grouping commands       8. Dimension and scaling commands | 1. Written tests 2. Oral Questioning 3. Portfolio of evidence |
| 1. Produce geometric drawings | * 1. Setting drawing lines      1. Recognize standard drawing line conventions * Dimension lines * Hidden detail lines * Extension lines * Section lines * Break lines * Chain   1. Using drawing lines   2. Constructing types of angles      1. Use trigonometry principles to construct acute, obtuse, and right angles.   3. Constructing geometrical forms      1. Create circles, rectangles, triangles, and polygons according to standards.   4. Developing geometric drawings      1. 2-Dimensional      2. Orthographic      3. Isometric |  |
| 1. Produce pictorial drawings | * 1. Drawing symbols and abbreviations      1. Apply standard drawing symbols and abbreviations in pictorial drawings.   2. Producing pictorial drawings      1. Techniques for creating isometric, oblique, cabinet, and cavalier drawings.   3. Saving pictorial drawings      1. Procedures for saving drawings in appropriate formats. |  |
| 1. Produce orthographic drawings. | * 1. Fundamentals of orthographic projection      1. Definition and importance of orthographic drawing.      2. Differences between orthographic and other drawing types (isometric, perspective).   2. Types of orthographic projections      1. First-angle projection.      2. Third-angle projection.   3. Understanding views      1. Front, top, and side views.      2. Additional views (sectional, auxiliary).   4. First angle orthographic drawings      1. Develop first-angle drawings adhering to standard conventions.   5. Third angle orthographic drawings      1. Create third-angle drawings based on standard practices.   6. Saving orthographic drawings      1. Techniques for properly saving orthographic drawings.   7. Dimensioning orthographic views   8. Printing orthographic views   9. Creating isometric drawing      1. Choosing isometric cursor      2. Dimensioning isometric drawing      3. Printing isometric drawing   10. Creating 3D model       1. Choosing 3D workspace       2. 3D workspace modifying tool (3D orbit, 3D mirrors, union, extrude, press pull, e.t.c)       3. Rendering       4. Printing 3D models |  |
| 1. Produce assembly drawings | * 1. Overview of assembly drawings      1. Definition and purpose of assembly drawings.      2. Importance in manufacturing and engineering.   2. Types of assembly drawings      1. General assembly drawings vs. detailed assembly drawings.      2. Exploded view vs. isometric assembly drawings.   3. Exploding orthographic views      1. Techniques for exploding views in accordance with standard conventions.   4. Exploding pictorial views      1. Create exploded pictorial views based on drawing specifications.   5. Assembling views      1. Assemble orthographic and pictorial views accurately.   6. Producing sectional views      1. Generate sectional views according to drawing standards.   7. Developing parts list      1. Creating a parts list based on the drawing schematic. |  |
| 1. Design mechanical components | * 1. Designing mechanical components      1. Apply CAD principles to design mechanical components per work requirements.   2. Applying CAE in simulation      1. Use computer-aided engineering tools for simulating mechanical designs.   3. Determining improvements      1. Analyze design results to identify efficiency improvements.   4. Creating a manufacturing database      1. Develop a database to support the manufacturing process.   5. Improving design documents      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** | | | |
|  | Textbooks | Comprehensive texts on CAD basics, history, and hardware requirements. | 5 pcs | 1:5 |
|  | Charts | Visual aids covering CAD software evolution and industry applications. | 10 pcs | 1:2.5 |
|  | PowerPoint Presentations | For trainer’s use, covering CAD definitions, history, and hardware requirements. | 1 | 1:25 |
| **B** | **Learning Facilities & Infrastructure** | | | |
|  | Lecture/Theory Room | Equipped with projector, seating for 25 trainees, ~60 sqm. | 1 | 1:25 |
|  | Computer Laboratory | Equipped with 25 computers installed with CAD software, ~80 sqm. | 25 | 1:1 |
|  | Printer/plotter | For printing CAD drawings | 2 | 1:13 |
|  | 3D printer | For printing 3D models | 2 | 1:13 |
|  | 3D printer filament | 3D printing material | 2 rolls | 1:13 |
| **C** | **Consumable Materials** | | | |
|  | USB Drives | For storing and transferring CAD project files. | 25 pcs | 1:1 |
|  | Notebooks | For trainees to take notes during CAD sessions. | 25 pcs | 1:1 |
| **D** | **Tools and Equipment** | | | |
|  | Computers | Equipped with CAD software and compatible hardware (e.g., high RAM, graphics support). | 25 pcs | 1:1 |
|  | Projector | For displaying CAD software demonstrations and presentations in lecture room. | 1 | 1:25 |
|  | External Hard Drives | For backing up CAD files and course materials. | 5 pcs | 1:5 |
|  | Drawing Tablets | For CAD software use, supporting stylus input for design precision. | 5 pcs | 1:5 |
| **E** | **Reference Materials** |  |  |  |
|  | CAD Software Manuals | Documentation detailing CAD software functionalities and hardware requirements. | 25 pcs | 1:1 |
|  | CAD Industry Case Studies | Case studies showcasing CAD applications in engineering and design. | 5 pcs | 1:5 |
|  | Practical Assessment Guides | Worksheets for practical assessments on CAD navigation and hardware requirements. | 25 pcs | 1:1 |
|  | 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

**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. Workplace health and safety standards      1. PPEs      2. Work permits      3. Waste management      4. Electrical wiring colour coding      5. Danger warning signage      6. Barricades      7. High voltage signage      8. Health policy   2. Safety measures in electrical installations      1. Electrical wiring color codes      2. High voltage and danger warning signage      3. Barricades and safety barriers   3. Waste management protocols      1. Disposal of electrical and mechanical waste      2. Environmental policies and regulations   4. Health policy compliance      1. Company and industry-specific health policies   5. Electromechanical system installation site survey      1. Site analysis techniques      2. Equipment and environmental considerations         1. Load-bearing capacity         2. Space         3. Accessibility      3. Documentation and Site Mapping         1. Survey reports         2. Hazard identification   6. Electromechanical installation schedule      1. Scheduling procedures         1. Timeline creation based on manufacturer’s guidelines      2. Task prioritization and resource allocation         1. Coordinating materials and human resources   7. Installation area set up      1. Preparing physical space         1. Equipment layout and setup      2. Compliance with manufacturer requirements      3. Initial safety checks and signage | * Oral assessment * Portfolio of evidence * Interviews * Third party report * Written assessment * Practical assessment * Projects |
| 1. Mount electromechanical system components | * 1. Health and safety procedures      1. Safety procedures during component mounting   2. Electromechanical system components      1. Circuit board      2. Variable frequency drive      3. Programmable logic controller      4. 2 bar linkage      5. 3 bar linkage      6. Bearings (ball bearing, rolling-element bearing etc.)      7. Electric motors (AC, DC, Stepper, Servo, Linear etc.)      8. Pulleys (fixed, block and tackle, movable etc.)      9. Chain drive      10. Clamp lever      11. Spring      12. Damper      13. Mechanical seal   3. Mechanical component mounting techniques      1. Pulleys, chain drives, clamps, springs, dampers, and mechanical seals   4. Documentation for assembly      1. Creating assembly records as per workplace guidelines   5. Configure electromechanical control systems      1. Control system overview         1. Introduction to SCADA, PLCs, distributed control systems      2. Configuration process         1. Programming stand-alone controllers, relay configurations   6. Verification of system settings      1. Testing to ensure configurations meet specifications   7. Electromechanical system tests      1. Types of system testing         1. Electrical,         2. Mechanical,         3. Functionality,         4. Safety tests      2. Test procedures and documentation         1. Creating and recording test data as per requirements   8. Installation report      1. Reporting standards and structure         1. Workplace guidelines for documenting the installation process      2. Key elements of installation report         1. Safety checks, component logs, configuration settings, testing results | * Oral assessment * Portfolio of evidence * Interviews * Third party report * Written assessment * Practical assessment * Projects |
| 1. Maintain electromechanical system. | * 1. Health and safety procedures      1. Safety protocols during maintenance   2. Develop electromechanical system maintenance schedule      1. Maintenance scheduling techniques         1. Preventive vs. corrective maintenance strategies      2. Resource planning for maintenance         1. Allocating time, materials, and workforce   3. Electromechanical system maintenance      1. Routine maintenance procedures         1. Cleaning, inspecting, and testing components      2. Replacing faulty components         1. Guidelines for replacing and reinstalling worn-out parts      3. Lubrication and adjustment of moving parts         1. Maintenance best practices for mechanical longevity   4. Troubleshoot electromechanical system      1. Identifying common issues         1. Electrical faults, mechanical malfunctions      2. Troubleshooting techniques and tools         1. Using diagnostic tools and reference to manufacturer guidelines      3. Documentation of troubleshooting processes         1. Logs for issue identification, resolution steps, and outcomes   5. Generate maintenance report      1. Report structure and essential elements         1. Faults identification         2. Corrective actions         3. Future maintenance suggestions      2. Filing and documentation standards         1. Workplace standards for recording and storing maintenance data | * Oral assessment * Portfolio of evidence * Interviews * Third party report * Written assessment * Practical assessment * Projects |

**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** | | | |
|  | Screwdriver sets | Various sizes for different screw types | 2 sets | 2:25 |
|  | Wrench sets | For tightening bolts and nuts in various sizes | 2 sets | 2:25 |
|  | Pliers Sets | For gripping and cutting wires and components | 2 sets | 2:25 |
|  | Clamps | For holding components securely during assembly | 13 pcs | 13:25 |
|  | Allen key sets | For hexagonal bolts and nuts | 2 sets | 2:25 |
|  | Digital multi-meters | For measuring voltage, current, and resistance | 5 pcs | 1:5 |
|  | Digital tachometers | For measuring rotational speed of motors | 5 pcs | 1:5 |
| **B** | **Materials and supplies** | | | |
|  | Whiteboard markers | For writing on whiteboards during instruction | Adequate |  |
|  | PCB boards | For circuit assembly and testing | 25 pcs | 1:1 |
|  | Switches | Mechanical and electronic types for circuit control | 10 pcs | 2:5 |
|  | Bolts, nuts, and washers | For securing components | Adequate |  |
|  | Fasteners | Used in assembly | 5 pcs | 1:5 |
|  | Bearings, gears, and rollers | Components for rotational systems | 5 sets | 1:5 |
|  | Electric cables and conductors | For electrical connections | 10 pcs | 2:5 |
|  | Breadboards | For prototype circuit assembly | 25 pcs | 1:1 |
|  | Trunking | For organizing and protecting cables | adequate |  |
|  | Fuses | For protecting circuits | 10 pcs | 2:5 |
|  | Electrical accessories | Connectors, sockets, and other components | 10 pcs | 2:5 |
|  | Oils and lubricants | For machinery maintenance | adequate |  |
|  | Oil seals and gaskets | For sealing components | 5 pcs | 1:5 |
|  | Assorted drive belts | For power transmission in machinery | 2 pcs | 2:25 |
|  | PLC modules | For programmable logic control setups | 2 pcs | 2:25 |
|  | Variable speed/frequency drives (VSD/VFD) | For motor control | 2 pcs | 1:25 |
| **C** | **Equipment** | | | |
|  | Projectors | For visual presentations | 1 | 1:25 |
|  | Whiteboards | For writing instructional content | 1 | 1:25 |
|  | Drills | Various types for assembly and installation | 5 pcs | 1:5 |
|  | Servomechanisms | For automation and control demonstrations | 5 pcs | 1:5 |
|  | Compressor systems | For pneumatic operations | 5 pcs | 1:5 |
|  | Pneumatic systems | For demonstrating fluid control systems | 5 pcs | 1:5 |
|  | PLC Modules | For electromechanical control exercises | 5 pcs | 1:5 |
|  | Gyroscopes | For rotational motion study | 5 pcs | 1:5 |
|  | Dynamometers | For measuring torque and rotational force | 5 pcs | 1:5 |
|  | Magnetic drums | For magnetic field and storage studies | 5 pcs | 1:5 |
|  | Brakes | For studying braking mechanisms | 5 pcs | 1:5 |
|  | Control linkage | For demonstrating mechanical linkages | 5 pcs | 1:5 |
|  | Actuators | For demonstrating movement control | 5 pcs | 1:5 |
| **D** | **Equipment** | | | |
|  | AC/DC electronics training modules | Training modules for AC/DC electronics | 1 pc | 1:25 |
|  | AC/DC machines control training modules | Modules for controlling AC/DC machines | 1 pc | 1:25 |
| **E** | **Reference Materials** | | | |
|  | Component and Equipment Manuals | Manuals for reference on component use and specifications | Sufficient |  |
|  | Health and Safety Manuals | For workplace safety instructions | Sufficient |  |
|  | Electromechanical Reference Books | Comprehensive guides on electromechanical systems | Sufficient |  |
| **F** | **Software** | | | |
|  | Electrical Circuit Design Software | Software for designing electrical circuits | 1 license |  |
|  | AUTOCAD | For creating and modifying digital schematics | 1 license |  |
| **G** | **Trainee Requirements** | | | |
|  | Computing Devices | Desktops, laptops, or tablets for individual use | 25 pcs | 1:1 |
|  | Protective Clothing | Dust coats, gloves, safety boots, goggles | 25 sets | 1:1 |

## COMMUNICATION SKILLS

**ISCED UNIT CODE:** **0031 541 02A**

**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 (Hrs)** |
| 1 | Apply communication channels. | 5 |
| 2 | Apply written communication skills. | 10 |
| 3 | Apply non-verbal skills. | 10 |
| 4 | Apply oral communication skills. | 10 |
| 5 | Apply group communication skills. | 5 |

**Learning outcomes, content, and suggested assessment methods**

| **Learning outcome** | **Content** | **Suggested assessment methods** |
| --- | --- | --- |
| 1. Apply communication channels | * 1. Communication process   2. Principles of effective communication   3. Channels/medium/modes of communication   4. Factors to consider when selecting a channel of communication   5. Barriers to effective communication   6. Flow/patterns of communication   7. Sources of information   8. Organizational policies | * Oral questions * Written assessment * Observation * Portfolio of evidence * Practical assessment * Third party report |
| 1. Apply written communication skills | * 1. Types of written communication   2. Elements of communication   3. Organization requirements for written communication | * Oral assessment * Written assessment * Observation * Portfolio of evidence * Practical assessment * Third party report |
| 1. Apply non-verbal communication skills | * 1. Utilize body language and gestures   2. Apply body posture   3. Apply workplace dressing code | * Oral assessment * Written assessment * Observation * Portfolio of evidence * Practical assessment * Third party report |
| 1. Apply oral communication skills | * 1. Types of oral communication pathways   2. Effective questioning techniques   3. Workplace etiquette   4. Active listening | * Oral assessment * Written assessment * Observation * Portfolio of evidence * Practical assessment * Third party report |
| 1. Apply group communication skills | * 1. Establishing rapport      1. Facilitating resolution of issues      2. Developing action plans      3. Group organization techniques      4. Turn-taking techniques      5. Conflict resolution techniques      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** | | | |
|  | Textbooks | Comprehensive texts books on communication skills | 30 pcs | 1:1 |
|  | Mobile phones | Smartphone for use by trainees | 30 pcs | 1:1 |
|  | Internet connection | Internet connection to aid communication between trainees |  |  |
|  | Powerpoint presentations | For trainer’s use, covering course content and practical applications | 1 | 1:30 |
|  | Projector | Functional projector for displaying content during presentations | 1 | 1:30 |
|  | White board | Quality whiteboard of approximately 6 ft by 3 ft for writing during theory instruction | 1 | 1:30 |
|  | Printer | An ink-jet, laser-jet or toner-cartridge printer for printing notes, instructions and working drawings | 1 | 1:30 |
|  | Templates | Templates for creating various documents e.g. CV, Cover Letter, minutes, reports etc. | 30 | 1:1 |
| **B** | **Learning facilities & infrastructure** | | | |
|  | 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 |
|  | 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** | | | |
|  | Printing papers | A4 and A3 printing papers suitable for the task | Adequate |  |
|  | Flashcards | For carrying out various activities by trainees | Adequate |  |
|  | Flipcharts | Sufficient for group work activities and displaying | Adequate |  |
|  | Whiteboard marker pens | Dry-erase markers for trainers use. Assorted colors | Adequate |  |

# MODULE THREE

## HYDRAULIC AND PNEUMATIC SYSTEMS INSTALLATION AND MAINTANANCE

**ISCED UNIT CODE: 0715 551 12A**

**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 |

**Learning outcomes, content and suggested assessment methods**

| **Learning outcome** | **Content** | **Suggested assessment methods** |
| --- | --- | --- |
| 1. Prepare hydraulic and pneumatic system installation site | * 1. Health and safety in installation sites      1. Overview of health and safety standards for hydraulic and pneumatic installations      2. Personal protective equipment (PPE) requirements      3. Emergency procedures and first aid basics      4. Hazard identification and risk assessment techniques      5. Safe handling and storage of tools and equipment   2. Surveying for hydraulic and pneumatic installations      1. Purpose and process of site surveys      2. Identification of site requirements based on system specifications      3. Assessment of environmental factors and site conditions      4. Documentation of survey findings and recommendations   3. Installation, scheduling and documentation      1. Components of an effective installation schedule      2. Installation timelines      3. Scheduling tools and software      4. Documentation of schedule   4. Site Preparation in line with technical and manufacturer requirements      1. Preparation of installation sites for hydraulic and pneumatic systems      2. Site specifications      3. Workspace layout and positioning of equipment      4. Verification of tools and materials are available and in working order | * Project * Practical * Third party report * Portfolio of evidence * Written tests * Oral questioning |
| 1. Mount hydraulic and pneumatic system components | * 1. Components of fluid power systems      1. Reservoirs, tanks and accumulators      2. Pumps (centrifugal, submersible, diaphragm, gear, peristaltic, piston etc.)      3. Motors (AC, DC, linear, servo, stepper etc.)      4. Actuators   2. Pipes and hoses (fixed, flexible)      1. Valves (pressure relief, pressure reducing etc.)      2. Switches (mechanical, electronic etc.)      3. Gauges (limit, pressure etc.)      4. Filters (pressure, oil, air etc.)      5. Cylinders      6. DCV      7. Compressors   3. Symbols and standard representations in fluid power systems   4. Hydraulic and pneumatic controllers      1. Distributed control systems      2. SCADA      3. Stand-alone controllers (PID, microprocessors, microcontrollers etc      4. Relay      5. PLC   5. Pneumatic principles and components      1. Working principle of pneumatic systems      2. Types of compressors and their applications      3. Air preparation units (filters, regulators, lubricators)   6. Pneumatic actuators and control valves      1. Types of pneumatic actuators (cylinders, motors, grippers)      2. Pneumatic valves (directional, flow control, check valves)   7. Pneumatic circuit design and analysis      1. Basic pneumatic circuit symbols and diagrams      2. Design of simple pneumatic circuits (using valves, actuators)      3. Troubleshoot common pneumatic system issues   8. Hydraulic principles and components      1. Fluid properties and their impact on hydraulic systems      2. Types of hydraulic pumps (gear, vane, piston) and their applications   9. 3.2 Hydraulic actuators and control valves      1. Hydraulic cylinders, hydraulic motors      2. Types of hydraulic valves (pressure, flow, directional control)   10. Hydraulic circuit design and analysis       1. Basic hydraulic circuit symbols and diagrams       2. Design of hydraulic circuits for different industrial applications   11. Introduction to fluid power simulation software       1. Overview of simulation software (e.g., automation studio, FluidSIM)   12. Simulation exercises       1. Design and simulation of pneumatic and hydraulic circuits       2. Analysis of circuit behaviour and identification of improvements   13. Component assembly and safety standards       1. Interpretation of manufacturer’s specifications       2. Sequence of component assembly for hydraulic and pneumatic systems       3. Safe and quality assemblies   14. Controller configuration procedures       1. Hydraulic and pneumatic control systems.       2. Configuration of controllers       3. Calibration of controllers to optimize performance       4. Safety checks, verification and post-configuration   15. System testing methods       1. Types of tests for hydraulic and pneumatic systems (pressure, leak, functionality, mechanical, electrical and safety)       2. Procedures for conducting initial and follow-up tests       3. Analysis of test results       4. Documentation of test outcomes.   16. Reporting protocols for installation processes       1. Required documentation for installation processes       2. Standard reporting formats and workplace protocols       3. Accuracy and completeness of reports       4. Communication of findings and installation status effectively   17. Practical exercises and assignments       1. Practice exercises in circuit building, modification, and installation | * Project * Practical * Third party report * Portfolio of evidence * Written tests * Oral questioning |
| 1. Maintain hydraulic and pneumatic system | * 1. Maintenance scheduling and safety protocols      1. Development of a preventive maintenance schedule      2. Importance of routine maintenance in hydraulic and pneumatic systems      3. Integration of health and safety protocols into maintenance activities      4. Record-keeping for maintenance schedules and updates   2. System troubleshooting techniques      1. Common issues and faults in hydraulic and pneumatic systems      2. Diagnostic techniques for identifying and isolating problems      3. Step-by-step troubleshooting approaches      4. Use of manufacturer guidelines for effective troubleshooting   3. Reporting of maintenance activities for compliance and quality control      1. Importance of maintenance documentation for compliance      2. Standard maintenance report templates and guidelines      3. Detailing findings, repairs, and system status in reports      4. Reports review   4. Practical exercises and assignments      1. Practice exercises in troubleshooting and maintenance | * Project * Practical * Third party report * Portfolio of evidence * Written tests * Oral questioning |

**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** | | | |
|  | Multimeters | For measuring voltage, current, and resistance | 25 pcs | 1:1 |
|  | Clamp meters | For measuring electrical current | 5 pcs | 1:5 |
|  | Power analysers | For analysing power quality and consumption | 5 pcs | 1:5 |
|  | Thermal imaging cameras | For visualizing heat patterns and identifying issues | 5 pcs | 1:5 |
|  | Assorted wrenches | For tightening and loosening fasteners | 5 Sets | 1:5 |
|  | Screwdrivers | For driving screws; various types included | 5 pcs | 1:5 |
|  | Pliers | For gripping and bending wires | 5 pcs | 1:5 |
|  | Hex keys | For hexagonal screws and bolts | 5 pcs | 1:5 |
|  | Cutters | For cutting wires and cables | 5 pcs | 1:5 |
|  | Tape measures | For measuring lengths and distances | 5 pcs | 1:5 |
|  | Callipers | For measuring internal and external dimensions | 5 pcs | 1:5 |
|  | Alignment lasers | For precise alignment of components | 2 pcs | 2:25 |
|  | Plumb bobs | For vertical alignment in installations | 5 pcs | 1:5 |
| **B** | **Learning facilities & infrastructure** | | | |
|  | Lecture/theory room | Approximately 60 sqm | 1 | 1:25 |
|  | Workshop | Approximately 80 sqm | 1 | 1:25 |
|  | Laboratory | Approximately 80 sqm | 1 | 1:25 |
| **C** | **Materials and supplies** | | | |
|  | Pressure gauges | For measuring pressure in pneumatic systems | 25 pcs | 1:1 |
|  | Vacuum gauges | For measuring vacuum levels in systems | 25 pcs | 1:1 |
|  | Pressure regulators | For controlling and regulating pressure | 25 pcs | 1:1 |
|  | Pipes and tubes | For various pneumatic and hydraulic applications | 100 pcs | 4:1 |
|  | Connectors | For connecting pipes and tubes | 100 pcs | 4:1 |
|  | Air compressors | For supplying compressed air for pneumatic tools | 25 pcs | 1:1 |
|  | Valves | For controlling the flow of fluids in systems | 25 pcs | 1:1 |
|  | Enclosures | For housing electrical and mechanical components | 25 pcs | 1:1 |
|  | Fittings | For connecting different sections of pipes and tubes | 25 pcs | 1:1 |
|  | Safety valves | For ensuring safety in pressure systems | 25 pcs | 1:1 |
|  | Pneumatic cylinders | Single/double | 10 pcs | 2:5 |
|  | Sensors | Assorted | 10 pcs | 2:5 |
|  | Controllers | Controlling automatic pneumatic systems | 5 pcs | 1:5 |
| **D** | **Equipment** | | | |
|  | Safety glasses | Eye protection for all trainees | 25 pcs | 1:1 |
|  | Gloves | Hand protection during training and operations | 25 pairs | 1:1 |
|  | Hearing protection | To safeguard against loud noises | 25 pcs | 1:1 |
|  | Hard hats | Head protection while working | 25 pcs | 1:1 |
|  | Oscilloscopes | For visualizing electrical signals | 2 units | 2:25 |
|  | Megohmmeters | For testing insulation resistance | 5 units | 1:5 |
|  | Pneumatic system training kits | For training | 5 units | 1:5 |
|  | Hydraulic system training kits | For training | 5 units | 1:5 |
| **E** | **Miscellaneous** | | | |
|  | Lubricating Equipment | For maintaining smooth operation of mechanical components | 1 unit | 1:25 |
|  | Vacuum Pump | For creating a vacuum for testing and operations | 1 unit | 1:25 |
| **F** | **Reference materials** | | | |
|  | Component and Equipment Manuals | Comprehensive guides on all tools and equipment | Adequate |  |
|  | Pneumatic and hydraulic system installation manuals | For proper setup and maintenance of pneumatic systems | Adequate |  |
|  | Other reference materials | Journals, past papers, and online resources for further study | Adequate |  |

## ELECTRICAL AND ELECTRONICS PRINCIPLES

**ISCED UNIT CODE:** 0713 541 08A

**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 |

**Learning outcomes, content and suggested assessment methods**

|  |  |  |
| --- | --- | --- |
| **Learning outcome** | **Content** | **Suggested assessment methods** |
| 1. Apply safety requirements for electricity | * 1. Personal protective equipment (PPE)      1. Types of PPE         1. Head protection, insulating gloves, eye protection         2. Usage guidelines and importance   2. Control of electrical hazards      1. Identification of Hazards         1. Shocks, explosions, electrocution, burns, fires, electric arcs         2. Risk assessment and management   3. Electric Hazard Prevention      1. Preventative measures         1. Lockout/tagout (LOTO) procedures         2. Safe work practices | * Project * Practical * Written tests * Oral Questioning * Portfolio of evidence |
| 1. Use the concept of basic electrical quantities | * 1. Basic SI units      1. Overview of SI Units         1. Power (Watts, W)         2. Current (Amperes, A)         3. Resistance (Ohms, Ω)         4. Voltage (Volts, V)   2. Conductors and insulators      1. Identification and characteristics         1. Metals vs. non-metals         2. Applications in electrical circuits   3. Electrical quantities      1. Charge, force, work, and power      2. Definitions and units      3. Calculations involving Electrical quantities   4. Ohm’s law      1. Understanding ohm's law      2. Practical applications and calculations   5. Basic electrical and electronic measurements      1. Measurement Techniques      2. Use of multimeters, oscilloscopes, and ammeters      3. Measurement accuracy and calibration | * Project * Practical * Written tests * Oral Questioning * Portfolio of evidence |
| 1. Apply DC and AC circuits | * 1. Introduction to electrical circuits      1. Introduction to electricity:      2. Voltage, current, and power.      3. Overview of DC and AC circuits.      4. Basic circuit elements: resistors, capacitors, and inductors.   2. DC Circuit Analysis      1. Series and parallel circuits.      2. Voltage and current division principles.      3. Kirchhoff's Vvltage law (KVL) and Kirchhoff's current law (KCL).      4. Analysis of complex circuits using KVL and KCL.      5. Introduction to circuit simulation software (e.g., SPICE).      6. Practical applications of DC circuit analysis.      7. Circuit design and testing using breadboards.      8. Hands-on lab: Building and testing DC circuits.   3. AC circuits analysis      1. Introduction to AC: Sinusoidal waveforms, frequency, and period.      2. RMS values, peak values, and average values.      3. AC voltage and current sources.      4. Phasor representation of AC quantities.      5. Impedance and admittance.      6. Series and parallel AC circuits.      7. Resonance in RLC circuits.      8. Practical analysis of AC circuits using phasors.      9. Power in AC Circuits         1. Power factor and power factor correction.         2. Real, reactive, and apparent power.         3. AC power calculations for single-phase and three-phase circuits.         4. Energy consumption and efficiency.         5. Applications of AC power in household and industrial settings.   4. Practical activity:      1. Connection in series and Parallel      2. Simulation | * Project * Practical * Written tests * Oral questioning * Portfolio of evidence |
| 1. Apply magnetism and electromagnetism | * 1. Magnetic circuits and devices      1. Introduction to magnetic circuits.      2. Magnetic flux, magnetic field density, magnetic field strength, Reluctance, magnetomotive force (MMF), and magnetic flux.      3. Calculations involving magnetic circuits      4. Analogies between electric and magnetic circuits.      5. Magnetic materials in electrical devices (soft and hard magnetic materials).   2. Electromagnetic induction      1. Faraday’s law of electromagnetic induction.      2. Lenz's law: Direction of induced EMF.      3. Practical applications: Electric generators and transformers.      4. Induced EMF in different configurations (moving conductors, changing magnetic fields).      5. Self-induction and mutual induction.      6. Transformers: Working principles, construction, and applications.      7. Step up and step-down transformers      8. Power losses in transformers.      9. Calculations involving transformers      10. Energy stored in magnetic fields. | * Project * Practical * Written tests * Oral questioning * Portfolio of evidence |
| 1. Apply single and three phase power supply principles | * 1. Overview of electrical power systems      1. Definition and importance of power supply systems      2. Types of power systems: Single-phase vs. three-phase      3. Basic electrical concepts         1. Voltage, current, power, and frequency         2. Phase relationships and power factor   2. Single-phase power supply      1. Characteristics of single-phase systems         1. Voltage and current waveforms         2. Applications and limitations of single-phase power      2. Circuit design and Implementation         1. Basic circuit configurations: series and parallel         2. Wiring techniques and component selection      3. Measurement Techniques         1. Measuring voltage, current, and power in single-phase circuits         2. Tools and instruments for measurements   3. Three-phase power supply      1. Fundamentals of three-phase systems         1. Characteristics of three-phase power: Star (Y) and Delta (Δ) configurations         2. Advantages of three-phase systems over single-phase      2. Circuit design and implementation         1. Wiring and connection techniques for three-phase systems         2. Component selection and configuration      3. Measurement techniques         1. Measuring line and phase voltages, currents, and power in three-phase circuits         2. Use of power analyzers and other measurement tools   4. Power calculations and analysis      1. Power calculations         1. Active, reactive, and apparent power calculations         2. Understanding the power triangle in both single and three-phase systems      2. Power factor correction         1. Importance of power factor in electrical systems         2. Techniques for improving power factor in both types of systems   5. Troubleshooting and maintenance      1. Common issues in power supply systems         1. Identifying and diagnosing faults in single and three-phase systems         2. Troubleshooting techniques and best practices | * Project * Practical * Written tests * Oral questioning * Portfolio of evidence |
| 1. Apply sensors and transducers principles | * 1. Introduction to sensors and transducers      1. Definitions and Concepts      2. Differences between sensors and transducers         1. Overview of their roles in measurement and control systems   2. Basic principles of operation      1. How sensors and transducers convert physical phenomena into electrical signals      2. Common physical quantities measured (e.g., temperature, pressure, moisture, position, oxygen, light)   3. Types of sensors      1. Temperature sensors      2. Thermocouples, thermistors, and infrared sensors      3. Principles of operations      4. Applications and selection criteria   4. **Pressure sensors**      1. Strain gauge, piezoelectric, and capacitive pressure sensors      2. Principles of operations      3. Measurement techniques and applications   5. **Proximity and displacement sensors**      1. Inductive, capacitive, and photoelectric sensors      2. Principles of operations      3. Use cases and installation considerations   6. Other **sensor types**      1. Humidity, moisture, oxygen, flow, level, and gas sensors      2. Overview of their principles and applications   7. Types of transducers      1. Definition **and Functionality**         1. Types of transducers (active vs. passive)         2. Examples and applications   8. Electrical **transducers**      1. Strain gauges, load cells, and piezoelectric transducers      2. Principles of operation and usage   9. Mechanical **transducers**      1. Overview of mechanical types and their applications      2. Integration into automated systems   10. Hands-on experiments on testing sensors and actuators. | * Project * Practical * Written tests * Oral questioning * Portfolio of evidence |
| 1. Apply principles of analogue electronics | * 1. Introduction to electronic components      1. Overview of electronics: What are electronic components?      2. Classification of components: passive, active, and electromechanical.      3. Introduction to circuit symbols and schematic diagrams.      4. Basic electrical quantities and units (voltage, current, resistance).      5. Understanding datasheets and component specifications.      6. Overview of testing and measurement tools (multimeters, oscilloscopes).   2. Passive Components      1. Resistors: types, color codes, power ratings, and applications.      2. Capacitors: types (ceramic, electrolytic, film), capacitance value, and working voltage.      3. Charging and discharging of capacitors in DC circuits.      4. Applications of capacitors in filtering, timing, and energy storage.      5. Inductors: types, inductance value, and applications.      6. Inductor behavior in DC and AC circuits.      7. Introduction to filters: RC, RL, and RLC circuits.   3. Semiconductor devices      1. Diodes: Introduction to PN junctions, characteristics, and types (LEDs, zener diodes, Schottky diodes).      2. Applications of diodes in rectification, voltage regulation, and signal clipping.      3. Transistors: types (BJT and MOSFET), characteristics, and configurations.      4. Basic transistor circuits: Switches and amplifiers.      5. Hands-on lab: Building and testing simple diode and transistor circuits.      6. Special semiconductor devices: thyristors, TRIACs, and optoelectronic devices.      7. Characteristics and applications in switching and control.   4. Integrated Circuits (ICs)      1. Overview of integrated circuits: Analog vs. digital ICs.      2. Operational amplifiers (Op-Amps): Characteristics and basic configurations.      3. Applications of Op-Amps in signal processing.      4. Timers and oscillators: 555 timer IC and its applications.      5. Voltage regulators: Linear and switching regulators.      6. Introduction to data converters (ADC and DAC).   5. Electromechanical and Specialized components      1. Relays: types, operation, and applications in switching.      2. Switches and connectors: types and usage in electronic circuits.      3. Transformers: basic operation, step-up/step-down functions, and isolation.      4. Displays: LED, LCD, and seven-segment displays.      5. Circuit design and practical applications      6. Basic circuit design principles: bread boarding, PCB layout, and soldering.      7. Introduction to circuit simulation tools (e.g., Multisim, LTSpice).      8. Testing and troubleshooting techniques.      9. Real-world applications of electronic components.      10. Building practical projects: Power supplies, audio amplifiers, and sensor-based circuits.      11. Hands-on lab: Final project assembly and testing. | * Project * Practical * Written tests * Oral questioning * Portfolio of evidence |
| 1. Apply principles of digital electronics | * 1. Basics of digital electronics      1. Introduction to digital electronics, importance, and applications      2. Introduction to binary, decimal, hexadecimal, and octal number systems   2. Number systems and conversions      1. Converting between binary, decimal, hexadecimal, and octal systems      2. Application of number systems in digital electronics   3. Digital logic gates      1. Boolean algebra      2. Types and functions of logic gates (AND, OR, NOT, NAND, NOR, XOR, XNOR)      3. Reading and interpreting logic gate symbols and truth tables      4. Construction of digital circuits using logic gates   4. Digital circuit construction      1. Building basic digital circuits with logic gates      2. Testing and verifying functionality according to design requirements      3. Practical exercises: simple logic gate projects | * Project * Practical * Written tests * Oral Questioning * Portfolio of evidence |
| 1. Design electronic circuits | * 1. Drawing electronic circuit schematics      1. Introduction to circuit schematic symbols and layout      2. Software tools for drawing schematic diagrams      3. Practical exercises: creating schematic diagrams   2. Identification and selection of circuit components      1. Identifying components and understanding their roles in circuits      2. Selection of components based on design specifications and functionality   3. Simulation of electronic circuits      1. Introduction to circuit simulation software      2. Simulation electronic circuits for testing and troubleshooting      3. Evaluation of simulation results and identifying design adjustments   4. Soldering and circuit assembly      1. Techniques in soldering and desoldering components      2. Assembly of circuits as per design specifications      3. Quality checks and safety protocols in circuit assembly   5. Testing and troubleshooting      1. Testing circuit functionality and performance      2. Identification and rectification of faults in assembled circuits      3. Practical exercises: testing and troubleshooting projects | * Project * Practical * Written tests * Oral Questioning * Portfolio of evidence |

**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 FOUR

## STAND-ALONE CONTROLLER INSTALLATION AND MAINTENANCE

**ISCED UNIT CODE:** 0715 551 13A

**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 |

**Learning outcomes, content and suggested assessment methods**

| **Learning outcome** | **Content** | **Suggested assessment methods** |
| --- | --- | --- |
| 1. Mount Stand-alone controller hardware | * 1. Healthand safety      1. PPEs      2. Work permits      3. Waste management      4. Electrical wiring colour coding      5. Danger warning signage      6. Barricades      7. High voltage signage      8. Health policy   2. Standalone controllers      1. Programmable Logic Controllers (PLCs)      2. Supervisory Control and Data Acquisition (SCADA)      3. Distributed Control System (DCS).      4. PIDs      5. Microcontroller      6. Digital signal processors      7. Motor controllers      8. Power inverters   3. Standalone controller Installation tools      1. Hand Tools      2. Screwdrivers, wrenches, pliers, and hex keys for securing components.      3. Power Tools      4. Impact drivers, and cordless screwdrivers for efficient assembly.      5. Measuring Tools   Tape measures, levels, and calipers for accurate placement and alignment.   * + 1. Cable Management Tools        1. Cable ties, trays, and labels for organizing and securing wiring.   1. Preparation of the installation cabinet for stand-alone controllers      1. Introduction to controller cabinets      2. Interpretation of manufacturer specifications for cabinet preparation (required dimensions, cooling or ventilation needs, and placement guidelines etc)      3. Environmental requirements      4. Cabinet preparation steps   2. Fitting stand-alone controllers in the cabinet      1. Interpretation of technical drawings      2. Controller mounting requirements      3. Step-by-step controller installation      4. Cable management   3. Stand-alone control system wiring      1. Power connections      2. Sensor wiring      3. Actuator wiring      4. Signal wiring      5. System testing   4. Practice: Hands-on exercises in cabinet preparation, controller fitting, and performing wiring according to IEEE standards. | * Oral assessment * Portfolio of evidence * Interviews * Third party report * Written assessment * Practical assessment * Projects |
| 1. Interface Stand-alone controller I/O | * 1. Stand-alone controller I/O      1. Input (I)         1. Digital Inputs:   Switches, push buttons, and various sensors (proximity, limit, photoelectric, pressure, temperature) for detecting states and conditions.  Encoder inputs for position feedback.   * + - 1. Analog Inputs:   Potentiometers, voltage and current sensors, RTDs, thermocouples, and strain gauges.   * + - 1. Communication Inputs:   Serial ports (RS-232, RS-485), Ethernet ports, CAN bus, and USB ports.   * + 1. Output (O)        1. Digital Outputs: Relays, transistors, indicator lights, buzzers, and LEDs for control and status indication.        2. Analog Outputs: PWM outputs for motor speed control, voltage, and current outputs for sending signals to devices.        3. Communication Outputs: Serial ports, Ethernet ports, CAN bus, and USB ports for transmitting data to other devices.     2. Power I/O     3. Power Supply | * Oral assessment * Portfolio of evidence * Interviews * Third party report * Written assessment * Practical assessment * Projects |
| 1. Program stand-alone controller | * 1. Standalone controller programming      1. Programming software         1. Arduino IDE         2. Raspberry Pi IDE         3. Gx works         4. Rs Logix         5. Step 7         6. TIA Portal      2. Objective definition: Task identification and performance criteria.      3. System flow chart      4. Control algorithms      5. Coding.      6. Compiling      7. Testing and debugging program      8. System simulation      9. Field testing      10. Code, algorithm documentation, and user manuals. | * Oral assessment * Portfolio of evidence * Interviews * Third party report * Written assessment * Practical assessment * Projects |
| 1. Maintain Stand-alone controller | * 1. Standalone controller maintenance schedule      1. Daily         1. Visual Inspection         2. Cleanliness Checks         3. Basic Functionality Test      2. Weekly         1. Lubrication         2. Sensor calibration         3. Fuse and battery check      3. Monthly         1. Comprehensive inspection         2. Software update         3. Detailed functional testing      4. Quarterly         1. Replacement of worn parts         2. Calibration: Conduct detailed calibration of sensors and actuators.         3. Safety system check      5. Annually         1. In-depth functional testing.         2. Data review         3. Comprehensive system audit         4. Upgrade assessment   2. Standalone controller system maintenance report      1. Daily      2. Weekly      3. Quarterly      4. Annual | * Oral assessment * Portfolio of evidence * Interviews * Third party report * Written assessment * Practical assessment * Projects |

**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** | | | |
|  | Multimeters | Digital multimeters for measuring voltage, current, and resistance | 25 pcs | 1:1 |
|  | Clamp Meters | For measuring current flow in electrical systems | 5 pcs | 1:5 |
|  | Power Analyzers | For analyzing power quality and consumption | 5 pcs | 1:5 |
|  | Sensors | Assorted sensors | 5 pcs | 1:5 |
| **B** | **Learning facilities & infrastructure** | | | |
|  | Lecture/Theory Room | Approximately 60 sqm | 1 | 1:25 |
|  | Workshop | Approximately 80 sqm | 1 | 1:25 |
|  | Laboratory | Approximately 80 sqm | 1 | 1:25 |
| **C** | **Hand tools** | | | |
|  | Wrenches | Adjustable wrenches for various sizes of nuts and bolts | 4 pcs | 1:6.25 |
|  | Screwdrivers | Phillips and flathead screwdrivers for assembly work | 5 pcs | 1:5 |
|  | Pliers | For gripping, twisting, and cutting wires | 5 pcs | 1:5 |
|  | Hex Keys | Allen wrenches for hexagonal screws and bolts | 5 pcs | 1:5 |
|  | Cutters | Wire cutters for precise cutting of electrical wires | 5 pcs | 1:5 |
| **D** | **Measuring tools** | | | |
|  | Tape measures | 5m tape measures for accurate measurements | 5 pcs | 1:5 |
|  | Calipers | For measuring internal and external dimensions precisely | 5 pcs | 1:5 |
|  | Alignment tools | Assorted | 5 pcs | 1:5 |
|  |  |  |  |  |
| **E** | **Materials and Supplies** | | | |
|  | Manipulators | For robotic manipulation tasks | 2 pcs | 2:25 |
|  | Controller units | For controlling robotic systems | 2 pcs | 2:25 |
|  | Sensors | Various sensors for feedback and measurement | 2 pcs | 2:25 |
|  | Actuators | For converting electrical signals into mechanical motion | 2 pcs | 2:25 |
|  | Encoders | For position sensing in robotic systems | 2 pcs | 2:25 |
|  | Gears | For mechanical transmission in robotics | 2 pcs | 2:25 |
|  | Motors | Includes servo motors, stepper motors, and linear motors | 2 pcs | 2:25 |
|  |  |  |  |  |
| **F** | **Equipment** | | | |
|  | ***Safety equipment*** | | | |
|  | Safety glasses | For eye protection during practical activities | 25 pcs | 1:1 |
|  | Gloves | For hand protection while working with machinery | 25 pairs | 1:1 |
|  | Hearing protection | Ear protection to prevent noise-related injuries | 25 pcs | 1:1 |
|  | Helmet | Head protection for safety during hands-on work | 25 pcs | 1:1 |
|  | ***Testing equipment*** | | | |
|  | Oscilloscopes | For visualizing electrical signals | 2 pcs | 2:25 |
|  | Megaohmmeters | For insulation resistance testing | 2 pcs | 2:25 |
|  | *Miscellaneous* | | | |
|  | Lubricating Equipment | For maintenance of mechanical systems | 1 set |  |
|  | Vacuum pump | For testing and cooling applications | 1 unit |  |
| **G** | **Reference materials** | | | |
|  | Component and equipment manuals | Detailed manuals for operation and maintenance | adequate |  |
|  | Robotic installation books | Texts covering the principles and practices of robotic systems | adequate |  |
|  | Other reference materials | Journals, past papers, and online resources for further learning | adequate |  |

## PLC SYSTEM INSTALLATION AND MAINTANANCE

**ISCED UNIT CODE:** 0715 551 14A

**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 |

**Learning outcomes, content and suggested assessment methods**

| **Learning Outcome** | **Content** | **Suggested assessment methods** |
| --- | --- | --- |
| 1. Mount PLC hardware | 1. Health and safety;    * 1. Operator safety      2. PPEs      3. Work permits      4. Waste management      5. Electrical wiring colour coding      6. Danger warning signage      7. Barricades      8. High voltage signage      9. Health policy 2. Selection of tools and equipment in PLC hardware mounting,    * 1. Clamp-meter      2. Multi-meter      3. Ethernet crimping tools      4. Set of screwdrivers      5. Set of wrenches      6. Set of Pliers 3. Preparation of PLC installation cabinet 4. Installation of PLC hardware in the cabinet    * 1. Power supply      2. Input module      3. Output module      4. Processor (CPU)      5. Rack or mounting assembly      6. Indicator lights 5. PLC wiring    * 1. Interpretation of PLC hardware component manuals      2. Interpretation of PLC software manuals      3. Interpretation of I/O modules installation manuals      4. Interpretation of installation drawings      5. Interpretation of electrical wiring drawings      6. Electrical wiring standards, codes and procedures 6. Practice: Cabinet preparation and hardware installation | * Practical assessment * Oral presentations * Observations * Trainee report * Supervisor’s report * Online assignments * Case studies * Trainer report * Written assessments * Portfolio assessment |
| 1. Interface PLC with I/O modules | * 1. PLC network working cables      1. Ethernet cable      2. USB Cable      3. Serial Cable      4. Profinet cables      5. Profibus cables      6. Coaxial cables   2. Fiber optic cables PLC cable layout and cable management   3. Network cables termination   4. Network cables testing      1. Professional testers      2. Continuity testers      3. LAN cable tester      4. Phone line tester   5. PLC device communication protocols and channels   6. PLC memory addressing   7. Human machine interface   8. Configuration of network ports      1. Ethernet ports      2. USB ports      3. HDMI ports      4. Mac serial ports   9. Practice: Network cable termination | * Practical assessment * Oral presentation * Observations * Trainee assessment * Supervisor’s report * Online assignments |
| 1. Program PLC | * 1. Installation of PLC programming software      1. RS Logix      2. Logosoft      3. Gx works      4. Step 5- Micro wins      5. Step 7- Simatic Manager      6. TIA portal   2. Configuration of PLC software and hardware   3. Flow diagrams      1. Cross functional flow diagrams      2. Swim lane flow diagrams   4. PLC programming languages      1. ladder logic      2. functional block diagrams      3. Structured Text      4. Sequential Flow Charts      5. Instruction Lists   5. Creation of PLC, I/O schedules   6. PLC programming      1. PLC program structure      2. PLC rungs   7. Simulation of PLC program   8. Troubleshoot PLC program faults      1. I/O module failure      2. Power supply failure      3. Corrupted memory      4. Failed voltage supply   9. Reconfiguration of PLC programming software   10. PLC operation modes   11. Establishment of PLC communication   12. Clearance of PLC memory   13. Downloading of PLC program to PLC hardware   14. Practice: Developing and debugging PLC programs | * Practical assessment * Oral presentations * Observations * Trainee report * Supervisor’s report * Online assignments * Case studies * Trainer report * Written assessments * Portfolio assessment |
| 1. Maintain PLC systems | * 1. Environmental and safety standards   2. PLC program back-up      1. Extraction of PLC program      2. Recovery of PLC program   3. PLC system tag out/Lock out and routine checks   4. PLC network data communication   5. Verification of I/O modules for normal operations   6. Verification of PLC’s CPU optimum performance   7. Verification of sensors for normal performance   8. PLC system configuration   9. PLC modules      1. Power supply module (PS)      2. CPU      3. Interface module (IM)      4. Signal modules (SM)      5. Function module (FM)      6. Communication processor (CP)   10. Identification of PLC wires and cables       1. Terminal cables       2. Tag cables   11. Interpretation of schematic diagrams and maintenance manuals   12. Visual checks on PLC attachments   13. Cleaning of PLC systems and peripheral devices   14. Restoration of PLC program   15. Format PLC system software   16. Maintenance of logging activities in maintenance management systems   17. Maintenance documentation       1. CPU module specification sheet       2. I/O terminal block specification sheet       3. Output specification sheet       4. DeviceNET link specification sheet       5. Flow diagrams       6. I/O schedule       7. PLC program   18. Practice: Prepare maintenance documentation report | * Practical assessment * Oral presentations * Observations * Trainee report * Supervisor’s report * Online assignments * Case studies * Trainer report * Written assessments * Portfolio assessment |

**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** | | | |
|  | Ethernet crimping tool | For crimping jacks | 5 pcs | 1:5 |
|  | Set of screwdrivers | Flat and star-assorted sizes. For fastening screws | 2 set each | - |
|  | Set of wrenches | For tightening bolts and nuts  in various sizes | 5 pcs | 1:5 |
|  | Clamp meter | For measuring current without connection to a circuit in series | 5 pcs | 1:5 |
|  | Continuity testers | For cable continuity testing | 5 pcs | 1:5 |
|  | LAN cable tester | For testing ethernet cables | 5 pcs | 1:5 |
|  | Phone line tester | For line fault diagnosis | 5 pcs | 1:5 |
| **B** | **Materials and supplies** | | | |
|  | Whiteboard markers | For writing on whiteboards during instruction | Adequate |  |
|  | PCB boards | For circuit assembly and testing | 10 pcs | 2:5 |
|  | Bolts, Nuts, and Washers | For securing components | Adequate |  |
|  | Fasteners | Used in assembly tasks | 5 pcs | 1:5 |
|  | Breadboards | For prototype circuit assembly | 10 pcs | 2:5 |
|  | Trunking | For organizing and protecting cables | Sufficient |  |
|  | DIN rail | For mounting components | Adequate |  |
|  | Sensors | Assorted-For PLC inputs | Adequate |  |
|  | PLC cables and wires | For PLC wiring | Adequate |  |
|  | Racks | For mounting PLC modules | Adequate |  |
| **c** | **Equipment** | | | |
|  | Projectors | For visual presentations | 1 | 1:25 |
|  | Actuators | For demonstrating movement control | 5 pcs | 1:5 |
|  | PLC Modules | For programmable logic control setups | 5 pcs | 1:5 |
|  | HMI | For Human Machine Interface | 5 pcs | 1:5 |
|  | Power supplies | For powering PLC systems | 5 pcs | 1:5 |
|  | RCD | For electrical shock prevention | 5 pcs | 1:5 |
|  | Contactors | For PLC outputs | 5 pcs | 1:5 |
| **D** | **Reference materials** | | | |
|  | PLC maintenance manuals/handbooks | Manuals for reference on PLC maintenance | Adequate |  |
|  | Health and safety manuals | For workplace safety instructions | Adequate |  |
|  | PLC operation manuals | Comprehensive guides on PLC systems | Adequate |  |
|  | Relevant PLC textbooks | For refencing | Adequate |  |
|  | Relevant journals and websites | For refencing | Sufficient | N/A |
| **E** | **Software** | | | |
|  | PLC software | For programming PLC | 1 license (distributable) | N/A |
|  | **Trainee requirements** | | | |
|  | Computing Devices | Desktops, laptops, or tablets for individual use | 25 pcs | 1:1 |
|  | 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 FIVE

## ROBOTIC SYSTEM INSTALLATION AND MAINTENANCE

**ISCED UNIT CODE:** 0715 551 15A

**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 |

**Learning outcomes, content and suggested assessment methods**

| **Learning outcome** | **Content** | **Suggested assessment methods** |
| --- | --- | --- |
| 1. Prepare robotic systems installation site | * 1. Health and safety      1. PPEs      2. Work permits      3. Waste management      4. Electrical wiring colour coding      5. Danger warning signage      6. Barricades      7. High voltage signage      8. Health policy   2. Robotic system installation site survey      1. Purpose and importance of site surveys      2. Components of a site survey      3. Environmental considerations      4. Site survey documentation   3. Developing a robotic system installation schedule      1. Reading and interpreting manufacturer’s guidelines      2. Project planning fundamentals      3. Resource allocation      4. Creating a Gantt chart      5. Contingency planning   4. Setting up the robotic system installation area      1. Preparing the physical space      2. Positioning equipment      3. System infrastructure setup   5. Documenting the robotic system site preparation      1. Importance of site preparation documentation      2. Guidelines for creating a site preparation report      3. Using documentation templates      4. Review and submission | * Oral assessment * Portfolio of evidence * Interviews * Third party report * Written assessment * Practical assessment * Projects |
| 1. Assemble   robotic system components | * 1. Types of robotic systems      1. Industrial robots      2. Mobile robots.      3. Service robots      4. Humanoid robot      5. Autonomous robots      6. Cartesian robots      7. Polar robot      8. Articulated robot      9. Teleoperated robots      10. Swarm robots      11. Modular robots      12. Soft robots      13. Bionic robots   2. Components of a robotic system      1. Sensors      2. Actuators      3. Controller      4. Manipulator      5. Encoder      6. Gears      7. Power Supply      8. Chassis and Frame      9. End Effectors      10. Motors (servo motors, stepper motors, linear motors, etc)   3. Robotic system tests      1. Electrical      2. Mechanical      3. Safety      4. Functional testing      5. Performance testing      6. Load testing      7. Durability testing      8. Safety testing      9. Integration testing      10. Usability testing      11. Reliability testing      12. Sensor Calibration testing | * Oral assessment * Portfolio of evidence * Interviews * Third party report * Written assessment * Practical assessment * Projects |
| 1. Program robotic system | * 1. Robotic system programming      1. Software         1. TIA portal         2. STEP 7         3. GX works         4. TWINCAT         5. Micro-Logix         6. C, C++ (Arduino, Raspberry Pi, STM32 etc)      2. Objective definition: Task identification and performance criteria.      3. System flow chart      4. Control algorithms      5. Integration of sensor data      6. Motion planning and obstacle avoidance algorithms.      7. Testing and debugging program      8. System simulation      9. Field testing      10. Code, algorithm documentation, and user manuals.   2. Practice: program robotic system | * Oral assessment * Portfolio of evidence * Interviews * Third party report * Written assessment * Practical assessment * Projects |
| 1. Maintain robotic system | * 1. Robotic system maintenance schedule      1. Daily         1. Visual inspection         2. Cleanliness checks         3. basic functionality test      2. Weekly         1. Lubrication         2. Sensor calibration         3. Battery check      3. Monthly         1. Comprehensive inspection         2. Software update         3. Detailed functional testing      4. Quarterly         1. Replacement of worn parts         2. Calibration: conduct detailed calibration of sensors and actuators.         3. Safety system check      5. Annually         1. Battery replacement         2. In-depth functional testing.         3. Data review         4. Comprehensive system audit         5. Training refresh         6. Upgrade assessment      6. Robotic system maintenance report         1. Daily         2. Weekly         3. Quarterly         4. Annual   2. Practice: Maintain robotics system | * Oral assessment * Portfolio of evidence * Interviews * Third party report * Written assessment * Practical assessment * Projects |

**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** | | | |
|  | Multimeters | Digital multimeters for measuring voltage, current, and resistance | 25 pcs | 1:1 |
|  | Clamp Meters | For measuring current flow in electrical systems | 5 pcs | 1:5 |
|  | Power Analyzers | For analyzing power quality and consumption | 5 pcs | 1:5 |
| **B** | **Learning facilities & infrastructure** | | | |
|  | Lecture/Theory Room | Approximately 60 sqm | 1 | 1:25 |
|  | Workshop | Approximately 80 sqm | 1 | 1:25 |
|  | Laboratory | Approximately 80 sqm | 1 | 1:25 |
| **C** | **Hand Tools** | | | |
|  | Wrenches | Adjustable wrenches for various sizes of nuts and bolts | 4 pcs | 1:6 |
|  | Screwdrivers | Phillips and flathead screwdrivers for assembly work | 5 pcs | 1:5 |
|  | Pliers | For gripping, twisting, and cutting wires | 5 pcs | 1:5 |
|  | Hex Keys | Allen wrenches for hexagonal screws and bolts | 5 pcs | 1:5 |
|  | Cutters | Wire cutters for precise cutting of electrical wires | 5 pcs | 1:5 |
| **D** | **Measuring tools** | | | |
|  | Tape measures | 5m tape measures for accurate measurements | 5 pcs | 1:5 |
|  | Calipers | For measuring internal and external dimensions precisely | 5 pcs | 1:5 |
|  | Alignment Tools | Assorted | 5 pcs | 1:5 |
|  |  |  |  |  |
| **E** | **Materials and supplies** | | | |
|  | Manipulators | For robotic manipulation tasks | 2 pcs | 2:25 |
|  | Controller Units | For controlling robotic systems | 2 pcs | 2:25 |
|  | Sensors | Assorted sensors for feedback and measurement | Adequate |  |
|  | Actuators | For converting electrical signals into mechanical motion | 2 pcs | 2:25 |
|  | Encoders | For position sensing in robotic systems | 2 pcs | 2:25 |
|  | Gears | For mechanical transmission in robotics | 2 pcs | 2:25 |
|  | Motors | Includes servo motors, stepper motors, and linear motors | 2 pcs | 2:25 |
|  |  |  |  |  |
| **F** | **Equipment** |  |  |  |
|  | *Safety equipment* |  |  |  |
|  | Safety Glasses | For eye protection during practical activities | 25 pcs | 1:1 |
|  | Gloves | For hand protection while working with machinery | 25 pairs | 1:1 |
|  | Hearing protection | Ear protection to prevent noise-related injuries | 25 pcs | 1:1 |
|  | Hard hats | Head protection for safety during hands-on work | 25 pcs | 1:1 |
|  | Robotics training kit | For training | 2 | 2:25 |
| **G** | **Testing Equipment** | | | |
|  | Oscilloscopes | For visualizing electrical signals | 2 pcs | 2:25 |
|  | Megaohmmeters | For insulation resistance testing | 2 pcs | 2:25 |
|  | Lubricating Equipment | For maintenance of mechanical systems | 1 set |  |
|  | Vacuum Pump | For testing and cooling applications | 1 unit |  |
|  |  |  |  |  |
| **G** | **Reference materials** | | | |
|  | Component and equipment manuals | Detailed manuals for operation and maintenance | Adequate |  |
|  | Robotic installation books | Texts covering the principles and practices of robotic systems | Adequate |  |
|  | 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

**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 |

**Learning outcomes, content and suggested assessment methods**

| **Learning outcome** | **Content** | **Suggested assessment methods** |
| --- | --- | --- |
| 1. Prepare SCADA system installation site | 1. Observe occupational health and safety 2. Types and usage of PPE 3. Industrial safety signs 4. SCADA installation tools and equipment 5. SCADA system parts and accessories 6. Installation management    * 1. Initiation      2. Planning      3. Execution      4. Work distribution   1.7 Project: Prepare site preparation plan | * Observation * Oral assessment * Portfolio of evidence * Interviews * Third party report * Written assessment * Practical assessment * Projects |
| 1. Mount SCADA system components | * 1. Health and safety      1. PPEs      2. Work permits      3. Waste management      4. Electrical wiring colour coding      5. Danger warning signage      6. Barricades      7. High voltage signage   2. Selection of tools and equipment in SCADA hardware mounting   3. Preparation of SCADA installation cabinet   4. SCADA components      1. Data input devices such as sensors      2. Data processing devices, such as a PLC or RTU      3. Data output devices such as an HMI or monitor, relays      4. Communication devices   5. SCADA system wiring      1. Industrial communication networks      2. Industrial automation control mechanisms      3. Transmission media         1. Wireless: radio waves         2. Wired: twisted pair, coaxial cable or fiber optics   6. Network troubleshooting   7. SCADA hierarchical levels      1. Field level      2. PLCs and RTU Level      3. Communications Level      4. HMI Level   8. Functional classification of industrial communication networks      1. Serial Communication      2. HART (Highway Addressable Remote Transducer)      3. DeviceNet      4. Modbus      5. Profibus      6. Foundation Fieldbus   9. SCADA Wiring regulations   10. Project: Mount and wire a SCADA system | * Observation * Oral assessment * Portfolio of evidence * Interviews * Third party report * Written assessment * Practical assessment * Projects |
| 1. Program SCADA system | * 1. SCADA programming software      1. WinTr      2. Siemens      3. MC Works64      4. Easy SCADA   2. Installation of SCADA program on SCADA system   3. SCADA program simulation   4. Downloading SCADA program   5. Testing SCADA program   6. Troubleshooting and restoration of SCADA program   7. Project: write and download a SCADA Program | * Observation * Oral assessment * Portfolio of evidence * Interviews * Third party report * Written assessment * Practical assessment * Projects |
| 1. Maintain SCADA system | * 1. SCADA system      1. SCADA software      2. Firewalls      3. Security updates      4. Firmware updates      5. PLCs   2. Backup SCADA program      1. Establishment of SCADA system      2. Extraction of SCADA program      3. Recovery of SCADA program      4. Troubleshooting and restoration of SCADA program   3. SCADA system tagging   4. Diagnosis of SCADA system faults      1. Interconnections of SCADA system      2. Online diagnostics of SCADA system      3. Identification of network faults   5. Replacement of faulty SCADA parts      1. Preparation of requisition forms as per operational regulation      2. Removal of faulty parts from system      3. Replacement of faulty parts with new parts      4. Test replaced parts as per maintenance manual   6. Routine maintenance      1. Inspection of remote terminal unit condition      2. Inspection of network utilities condition      3. Servicing of sensors      4. SCADA system updating   7. Maintenance records documentation      1. Filling work orders as per workplace standards      2. Filling maintenance check sheets      3. Generation of maintenance reports   8. Project: Diagnose and replace SCADA faulty part. | * Observation * Oral assessment * Portfolio of evidence * Interviews * Third party report * Written assessment * Practical assessment * Projects |

**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** | | | |
|  | Multipurpose network cable tester | For testing cables | 10 pcs | 2:5 |
|  | Ethernet crimping tool | For crimping jacks | 25 pcs | 1:1 |
|  | Soldering gun | For soldering components | 25 pcs | 1:1 |
|  | Breadboard | For experimenting electronic components | 25 pcs | 1:1 |
|  | Variable power supplies | For powering up circuits | 5 pcs | 1:5 |
|  | Oscilloscope | For waves analysis | 5 pcs | 1:5 |
|  | Greasing guns/pumps | For greasing joints and bearings | 5 pcs | 1:5 |
|  | Assorted screw drivers | Flat and star-assorted sizes. For fastening screws | adequate |  |
|  | Pliers | For gripping | 25 pcs | 1:1 |
|  | Bearing extraction tools | For removing bearings | 5 pcs | 1:5 |
|  | Spanners | Assorted sizes for fastening nuts. | adequate |  |
|  | Allen keys, | Assorted sizes for hexagonal bolts and nuts | adequate |  |
|  | Multi-meters | For measuring electrical quantities. | 5 pcs | 1:5 |
|  | Pipe wrenches | For tightening bolts and nuts  in various sizes | 5 pcs | 1:5 |
|  | Tape measures | For linear measurements | 10 pcs | 2:5 |
|  | portable drilling machines | For drilling holes | 10 pcs | 2:5 |
|  | Square | For right angle measurement | 25 pcs | 1:1 |
|  | Scribers | For marking out | 10 pcs | 2:5 |
|  | Centre punches | For holes piloting | 10 pcs | 2:5 |
|  | Files | For filing materials | 25 pcs | 1:1 |
|  | Taps and dies | For creating threads | 5 pcs | 1:5 |
|  | Vernier calipers | For internal and external measurement | 10 pcs | 2:5 |
|  | Micrometer screw gauge | For internal and external measurement | 10 pcs | 2:5 |
|  | Assorted gauges | Measuring different objects with different dimensions | 10 pcs | 2:5 |
|  | Signal generator | For generating repeating and non-repeating waveforms | 5 pcs | 1:5 |
|  | Continuity testers | For cable continuity testing | 5 pcs | 1:5 |
|  | Phone line tester | For line fault diagnosis | 5 pcs | 1:5 |
|  | SCADA cables and wires | For SCADA networking | sufficient |  |
| **B** | **Materials and supplies** | | | |
|  | Whiteboard Markers | For writing on whiteboards during instruction | adequate |  |
|  | PCB boards | For circuit assembly and testing | 10 pcs | 2:5 |
|  | Bolts, nuts, and washers | For securing components | adequate |  |
|  | Fasteners | Used in fastening | 5 pcs | 1:5 |
|  | Breadboards | For prototype circuit assembly | 10 pcs | 2:5 |
|  | Trunking | For cable management | adequate |  |
| **C** | **Equipment** | | | |
|  | Projectors | For visual presentations | 1 | 1:25 |
|  | Actuators | For demonstrating movement control | 10 pcs | 2:5 |
|  | PLC modules | For programmable logic control setups | 10 pcs | 2:5 |
|  | HMI | For human machine interface | 10 pcs | 2:5 |
|  | RTUs | For connecting hardware to a SCADA system | 10 pcs | 2:5 |
| **D** | **Reference materials** | | | |
|  | SCADA maintenance manuals/handbooks | Manuals for reference on SCADA maintenance | adequate |  |
|  | Health and safety manuals | For workplace safety instructions | adequate |  |
|  | SCADA operation manuals | Comprehensive guides on SCADA systems | adequate |  |
|  | Periphery equipment maintenance manuals | Comprehensive guides on periphery systems | adequate |  |
|  | Relevant SCADA textbooks | For referencing | adequate |  |
|  | Relevant journals and websites | For referencing | adequate |  |
| **E** | **Software** | | | |
|  | SCADA software | For programming SCADA | 1 license (distributable) |  |
|  | PLC software | For programming PLC | 1 license (distributable) |  |
| F | **Trainee Requirements** | | | |
|  | Computing devices | Desktops, laptops, or tablets for individual use | 25 pcs | 1:1 |
|  | 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 SIX

## ENGINEERING MECHANICS

**ISCED UNIT CODE: 0715 541 07A**

**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 |

**Learning outcomes, content and suggested assessment methods**

|  |  |  |
| --- | --- | --- |
| **Learning outcome** | **Content** | **Suggested assessment methods** |
| 1. Apply forces and moments in a mechanical system | * 1. Force      1. Definition      2. Types         1. Tensional         2. Compressional         3. Shear      3. Applications   2. Moments      1. Definition      2. Types         1. Bending moments      3. Applications | * Written Tests |
| 1. Apply friction principles in mechanical systems | * 1. Friction      1. Static      2. Dynamic         1. Rolling friction         2. Sliding friction   2. Coefficient of friction   3. Limiting friction   4. Laws of friction   5. Factors affecting friction   6. Advantages and disadvantages of friction   7. Applications of friction   8. Lubrication      1. Types of lubricants      2. Advantages of lubricants   9. Analysis of Friction      1. Friction on a horizontal plane      2. Friction on an inclined plane   10. Applications of friction in engineering       1. Tyre traction       2. Braking systems       3. Bearing and bushings       4. Grinding of tools       5. Transmission systems   11. Coolants and cutting fluids       1. Categories and types       2. Functions       3. Properties of an ideal cutting fluid | * Written tests |
| 1. Apply kinematics of motion in mechanical systems | * 1. Introduction to kinematics of motion      1. Definition of kinematics      2. Linear and angular motion         1. Linear and angular displacement         2. Linear and angular velocity         3. Linear and angular acceleration         4. Relative velocity      3. Applications of kinematics of motion in mechanical systems         1. Cam and follower systems         2. Piston and engine mechanisms         3. Elevators and escalators   2. Structural supports      1. Load analysis      2. Material selection for structural supports      3. Structural support components      4. Deflection and stiffness requirements for structural supports   3. Displacement/time graphs      1. Body moving with uniform velocity      2. Body moving with varied velocity | * Written Tests |
| 1. Apply mechanical work-energy theorem | * 1. Work      1. Definition      2. Calculations of work done   2. Energy      1. Definition      2. Calculations of energy requirements and efficiency   3. Power      1. Definition      2. Calculations of power | * Written tests |
| 1. Apply kinetics of motion in mechanical systems | * 1. Definition of KINETICS   2. Newtons laws of motion      1. First law      2. Second law      3. Third law   3. Applications of kinetics in mechanical systems   4. Structural Supports      1. Definition and types of structural supports      2. Forces acting on structural supports      3. Loads and reactions in structural supports      4. Stress and strain in structural supports      5. Designing structural supports for motion   5. Kinetic linkages      1. Definition and types      2. Factors in selecting kinematic linkages | * Written tests |
| 1. Apply law of machines | * 1. Simple machines      1. Definition      2. Working principles and applications         1. Lever         2. Wedge         3. Inclined plane         4. Pulley         5. Wheel and axle         6. Screw jack      3. Simple machine analysis         1. Load and load distance         2. Effort and effort distance         3. Ideal load and effort         4. Mechanical advantage         5. Velocity ratio         6. Efficiency         7. Law of machine      4. Factors affecting the efficiency of simple machines   2. Selection of simple machines      1. Advantages and disadvantages of each type of simple machine      2. Factors to consider when selecting a simple machine   3. Simple machines speed adjustment      1. Relationship between speed and mechanical advantage      2. Adjusting speed with different simple machines      3. Combining simple machines for speed and efficiency | * Written Tests |
| 1. Determine loading conditions in mechanical systems | * 1. Define structure   2. Types of loading      1. Point load      2. Uniformly distributed load      3. Varying load   3. Types of beams      1. Simply supported beams      2. Cantilever beam      3. Overhanging beam | Written tests |
| 1. Apply simple mechanisms | * 1. Define simple mechanism   2. Components of simple mechanism      1. Link      2. Element   3. Types of mechanisms      1. Single slider mechanism      2. Double slider mechanism | * Written tests |
| 1. Design belts, ropes and chain drives | * 1. Definition      1. Belt      2. Rope      3. Chain   2. Belts      1. Material used for belt         1. Rubber         2. Cotton         3. Leather      2. Types of belts         1. Flat         2. V belt         3. Circular      3. Configuration of belt drive         1. Open         2. Crossed      4. Design analysis of flat and V-Belts         1. Velocity ratio         2. Length of belt         3. Angle of contact         4. Power transmitted   3. Rope drives      1. Types of rope drives   4. Chain drives      1. Types of chain drives | * Written tests |
| 1. Design toothed gears and gear trains | * 1. Types of gears      1. Spur      2. Helical      3. Double helical   2. Types of gear trains      1. Simple gear train         1. Design calculations      2. Compound gear train         1. Design calculations      3. Reverted gear train         1. Design calculations      4. Epicyclic gear train   3. Lubrication of gears | * Written tests |
| 1. Design mechanical rotor dynamic machines | * 1. Types of pumps and operation principle      1. Reciprocating pump      2. Centrifugal pump   2. Derivation of equations for      1. Reciprocating pumps      2. Centrifugal pumps   3. Analysis of pumps      1. Discharge      2. Efficiency      3. Power      4. Head      5. Weight per unit   4. Types and operation principle of rotary compressors      1. Rotary screw compressors      2. Rotary vane compressors      3. Scroll compressor      4. Rotary lobe   5. Analysis of compressors      1. Inlet and outlet flow      2. Work done      3. Mass flow rate      4. Power requirement      5. Efficiency   6. Compressor fans and vanes      1. Structure and functions of compressor fans and vanes      2. Operation principles of fans and vanes in rotary compressors      3. Maintenance of fans and vanes   7. Design analysis      1. Vane efficiency      2. Fan efficiency      3. Power consumption | * Written tests |
| 1. Apply stress and strain concepts in mechanical systems | * 1. Define stress and strain   2. Types of simple stresses      1. Direct      2. Shear      3. Ultimate tensile stress      4. Yield stress      5. Breaking stress      6. True stress   3. Analysing stress on      1. Beams      2. Thin cylinders      3. Thin shells   4. Applications of stress and strain concepts      1. Bolts and nuts      2. Shafts | * Written tests |
| 1. Apply simple bending theory in mechanical systems | * 1. Engineers bending equation   2. Types of Beams      1. Simply supported beams      2. Cantilever beam      3. Overhanging beam   3. Analysis of beams      1. T-section      2. L-section      3. I-section   4. Types of shafts      1. Solid      2. Tubular      3. stepped   5. Analysis of shafts      1. Solid      2. Tubular      3. Stepped | * Written tests |
| 1. Apply torsion theory in mechanical systems | * 1. Define torsion   2. Torque analysis   3. Analysis of shafts      1. Series arranged shafts      2. Parallel arranged shafts   4. Determine angle of twist      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** | | | |
|  | Textbooks | Comprehensive textbooks on Engineering mechanics principles | 30 | 1:1 |
|  | Graph books | For graphical representation of solutions | 30 | 1:1 |
|  | Projector | Functional projector for displaying content during presentations | 1 | 1:30 |
|  | Computer | Functional desktop computer with online instructional content | 1 | 1:30 |
|  | White board | Quality whiteboard of approximately 6 ft by 3 ft for writing during theory instruction | 1 | 1:30 |
|  | Printer | An ink-jet, laser-jet or toner-cartridge printer for printing notes, instructions and working drawings | 1 | 1:30 |
| **B** | **Learning facilities & infrastructure** | | | |
|  | Lecture/theory room | Spacious room with seats for 25 trainees, approximately 60 sqm | 1 | 1:30 |
| **C** | **Materials and supplies** | | | |
|  | First aid kit | Fully equipped first aid kit for use in case of accidents | 1 | 1:30 |
| **D** | **Tools and equipment** | | | |
|  | Calculators | For calculations | 30 | 1:1 |
|  | Firefighting extinguishers | Water, carbon dioxide and chemical powder fire extinguishers for fire fighting | 1 | 1:30 |
| **F** | **Reference materials** | | | |
|  | 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

**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 |

**Learning outcomes, content and suggested assessment methods**

| **Learning outcome** | **Content** | **Suggested assessment methods** |
| --- | --- | --- |
| 1. Analyse electrical machines | * 1. Electrical principles application      1. Ohm's law and its applications      2. Kirchhoff’s laws in circuit analysis      3. Fundamentals of electromagnetism in motor function      4. Electrostatics principles in machine design   2. Electrical machines      1. Introduction to AC and DC motors      2. Characteristics of special motors      3. Transformers and their applications      4. Distinctions between AC and DC generators   3. Sizing electrical machines      1. Machine capacity load requirements      2. Power rating and efficiency considerations      3. Calculation of load demands for specific applications   4. Power requirements identification      1. Assessment of voltage and current needs      2. Power factor and energy efficiency      3. Backup power requirements for machines   5. Electrical machine analysis reporting      1. Documentation of analysed results      2. Standard reporting procedures in workplace documentation | * Project * Practical * Third party report * Portfolio of evidence * Written tests * Oral questioning |
| 1. Install electrical machines | * 1. Personal protective equipment (PPE)      1. Types of PPE for electrical installation      2. Safety protocols and regulations   2. Installation tools and equipment      1. Hand tools:         1. Pliers         2. Hammer         3. Spanners         4. Wire stripper         5. Crimping tool         6. Allen keys         7. Screw drivers         8. Multimeters      2. Specialized equipment:         1. Lifting gear         2. Scaffold         3. Motors         4. Transformers         5. Generators         6. Compressors         7. Pumps   3. Electrical machines mounting      1. Interpretation of design specifications      2. Mounting methods for different Types of machines      3. Safety considerations during mounting   4. Termination and connection of electrical machines      1. Wire termination techniques and standards      2. Component coupling and alignment      3. Safety checks before powering machines   5. Electrical machines testing      1. Functionality tests      2. Electrical tests      3. Endurance tests      4. Speed tests | * Project * Practical * Third party report * Portfolio of evidence * Written tests * Oral questioning |
| 1. Maintain electrical machines | * 1. Maintenance schedule preparation      1. Routine and preventative maintenance schedules      2. Documentation and tracking of maintenance tasks   2. PPE for maintenance      1. PPE requirements specific to maintenance tasks      2. Hazard prevention during maintenance   3. Maintenance tools, equipment, and spares      1. Tools         1. Pliers         2. Hammer         3. Spanners         4. Wire stripper         5. Crimping tool         6. Allen keys         7. Screw drivers         8. Multimeters      2. Equipment         1. Lifting gear         2. PPE         3. Spares         4. Motors         5. Motor parts         6. Bearings         7. Generators         8. Cables   4. Maintenance tasks      1. Inspection      2. Testing and measurements      3. Cleaning      4. Lubrication      5. Tightening      6. Replacing consumables   5. Maintenance reporting      1. Maintenance records      2. Workplace documentation standards | * Project * Practical * Third party report * Portfolio of evidence * Written tests * Oral questioning |
| 1. Analyse mechanical drives | * 1. Mechanical drives      1. Types of mechanical drives         1. Pulleys         2. Gears         3. Belts         4. Chains         5. Conveyers      2. Application and function of each drive type   2. Sizing mechanical drives      1. Determination of sizing based on power requirements      2. Load and torque calculations   3. Mechanical drive analysis reporting      1. Analysis and documentation      2. Workplace report standards | * Project * Practical * Third party report * Portfolio of evidence * Written tests * Oral questioning |
| 1. Assemble mechanical drives | * 1. PPE for assembly      1. PPE for assembling mechanical components      2. Safety protocols for mechanical assembly tasks   2. Tools and equipment      1. Tools: hand tools, alignment lasers, pullers      2. Equipment: lifting and climbing gear   3. Mechanical drives assembly      1. Assembly procedures based on design specs      2. Precision alignment and fitting of components   4. Mechanical drive tests      1. Alignment      2. Functionality test      3. Load test and vibration tests | * Project * Practical * Third party report * Portfolio of evidence * Written tests * Oral questioning |
| 1. Maintain mechanical drives | * 1. Maintenance schedule preparation      1. Schedules for routine drive maintenance      2. Task scheduling   2. PPE for maintenance      1. PPE requirements for drive maintenance tasks      2. Safety standards   3. Maintenance tools, equipment, and spares      1. Tools         1. Hand tools            1. Alignment laser            2. Cleaning tools      2. Equipment         1. Pullers         2. Lifting gear         3. Climbing gear      3. Spares         1. Chains         2. Sprocket         3. Belts         4. Fasteners         5. Gears         6. Pulleys   4. Maintenance Tasks      1. Inspection      2. Cleaning      3. Tightening procedures      4. Lubrication,      5. Replacement of worn parts, and testing   5. Maintenance reporting      1. Maintenance reports      2. Findings and future recommendations | * Project * Practical * Third party report * Portfolio of evidence * 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** | | | |
|  | Screwdriver sets | assorted screw types | 2 sets | 2:25 |
|  | Wrench Sets | For tightening bolts and nuts in various sizes | 2 sets | 2:25 |
|  | Pliers Sets | For gripping and cutting wires and components | 2 sets | 2:25 |
|  | Clamps | For holding components securely during assembly | 13 pcs | 13:25 |
|  | Allen Key Sets | Assorted | 2 sets | 2:25 |
|  | Digital Multi-meters | For measuring voltage, current, and resistance | 5 pcs | 1:5 |
|  | Digital Tachometers | For measuring rotational speed of motors | 5 pcs | 1:5 |
| **B** | **Materials and supplies** | | | |
|  | Whiteboard Markers | For writing on whiteboards during instruction | Adequate |  |
|  | PCB Boards | For circuit assembly and testing | 10 pcs | 2:5 |
|  | Switches | Mechanical and electronic types for circuit control | 10 pcs | 2:5 |
|  | Fasteners | Used in fastening | Adequate |  |
|  | Bearings, Gears, and Rollers | Components for rotational systems | 5 sets | 1:5 |
|  | Assorted electric cables and conductors | For electrical connections | Adequate |  |
|  | Breadboards | For prototype circuit assembly | 10 pcs | 2:5 |
|  | Trunking | For cable management | Adequate |  |
|  | Fuses | For protecting circuits | Adequate |  |
|  | Electrical Accessories | Connectors, sockets, and other components | Adequate |  |
|  | Oils and lubricants | For machinery maintenance | Adequate |  |
|  | Oil seals and gaskets | For sealing components | 5 pcs | 1:5 |
|  | Drive belts | For power transmission in machinery | Adequate |  |
|  | Variable speed/frequency drives | For motor control | 1 pc | 1:25 |
| **C** | **Equipment** | | | |
|  | Projectors | For visual presentations | 1 | 1:25 |
|  | Whiteboards | For writing instructional content | 1 | 1:25 |
|  | Hand drilling machine | Various types for assembly and installation | 5 pcs | 1:5 |
|  | Servomechanisms | For automation and control demonstrations | 5 pcs | 1:5 |
|  | Compressor systems | For pneumatic operations | 1 pc | 1:25 |
|  | Gyroscopes | For rotational motion study | 5 pcs | 1:5 |
|  | Dynamometers | For measuring torque and rotational force | 5 pcs | 1:5 |
|  | Magnetic drums | For magnetic field and storage studies | 5 pcs | 1:5 |
|  | Drives brakes | For studying braking mechanisms | 5 pcs | 1:5 |
|  | Control linkage | For demonstrating mechanical linkages | 5 pcs | 1:5 |
|  | Actuators | For demonstrating movement control | Adequate |  |
| **D** | **Equipment** | | | |
|  | AC/DC electronics training modules | Training modules for AC/DC electronics | 1 pc | 1:25 |
|  | AC/DC machines control modules | Modules for controlling AC/DC machines | 1 pc | 1:25 |
| **E** | **Reference Materials** | | | |
|  | Component and equipment manuals | Manuals for component use and specifications | Adequate |  |
|  | Health and safety manuals | For workplace safety instructions | Adequate |  |
|  | Electromechanical reference books | Comprehensive guides on electromechanical systems | Adequate |  |
| **F** | **Software** | | | |
|  | Electrical circuit design software | For designing electrical circuits | 1 license |  |
|  | AUTOCAD | For creating and modifying digital schematics | 1 license |  |
| **G** | **Trainee requirements** | | | |
|  | Computing devices | Desktops, laptops, or tablets for individual use | 25 pcs | 1:1 |
|  | Protective clothing | Dust coats, gloves, safety boots, goggles | 25 sets | 1:1 |

## DIGITAL LITERACY

**ISCED UNIT CODE: 0611 551 01A**

**Relationship with occupational standards**

This unit addresses the unit of competency: Apply digital literacy

**Duration of unit: 80 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 | 10 |
| 2 | Solve tasks using office suite | 10 |
| 3 | Manage data and information | 10 |
| 4 | Perform online communication and collaborations | 10 |
| 5 | Apply cybersecurity skills | 10 |
| 6 | Perform online jobs | 10 |
| 7 | Apply job entry techniques | 10 |

**Learning outcomes, content, and suggested assessment methods**

| **Learning outcome** | **Content** | **Suggested**  **assessment methods** |
| --- | --- | --- |
| 1. Operate computer devices | * 1. Meaning and importance of digital literacy   2. Functions and uses of computers   3. Classification of computers   4. Components of a computer system   5. Computer hardware      1. The system unit e.g. motherboard, CPU, casing      2. Input devices e.g. pointing, keying, scanning, voice/speech recognition, direct data capture devices.      3. Output devices e.g. hardcopy output and softcopy output      4. Storage devices e.g. main memory e.g. RAM, secondary storage (Solid state devices, hard drives, CDs & DVDs, memory cards, flash drives      5. Computer ports e.g. HDMI, DVI, VGA, USB type C etc.   6. Classification of computer software   7. Operating system functions   8. Procedure for turning/off a computer   9. Mouse use techniques   10. Keyboard parts and use techniques   11. Desktop customization   12. File and files management using an operating system   13. Computer internet connection options       1. Mobile Networks/data plans       2. Wireless hotspots       3. Cabled (Ethernet/Fiber)       4. Dial-Up       5. Satellite   14. Computer external devices management       1. Device connections       2. Device controls (volume controls and display properties) | * Observation * Written assessment * Oral assessment * Practical assessment |
| 1. Solve tasks using office suite | * 1. Meaning and importance of word processing   2. Examples of word processors   3. Working with word documents      1. Open and close word processor      2. Create a new document      3. Save a document      4. Switch between open documents   4. Enhancing productivity      1. Set basic options/preferences      2. Help resources      3. Using magnification/zoom tools      4. Display, hide built-in tool bar      5. Using navigation tools   5. Typing text   6. Document editing (copy, cut, paste commands, spelling and grammar check)   7. Document formatting      1. Formatting text      2. Formatting paragraph      3. Formatting styles      4. Alignment      5. Creating tables      6. Formatting tables   8. Graphical objects      1. Insert object (picture, drawn object)      2. Select an object      3. Edit an object      4. Format an object   9. Document print setup      1. Page layout,      2. Margins set up      3. Orientation.   10. Word document printing   11. Meaning & importance of electronic spreadsheets   12. Components of spreadsheets   13. Application areas of spreadsheets   14. Using spreadsheet application       1. Parts of excel screen: ribbon, formula bar, active cell, name box, column letter,row number, quick access toolbar.       2. Cell data types       3. Block operations       4. Arithmetic operators (formula bar (-, +, \*, /).       5. Cell referencing   15. Data manipulation       1. Using functions (Sum, average, sumif, count, max, max, if, rank, product, mode etc)       2. Using formulae       3. Sorting data       4. Filtering data       5. Visual representation using charts   16. Worksheet printing   17. Electronic presentations   18. Meaning and importance of electronic presentations   19. Examples of presentation software   20. Using the electronic presentation application       1. Parts of the powerpoint screen (slide navigation pane, slide pane, notes, the ribbon, quick access toolbar, and scroll bars).       2. Open and close presentations       3. Creating slides (insert new slides, duplicate, or reuse slides.)       4. Text management (insert, delete, copy, cut and paste, drag and drop, format, and use spell check).       5. Using magnification/zoom tools       6. Apply or change a theme.       7. Saving a presentation       8. Switching between open presentations   21. Developing a presentation       1. Presentation views       2. Slides       3. Master slide   22. Text       1. Editing text       2. Formatting       3. Tables   23. Charts       1. Using charts       2. Organization charts   24. Graphical objects       1. Insert, manipulate       2. Drawings   25. Prepare outputs       1. Applying slide effects and transitions       2. Check and deliver          1. Spell check a presentation          2. Slide orientation          3. Slide shows, navigation   26. Print presentations (slides and handouts) | * Observation * Portfolio of Evidence * Project * Written assessment * Practical assessment * Oral assessment |
| 1. Manage data and information | * 1. Meaning of data and information   2. Importance and uses of data and information   3. Types of internet services      1. Communication Services      2. Information retrieval services      3. File transfer      4. World wide web services      5. Web services      6. Automatic network address configuration      7. News group      8. Ecommerce   4. Types of internet access applications   5. Web browsing concepts      1. Key concepts      2. Security and safety   6. Web browsing      1. Using the web browser      2. Tools and settings      3. Clearing cache and cookies      4. URIs      5. Bookmarks      6. Web outputs   7. Web based information      1. Search      2. Critical evaluation of information      3. Copyright, data protection   8. Downloads management   9. Performing digital data backup (Online and offline)   10. Emerging issues in internet | * Observation * Portfolio of Evidence * Project * Written assessment * Practical assessment * Oral assessment |
| 1. Perform online communication and collaboration | * 1. Netiquette principles   2. Communication concepts      1. Online communities      2. Communication tools      3. Email concepts   3. Using email      1. Sending email      2. Receiving email      3. Tools and settings      4. Organizing email   4. Digital content copyright and licenses   5. Online collaboration tools      1. Online Storage (Google Drive)      2. Online productivity applications (google docs & forms)      3. Online meetings (google meet/zoom)      4. Online learning environments      5. Online calendars (google calendars)      6. Social networks (facebook/twitter - settings & privacy)   6. Preparation for online collaboration      1. Common setup features      2. Setup   7. Mobile collaboration      1. Key concepts      2. Using mobile devices      3. Applications      4. Synchronization | * Observation * Portfolio of Evidence * Project * Written assessment * Practical assessment * Oral assessment |
| 1. Apply cybersecurity skills | * 1. Data protection and privacy      1. Confidentiality of data/information      2. Integrity of data/information      3. Availability of data/information   2. Internet security threats      1. Malware attacks      2. Social engineering attacks      3. Distributed denial of service (DDoS)      4. Man-in-the-middle attack (MitM)      5. Password attacks      6. IoT attacks      7. [Phishing attacks](https://onlinedegrees.sandiego.edu/top-cyber-security-threats/#phishing-attacks)      8. [Ransomware](https://onlinedegrees.sandiego.edu/top-cyber-security-threats/#ransomware)   3. Computer threats and crimes   4. Cybersecurity control measures      1. Physical controls      2. Technical/logical controls (passwords,PINs, biometrics)      3. Operational controls   5. Laws governing protection of ICT in Kenya      1. The Computer Misuse and Cybercrimes Act No. 5 of 2018      2. The data protection Act No. 24 Of 2019 | * Observation * Portfolio of Evidence * Project * Written assessment * Practical assessment * Oral assessment |
| 1. Perform online Jobs | * 1. Introduction to online working   2. Types of online jobs   3. Online job platforms      1. Remotask      2. Data annotation tech      3. Cloud worker      4. Upwork      5. Oneforma      6. Appen   4. Online account and profile management   5. Identifying online jobs/job bidding   6. Online digital identity   7. Executing online tasks   8. Management of online payment accounts. | * Observation * Portfolio of Evidence * Project * Written assessment * Practical assessment * Oral assessment |
| 1. Apply job entry techniques | * 1. Types of job opportunities      1. Self-employment      2. Service provision      3. product development      4. salaried employment         1. Sources of job opportunities   2. Resume/ curriculum vitae      1. What is a CV      2. How long should a CV be      3. What to include in a CV      4. Format of CV      5. How to write a good CV      6. Don’ts of writing a CV   3. Job application letter      1. What to include      2. Addressing a cover letter      3. Signing off a cover letter   4. Portfolio of evidence      1. Academic credentials      2. Letters of commendations      3. Certification of participations      4. Awards and decorations   5. Interview skills      1. Listening skills      2. Grooming      3. Language command      4. Articulation of issues      5. Body language      6. Time management      7. Honesty   6. Generally knowledgeable in current affairs and technical area | * + Observation   + Oral assessment   + Portfolio of evidence   + Third party report * Written assessment |

**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** | | | |
|  | Textbooks | Comprehensive texts books on digital literacy | 5 pcs | 1:6 |
|  | Installation manuals | Detailed guides for equipment and software installation and troubleshooting | 5 pcs | 1:6 |
|  | Powerpoint presentations | For trainer’s use, covering course content and practical applications | 1 | 1:30 |
|  | Projector | Functional projector for displaying content during presentations | 1 | 1:30 |
|  | White board | Quality whiteboard of approximately 6 ft by 3 ft for writing during theory instruction | 1 | 1:30 |
|  | Printer | An ink-jet, laser-jet or toner-cartridge printer for printing notes, instructions and working drawings | 1 | 1:30 |
|  | Templates | Templates for creating various documents e.g. CV, Cover Letter, etc. | 30 | 1:1 |
| **B** | **Learning Facilities & Infrastructure** | | | |
|  | 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 |
|  | 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** | | | |
|  | Printing papers | A4 and A3 printing papers suitable for the task | adequate |  |
|  | Whiteboard marker pens | Dry-erase markers for trainers use. Assorted colors | adequate |  |
|  | Storage devices | Any of the following storage devices:   * USB flash drive * USB hard drive * Compact disks (CDs) * Digital versatile disks (DVDs) | adequate |  |

# MODULE SEVEN

## FABRICATION MACHINERY OPERATION

**ISCED UNIT CODE:** 0715 551 18A

**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 |

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. Workshop safety      1. Workshop safety definition      2. Types and uses of PPE’s   2. Emergency responses steps      1. Common emergencies         1. Fire         2. Chemical spills         3. Injuries   3. Fire safety      1. Fire extinguishers types and uses      2. Flammable materials identification      3. Fire prevention   4. Safe handling and disposal of chemicals and materials      1. Chemical hazard identification      2. Safe handling procedure      3. Storage and labelling of chemicals      4. Chemical disposal procedures      5. Emergency response for chemical exposure   5. Identifying and marking hazardous zones      1. Common hazardous zones         1. Flammable zones         2. High traffic zones         3. Electrical hazard zones         4. Chemical storage areas   6. Work area organization and maintenance      1. Setting up      2. Proper storage and labelling of tools and equipment   7. Workplace hazards      1. Physical hazards         1. Noises         2. Vibration         3. Heat         4. Sharp object      2. Chemical hazards         1. Fuels         2. Oils         3. Cleaning agents      3. Electric hazards         1. Live wires         2. Batteries         3. Electrical systems   8. Workshop accidents, causes and prevention      1. Near accident      2. Trivial accident      3. Minor accident      4. Serious accident      5. Fatal accident | * Apply workshop safety |
| 1. Apply material science principles | * 1. Material science principles      1. Definition      2. Importance of material science in engineering   2. Engineering materials classification and characteristics      1. Metals      2. Polymers      3. Ceramics   3. Properties of engineering materials      1. Mechanical properties         1. Strength         2. Hardness         3. Toughness         4. Malleability         5. Ductility         6. Rigidity      2. Thermal properties         1. Specific heat         2. Thermal expansion      3. Chemical properties         1. Corrosion resistance      4. Electrical properties         1. Electrical conductivity         2. Insulation properties   4. Material selection for engineering materials      1. Factors to consider   5. Material handling safety      1. Handling metals and alloys      2. Chemical and fuels      3. Safety measures for plastics and composites      4. Electrical safety and conductive materials | * Apply material science principles |
| 1. Apply workshop tools and equipment | * 1. Tools and equipment safety and maintenance practices      1. Inspection      2. Safe handling techniques   2. Technical drawing interpretation      1. Purpose of assembly drawing      2. Bill of quantity      3. Assembly instructions   3. Workshop tools and equipment uses and maintenance      1. Measuring tools         1. Tape measure         2. Steel rule         3. Callipers         4. Micrometer gauge         5. Protractor         6. Spirit level         7. Dial indicator         8. Torque wrench      2. Marking out tools         1. Scriber         2. Marking gauge         3. Combination square      3. Cutting tools         1. Hacksaw         2. Chisel         3. Files         4. Scissors      4. Fitting tools         1. Wrenches         2. Sockets         3. Pliers         4. Hammers         5. Punch         6. Tap and die      5. Forging tools         1. Anvil         2. Hammers         3. Tongs         4. Swage block      6. Sheet metal tools         1. Shears         2. Tin snips         3. Rivet gun         4. Vise      7. Workshop machine         1. Grinding machine         2. Arc welding machine         3. Gas welding machine         4. Drilling machine | * Apply workshop tools and equipment |
| 1. Carry out metal joining processes | * 1. Observation of safety      1. Safety gears      2. Machine operation manuals   2. Metal joining methods      1. Welding         1. Arc welding         2. Gas welding      2. Riveting      3. Fastening   3. Material preparation      1. Measuring      2. Marking out   4. Process of metal finishing      1. Grinding      2. Filing      3. Polishing | * Carry out metal joining processes |
| 1. Apply workshop organisation techniques | * 1. Workshop layout      1. Types of workshop layout         1. Fixed layout         2. Process layout         3. Line layout         4. Operation layout         5. Combination/group layout      2. Safety signs      3. Emergency exits   2. Management inventory      1. Types of inventories      2. Record keeping      3. Job card preparation   3. Maintenance schedules      1. Goals of maintenance schedule         1. Reactive         2. Equipment failure         3. Maintenance backlog      2. Types of maintenance         1. Preventive maintenance         2. Corrective maintenance         3. Condition based maintenance         4. Predictive maintenance         5. Break down maintenance   4. Housekeeping      1. Definition      2. importance of housekeeping   5. Housekeeping activities and their importance      1. Tool and equipment organization      2. Work area cleanliness      3. Safe handling and disposal of hazardous materials      4. Inspection and maintenance of equipment      5. Personal protective equipment management      6. Air and ventilation maintenance      7. Incident prevention and reporting   6. Housekeeping tools and equipment      1. Uses and maintenance         1. Brooms and brushes         2. Dustpans and squeegees         3. Vacuum cleaners         4. Mops and mop buckets         5. Waste bins and recycling containers   7. Housekeeping materials      1. Cleaning cloths and rags      2. Cleaning agents and solvents      3. Lubricants      4. Gloves and PPE’s      5. Disposable bags and liners   8. Workshop waste sorting and disposal      1. Types of waste         1. General waste         2. Hazardous waste         3. Recyclable waste         4. Organic waste         5. e-waste      2. Waste sorting procedure         1. Designated bins for different types of waste         2. Sorting by material         3. Pre-sorting hazardous waste      3. Hazardous waste disposal         1. Chemical waste         2. Used oil and solvents         3. Paints and finishes | * Apply workshop organisation techniques |
| 1. Create part designs | * 1. Health and safety in part design      1. Overview of health and safety standards in the workshop         1. Work permits         2. Waste management         3. Electrical wiring colour coding         4. Danger warning signage         5. Barricades         6. High voltage signage      2. Personal protective equipment (PPE) for design processes      3. Hazard identification and risk mitigation in design stages   2. Part design drawings      1. Interpretation of technical drawings and blueprints      2. Symbols, terminology, and specifications in part designs      3. Sources for obtaining part design documentation and blueprints   3. Preparation of operation sequence plans      1. Importance of an operation sequence plan      2. Steps for creating a sequence plan aligned with part design specifications      3. Case studies: planning sequences for common fabrication parts   4. Creation of part designs based on specifications      1. Design specifications         1. Dimensions         2. Geometry         3. Surface finish      2. Design creation techniques (CAD software and manual drafting)      3. Translation of specifications into physical part designs      4. Design validation and verification processes   5. Precision in part design      1. Precision standards and tolerances in fabrication      2. Techniques for maintaining accuracy in part design      3. Tools and practices to verify design precision | * Project * Practical * Third party report * Portfolio of evidence * Written tests * Oral questioning |
| 1. Perform machine configuration | * 1. Health and safety in machine configuration      1. Safety protocols specific to machine setup and configuration      2. Emergency procedures and equipment handling guidelines      3. PPE and environmental safety checks before machine setup   2. Tool setting on fabrication machinery      1. Tooling types and selection      2. Hands-on practice: securing tooling with accuracy and alignment      3. Challenges in tooling setup and troubleshooting methods   3. Preparation of materials for fabrication      1. Material selection criteria      2. Techniques for loading, securing, and positioning materials      3. Material compatibility with fabrication machines   4. Configuration of fabrication machine      1. Configuring machine parameters (speed, feed rate, pressure, etc.)      2. Practical exercises on machine configuration for different tasks      3. Configuration of machine operational requirements | * Project * Practical * Third party report * Portfolio of evidence * Written tests * Oral questioning |
| 1. Perform machining processes | * 1. Health and safety in machining operations      1. Hazard prevention in machining operations      2. PPE and safe practices during machining      3. Risks reduction during machine operation and part handling   2. Executing Fabrication Machining Operations      1. Overview of conventional machining processes         1. Drilling         2. Turning         3. Milling         4. Grinding      2. Introduction to CNC (Computer Numerical Control) Machining         1. Definition and purpose of CNC machining in fabrication         2. Comparison of CNC machining vs. conventional machining         3. Overview of common CNC machines (milling, lathe, router, etc.)      3. CNC Machine Components         1. Major components: controller, worktable, spindle, tool holder, etc.         2. Role of each component in the CNC machining process         3. Types of CNC tooling and their applications      4. CNC Programming basics         1. Introduction to G-code, F-code, S-code, and M-code commands         2. Overview of CNC software for part design and programming         3. Translation of design specifications into CNC programming code         4. Programming exercises      5. CNC machine set up         1. Safety precautions specific to CNC operations         2. Loading and securing materials for CNC processes         3. Tools alignment         4. Input and verification of CNC programs on the machine      6. Executing CNC Machining Operations         1. Step-by-step process for running a CNC machine         2. Monitoring CNC operations for accuracy and quality         3. Adjustments and troubleshooting during the machining process      7. Techniques for executing precise machining tasks      8. Hands-on exercises with different fabrication operations   3. Inspection of fabrication machinery parts      1. Inspection standards and techniques (visual, dimensional, tolerance)      2. Quality control checkpoints during and post-machining      3. Gauges, callipers, and other inspection tools   4. Documentation of fabrication machinery operations      1. Importance of accurate documentation in fabrication      2. Workplace standards for machine setup and operation logs      3. Practicing accurate and complete documentation processes | * Project * Practical * Third party report * Portfolio of evidence * Written tests * Oral questioning |

**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** | | | |
|  | Multimeters | For measuring voltage, current, and resistance | 5 pcs | 1:5 |
|  | Callipers | For measuring internal and external dimensions | 5 pcs | 1:5 |
|  | CAD software licenses | Licenses for CAD software (e.g., AutoCAD) | 25 pcs | 1:1 |
|  | Assorted wrenches | For tightening and loosening fasteners | 5 sets | 1:5 |
|  | Screwdrivers | Various types for driving screws | 5 sets | 1:5 |
|  | Pliers | For gripping, bending, and cutting wires | 5 pcs | 1:5 |
| **B** | **Learning facilities & infrastructure** | | | |
|  | Lecture/Theory Room | Approximately 60 sqm for theoretical training | 1 | 1:25 |
|  | Workshop | Approximately 80 sqm for hands-on practice | 1 | 1:25 |
|  | Laboratory | Approximately 80 sqm for equipment testing and practice | 1 | 1:25 |
| **C** | **Materials and Supplies** | | | |
|  | Metal and composite blocks | Raw materials for machining exercises | adequate |  |
|  | Tooling sets | Various cutting and shaping tools for lathes and CNC machines | 5 sets | 1:5 |
|  | Fasteners and connectors | Nuts, bolts, and connectors for assembling parts | adequate |  |
|  | Safety Signs | Danger warning, barricades, and high-voltage signage for workshop safety | adequate |  |
|  | PPE Kits (gloves, masks, ear protection) | Full PPE for safety during machine operation | 25 sets | 1:1 |
|  | Inspection gauges | Tools for quality control and verification | 5 pcs | 1:5 |
| **D** | **Equipment** | | | |
|  | CNC Simulators | Simulation devices for CNC training | 5 pcs | 1:5 |
|  | CNC Tooling | Assorted tooling specifically for CNC machines | 5 sets | 1:5 |
|  | CNC programming software licenses | Software for CNC machine programming | 1-distributable | 1:25 |
|  | CNC machines | CNC milling and lathe machines for machining processes | 1 pc | 1:25 |
|  | Lathe machines | Conventional lathes for hands-on training in machining | 1 pc | 1:25 |
|  | Drill presses | For drilling holes in materials during machining | 1 pc | 1:25 |
|  | Grinding machines | For surface finishing and precision grinding | 1 pc | 1:25 |
| **E** | **Miscellaneous** | | | |
|  | Lubrication equipment | For maintenance of machines and smooth operation | 1 unit | 1:25 |
|  | First-aid kits | For emergency medical care | 2 kits |  |
| **F** | **Reference materials** | | | |
|  | Safety manuals | Guides on health and safety protocols | adequate |  |
|  | CNC programming guidebooks | Manuals for codes and CNC software | adequate |  |
|  | Design and inspection standards manuals | Guides for design verification and precision standards | adequate |  |

## WORK ETHICS AND PRACTICES

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

**Relationship with occupational standards**

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

**Duration of unit: 50 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 | 5 |
| 2 | Promote ethical practices and values | 10 |
| 3 | Promote teamwork | 10 |
| 4 | Maintain professional and personal development | 10 |
| 5 | Apply problem-solving skills | 10 |
| 6 | Promote customer care. | 5 |

**Learning outcomes, content, and suggested assessment methods**

| **Learning outcome** | **Content** | **Suggested assessment methods** |
| --- | --- | --- |
| 1. Apply self-management skills | * 1. Self-awareness   2. Formulating personal vision, mission, and goals   3. Healthy lifestyle practices   4. Strategies for overcoming work challenges   5. Emotional intelligence   6. Coping with work stress.   7. Assertiveness versus aggressiveness and passiveness      1. Developing and maintaining high self-esteem      2. Developing and maintaining positive self-image      3. Time management      4. Setting performance targets      5. Monitoring and evaluating performance targets | * Observation * Written assessment * Oral assessment * Third party reports * Portfolio of evidence * Project * Practical |
| 1. Promote ethical work practices and values | * 1. Integrity   2. Core Values, ethics and beliefs   3. Patriotism   4. Professionalism   5. Organizational codes of conduct   6. Industry policies and procedures | * Observation * Written assessment * Oral assessment * Third party reports * Portfolio of evidence * Project * Practical |
| 1. Promote teamwork | * 1. Types of teams   2. Team building      1. Individual responsibilities in a team      2. Determination of team roles and objectives      3. Team parameters and relationships      4. Benefits of teamwork      5. Qualities of a team player      6. Leading a team      7. Team performance and evaluation   3. Conflicts and conflict resolution   4. Gender and diversity mainstreaming   5. Developing healthy workplace relationships   6. Adaptability and flexibility   7. Coaching and mentoring skills | * Observation * Written assessment * Oral assessment * Third party reports * Portfolio of evidence * Project * Practical |
| 1. Maintain professional and personal development | * 1. Personal vs professional development and growth   2. Avenues for professional growth   3. Recognizing career advancement   4. Training and career opportunities      1. Assessing training needs      2. Mobilizing training resources   5. Licenses and certifications for professional growth and development   6. Pursuing personal and organizational goals   7. Managing work priorities and commitments   8. Dynamism and on-the-job learning | * Observation * Written assessment * Oral assessment * Third party reports * Portfolio of evidence * Project * Practical |
| 1. Apply problem-solving skills | * 1. Causes of problems   2. Methods of solving problems   3. Problem-solving process   4. Decision making   5. Creative thinking and critical thinking process in development of innovative and practical solutions | * Observation * Written assessment * Oral assessment * Third party reports * Portfolio of evidence * Project * Practical |
| 1. Promote customer care | * 1. Identifying customer needs   2. Qualities of good customer service   3. Customer feedback methods   4. Resolving customer concerns   5. Customer outreach programs   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** | | | |
|  | Textbooks | Comprehensive texts books on work ethics and practices | 30 pcs | 1:1 |
|  | Powerpoint presentations | For trainer’s use, covering course content and practical applications | 1 | 1:30 |
|  | Projector | Functional projector for displaying content during presentations | 1 | 1:30 |
|  | Media Resources | This include but are not limited to:   * Video clips * Audio clips * TV sets * Radio sets | Adequate |  |
|  | White board | Quality whiteboard of approximately 6 ft by 3 ft for writing during theory instruction | 1 | 1:30 |
| **B** | **Learning facilities & infrastructure** | | | |
|  | 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 |
|  | 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** | | | |
|  | Printing papers | A4 and A3 printing papers suitable for the task | Adequate |  |
|  | Flashcards | For carrying out various activities by trainees | Adequate |  |
|  | Charts | Sufficient for group work activities and displaying | Adequate |  |
|  | Whiteboard marker pens | Dry-erase markers for trainers use. Assorted colors | Adequate |  |

## ENTREPRENEURIAL SKILLS

**ISCED UNIT CODE: 0413 541 04A**

**Relationship with occupational standards**

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

**Duration of unit: 60 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 | 10 |
| 2 | Apply the entrepreneurial concept | 10 |
| 3 | Identify entrepreneurship opportunities | 10 |
| 4 | Apply business legal aspects | 10 |
| 5 | Innovate business strategies | 10 |
| 6 | Develop business plan | 10 |

**Learning outcomes, content and suggested assessment methods**

| **Learning outcome** | **Content** | **Suggested assessment methods** |
| --- | --- | --- |
| 1. Apply financial literacy | * 1. Personal finance management   2. Balancing between needs and wants   3. Budget preparation   4. Saving management   5. Factors to consider when deciding where to save   6. Debt management   7. Factors to consider before taking a loan   8. Investment decisions   9. Types of investments   10. Factors to consider when investing money   11. Insurance services   12. insurance products available in the market   13. Insurable risks | * Observation * Project * Written assessment * Oral assessment * Third party report * Interviews |
| 1. Apply entrepreneurial concept | * 1. Difference between Entrepreneurs and business persons   2. Types of entrepreneurs   3. Ways of becoming an entrepreneur   4. Characteristics of Entrepreneurs   5. salaried employment and self-employment   6. Requirements for entry into self-employment   7. Roles of an entrepreneur in an enterprise   8. Contributions of Entrepreneurship | * Observation * Project * Written assessment * Oral assessment * Third party report |
| 1. Identify entrepreneurship opportunities | * 1. Sources of business ideas   2. Factors to consider when evaluating business opportunity   3. Business life cycle | * Observation * Project * Written assessment * Oral assessment * Third party report |
| 1. Apply business legal aspects | * 1. Forms of business ownership   2. Business registration and licensing processing   3. Types of contracts and agreements   4. Employment laws   5. Taxation laws | * Observation * Project * Written assessment * Oral assessment * Third party report |
| 1. Innovate business Strategies | * 1. Creativity in business   2. Innovative business strategies   3. Entrepreneurial linkages   4. ICT in business growth and development | * Observation * Project * Written assessment * Oral assessment * Third party report |
| 1. Develop business plan | * 1. Business description   2. Marketing plan   3. Organizational/management plan   4. Production/operation plan   5. Financial plan   6. Executive summary   7. Business plan presentation   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** |  |  |  |
|  | Textbooks | Comprehensive texts books on entrepreneurial skills | 30 pcs | 1:1 |
|  | Powerpoint presentations | For trainer’s use, covering course content and practical applications | 1 | 1:30 |
|  | Projector | Functional projector for displaying content during presentations | 1 | 1:30 |
|  | Media resources | These include but are not limited to:   * Video clips * Audio clips * TV sets * Radio sets * Newspapers * Business journals * Case studies | Adequate |  |
|  | Templates | Templates for creating various documents e.g. business plan, invoices etc. | 30 | 1:1 |
|  | White board | Quality whiteboard of approximately 6 ft by 3 ft for writing during theory instruction | 1 | 1:30 |
| **B** | **Learning facilities & infrastructure** | | | |
|  | 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 |
|  | 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** | | | |
|  | Writing Materials | Writing materials for note taking | Adequate |  |
|  | Flashcards | For carrying out various activities by trainees | Adequate |  |
|  | Charts | Sufficient for group work activities and displaying | Enough |  |
|  | Whiteboard Marker Pens | Dry-erase markers for trainers use. Assorted colors | Enough |  |