

**REPUBLIC OF KENYA**

**COMPETENCY BASED MODULARISED CURRICULUM**

**FOR**

**INSTRUMENTATION AND CONTROL TECHNOLOGY**

**KNQF LEVEL 6**

**ISCED PROGRAMME CODE: 0714 554A**

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**FOREWORD**

The provision of quality education and training is fundamental to the Government’s overall strategy for social and economic development. Quality education and training contribute to the achievement of Kenya’s development blueprint and sustainable development goals.

Reforms in the education sector are necessary to achieve Kenya Vision 2030 and meet the provisions of the Constitution of Kenya 2010. The education sector had to be aligned to the Constitution, and this resulted in the formulation of the Policy Framework for Reforming Education and Training in Kenya (Sessional Paper No. 14 of 2012). A key feature of this policy is the radical 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 the mode of delivery allow for multiple entry and exit in TVET programmes.

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. For trainees to build their skills on foundational hands-on activities of the occupation, units of learning are grouped in modules. This has eliminated duplication of content and streamlined exemptions based on skills acquired as a trainee progresses in the up-skilling process, while at the same time allowing trainees to be employable in the shortest time possible through the acquisition of part qualifications.

It is my conviction that this curriculum will play a great role in developing competent human resources for the ………………… Sector’s growth and development.

**PRINCIPAL SECRETARY**

**STATE DEPARTMENT FOR TVET**

**MINISTRY OF EDUCATION**

**PREFACE**

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

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

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

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

**ACKNOWLEDGMENT**

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 were received from expert trainers, institutions and organizations.

I recognize with appreciation the role of the ……… National Sector Skills Committee (NSSC) in ensuring that competencies required by the industry are addressed in the curriculum. I also thank all stakeholders in the ………… sector for their valuable input and everyone who participated in developing this curriculum.

I am convinced that this curriculum will go a long way in ensuring that individuals aspiring to work in the ……………… Sector acquire competencies to perform their work more efficiently and effectively.

**TABLE OF CONTENTS**

Contents

[**FOREWORD** iii](#_Toc197085582)

[**ACKNOWLEDGMENT** v](#_Toc197085583)

[**TABLE OF CONTENTS** vi](#_Toc197085584)

[**ACRONYMS AND ABBREVIATION** viii](#_Toc197085585)

[**KEY TO ISCED UNIT CODE** x](#_Toc197085586)

[**COURSE OVERVIEW** xi](#_Toc197085587)

[**MODULE 1** 16](#_Toc197085588)

[ELECTRICAL INSTALLATION 17](#_Toc197085589)

[INSTRUMENTATION AND CONTROL SYSTEM COMPONENTS INSTALLATION 26](#_Toc197085590)

[MODULE 2 34](#_Toc197085591)

[INSTRUMENTATION AND CONTROL SYSTEM OPERATIONS 35](#_Toc197085592)

[INSTRUMENTATION AND CONTROL SYSTEMS MAINTENANCE 41](#_Toc197085593)

[**MODULE 3** 50](#_Toc197085594)

[DIGITAL LITERACY 51](#_Toc197085595)

[ENGINEERING DRAWINGS 65](#_Toc197085596)

[ELECTRONICS CIRCUIT FABRICATION 73](#_Toc197085597)

[ELECTRICAL PRINCIPLES 88](#_Toc197085598)

[HYDRAULIC AND PNEUMATIC SYSTEM INSTALLATION 103](#_Toc197085599)

[**MODULE 4** 115](#_Toc197085600)

[WORK ETHICS AND PRACTICES 116](#_Toc197085601)

[COMMUNICATION SKILLS 123](#_Toc197085602)

[ENTREPRENEURIAL SKILLS 128](#_Toc197085603)

[BASIC MATHEMATICS 133](#_Toc197085604)

[LOGIC CONTROLLERS’ INSTALLATION 144](#_Toc197085605)

[ELECTRICAL MACHINES INSTALLATION 155](#_Toc197085606)

[**MODULE 5** 165](#_Toc197085607)

[ENGINEERING TECHNICIAN MATHEMATICS 166](#_Toc197085608)

[ADVANCED ELECTRONICS CIRCUIT FABRICATION 175](#_Toc197085609)

[ELECTRICAL MEASUREMENT AND FAULT DIAGNOSIS 182](#_Toc197085610)

[CONTROL AND INSTRUMENTATION SYSTEMS MONITORING 190](#_Toc197085611)

[**MODULE 6** 199](#_Toc197085612)

[CONTROL SYSTEMS 200](#_Toc197085613)

[RESEARCH METHODS 208](#_Toc197085614)

[INDUSTRIAL MEASUREMENT INSTRUMENTS CALIBRATION 215](#_Toc197085615)

[INSTRUMENTATION AND CONTROL SYSTEM SUPERVISION 222](#_Toc197085616)

**ACRONYMS AND ABBREVIATION**

**ADCs –** Analogue to digital converters

**ISCED** – International Standard Classification of Education

**CEO** – Chief Executive Officer

**TVET** – Technical and Vocational Education and Training

**CBET** – Competency-Based Education and Training

**CBETA** – **Competency-Based Education and Training Authority**

**CDACC** – Curriculum Development, Assessment, and Certification Council

**AC** – Alternating Current

**CAD** – Computer-Aided Design

**CPU** – Central Processing Unit

**CV** – Curriculum Vitae

**DACs** – Digital to analogue converters

**DC** – Direct Current

**DOL** – Direct-On-Line

**DVI** – Digital Visual Interface

**HDMI** – High-Definition Multimedia Interface

**IEE** Institution of Engineering and Technology

**IET** – Institution of Engineering and Technology

**KCL** – Kirchhoff’s Current Law

**KCSE** – Kenya Certificate of Secondary Education

**KNQF** – Kenya National Qualifications Framework

**KVL** – Kirchhoff’s Voltage Law

**NEMA** – National Environment Management Authority

**NP** – Net Power

**OSHA** – Occupational Safety and Health Administration

**PPE** – Personal Protective Equipment

**RAM** – Random Access Memory

**RPL** – Recognition of Prior Learning

**SI** – International System of Units

**SMP** – Symmetric Multiprocessing

**SMS** – Short Message Service

**TV** – Television

**TVET** – Technical and Vocational Education and Training

**TVETA** – Technical and Vocational Education and Training Authority

**USB** – Universal Serial Bus

**UV** – Ultraviolet

**VGA** – Video Graphics Array

**PVC** – Polyvinyl Chloride

**VFD** – Variable Frequency Drive

**VGA** – Video Graphics Array

**VSD** – Variable Speed Drive

**PWM** – Pulse Width Modulation

**PCB** – Printed Circuit Board

**KEY TO ISCED UNIT CODE**



**COURSE OVERVIEW**

This Instrumentation and control technology Level 6 curriculum consists of competencies that an individual must achieve to perform instrumentation and control activities. It involves installing electrical systems, installing instrumentation and control system operations, maintaining instrumentation and control system ,installing instrumentation and control system components, installing logic controllers, fabricate electronics circuits, installing electrical machines, installing hydraulic and pneumatic system and Control, instrumentation systems monitoring, industrial measurement instruments calibration and instrumentation and control system supervision.

**Units of Learning**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **CORE UNITS OF LEARNING** | | | | | | | |
| **Unit code** | | **Unit title** | | **Hours** | **Credit factor** | | |
| **Module 1** | | | | | | | |
| 0713 551 13A | | Electrical Installation | | 80 | 8 | | |
| 0714 551 14A | | Instrumentation And Control System Components installation | | 160 | 16 | | |
|  | | **TOTAL** | | **240** | **24** | | |
| **Module 2** | | | | | | | |
| 0714 551 15A | | Instrumentation And Control System Operations | | 160 | 16 | | |
| 0714 551 16A | | Instrumentation And Control System Maintenance | | 160 | 16 | | |
|  | | **TOTAL** | | **320** | **32** | | |
| **Module 3** | | | | | | |
| 0611 451 01A | Digital Literacy | | 60 | | | 6 |
| 0732 451 06A | Engineering Drawing | | 60 | | | 6 |
| 0713 451 07A | Electrical Principles | | 120 | | | 12 |
| 0714 451 08A | Electronic Circuit Fabrication | | 100 | | | 10 |
| 0715 451 19A | Hydraulic and Pneumatic System Installation | | 120 | | | 12 |
|  | **TOTAL** | | **460** | | | **46** |
| **Module 4** | | | | | | |
| 0031 451 02B | Communication Skills | | 40 | | | 4 |
| 0417 451 03B | Work Ethics and Practices | | 40 | | | 4 |
| 0413 451 04B | Entrepreneurial Skills | | 40 | | | 4 |
| 0541 451 05A | Basic Mathematics | | 80 | | | 8 |
| 0714 451 17A | Logic Controllers Installation | | 120 | | | 12 |
| 0713 451 20A | Electrical Machines Installation | | 120 | | | 12 |
|  | **TOTAL** | | **440** | | | **44** |
| **Module 5** | | | | | | |
| 0541 551 10A | Engineering mathematics | | 100 | | | 10 |
| 0714 551 08A | Advanced electronic circuit Fabrication | | 120 | | | 12 |
| 0713 551 09A | Electrical Measurement and Fault Diagnosis | | 60 | | | 6 |
| 0714 551 21A | Control and Instrumentation Systems Monitoring | | 120 | | | 12 |
|  | **TOTAL** | | **400** | | | 40 |
| **Module 6** | | | | | | |
| 0714 551 12A | Control Systems | | 100 | | | 10 |
| 0111 551 11A | Research Methods | | 60 | | | 6 |
| 0714 551 22A | Industrial Measurement Instruments Calibration | | 120 | | | 12 |
| 0714 551 23A | Instrumentation and Control System Supervision | | 120 | | | 12 |
|  | **TOTAL** | | **400** | | | **40** |
| **Industrial attachment** | | | **480** | | | **48** |
| **GRAND TOTAL** | | | **2760** | | | **276** |

**Entry Requirements**

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

1. Kenya Certificate of Secondary Education (KCSE) mean grade C-, KCE Div. 3 or its equivalent

**Or**

1. Qualification certificate in Instrumentation and Control Technology level 5.

**Or**

1. Any other qualification equivalent to that of instrumentation and control technology Level 5 as determined by the Technical and Vocational and Training Authority (TVETA).

**Trainer Qualification**

Qualifications of a trainer for this course include:

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

**Industry Training**

A n individual enrolled in this course will be required to undergo Industry training for a minimum period of 480 hours in Instrumentation and control 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. Number of formative assessments shall minimally be equal to the number of elements in a unit of competency.
3. During summative assessment basic and common units may be integrated in the core units or assessed as discrete units.
4. Theoretical and practical weight for each unit of learning shall be as follows:
5. 10:90 for units in modules 1 and 2;
6. 30:70 for units in modules 3 and 4;
7. 40:60 for units in modules 5 and 6.
8. Formative and summative assessments shall be weighted at 60% and 40% respectively in the overall unit of learning score
9. For a candidate to be declared competent in a unit of competency, the candidate must meet the following conditions:
10. Obtained at least 40% in theory assessment in formative and summative assessments.
11. Obtained at least 60% in practical assessment in formative and summative assessment where applicable.
12. Obtained at least 50% in the weighted results between formative assessment and summative assessment where the former constitutes 60% and the latter 40% of the overall score.
13. 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 core Unit of Competency. To be issued with Kenya **National TVET Certificate** in Instrumentation and Control Technology KNQF Level 5 the candidate must demonstrate competence in all the Units of Competency as given in the qualification pack. A Statement of Attainment certificate may be issued upon demonstration of competence in a certifiable element within a unit.

The certificates will be issued by the ……………… (Qualification Awarding Institution).

# **MODULE 1**

## ELECTRICAL INSTALLATION

**UNIT CODE:** 0713 351 13A

**Relationship to Occupational Standards**

**This unit addresses the unit of competency: Perform Electrical Installation**

**Duration of Unit:** 80 Hours

**Unit Description**

This unit specifies the competencies required for performing electrical installation. It involves preparing a list of tools equipment and materials, performing piping, and laying of cables, installing of electrical components, terminating of electrical installation, inspecting and testing the installation and documenting an electrical installation.

**Summary of Learning Outcomes**

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

|  |  |  |
| --- | --- | --- |
| **S/NO** | **LEARNING OUTCOMES** | **DURATION(HOURS)** |
|  | Prepare list of tools, equipment, and materials | **10** |
|  | Perform piping and laying of cables | **20** |
|  | Install electrical components | **18** |
|  | Terminate electrical installation | **12** |
|  | Inspect and test installation | **10** |
|  | Document an Electrical installation | **10** |
|  | **TOTAL HOURS** | **80** |

**Learning Outcomes, Content and Suggested Assessment Methods**

| **Learning Outcome** | **Content** | **Suggested Assessment Methods** |
| --- | --- | --- |
| 1. Prepare a list of tools, equipment and materials | 1. Health and safety procedures 2. PPEs 3. Safety, Rules and, regulations 4. Hazards    1. Electrical installation tools and materials 5. Cutting tools 6. Measuring tools 7. Measuring equipment 8. Cables and conductors 9. Crimping tools 10. Conduits 11. Trunking 12. Consumables     1. Types, application, care, maintenance and storage of:        1. Tools           1. Cable strippers           2. Pliers           3. Screw drivers           4. Hammers           5. Chisels           6. Allen keys           7. Electrician knives           8. Crimping tools           9. Bending springs           10. Steel tapes           11. Draw wires           12. Hack saws           13. Drills        2. Equipment           1. Stock and die           2. Vice        3. Materials           1. Cables           2. Fittings           3. Accessories     2. Assemble electrical installation tools, equipment and materials | * Oral questioning * Written tests * Observation * Practical |
| 1. Perform piping and laying of cables | 1. Meaning of terms 2. Procedures for piping 3. Cables and cable joints 4. Wiring systems and accessories 5. Types and applications    * + 1. Conduits        2. Cable trays        3. Cable ducts        4. Trunking 6. Preparation of wiring systems    * + 1. Marking out        2. Cutting        3. Bending        4. Threading        5. Chiseling        6. Trenching    1. Draw –in/Lay of cables routes       1. Cable Identification    2. IEE regulations | * Written tests * Observation * Oral questioning * Practical test |
| 1. Install electrical components | 1. Meaning of terms 2. Electrical symbols and abbreviations 3. Meaning of electrical drawings 4. Drawing of electrical diagrams    * 1. block      2. schematic      3. circuit      4. line      5. wiring 5. Electrical components    * 1. Junction boxes      2. Ceiling rose      3. Switches      4. Socket outlets      5. Bulb holders      6. IEE regulations | * Written tests * Oral questioning * Practical tests * Observation |
| 1. Terminate electrical installation | 1. Meaning of Terms 2. Importance of termination 3. Cable labelling 4. Cable lugging 5. Tools used in cable termination e.g. 6. Crimping tool 7. Strip Knife    1. IEE regulations    2. Disposal of waste materials | * Written tests * Oral questioning * Practical tests * Observation |
| 1. Inspect and test installation | 1. Types of tests on an electrical installation system 2. IEE regulations in regard to electrical installation testing and inspection 3. Electrical testing instruments | * Written tests * Oral questioning * Practical tests * Observation |
| 1. Document an Electrical installation | * 1. Report preparation   2. Sharing of the installation report   3. Report filing | * Written tests * Oral questioning * Practical tests * Observation |

**Suggested Methods of Instruction**

* Demonstration by trainer
* Practice by the trainee
* Field trips
* On-job-training
* Discussions

**Recommended Resources for 25 trainees**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S/No.** | **Category/Item** | **Description/ Specifications** | **Quantity** | **Recommended Ratio**  (Item: Trainee) |
| **A** | **Learning Materials** |  |  |  |
|  | Textbooks | 1. B. Scaddan Electrical installation work 2. J. Hyde Electrical Installation Principles and Practices 3. Electrical Theory for the Electrician**"** by Mike Holt 4. Electrical installation work by Brian Scaddan | 5 pcs | 1:5 |
|  | Installation manuals | IEEE regulation  BS3939  NEMA regulations  OSHA | 5 pcs | 1:5 |
|  | Charts | Single line diagram  Circuit diagrams  Colour codes | 1 pcs for each | 1:25 |
|  | Power point presentations | For trainer’s use | 1 | 1:25 |
| **B** | **Learning Facilities & infrastructure** |  |  |  |
|  | Lecture/theory room | 60m2 | 1 | 1:25 |
|  | Workshop | 150m2 | 1 | 1:25 |
|  | Site |  |  |  |
| **C** | **Consumable materials** |  |  |  |
|  | Electrical wires | 1.5mm2(red, black green) | 5 rolls | 1:5 |
| 2.5mm2(red, black green) | 5 rolls | 1:5 |
| 4.0 mm2(red, black green) | 3 rolls | 1:10 |
| 6.0 mm2(red, black green) | 2 rolls | 1:12 |
| 10 mm2(red, black green) | 2 rolls | 1:12 |
|  | Insulation tapes |  | 25 pcs | 1:1 |
|  | Accessories | Switches, sockets, Junction boxes, Consumer units, Lamp holders, Patrice boxes, Circuit breakers, energy meter, cut out, cooker unit, instant water heater switch, | 25 pcs | 1:1 |
|  | Conduits and trunkings | PVC conduits, Steel conduits, Mini trunking | 25 pcs | 1:1 |
|  | **Tools and Equipment** |  |  |  |
|  | Hacksaws |  | 25 pcs | 1:1 |
|  | Striping knives |  | 25 pcs | 1:1 |
|  | Side cutters |  | 25 pcs | 1:1 |
|  | Pliers |  | 25 pcs | 1:1 |
|  | Tape measure |  | 25 pcs | 1:1 |
|  | Try Square |  | 25 pcs | 1:1 |
|  | Spirit level |  | 25 pcs | 1:1 |
|  | Assorted Screw driver |  | 25 pcs | 1:1 |
|  | Assorted hammers |  | 25 pcs | 1:1 |
|  | PPEs |  | 25 pcs | 1:1 |
|  | Multimeters |  | 5 pcs | 1:5 |
|  | Clamp meters |  | 5 pcs | 1:5 |
|  | Earth resistance meter |  | 5 pcs | 1:5 |
|  | Stocks & Dies |  | 5 pcs | 1:5 |
|  | Vices |  | 5 pcs | 1:5 |
|  | Pipe bending Machine |  | 5 pcs | 1:5 |
|  | Bending spring |  | 5 pcs | 1:5 |
|  | Drilling machines |  | 5 pcs | 1:5 |
|  | Work stations |  | 25 | 1:1 |
|  | Installation boards |  | 13 pcs | 1:2 |

## INSTRUMENTATION AND CONTROL SYSTEM COMPONENTS INSTALLATION

**UNIT CODE:** 0714 351 14A

**Relationship to Occupational Standards**

This unit addresses the unit of competency: Install instrumentation and control components.

**Duration of Unit:** 160 Hours

**Unit Description**

This unit covers the competencies required to install instrumentation and control components. It involves preparing for installation of instrumentation and control system components, assembling instrumentation and control system components and testing instrumentation and control system components.

**Summary of Learning Outcomes**

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

|  |  |  |
| --- | --- | --- |
| **S/NO** | **LEARNING OUTCOMES** | **DURATION (HOURS)** |
|  | Prepare for installation of instrumentation and control system component | 64 |
|  | Assemble instrumentation and control system components | 56 |
|  | Test instrumentation and control system components. | 40 |
|  | **TOTAL HOURS** | **160** |

**Learning Outcomes, Content and Suggested Assessment Methods**

|  |  |  |
| --- | --- | --- |
| **Learning Outcome** | **Content** | **Suggested Assessment Methods** |
| 1. Prepare for installation of instrumentation and control system component. | * 1. Site survey consideration  1. Temperature 2. Humidity 3. Distance 4. Dust 5. Light intensity 6. Pressure    1. Meaning of workshop tools, instruments and equipment    2. Uses of workshop tools, Instruments and equipment       1. Cutting tools       2. Fastening tools       3. Marking tools       4. Drilling tools       5. Crimping tools       6. Alignment tools       7. Measuring equipment       8. Testing equipment    3. Handling, care and maintenance of workshop tools and Instruments    4. Instrumentation and control system components    5. Type of instrumentation and control components and their specifications       * 1. Sensors         2. Controllers         3. Communication devices         4. Actuators    6. Types of electric motors       * 1. DC motors         2. AC motors    7. Transmitters    8. Motor control       * 1. DOL         2. Forward/Reverse         3. Star/Delta         4. Soft Starters         5. VFD/VSD    9. Signal processing    10. Signal conditioning    11. Display    12. Instrumentation transmission system components        1. Pressure system components        2. Flow rate measurement components        3. Level measurement components        4. Temperature measurement components | 1. Written Assessment 2. Oral Questioning 3. Practical Assessment 4. Project 5. Third party report 6. Portfolio of evidence |
| 1. Assemble instrumentation and control system components | 1. System components mounting.    * 1. Factors to consider when mounting. 2. Interpretation of installation documents    * 1. Line diagrams      2. Wiring diagrams      3. Layouts      4. Installation manuals 3. Mounting instrumentation devices and components    * 1. Environmental conditions      2. Vibration and shock      3. Weight and size of component      4. Electrical safety      5. Accessibility 4. Cable lugging and tagging    * 1. Types of cable lugs and tags      2. Cable lugging and tagging standards 5. Cable laying 6. Terminations and joints 7. Housekeeping activities    * 1. Cleaning      2. Tools and equipment storage      3. Waste disposal      4. Documentation | 1. Written Assessment 2. Oral Questioning 3. Practical Assessment 4. Project 5. Third party report 6. Portfolio of evidence |
| 1. Test instrumentation and control system components | 1. Importance of instrumentation system testing 2. Meaning of terms 3. Inspection 4. Testing 5. Types of tests e.g. 6. Electrical tests 7. Functionality tests    * + 1. Test Signal Conditioning Elements        2. Test Signal Processing elements        3. Test Data presentation elements 8. Testing tools and equipment 9. Multimeter 10. Insulation resistance tester 11. Signal generators 12. Troubleshooting techniques 13. Performance characteristics 14. Statics and dynamics 15. Error and loading effects 16. Accuracy 17. Precision 18. Linearity 19. Sensitivity 20. Resolution 21. Response time 22. Drift 23. Calibration 24. Functional integration 25. Instrumentation system test report | 1. Written Assessment 2. Oral Questioning 3. Practical Assessment 4. Project 5. Third party report 6. Portfolio of evidence |

**Suggested Methods of Instruction**

* Group discussions
* Demonstration
* Visit to manufacturing and processing industries

**Recommended Resources for 25 trainees**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S/No.** | **Category/Item** | **Description/ Specifications** | **Quantity** | **Recommended Ratio**  (Item: Trainee) |
| **A** | **Learning Materials** |  |  |  |
|  | Reference books | A.K Sawhney  Electrical and Electronic Measurement and Instrumentation.  Arun. K Ghoshi  Introduction to Measurements and Instrumentation 2nd edition  R.K Rajput  Electrical Measurements and Instrumentation 2nd edition | 5 pcs | 1:5 |
|  | Installation manuals | Assorted Systems component Manufacturer’s manuals and data sheets  Instrumentation Handbooks | 5 pcs | 1:5 |
|  | Maintenance manuals | Assorted Systems component Manufacturer’s manuals and data sheets  Maintenance Handbooks | 5 pcs | 1:5 |
|  | Checklists | Assorted Systems checklists | 5 pcs | 1:5 |
|  | Audio visual presentations | Projector | 1 | 1:25 |
| **B** | **Learning Facilities & infrastructure** |  |  |  |
|  | Lecture/theory room | 60m2 | 1 | 1:25 |
|  | Workshop | 150m2 | 1 | 1:25 |
|  | Computer laboratory | 100m2 | 1 | 1:25 |
| **C** | **Consumable materials** |  |  |  |
|  | Installation materials | Insulation tapes and tubes, cleaning agents, Lubrication oil, assorted electrical cable rolls, cable tags and lags, soldering wire | 25 pcs each | 1:1 |
| **D** | **Tools and Equipment** |  |  |  |
|  | Assorted tools and equipment | Side cutters, Side cutters, Pliers, Screwdriver, Crimping tools, multi-meter, torque wrench, Oscilloscope, clamp meters, drilling tools | 25 pcs | 1:1 |
|  | PPEs | Safety boots, overall, helmets | 25 pcs | 1:1 |
|  | Work stations | Electrical works station with mounting boards, 3θ power source. | 25 pcs | 1:1 |
|  | Process control training | With simulations faults | 25 pcs | 1:1 |

# MODULE 2

## INSTRUMENTATION AND CONTROL SYSTEM OPERATIONS

**UNIT CODE: 0714 351 15A**

**Relationship to Occupational Standards**

This unit addresses the unit of competency: Operate instrumentation and control system **Duration of Unit:** 160 Hours

**Unit Description**

This unit covers the competencies required to operate instrumentation and control system. It involves performing instrumentation and control system start up, changing instrumentation and control system dies and running instrumentation and control systems.

**Summary of Learning Outcomes**

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

|  |  |  |
| --- | --- | --- |
| **S/No.** | **Learning Outcomes** | **Duration (Hours)** |
|  | Perform instrumentation and control system start up | 60 |
|  | Changeover instrumentation and control system dies | 50 |
|  | Run instrumentation and control system | 50 |
|  | **TOTAL HOURS** | **160** |

**Learning Outcomes, Content and Suggested Assessment Methods**

|  |  |  |
| --- | --- | --- |
| **Learning Outcome** | **Content** | **Suggested Assessment Methods** |
| 1. Perform instrumentation and control system start up | 1. Instrumentation and control system inspection 2. Visual inspection 3. Functional inspection 4. Procedure of Instrumentation and control system start up 5. Types of instrumentation control alarms    * 1. Indicators 6. sirens 7. codes 8. Instrumentation and control system dry run | 1. Written Assessment 2. Oral Questioning 3. Practical Assessment 4. Project 5. Third party report 6. Portfolio of evidence |
| 1. Perform instrumentation and control system changeover dies | * 1. Instrumentation and control system dies  1. Moulds 2. Star wheels 3. Guide ways 4. Worm wheels    1. Tools and equipment       1. Cutting tools       2. Forming tools       3. Shaping tool       4. Fastening tools       5. Calibration equipment    2. System dies change over    3. System dies testing 5. Visual inspection 6. Functional test | 1. Written Assessment 2. Oral Questioning 3. Practical Assessment 4. Project 5. Third party report 6. Portfolio of evidence |
| 1. Run instrumentation and control system | 1. Factor to consider when selecting the recipe 2. Sequence of events 3. Process type 4. Factors to consider when loading raw materials 5. Safety 6. Environmental 7. System parameters 8. Temperature 9. Pressure 10. Flow rate 11. Level sensing 12. System parameter adjustment 13. Adjustment techniques 14. Parameter testing 15. System monitoring 16. Monitoring tools and indicators 17. Interpreting alarms and indicators 18. Data logging techniques 19. Documentation and record-keeping     * 1. Types of documentation          1. Installation manuals          2. Maintenance manuals          3. Checklists          4. Maintenance schedules | 1. Written Assessment 2. Oral Questioning 3. Practical Assessment 4. Project 5. Third party report 6. Portfolio of evidence |

**Suggested Methods of Instruction34I**

* Group discussions
* Demonstration
* Visit to manufacturing and processing industries

**Recommended Resources for 25 trainees**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S/No.** | **Category/Item** | **Description/ Specifications** | **Quantity** | **Recommended Ratio**  (Item: Trainee) |
| **A** | **Learning Materials** |  |  |  |
|  | Reference books | A.K Sawhney  Electrical and Electronic Measurement and Instrumentation.  Arun. K Ghoshi  Introduction to Measurements and Instrumentation 2nd edition  R.K Rajput  Electrical Measurements and Instrumentation 2nd edition | 5 pcs | 1:5 |
|  | Installation manuals | Assorted Systems component Manufacturer’s manuals and data sheets  Instrumentation Handbooks | 5 pcs | 1:5 |
|  | Maintenance manuals | Assorted Systems component Manufacturer’s manuals and data sheets  Maintenance Handbooks | 5 pcs | 1:5 |
|  | Checklists | Assorted Systems checklists | 5 pcs | 1:5 |
|  | Audio visual presentations | Projector | 1 | 1:25 |
| **B** | **Learning Facilities & infrastructure** |  |  |  |
|  | Lecture/theory room | 60m2 | 1 | 1:25 |
|  | Workshop | 150m2 | 1 | 1:25 |
|  | Computer laboratory | 100m2 | 1 | 1:25 |
| **C** | **Consumable materials** |  |  |  |
|  | Installation materials | Indicators, sirens, insulation tape, cables | 25 pcs | 1:1 |
|  | Assorted dies | Moulds, star wheels, guide ways, worm wheels | 5 for each category | 1:5 |
| **D** | **Tools and Equipment** |  |  |  |
|  | Assorted tools and equipment | Side cutters, Side cutters, Pliers, Screw driver, Crimping tools, Mult-meter, torque wrench | 25 pcs | 1:1 |
|  | PPEs | Safety boots, overall | 25 pcs | 1:1 |
|  | Work stations |  | 25 | 1:1 |

## INSTRUMENTATION AND CONTROL SYSTEMS MAINTENANCE

**UNIT CODE: 0714 351 16A**

**Relationship to Occupational Standards**

This unit addresses the unit of competency: Maintain instrumentation and control systems. **Duration of Unit:** 160 Hours

**Unit Description**

This unit covers the competencies required to maintain instrumentation and control systems. It involves preparing instrumentation and control systems maintenance schedule, conducting instrumentation and control systems preventive maintenance, conducting instrumentation and control systems corrective maintenance, testing and commissioning instrumentation and control systems.

**Summary of Learning Outcomes**

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

|  |  |  |
| --- | --- | --- |
| **S/NO** | **LEARNING OUTCOMES** | **DURATION (HOURS)** |
|  | Prepare instrumentation and control systems maintenance schedule | **35** |
|  | Conduct instrumentation and control systems preventive maintenance | **35** |
|  | Conduct instrumentation and control systems corrective maintenance | **45** |
|  | Test and commission instrumentation and control system | **45** |
|  | **TOTAL HOURS** | **160** |

**Learning Outcomes, Content and Suggested Assessment Methods**

|  |  |  |
| --- | --- | --- |
| **Learning Outcome** | **Content** | **Suggested Assessment Methods** |
| 1. Prepare instrumentation and control systems maintenance schedule | 1. Maintenance scheduling 2. Types of maintenance and procedures 3. Preventive maintenance 4. Predictive maintenance 5. Corrective maintenance 6. Condition based maintenance 7. Predetermined maintenance 8. Reactive maintenance 9. Maintenance Work plan 10. Risk Assessment and Job Safety Analysis 11. Permit-to-Work System 12. Lockout/Tagout Procedures 13. Maintenance Tasks 14. Documentation     * + 1. Date and time of maintenance         2. Equipment identification         3. Maintenance tasks performed         4. Spare parts used         5. Calibration results         6. Non-conformances and corrective actions 15. Spare Parts Management 16. Training and Competency 17. Continuous Improvement 18. Maintenance documents 19. Maintenance manual 20. Maintenance report 21. Maintenance logs 22. Maintenance checklist | 1. Written tests 2. Oral Questioning 3. Practical assessment 4. Project 5. Third party report 6. Portfolio of evidence |
| 1. Conduct instrumentation and control systems preventive maintenance | 1. Critical instrumentation and control system components for maintenance    * 1. Audio sensitive gauges      2. Optical gauges      3. Pressure gauges      4. Temperature gauges      5. Vibration analysers 2. Preventive maintenance activities    * 1. Regular inspections      2. Cleaning      3. Adjustments e.g. alignment, balancing      4. Wear components check      5. lubrication      6. Calibrations | 1. Written tests 2. Oral Questioning 3. Practical assessment 4. Project 5. Third party report 6. Portfolio of evidence |
| 1. Conduct instrumentation and control systems corrective maintenance | 1. Troubleshooting procedure in systems 2. Identification of maintenance activities 3. Types of faults    * 1. Sensor Faults:         1. Calibration drift         2. Sensor failure         3. Noise and interference      2. Signal Transmission Faults:         1. Signal attenuation         2. Signal distortion         3. Signal loss      3. Signal Conditioning Faults:         1. Gain error         2. Offset error         3. Nonlinearity      4. Data Acquisition Faults:         1. Sampling rate errors         2. Quantization errors         3. Data corruption      5. Processing Faults:         1. Algorithm errors         2. Computational errors         3. Software bugs      6. Human Error:         1. Incorrect calibration         2. Improper maintenance         3. Misinterpretation of data 4. Corrective maintenance activities    * 1. Replacement      2. Repair      3. Overhaul      4. Alignment      5. Reset      6. Readjustment      7. Software updates      8. Recalibration 5. System isolation points    * 1. Circuit breakers      2. Fuses      3. Isolators      4. Couplers      5. Fittings 6. Fault rectification | 1. Written tests 2. Oral Questioning 3. Practical assessment 4. Project 5. Third party report 6. Portfolio of evidence |
| 1. Test and Commission instrumentation and control system | 1. SI unit of various types of Electrical parameters    * 1. Power – Watts (W)      2. Current – Amperes (A)      3. Resistance – Ohms(Ω)      4. Voltage – Volts (V) 2. Electrical tests 3. Polarity test 4. Earth loop impedance test 5. Insulation resistance test 6. Earth electrode resistance test 7. Functionality test 8. Commissioning documents 9. Start up and shutdown procedures 10. Safety documentation 11. Handover report 12. Commissioning documents:     * 1. Pre-commissioning Checklist       2. Commissioning Test Procedures       3. Commissioning Data Sheets       4. Calibration Certificates:       5. Instrument Calibration Certificates       6. Calibration Procedures       7. Spare Parts List:       8. Vendor Information       9. Maintenance Schedules and Procedures:       10. Preventive Maintenance Schedule       11. Corrective Maintenance Procedures       12. Emergency Procedures       13. Operator Training Manuals       14. Safety Manuals | 1. Written tests 2. Oral Questioning 3. Practical assessment 4. Project 5. Third party report 6. Portfolio of evidence |

**Suggested Methods of Instruction**

* Demonstrations
* Simulation
* Role play
* Group Discussion
* Presentations
* Projects
* Case studies
* Assignments

**Recommended Resources for 25 trainees**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S/No.** | **Category/Item** | **Description/ Specifications** | **Quantity** | **Recommended Ratio**  (Item: Trainee) |
| **A** | **Learning Materials** |  |  |  |
|  | Reference books | A.K Sawhney  Electrical and Electronic Measurement and Instrumentation.  Arun. K Ghoshi  Introduction to Measurements and Instrumentation 2nd edition  R.K Rajput  Electrical Measurements and Instrumentation 2nd edition | 5 pcs | 1:5 |
|  | Maintenance manuals | Assorted Systems component Maintenance reports, manufacture’s manuals and data sheets  Instrumentation Handbooks | 5 pcs | 1:5 |
|  | Charts | Assorted instrumentation systems circuit diagrams  P& ID charts | 1 pcs for each | 1:25 |
|  | Software | Assorted CAD software  e.g Circuit wizard, Auto CAD | 25 | 1:1 |
|  | Audio visual presentations | Projector | 1 | 1:25 |
| **B** | **Learning Facilities & infrastructure** |  |  |  |
|  | Lecture/theory room | 60m2 | 1 | 1:25 |
|  | Workshop | 150m2 | 1 | 1:25 |
|  | Computer laboratory | 100m2 | 1 | 1:25 |
| **C** | **Consumable materials** |  |  |  |
|  | Installation materials | Insulation tape, cables | 25 pcs | 1:1 |
|  | Assorted electrical components | Contactors, transformer, overload relays, timers | 25 pcs | 1:1 |
|  | Assorted instrumentation components | Sensors, transducers, actuators | 25 | 1:5 |
| **D** | **Tools and Equipment** |  |  |  |
|  | Assorted tools and equipment | Side cutters, Side cutters, Pliers, Screw driver, Crimping tools, Mult-meter, Oscilloscope, Solder guns | 25 pcs | 1:1 |
|  | PPEs | Safety boots, overall | 25 pcs | 1:1 |
|  | Function generator |  | 5 pcs | 1:5 |
|  | Variable power supply |  | 5 pcs | 1:5 |
|  | Trainers kit | Digital electronics, PWM kit | 5 pcs | 1:5 |
|  | PCB prototyping machine |  | 2 | 1:13 |
|  | Hot air gun |  | 5 pcs | 1:5 |
|  | Drilling machines |  | 5 pcs | 1:5 |
|  | Work stations |  | 25 | 1:1 |

# **MODULE 3**

## DIGITAL LITERACY

**UNIT CODE: 0611 451 01A**

**Relationship to Occupational Standards**

This unit addresses the unit of competency: Apply digital literacy.

**Duration of Unit:** 60 Hours

**Unit Description**

This unit covers the competencies required to apply digital literacy. It involves operating computer devices, solving tasks using office suite, managing data and information, accessing online/offline data and information, performing online communication and collaboration, applying cybersecurity skills, performing online jobs, and applying for job entries.

**Summary of Learning Outcomes**

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

|  |  |  |
| --- | --- | --- |
| **S/NO** | **LEARNING OUTCOMES** | **DURATION (HOURS)** |
|  | Operate Computer Devices | 6 |
|  | Solve Tasks Using Office Suite | 14 |
|  | Manage Data and Information | 6 |
|  | Perform Online Communication and Collaboration | 4 |
|  | Apply Cybersecurity Skills | 4 |
|  | Perform Online Jobs | 4 |
|  | Apply job entry techniques. | 2 |
|  | **TOTAL HOURS** | **60** |

**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 devices:      1. Desktops      2. Laptops      3. Smartphones      4. Tablets      5. Smart watches   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. Computer software:      1. System software e.g. Operating System (Windows, Macintosh, Linux, Android, iOS)      2. Application Software (Word Processors, Spreadsheets, Presentations).      3. Utility Software (Antivirus programs)   7. Classification of computer software   8. Operating system functions   9. Procedure for turning/off a computer   10. Mouse use techniques   11. Keyboard Parts and Use Techniques   12. Desktop Customization   13. File and Files Management using an operating system   14. Computer Internet Connection Options       1. Mobile Networks/Data Plans       2. Wireless Hotspots       3. Cabled (Ethernet/Fiber)       4. Dial-Up       5. Satellite   15. Computer external devices management       1. Device connections       2. Device controls (volume controls and display properties) | 1. Written Assessment 2. Oral Questioning 3. Practical Assessment 4. Project 5. Third party report 6. Portfolio of evidence |
| 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. Use 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. Use magnification/zoom tools       6. Apply or change a theme.       7. Save a presentations       8. Switch 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       3. Print presentations (slides and handouts) | 1. Written Assessment 2. Oral Questioning 3. Practical Assessment 4. Project 5. Third party report 6. Portfolio of evidence |
| 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. NewsGroup      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 | 1. Written Assessment 2. Oral Questioning 3. Practical Assessment 4. Project 5. Third party report 6. Portfolio of evidence |
| 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 | 1. Written Assessment 2. Oral Questioning 3. Practical Assessment 4. Project 5. Third party report 6. Portfolio of evidence |
| 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 | 1. Written Assessment 2. Oral Questioning 3. Practical Assessment 4. Project 5. Third party report 6. Portfolio of evidence |
| 1. Perform Online Jobs | * 1. Introduction to online working      1. Types of online Jobs      2. Online job platforms         1. Remotask         2. Data annotation tech         3. Cloud worker         4. Upwork         5. Oneforma         6. Appen   2. Online account and profile management   3. Identifying online jobs/job bidding   4. Online digital identity   5. Executing online tasks   6. Management of online payment accounts. | 1. Written Assessment 2. Oral Questioning 3. Practical Assessment 4. Project 5. Third party report 6. Portfolio of evidence |
| 1. Apply job entry techniques. | * 1. Types of job opportunities      1. Self-employment      2. Service provision      3. product development      4. salaried employment   2. Sources of job opportunities   3. Resume/ curriculum vitae      1. What is a CV      2. How long should a CV be      3. What to include in a AC      4. Format of CV      5. How to write a good CV      6. Don’ts of writing a CV   4. Job application letter      1. What to include      2. Addressing a cover letter      3. Signing off a cover letter   5. Portfolio of Evidence      1. Academic credentials      2. Letters of commendations      3. Certification of participations      4. Awards and decorations   6. Interview skills      1. Listening skills      2. Grooming      3. Language command      4. Articulation of issues      5. Body language      6. Time management      7. Honesty   7. Generally knowledgeable in current affairs and technical area | 1. Written Assessment 2. Oral Questioning 3. Practical Assessment 4. Project 5. Third party report 6. Portfolio of evidence |

**Suggested Delivery Methods**

* + Demonstration
  + Practical
  + Multimedia
  + Group discussions
  + Project
  + Role play
  + Case study

**Recommended Resources for 25 Trainees**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S/No.** | **Category/Item** | **Description/**  **Specifications** | **Quantity** | **Recommended**  **Ratio**  (Item: Trainee) |
| **A** | **Learning Materials** |  |  |  |
|  | Textbooks | Digital Literacy: Concepts and Applications by Ben Brow | 10 pcs | 1:3 |
|  | Printed training materials | Sample CVs  Sample job applications | 5 pcs  5 pcs | 1:5  1:5 |
|  | Online Resources | Khan Academy, Coursera, and YouTube for supplementary video content. | Accessible in 25 computers | 1:1 |
| **B** | **Learning Facilities & infrastructure** |  |  |  |
|  | Lecture/theory room | 60m2 | 1 | 1:25 |
|  | Computer workshop | 160 m2 | 1 | 1:25 |
|  | Computers | Operating System: 64-bit Windows 11 or 10 version 1809 or above  Processor: 2.5 GHz (3+ GHz recommended),  Memory: 8 GB (32GB recommended)  Disk space: 10 GB  Display: 1920 x 1080 resolution  Display Card: 2 GB GPU (8 GB recommended) and DirectX 11 compliant (DirectX 12 recommended) | 25 pcs | 1:1 |
|  | Projector | high-resolution projectors with HDMI input | 1 | 1:25 |
|  | Smartboard/Smart TV | Specifications: 77-inch interactive whiteboard with touch and pen functionality. | 1 | 1:25 |
|  | Whiteboard | Traditional whiteboard | 1 | 1:25 |
|  | External storage media | USB flash drives (32GB), External HDD/SSD | 25 pcs | 1:1 |
|  | Webcams | HD (1080p) | 25 pcs | 1:1 |
|  | Printers | With Print, Copy, Scan and Fax | 2 | 1:13 |
|  | Over-ear headphones | Large diaphragm | 25 pcs | 1:1 |
| **C** | **Software** |  |  |  |
|  | Operating systems | Windows/Linux/Macintosh Operating System | For 25 computers | 1:1 |
|  | Office | Microsoft Office Software | For 25 computers | 1:1 |
|  | Workspace | Google Workspace Account | For 25 computers | 1:1 |
|  | Antivirus Software |  | For 25 computers | 1:1 |
|  | Photo editing software | Adobe Photoshop, Canva, GIMP | For 25 computers | 1:1 |
|  | Video editing software | Adobe Premiere Pro, iMovie, DaVinci Resolve | For 25 computers | 1:1 |
|  | Web Browsers | Chrome, Firefox, Edge, Safari | For 25 computers | 1:1 |
| **D** | **Consumables** |  |  |  |
|  | Pens, pencils, rulers and paper | Whiteboard markers, 2H pencils, plastic rulers, A2 white papers | Enough |  |
|  | Printing papers | A4 and A3 | Enough |  |

## ENGINEERING DRAWINGS

**UNIT CODE:** 0732 441 05A

**Relationship to Occupational Standards**

This unit addresses the unit of competency: Prepare engineering drawings.

**Duration of Unit:** 60 Hours

**Unit Description**

This unit covers the competencies required to prepare and interpret engineering drawings. It involves managing basic operations in AutoCAD, developing 2D Drawings in AutoCAD, producing pictorial and orthographic drawings of components and .

**Summary of Learning Outcomes**

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

|  |  |  |
| --- | --- | --- |
| **S/NO** | **LEARNING OUTCOMES** | **DURATION(HOURS)** |
|  | Manage basic operations in AutoCAD | **10** |
|  | Develop 2D Drawings in AutoCAD | **15** |
|  | Produce pictorial and orthographic drawings of components | **20** |
|  | Develop electrical schematic drawings using simulation software | **15** |
|  | **TOTAL** | **60** |

**Learning Outcomes, Content and Suggested Assessment Methods**

|  |  |  |
| --- | --- | --- |
| **Learning Outcome** | **Content** | **Suggested Assessment Methods** |
| 1. Manage basic operations in AutoCAD | * 1. Introductionto CAD      1. Definition of CAD      2. Uses of CAD      3. Merits and demerits of AutoCAD over traditional method of engineering drawing.   2. AutoCAD installation      1. Computer system requirements for AutoCAD      2. CAD software type and versions         1. AutoCAD Electrical         2. AutoCAD Architecture         3. AutoCAD Mechanical   3. AutoCAD installation procedure   4. Getting started with CAD      1. Creating a new project in CAD.      2. AutoCAD user interface         1. Ribbon         2. Panels         3. Model space         4. Layout tabs         5. Status bar         6. Properties   5. Working with commands      1. Methods of inputting command in CAD.         1. Use icons on Ribbon         2. Use the commands box         3. Use Shortcuts      2. Selection methods in CAD.         1. One click         2. Window selection         3. Cross selection      3. 2D Cartesian workspace      4. Opening an existing project      5. Saving a new project. | 1. Written Assessment 2. Oral Questioning 3. Practical Assessment 4. Project 5. Third party report 6. Portfolio of evidence |
| 1. Develop 2D Drawings in AutoCAD | * 1. Basic Drawings and Editing Commands      1. Types of lines and application         1. Construction lines         2. Centre lines         3. Hidden detail lines         4. Border lines         5. Outline      2. Drawing lines         1. Vertical lines         2. Horizontal lines         3. Angular lines      3. Erasing objects         1. Use of command box         2. Selecting and pressing delete         3. Use of erase icon on ribbon      4. Drawing plane geometry         1. Triangles         2. Circles and tangents         3. Arcs         4. Quadrilaterals         5. Polygons         6. Orthographic projections            1. First angle orthographic            2. Third angle orthographic         7. Surface development         8. Simple floor plans         9. Electrical drawings            1. Block diagram            2. Schematic diagram            3. Line and wiring circuits   2. Drawing Precision in CAD      1. Using object snap overrides      2. Polar tracking at angles      3. Object snap tracking      4. Drawing with snap and grid   3. Making changes in your drawings      1. Selecting objects for editing      2. Moving      3. Copying      4. Rotating      5. Mirroring      6. Scaling      7. Trimming and extending      8. Stretching      9. Creating fillets and chamfers      10. Creating arrays   4. Annotations      1. Adding a text in a drawing      2. Modifying multiline text      3. Formatting multiline text      4. Creating tables         1. Title block         2. Modifying tables   5. Adding dimensions to drawings      1. Dimensioning concepts      2. Adding linear dimensions      3. Adding radial and angular dimensions      4. Editing dimensions   6. 2D drawings documentation      1. Printing concepts      2. Printing layouts      3. Print and plot settings | 1. Written Assessment 2. Oral Questioning 3. Practical Assessment 4. Project 5. Third party report 6. Portfolio of evidence |
| 1. Produce pictorial and orthographic drawings of components | * 1. Pictorial and orthographic drawings   2. Drawing and interpretation of orthographic elevations using CAD   3. Dimensioning of orthographic elevations   4. 3D CAD user interface      1. Ribbon      2. Panels      3. Model space      4. Layout tabs      5. Status bar      6. Properties   5. Working with 3D commands      1. Methods of inputting command in CAD.         1. Use icons on Ribbon         2. Use the commands box         3. Use Shortcuts      2. Selection methods in CAD.         1. One click         2. Window selection         3. Cross selection   6. 3D Cartesian workspace      1. 3D CAD drawingsare drafted as per work requirement   7. Basic solids      1. Cylinder      2. Cubes      3. Cuboids      4. Prisms      5. Pyramids      6. Cones   8. Produce pictorial drawings      1. Oblique drawing      2. Isometric drawing   9. Produce Assembly drawings   10. 3D drawings documentation       1. Printing layouts       2. Print and plot settings | 1. Written Assessment 2. Oral Questioning 3. Practical Assessment 4. Project 5. Third party report 6. Portfolio of evidence |
| 1. Develop electrical schematic drawings using simulation software | * 1. Introduction to schematic drawing and simulation software (e.g., Circuit Wizard, Multisim)   2. Navigating the software interface: menus, toolbars, and workspace   3. Selection and insertion of electrical and electronic components   4. Assigning correct symbols and values to components (resistors, capacitors, transistors, ICs, etc.)   5. Labelling components and circuits with reference designators and values   6. Use of virtual instruments (e.g., voltmeter, ammeter, oscilloscope)   7. Running simulations to test circuit functionality   8. Identifying and correcting circuit errors using built-in diagnostics   9. Saving schematic files in appropriate formats (native and export)   10. Printing and exporting schematic diagrams for documentation and reports | 1. Written Assessment 2. Oral Questioning 3. Practical Assessment 4. Project |

**Suggested Delivery Methods**

* Trainer demonstration
* Simulation
* Discussions
* Direct instruction

**List of Recommended Resources for 25 trainees**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S/No.** | **Category/Item** | **Description/**  **Specifications** | **Quantity** | **Recommended**  **Ratio**  (Item: Trainee) |
| **A** | **Learning Materials** |  |  |  |
|  | Textbooks | Introduction to Drafting and AutoCAD 2D  Comprehensive Guide for Beginners and Intermediate Users by CAD Artifex  Technical Drawing 101 with AutoCAD by Ashleigh Congdon-Fuller, Antonio Ramirez and Douglas Smith  Circuit Simulation with Multisim by David Baez-Lopez  SPICE for Circuits and Electronics Using PSpice by Muhammad H. Rashid | 5 pcs  5 pcs  5 pcs | 1:5  1:5  1:5 |
|  | Installation manuals | AutoCAD software installation manual, circuit wizard installation manual | 25 pcs | 1:51 |
|  | Power point presentations | For trainer’s use | 1 | 1:25 |
| **B** | **Learning Facilities & infrastructure** |  |  |  |
|  | Lecture/theory room | 60m2 | 1 | 1:25 |
|  | Computer laboratory | 160m2 | 1 | 1:25 |
|  | Computer | Operating System: 64-bit Windows 11 or 10 version 1809 or above  Processor: 2.5 GHz (3+ GHz recommended),  Memory: 8 GB (32GB recommended)  Disk space: 10 GB  Display: 1920 x 1080 resolution  Display Card: 2 GB GPU (8 GB recommended) and DirectX 11 compliant (DirectX 12 recommended) | 25 pcs | 1:1 |
|  | Projector | At least 3000 lumens | 1 | 1:25 |
|  | Interactive screen | 75 inches | 1 | 1:25 |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **C** | **Software** |  |  |  |
|  | Solid works | Solid works 2024 Standard | 1 | 1:25 |
|  | AutoCAD | AutoCAD 2025 | 1 | 1:25 |
|  | Circuit Wizard or any other equivalent schematic circuit simulation software | Circuit Wizard 2025 | 1 | 1:25 |
|  | Solid works licenses | Solid works 2024 Standard version licenses | 25 | 1:1 |
|  | AutoCAD licenses | AutoCAD 2025 licenses | 25 | 1:1 |
|  | Circuit Wizard license | Circuit Wizard 2025 license | 25 | 1:1 |

## ELECTRONICS CIRCUIT FABRICATION

**UNIT CODE:** 0714 451 08A

**Relationship to Occupational Standards**

This unit addresses the unit of competency: Fabricate electronic circuits.

**Duration of Unit:** 120 Hours

**Unit Description**

This unit covers the competencies required to fabricate electronic circuits. It involves building logic gate circuits, fabricating semiconductor diode circuits, building amplifier circuits, fabricating signal generators, signal filter circuits and microprocessor-based systems.

**Summary of Learning Outcomes**

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

|  |  |  |
| --- | --- | --- |
| **S/NO** | **LEARNING OUTCOME** | **DURATION (HOURS)** |
|  | Build Logic Gate Circuits | **20** |
|  | Fabricate semiconductor diode circuits | **15** |
|  | Build amplifier circuits | **30** |
|  | Fabricate signal generators | **15** |
|  | Fabricate signal filter circuits | **15** |
|  | Fabricate microprocessor-based systems | **25** |
|  | **TOTAL HOURS** | **120** |

**Learning Outcomes, Content and Suggested Assessment Methods**

| **Learning Outcome** | **Content** | **Suggested Assessment Methods** |
| --- | --- | --- |
| 1. Build Logic Gate Circuits | * 1. Difference between analog and digital   2. Number systems      1. Types of Number Systems         1. Binary         2. Decimal         3. Hexadecimal         4. Octal      2. Conversions between Number Systems      3. Binary Arithmetic         1. Addition and subtraction   3. Logic gates      1. AND      2. OR      3. NOT      4. NAND      5. NOR      6. XOR   4. Truth tables for logic gates   5. Boolean algebra and simplification.   6. Combinational logic circuits      1. Half-adders build with two logic gates:         1. XOR         2. AND      2. Decoders:         1. 2-to-4         2. 3-to-8      3. Multiplexers         1. 2-to-1         2. 4-to-1   7. Test combinational logic circuits   8. Sequential logic circuits      1. SR Latch using NAND/NOR gates      2. D Flip-Flop      3. Counters         1. Binary counters         2. Asynchronous counters      4. 4-bit shift register   1.15 Test logic circuits | 1. Written Assessment 2. Oral Questioning 3. Practical Assessment 4. Project 5. Third party report 6. Portfolio of evidence |
| 1. Fabricate semiconductor diode circuits | * 1. Atomic structure  1. Structure of the Atom 2. Energy band theory    1. Types of materials 3. Insulators 4. Conductors 5. Semiconductors    1. Types of semiconductors materials 6. Intrinsic semiconductors 7. Extrinsic semiconductors    1. pn junction/crystal diode    2. Characteristics of the crystal diode    3. Biasing of the crystal diode    4. Special purpose diodes       1. LED       2. Photodiode       3. Optoisolator       4. Schockley diode       5. Application of semiconductor diodes    5. Fabrication tools and equipment       1. Hand Tools          1. Soldering iron          2. Desoldering pump          3. Pliers          4. Wire strippers          5. Cutters.       2. Measurement tools          1. Multimeter          2. Logic analyzer          3. Oscilloscope          4. LCR meter.          5. Understanding       3. Soldering Stations       4. Breadboard    6. Build semiconductor diode circuits       1. Rectifiers          1. Half-wave rectifier          2. Full wave rectifier          3. Application of rectifiers    7. Types of converters       1. DC to AC Converter (Inverter)       2. DC to DC Converter       3. AC to AC Converter       4. Application of converters    8. Voltage regulation       1. Voltage regulator IC method.    9. Test semiconductor diode circuits       1. Measurement techniques for diode voltage and current.       2. Display input and output waveforms       3. Continuity test       4. Test LED illumination.       5. Testing diode faults | 1. Written Assessment 2. Oral Questioning 3. Practical Assessment 4. Project 5. Third party report 6. Portfolio of evidence |
| 1. Build amplifier circuits | 1. Introduction to transistors    * 1. BJT transistors         1. NPN         2. PNP      2. FET transistors         1. JFET         2. MOSFETs 2. Biasing techniques 3. Amplifier ICs    * 1. Introduction to common amplifier IC families:         1. TDA series         2. LM series         3. LA series. 4. Construct amplifier circuits    * 1. Single-stage CE amplifier      2. Two-stage amplifier      3. Op-Amp inverting and non-inverting amplifiers      4. Simple audio amplifiers using amplifier ICs 5. Test amplifier circuits    * 1. Measure voltage and current flow      2. Observe input and output voltage waveforms      3. Check for distortion      4. Confirm continuity and polarity using a multimeter | 1. Written Assessment 2. Oral Questioning 3. Practical Assessment 4. Project 5. Third party report 6. Portfolio of evidence |
| 1. Fabricate signal generators | * 1. Introduction signal generator circuits      1. Oscillators         1. Crystal oscillator (radio frequency oscillator)      2. Multivibrator circuits:         1. Bistable         2. Astable   2. Construct signal generator circuits      1. Bistable multivibrator      2. Astable multivibrator   3. Generate waveforms using the function generator   4. Test signal generator circuits  1. Measure voltage, current, and display waveforms 2. Record the amplitude, frequency, and period | 1. Written Assessment 2. Oral Questioning 3. Practical Assessment 4. Project 5. Third party report 6. Portfolio of evidence |
| 1. Fabricate signal filter circuits | * 1. Introduction to types of active Opamp-based filters      1. low-pass      2. high-pass      3. band-pass   2. Construct signal filter circuits;  1. Low-pass filter circuit 2. High-pass filter circuit 3. Band-pass filter circuit    1. Test signal filter circuits 4. Measure the output waveform 5. Verify the filter passes or blocks the correct frequency range. 6. Measure the cut-off frequency to match circuit specification. | 1. Written Assessment 2. Oral Questioning 3. Practical Assessment 4. Project 5. Third party report 6. Portfolio of evidence |
| 1. Fabricate microcontroller-based systems | * 1. Introduction to Basic architecture of a microprocessor/microcontroller      1. CPU      2. Memory      3. Input/output ports   2. Basic microprocessors or microcontroller programming.      1. Arduino or      2. Raspberry-Pi   3. Interfacing of peripherals to a microprocessor/microcontroller.      1. LCD/LED displays      2. Keypads      3. Push buttons      4. Temperature sensors      5. Light sensors      6. Actuators: motors, or relays   4. Construct microprocessor-based systems      1. Simple LED control system (using microcontrollers)      2. Temperature monitoring system with sensor feedback      3. Motor control system (DC/servo motors)   5. Test microprocessor-based systems      1. Measure voltages and signals      2. Debug programs and hardware circuits to identify and correct errors      3. Simulate inputs to verify system response.      4. Test communication between the microcontroller and peripherals. | 1. Written Assessment 2. Oral Questioning 3. Practical Assessment 4. Project 5. Third party report 6. Portfolio of evidence |

**Suggested Methods of Instruction**

* Group discussions
* Demonstration
* Case studies
* Industry visits

**Recommended Resources for 25 trainees**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S/No.** | **Category/Item** | **Description/ Specifications** | **Quantity** | **Recommended Ratio**  (Item: Trainee) |
| **A** | **Learning Materials** |  |  |  |
|  | Reference books | Mehta, V. K., & Mehta, R. (2020). Principles of electronics (12 edition). S. Chand and Company Limited, Theraja, B. L., & Theraja, A. K. (2005).  A textbook of electrical technology (1st multicolour ed., Multicolour illustrative ed., 23rd rev. multicoloured ed). S. Chand & Co.  Bird, J. O. (2022). Bird’s electrical and electronic principles and technology (Seventh edition). Routledge, Taylor & Francis Group.  Wilcher, D. (2015). Arduino electronics blueprints: make common electronic devices interact with an Arduino board to build amazing out-of-the-box projects. Packt Publishing.  Maini, A. K. (2008). Digital electronics: principles, devices and applications. Wiley India. | 10 pcs for each book | 1:3 |
|  | Software | Simulation software: Circuit wizard, Proteus, Multisim. | Enough | - |
|  | Audio visual presentations | Projector at least 3000 lumens | 1 | 1:25 |
| **B** | **Learning Facilities & infrastructure** |  |  |  |
|  | Lecture/theory room | 60m2 | 1 | 1:25 |
|  | Workshop | 150m2 | 1 | 1:25 |
|  | Computer laboratory | 100m2 | 1 | 1:25 |
| **C** | **Consumable materials** |  |  |  |
|  | Resistors 1/4W rating | 1 Ω, 2.2 Ω, 3.3 Ω ,10 Ω, 22 Ω, 47 Ω, 68 Ω, 100 Ω, 120 Ω, 150 Ω, 220 Ω, 330 Ω, 470 Ω, 560 Ω 680 Ω, 1 kΩ, 1.2 kΩ, 2kΩ, 3.3 kΩ, 4.7 kΩ, 5.6kΩ, 10 kΩ, 22 kΩ, 33 kΩ, 47 kΩ, 100 kΩ, 220 kΩ, 330 kΩ, 470 kΩ, 1 MΩ, 2.2 MΩ | 100 pcs for each category | 4:1 |
|  | Potentiometers | 1 kΩ, 10 kΩ, 50 kΩ, 100 kΩ | 50 pcs for each category | 2:1 |
|  | Polarised electrolytic capacitors | 1µF(16V, 25V, 50V), 4.7µF(16V, 25V, 50V), 10µF(16V, 25V, 50V, 63V), 22µF(16V, 25V, 50V), 33µF(25V, 35V, 50V), 47µF(16V, 25V, 50V), 100µF(16V, 25V, 35V, 50V), 220µF(25V, 35V, 50V, 63V)  470µF(16V, 25V, 35V, 50V)  1000µF(16V, 25V, 35V, 50V), 2200µF(25V, 35V, 50V), 4700µF(25V, 35V, 50V) | 50 pcs for each category for each voltage rating. | 2:1 |
|  | Ceramic capacitors aassortment kit 10pf to 100nF (non-polarized) | 10pF(100), 20pF(200), 30pF(300), 47pF(470), 56pF(560), 68pF(680), 100pF(101), 220pF(221), 330pF(331), 680pF(681), 1nF(102), 4.7nF(472), 10nF(101), 47nF(471), 100nF(104) | 50 pcs for each category | 2:1 |
|  | Polyester film capacitor assortment kit - 0.22nF to 470nF / 100V (non-polarised) | 0.22nF(221), 0.33nF(331), 0.47nF(471), 0.56nF(561), 0.68nF(681), 1nF(102), 2.2nF(222), 2.7nf(272), 3.3nF(332), 3.9nF(392), 4.7nF(472), 6.8nF(682), 10nF(103), 15nF(153), 22nF(223), 33nF(333), 39nF(393), 47nF(473), 68nF(683), 82nF(823), 100nF(104), 150nF(154), 220nF(224), 470nF(474) | 50 pcs for each category | 2:1 |
|  | Transformer | 120-240Vac, 12V-0-12V, 2A, 50Hz | 25 pcs for each category | 1:1 |
|  | Rectifier diode | 1N4001, 1N4002. | 25 pcs for each category | 2:1 |
|  | Zener diodes 0.5W | 5.1V, 7.5V, 12V, 18V, 24V | 25pcs for each category | 1:1 |
|  | Voltage regulators | L7805, L7809, L7812, L7815, L7824, L7905, L7912, | 25pcs for each category | 1:1 |
|  | MOSFET | IRFZ44N, IRF520, IRF540 | 25pcs for each category | 1:1 |
|  | Assorted colors of light emitting diodes (LEDs) | 3mm, 5mm | 500 pieces for each category | 20:1 |
|  | Schottky diode | IN5817, IN5819 | 10 pcs for each category | 1:3 |
|  | Strip boards | Stripboard 6.5cm x 14.5cm Single Sided | 50 pieces | 2:1 |
|  | Solder wire | 1mm-diameter, rosin activated, lead free soldering wire 50g | 2pcs for each category | 1:13 |
|  | Flux | Soldering paste flux 150g | 2pcs for each category | 1:13 |
|  | DIP IC sockets |  | 100 pieces | 4:1 |
|  | Assorted jumper wires (soft) for stripboard | Red, blue, green, yellow, black | 50m for each category | 2:1 |
|  | Assorted jumper wire (hard) for breadboard | Red, blue, green, black | 50m for each category | 2:1 |
|  | Audio connector jack pin |  | 50 pcs | 2:1 |
|  | Audio speaker |  | 25 pcs | 1:1 |
|  | Female - DC power connector |  | 25 pcs | 1:1 |
|  | Solder wire |  |  |  |
|  | Crocodile/ alligator clips | 50cm Test Leads Alligator Clips Double-end | 25 pcs | 1:1 |
|  | 555 Timer | NE555 IC DIP-8 | 25 pcs | 1:1 |
|  | Arduino 8-Bit Processor chip | Atmel's ATMega328P | 25 pcs | 1:1 |
|  | Arduino board | Arduino Uno R3 (with removable IC Chip) complete with USB Cable | 25 pcs | 1:1 |
|  | LCD display | LCD 20X4 (2004) | 25 pcs | 1:1 |
|  | Assorted jumpers with connector pins | M-M jumpers, M-F jumpers, F-F jumpers | 200 pcs for each category | 8:1 |
|  | PIR Motion sensor module |  | 10 pcs | 1:3 |
|  | BJT (NPN) transistor | BC547, BC108, 2N3904, 2N2222, TIP31, | 50 pcs | 2:1 |
|  | BJT (PNP) transistor | BC557, 2N3906, 2N2907, TIP32, | 25 pcs | 1:1 |
|  | Light Dependent Resistor | LDR 12mm | 25 pcs | 1:1 |
|  | OPAMPs | LM358, LM741 | 25 pcs for each category | 1:1 |
|  | Audio amplifier ICs | TDA2030, LM386, LA4445, LA4440 | 25 pcs for each category | 1:1 |
|  | 74 series logic gates - TTL Logic | 7400, 7402, 7404, 7408, 7432, | 25pcs for each category | 1:1 |
|  | 4000-series CMOS ICs | CD4011, CD4013, CD4027, CD4026, CD4047, CD4060, CD4051, CD4052, CD4093 | 25pcs for each category | 1:1 |
|  | 74 series ICs | 74LS74, 74LS76, 74LS86, 74LS90, 74LS138, 74LS145, 74LS151, 74LS153 ICs | 25pcs for each category | 1:1 |
|  | SPDT Relay (125-250Vac) | 5V DC SPDT Relay, 12V DC SPDT Relay. | 25pcs for each category | 1:1 |
|  | Multi-channel Relay Module (125-250Vac) | 5V DC 4-Channel Relay,  12V DC 4-Channel Relay | 25 pcs for each category | 1:1 |
|  | Push button non-self-locking | mini-switch | 25pcs for each category | 1:1 |
|  | Push button self-locking | mini-switch | 25pcs for each category | 1:1 |
|  | Slide switch SPDT 3 pins | mini-switch | 25pcs for each category | 1:1 |
|  | DC motor | DC 3V-6V 2000RPM R140 motor | 10 pcs | 1:3 |
|  | NTC Thermistors | 10kΩ,100kΩ | 25pcs for each category | 1:1 |
|  | Temperature sensor | Digital temperature sensor | 25pcs for each category | 1:1 |
|  | Fluid level sensor | eTape Liquid Level Sensors | 2 pcs | 1:13 |
|  | Soil Moisture Sensor |  | 5 pcs for each category | 1:5 |
|  | IR (infrared) sensor module | Detection Range: 10 cm to 80 Wavelength: Around 850 nm to 950 nm | 13 pcs | 1:2 |
|  | Ultrasonic Sensor | Operating Voltage: 5V DC | 13 pcs | 1:2 |
|  | Temperature and Humidity Sensor | Temperature Range: -40°C to +75°C  Humidity Range: 0 to 100% | 13 pcs | 1:2 |
|  | Water Level Sensor Float Switch | Max Contact Rating: 10W | 5 pcs | 1:5 |
| **D** | **Tools and Equipment** |  |  |  |
|  | Bread boards |  | 25 pcs | 1:1 |
|  | Assorted tools | Side cutters, Pliers, crimping, Tweezers, Long-nose, Assorted screw drivers. | 25 pcs | 1:1 |
|  | Solder gun/iron | Solder gun/iron 15W - 30W, Solder gun/iron 40W - 60W, | 25 pcs for each category | 1:1 |
|  | Solder tip cleaning wire and holder | Cleaning wire: Brass or stainless-steel wire with a suitable diameter for cleaning solder tips. Holder: Magnetic or spring-loaded holder for convenient storage and access. | 25pcs for each category | 1:1 |
|  | Solder sucker | Solder sucker with a durable rubber bulb and a suitable nozzle size for removing excess solder. | 25 pcs for each category | 1:1 |
|  | Digital Oscilloscope, | Dual-channel oscilloscope with a bandwidth of at least 100 MHz, sampling rate of 1 GSa/s, memory depth of at least 1 Mpts. | 5 pcs | 1:5 |
|  | Digital Multimeter | True RMS digital multimeter with auto-ranging capability, measuring AC/DC voltage up to 600V, AC/DC current up to 10A, resistance, capacitance, frequency, and diode test. | 25 pcs | 1:1 |
|  | Digital functional generator | Digital function generator capable of generating sine, square, triangle, and other waveforms with adjustable frequency (up to at least 20 MHz) and amplitude. | 5 pcs | 1:5 |
|  | Laser jet printer |  | 2 pcs | 1:13 |
|  | Variable power supply | With option for both voltage and current adjustment | 5 pcs | 1:5 |
|  | Power adapters | 5V Power adapters  9V Power adapters  12V Power adapters. | 10 pcs | 1:3 |
|  | Trainers kit | Analogue training kits, Digital training kits, | 5 pcs for each category | 1:5 |
|  | PCB prototyping material | Copper board, ferrite chloride solution, see-through printing paper, HASL finishing PCB | 25 for each category | 1:1 |
|  | Drilling gun | Cordless drill/driver with variable speed and torque settings, including a chuck for various drill bit sizes. | 3 pcs | 1:8 |
|  | Work stations | Individual workbenches with features like tool holders, storage compartments, and built-in lighting. | 5 | 1:5 |
| **D** | **Software** |  |  |  |
|  | Arduino IDE | Latest stable version of the Arduino IDE | Installed in 25 computers | 1:1 |
|  | Simulation software | Circuit wizard/Multisim/Proteus | Installed in 25 computers | 1:1 |

## ELECTRICAL PRINCIPLES

**UNIT CODE:** 0713 451 07A

**Relationship to Occupational Standards**

This unit addresses the unit of competency: Apply electrical principles.

**Duration of Unit:** 100 Hours

**Unit Description**

This unit covers the competencies required to apply electrical principles. It involves applying electrical quantities, using cells and batteries, applying concepts of dc circuit, magnetism and electromagnetism, electrostatics principles, and ac circuits.

**Summary of Learning Outcomes**

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

|  |  |  |
| --- | --- | --- |
| **S/NO** | **LEARNING OUTCOMES** | **DURATION (HOURS)** |
|  | Apply electrical quantities | 8 |
|  | Use cells and batteries | 12 |
|  | Apply concepts of dc circuit | 20 |
|  | Apply magnetism and electromagnetism | 25 |
|  | Apply electrostatics principles | 15 |
|  | Apply ac circuits | 20 |
|  | **TOTAL HOURS** | **100** |

**Learning Outcomes, Content and Suggested Assessment Methods**

|  |  |  |
| --- | --- | --- |
| **Learning Outcome** | **Content** | **Suggested Assessment Methods** |
| 1. Apply Electrical quantities | * 1. Fundamental Electrical Concepts      1. Electrical quantities         1. Charge         2. Current         3. Voltage         4. Power         5. Energy      2. Units of measurement (SI units)         1. SI unit definition         2. Electrical quantities SI units      3. Practical calculations involving electrical quantities      4. Measuring electrical quantities         1. Using electrical quantities measuring instruments * Voltmeters * Ammeters * Ohmmeters * Multimeters * Power meters * Oscilloscope | 1. Written Assessment 2. Oral Questioning 3. Practical Assessment 4. Project 5. Third party report 6. Portfolio of evidence |
| 1. Use cells and batteries | * 1. Introduction to Cells and Batteries      1. Role of cells and batteries as sources of electrical energy in various systems.      2. Basic Concepts         1. Cell         2. Battery   2. Types of Cells      1. Primary Cells and Secondary Cells      2. Examples of Primary Cells and Secondary Cells      3. Applications of Primary Cells and Secondary Cells   3. Battery Configurations and Ratings      1. Series Connection      2. Parallel Connection.      3. Ratings         1. Voltage         2. Capacity (mAh or Ah)         3. Energy Density   4. Working Principles of Cells and Batteries      1. Electrochemical Reaction      2. Basic Components         1. Anode         2. Cathode.         3. Electrolyte      3. Operation Cycle         1. Discharge         2. Recharge      4. E.M.F and internal resistance of cells   5. Types of Batteries and Applications      1. Lead-Acid Batteries         1. Advantages and disadvantages         2. Applications      2. Lithium-Ion (Li-ion) Batteries         1. Advantages and disadvantages         2. Applications      3. Lithium-Polymer (Li-Po) Batteries         1. Advantages and disadvantages         2. Applications   6. Battery Maintenance and Safety | 1. Written Assessment 2. Oral Questioning 3. Practical Assessment 4. Project 5. Third party report 6. Portfolio of evidence |
| 1. Apply Concepts of DC circuit | * 1. Basics of DC Circuits      1. Definition of a DC circuit      2. Key Components in a DC circuit         1. Voltage (V)         2. Current (I)         3. Resistance (R)      3. Ohm's Law         1. Relationship between voltage, current, and resistance         2. Applying Ohm’s law   2. Series and Parallel Circuits      1. Series Circuits      2. Parallel Circuits      3. Series-parallel circuits   3. Kirchhoff's Laws      1. Kirchhoff's Current Law (KCL)      2. Kirchhoff's Voltage Law (KVL)      3. Applications of KCL and KVL   4. Voltage and current dividers   5. Power in DC Circuits      1. Power definition      2. or or      3. Applications         1. Calculating energy consumption         2. Heat dissipation         3. Efficiency of DC circuit components.   6. Energy Stored in DC Circuits      1. Energy (E) definition      2. where *t* is time      3. Applications         1. Estimating battery life         2. Capacitor charge/discharge         3. Energy storage.   7. Capacitors and Inductors in DC Circuits      1. Capacitors         1. Functions in DC circuits         2. Behaviour in DC Circuits      2. Inductors         1. Functions in DC circuits         2. Behaviour in DC Circuits   8. DC Circuit Applications      + 1. Lighting circuits        2. Motor control circuits | 1. Written Assessment 2. Oral Questioning 3. Practical Assessment 4. Project 5. Third party report 6. Portfolio of evidence |
| 1. Apply magnetism and electromagnetism | * 1. Introduction to Magnetism      1. Definition of terms         + Magnetism         + Magnetic field         + Magnetic field lines         + Magnetic field strength units         + Magnetization   2. Magnetism and magnetic fields      1. Types of Magnetic Materials:         + Ferromagnetic         + Paramagnetic         + Diamagnetic.         + Permanent and Temporary Magnets   3. Electromagnetism Basics      1. Magnetic Field Around a Current-Carrying Conductor      2. Right-Hand Rule      3. Electromagnet      4. Applications of electromagnets      5. Key Principles of Electromagnetism         + Ampere’s Law         + Faraday’s Law of Electromagnetic Induction         + Lenz’s Law         + Magnetic Flux      6. Applications of Electromagnetism         + Transformers         + Electric Motors and Generators         + Relays and Solenoids         + Magnetic Storage   4. Magnetic Circuits and Permeability      1. Introduction to Magnetic Circuits         + Definition and components of magnetic circuits.         + Difference between magnetic and electric circuits.         + Overview of magnetic flux, MMF, reluctance, and permeability.      2. Magnetic Flux and MMF         + Magnetic flux calculation and interpretation.         + Concepts of magnetomotive force (MMF) and its importance in magnetic circuits.         + Introduction to magnetic field strength (H) and flux density (B).      3. Permeability and Reluctance         + Definition of permeability and how it affects magnetic materials.         + Reluctance calculation and role in magnetic circuits.      4. Ohm’s Law for Magnetic Circuits         + Application of Ohm’s Law analogy to magnetic circuits.         + Calculation exercises​.         + Analyzing magnetic circuit diagrams.      5. Transformer and Motor Magnetic Circuits         + Components of a Transformer * Primary windings * Secondary windings * Core materials   + - * Application of magnetic circuits in transformers.       * Overview of DC and AC motor magnetic circuits       * Operational principles of DC and AC motor magnetic circuits.     1. Inductors        - Magnetic circuits in inductors        - Relationship between inductance, flux linkage, and stored energy.        - Hands-on inductor circuit building and testing.        - Applications of inductors  1. Filter circuits 2. Storage devices    1. Magnetic and Electromagnetic Devices in Industrial Applications       1. Magnetic Sensors       2. Electromagnetic Brakes and Clutches.    2. Electromagnetic Safety and Shielding       1. Electromagnetic Interference (EMI).       2. Shielding       3. Safety Precautions | 1. Written Assessment 2. Oral Questioning 3. Practical Assessment 4. Project 5. Third party report 6. Portfolio of evidence |
| 1. Apply Electrostatics principles | * 1. Fundamental Concepts of Electrostatics      1. Electric Charge      2. Coulomb's Law      3. Electric Field         1. Definition and properties         2. Electric field lines         3. Electric field intensity      4. Electric Potential and Potential Energy         1. Electric potential difference (voltage)         2. Electric potential energy         3. Relationship between electric field and potential      5. Electrostatic Induction      6. Electrostatic Shielding         1. Protection from external electric fields         2. Faraday cage principle   2. Capacitance and Capacitors      1. Capacitance         1. Definition and unit of capacitance         2. Factors affecting capacitance      2. Capacitors         1. Types of capacitors         2. Capacitor charging and discharging         3. Voltage-current relationship.         4. Capacitor behavior in AC and DC circuits.      3. Capacitor circuits         1. Series and parallel connection         2. RC circuits         3. LC circuits         4. RLC circuits      4. Capacitor Applications         1. Energy storage.         2. Filtering in power supplies.         3. Signal coupling and decoupling in circuits.         4. Timing circuits         5. Tuning and oscillation in radios and audio circuits.      5. Capacitor Testing and Maintenance         1. Multimeter Capacitance and leakage test.         2. Visual inspection         3. Safety considerations | 1. Written Assessment 2. Oral Questioning 3. Practical Assessment 4. Project 5. Third party report 6. Portfolio of evidence |
| 1. Apply AC circuits | * 1. AC Fundamentals      1. Definition and generation of AC voltage and current      2. Waveform characteristics:         1. Amplitude         2. Period         3. Frequency         4. phase angle      3. RMS, peak, average, and instantaneous values      4. Phasor representation and vector diagrams   2. Calculations involving passive elements      1. Behavior of resistors, inductors, and capacitors in AC      2. Reactance (, ) and impedance (Z)      3. Series and parallel RLC circuits      4. Voltage and current phase relationships      5. Use of Ohm’s Law and impedance in AC: V=IZ   3. Power triangle      1. True power (P)      2. Reactive power (Q)      3. Apparent power (S)      4. Relationship among P, Q, and S      5. Units:         1. Watts         2. VARs         3. VA   4. Concept power factor (cos φ) and its significance   5. Calculations of power factor correction      1. Calculation of PFC capacitor values for motors   6. Methods of Power Factor Correction      1. Static correction (using shunt capacitors)      2. Automatic PFC systems (APFC panels)      3. Use of synchronous condensers      4. PFC in industrial setups (inductive loads)   7. Safety and maintenance of PFC devices   8. Inspection and testing of capacitor banks | 1. Written Assessment 2. Oral Questioning 3. Practical Assessment 4. Project 5. Third party report 6. Portfolio of evidence |

**Suggested Delivery Methods**

* Demonstration
* Discussions
* Direct instruction
* Industry visits

**List of Recommended Resources for 25 trainees**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S/No.** | **Category/Item** | **Description/**  **Specifications** | **Quantity** | **Recommended**  **Ratio**  (Item: Trainee) |
| **A** | **Learning Materials** |  |  |  |
|  | Textbooks | Comprehensive guides on electrical principles, such as Electrical Engineering Fundamentals by Vincent Del Toro.  Electrical and Electronic Principles and Technology  By[John Bird](https://www.taylorfrancis.com/search?contributorName=John%20Bird&contributorRole=author&redirectFromPDP=true&context=), [John Bird](https://www.taylorfrancis.com/search?contributorName=John%20Bird&contributorRole=author&redirectFromPDP=true&context=) | 5 pcs  5 pcs | 1:5  1:5 |
|  | Lab Manuals | |  | | --- | |  |   Manuals detailing step-by-step experimental procedures for basic electrical concepts | Enough | - |
|  | Charts and Posters | Visual aids illustrating Ohm’s Law, Kirchhoff’s Laws, AC/DC principles, and single/three-phase power concep | 5 copies | 1:5 |
|  | Safety Guidelines | OSHA-compliant electrical safety procedures and best practices. | 5 copies | 1:5 |
|  | Videos and Tutorials | Demonstrations of key electrical concepts and principles in practical scenarios. | Enough | - |
| **B** | **Learning Facilities & infrastructure** |  |  |  |
|  | Lecture/theory room | 60m2 | 1 | 1:25 |
|  | Workshop | 160m2  With ventilation system of specifications: Fume extractor with HEPA filter, adjustable airflow  With fire extinguishers, first aid kits, ESD mats, grounding straps  With workbenches of specifications: ESD-safe, adjustable height, 1500mm x 750mm  With soldering stations Specifications: Adjustable temperature control (200°C - 480°C), ESD-safe  With hot air rework stations | 1  25 pcs  25 pcs  10 pcs | 1:25  1:1  1:1  1:3 |
|  | Projector | 3000 lumens | 1 pc | 1:25 |
|  | Interactive display screen | 75 inches | 1 pc | 1:25 |
|  | Computers with internet access | Processor: Intel Core i5/i7 or equivalent  RAM: 8GB or higher  Storage: 256GB SSD or higher | 10 pcs | 1:3 |
| **C** | **Equipment** | | | |
|  | Oscilloscope | Specifications: Digital, 100MHz bandwidth, 4 channels | 5 pcs | 1:5 |
|  | Multimeter | Specifications: Digital, true RMS, auto-ranging, measure voltage, current, resistance, capacitance | 25 pcs | 1:1 |
|  | Function generator | Specifications: Frequency range 0.1Hz to 10MHz, various waveforms (sine, square, triangle) | 10 pcs | 1:3 |
|  | Transformers | Single-phase step-down transformers (230V/12V). | 25 pcs | 1:1 |
|  | Power supply | Specifications: Dual output, 0-30V, 0-5A, adjustable | 10 pcs | 1:3 |
|  | Component tester | Specifications: Test resistors, capacitors, inductors, diodes, transistors | 5 pcs | 1:5 |
|  | Tweezers | Specifications: ESD-safe, various tips (straight, angled) | 25 pcs each category | 1:1 |
|  | Cutters | ESD-safe, flush cutters | 25 pcs | 1:1 |
|  | Pliers | ESD-safe needle-nose pliers | 25 pcs | 1:1 |
|  | Screwdrivers | Specifications: Precision set, various sizes (Phillips, flathead) | 5 sets | 1:5 |
|  | ESD mats | Specifications: Workbench and floor mats, grounding cords | 10 pcs | 1:3 |
|  | Wrist straps | Specifications: Adjustable, grounding cord with 1MΩ resistor | 25 pcs | 1:1 |
|  | Electrical Trainers | Modular trainer kits for basic electrical circuits, including resistors, capacitors, and inductors. | 5 sets | 1:5 |
| **C** | **Consumable materials** |  |  |  |
|  | Resistors | Specifications: 1/4 watt, 1%, various values (10Ω - 1MΩ) | 100 pcs each category | 4:1 |
|  | Capacitors | Specifications: Ceramic, electrolytic, tantalum, various values (1pF - 1000µF) | 100 pcs each category | 4:1 |
|  | Inductors | Specifications: Various values (1µH - 10mH) | 100 pcs each category | 4:1 |
|  | Diodes | Specifications: 1N4001, 1N4148, Zener diodes of various voltages | 100 pcs each category | 4:1 |
|  | Transistors | Specifications: NPN (2N2222), PNP (2N2907), MOSFET (IRF540N) | 100 pcs each category | 4:1 |
|  | Integrated Circuits | Specifications: Op-amps (LM741), Timers (NE555) | 100 pcs each category | 4:1 |
|  | Connectors and headers | Specifications: Male and female headers, USB connectors, screw terminals | Enough |  |
|  | Solder wire | Specifications: Lead-free, 0.8mm diameter, Sn63/Pb37 composition | 25 rolls | 1:1 |
|  | Soldering Flux | Specifications: Rosin flux, liquid and paste | Enough |  |
|  | Cleaning reagents | Isopropyl of 99% purity | 20 litres | 1:1.25 |
|  | Brushes | Specifications: Anti-static, soft bristles | 25 | 1:1 |
|  | Solder wires | Red and black | 5 rolls each category | 1:5 |
|  | Bread boards | Specifications: 830 tie-points, solderless, multiple power rails | 50 pcs | 1:2 |
|  | Printed Circuit Boards | Pre-designed PCBs and blank boards for soldering exercises and circuit prototyping. | 50 pcs | 1:2 |
|  | Strip boards |  | 200 | 1:8 |
|  | 100 Light Emitting Diodes | Red/yellow/green/white | 100 pcs each category | 4:1 |
| **D** | **Software** |  |  |  |
|  | Simulation software | LTSpice, Proteus and Multisim  Specifications: Simulate electronic circuits, support for various components and models | Installed in 25 computers | 1:1 |

## HYDRAULIC AND PNEUMATIC SYSTEM INSTALLATION

**UNIT CODE:** 0715 451 19A

**Relationship to Occupational Standards**

This unit addresses the unit of competency: Install hydraulic and pneumatic systems.

**Duration of Unit:** 120 Hours

**Unit Description**

This unit covers the competencies required to install hydraulic and pneumatic systems. It involves conducting hydraulic and pneumatic system site survey, preparing for installation of hydraulic and pneumatics, mounting hydraulic systems, mounting pneumatic systems, and testing and commissioning of hydraulic and pneumatic systems.

**Summary of Learning Outcomes**

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

|  |  |  |
| --- | --- | --- |
| **S/NO** | **LEARNING OUTCOME** | **DURATION (HOURS)** |
|  | To conduct hydraulic and pneumatic system site survey | **15** |
|  | To prepare for installation of hydraulic and pneumatics | **20** |
|  | To mount hydraulic system | **35** |
|  | To mount pneumatic systems | **30** |
|  | To test and commission hydraulic and pneumatic systems | **20** |
|  | **TOTAL HOURS** | **120** |

**Learning Outcomes, Content and Suggested Assessment Methods**

|  |  |  |
| --- | --- | --- |
| **Learning Outcome** | **Content** | **Suggested Assessment Methods** |
| 1. Conduct hydraulic and pneumatic system site survey | 1. Health and safety procedures 2. Introduction to hydraulic and pneumatic systems 3. Hydraulic and pneumatic system components and symbols 4. General layout of hydraulic and pneumatic system 5. Applications of hydraulic and pneumatic systems 6. Factors influencing the location of Hydraulic and pneumatic system 7. Safety 8. Accessibility 9. Environmental Conditions 10. Utilities 11. Space Requirements 12. Noise and Vibration 13. Regulatory Compliance 14. Site condition evaluation 15. Temperature 16. Humidity 17. Dust and contaminants 18. Vibration 19. Electromagnetic interference (EMI) 20. Space constraints 21. Accessibility 22. Ground conditions 23. Utilities 24. Fire hazards 25. Noise pollution 26. Safety equipment 27. Hydraulic and pneumatic system installation layout 28. Functional layout 29. Flow-based layout 30. Modular layout 31. Compact layout 32. Hydraulic and pneumatic system layout measurements 33. Component dimensions 34. Pressure drop 35. Flow rate 36. Ambient temperature 37. Vibration levels 38. Noise levels 39. Site survey report 40. System objectives 41. System description 42. Environmental conditions 43. Layout 44. Measurement records 45. Material take-off list | 1. Written tests 2. Oral Questioning 3. Practical assessment 4. Project 5. Third party report 6. Portfolio of evidence |
| 1. Prepare for installation of hydraulic and pneumatics | 1. Reading and interpreting diagrams 2. Symbols and notations 3. Hydraulic connections and pathways 4. Component identification and specifications 5. Types of hydraulic and pneumatic diagrams    * + 1. Schematic diagrams        2. Circuit diagrams        3. Block diagrams 6. Developing a hydraulic system installation work plan 7. Defining scope and objectives 8. Scheduling and milestones 9. Resource allocation 10. Components selection as per job specifications 11. Hydraulic and pneumatic system Installation documents 12. Installation schedule 13. Installation manual 14. Installation checklist 15. Installation reports | 1. Written tests 2. Oral Questioning 3. Practical assessment 4. Project 5. Third party report 6. Portfolio of evidence |
| 1. Mount hydraulic system | 1. Tools and equipment    * 1. Adjustable wrenches      2. Hydraulic torque wrench      3. Sets of combinational wrenches      4. Assorted size socket wrenches      5. Assorted sizes of screw drivers      6. Assorted sizes of Allen keys      7. Cordless drills      8. Angle grinders      9. Steel pipe benders      10. Hydraulic hose cutters      11. Flushing equipment      12. Digital multimeters      13. Lifting jacks 2. Hydraulic system components    * 1. Single acting hydraulic cylinders      2. Double acting hydraulic cylinders      3. Hydraulic motors      4. Directional control valves      5. Pressure control valves      6. Flow control valves      7. Oil reservoirs      8. Solenoid valves      9. Filters      10. Hydraulic system accumulators      11. Industrial pressure sensors      12. Industrial temperature sensors      13. Industrial flow rate sensors 3. Types of hydraulic piping materials    * 1. Steel pipes      2. Stainless steel pipes      3. Plastic pipes      4. Copper pipes      5. Aluminium pipes 4. Hydraulic pipes selection criteria    * 1. Pressure rating      2. Temperature range      3. Compatibility with hydraulic fluid      4. Environmental consideration 5. Hydraulic piping techniques    * 1. Cutting      2. Bending      3. Joining 6. Installing hydraulic system pipes and fittings    * 1. Types of fittings: compression fittings, flare fittings, bite-type fittings, O-ring face seal fittings      2. Preparing, aligning and installing hydraulic pipes and fittings      3. Piping supports 7. Mounting Accessories and Equipment    * 1. Mounting hydraulic components.      2. Mounting techniques.      3. Positioning and securing accessories and equipment      4. Ensuring accessibility for maintenance and operation | 1. Written tests  2. Oral Questioning  3. Practical assessment  4. Project  5. Third party report  6. Portfolio of evidence |
| 1. Mount pneumatic systems | 1. Preparation of list of tools and equipment 2. Tools and equipment 3. Adjustable wrenches 4. Hydraulic torque wrench 5. Sets of combinational wrenches 6. Assorted size socket wrenches 7. Assorted sizes of screw drivers 8. Assorted sizes of Allen keys 9. Ball-pen hammers 10. Rubber mallet hammers 11. Claw hammers 12. Tape measures 13. Utility knives 14. Cordless drills 15. Pneumatic components 16. Directional control valves 17. Pressure control valves 18. Flow control valves 19. Compressors 20. Solenoid valves 21. Pneumatic relays 22. Pneumatic timers 23. Limit switches 24. Industrial pressure sensors 25. Industrial temperature sensors 26. Flow meters 27. Types of piping materials 28. Pneumatic metallic pipes 29. Pneumatic plastic pipes 30. Pneumatic hoses 31. Piping techniques 32. Cutting 33. Bending 34. Joining 35. Installing Piping as per Layout 36. Aligning pipes according to the layout 37. Ensuring proper support and securing of pipes 38. Mounting Accessories and Equipment 39. Mounting pneumatic components. 40. Mounting techniques. 41. Positioning and securing accessories and equipment 42. Ensuring accessibility for maintenance and operation 43. Pneumatic system fittings 44. Types of Fittings: Push-in fittings, compression fittings, threaded fittings 45. Fittings installation 46. Preparing, aligning and installing pneumatic fittings. | 1. Written tests  2. Oral Questioning  3. Practical assessment  4. Project  5. Third party report  6. Portfolio of evidence |
| 1. Test and commission hydraulic and pneumatic systems | 1. Test run for hydraulic and pneumatic systems.    * 1. Pressure test      2. Flow rate test      3. Performance test      4. Air dryness test. 2. Electrical tests 3. Housekeeping    * 1. Importance of housekeeping      2. Housekeeping procedure; cleaning up the installation site, organizing tools, materials and equipment.      3. Types of waste and their disposal methods      4. Segregation of waste      5. Safe and environmental- friendly disposal practices. 4. Preparing Maintenance Reports    * 1. Date and time of maintenance      2. Description of tasks performed      3. Parts replaced or repaired      4. Observations and recommendations      5. Personnel involved      6. Importance of maintenance reports 5. End user training 6. Handover of pneumatic systems 7. Commissioning documents 8. Commissioning plan 9. Test procedures and checklist 10. Instrumentation data sheet 11. Calibration certificate 12. Safety documentation 13. Commissioning reports 14. Handover report 15. Test results | 1. Written tests  2. Oral Questioning  3. Practical assessment  4. Project  5. Third party report  6. Portfolio of evidence |

**Suggested Delivery Methods**

* + Demonstrations
  + Simulation
  + Role play
  + Group Discussion
  + Presentations
  + Projects
  + Case studies
  + Assignments

**List of Recommended Resources for 25 trainees**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S/No.** | **Category/Item** | **Description/ Specifications** | **Quantity** | **Recommended Ratio**  (Item: Trainee) |
| **A** | **Learning Materials** |  |  |  |
| 1. | Reference books | Industrial | 5 pcs | 1:5 |
|  |  | automation and |  |  |
|  |  | robotics: An |  |  |
|  |  | introduction by |  |  |
|  |  | Jean Riescher |  |  |
|  |  | Westcott |  |  |
|  |  | Hydraulic and |  |  |
|  |  | pneumatic |  |  |
|  |  | actuators- |  |  |
|  |  | welcome to | 5 pcs | 1:5 |
|  |  | mechatronics by |  |  |
|  |  | Dr. Kevin Craig |  |  |
|  |  | Hydraulics and |  |  |
|  |  | pneumatics, |  |  |
|  |  | Third edition: A | 5 pcs | 1:5 |
|  |  | technician’s and |  |  |
|  |  | engineer’s guide |  |  |
|  |  | by Andrew Paar |  |  |
| 2. | Manuals | Hydraulic system | 5 pcs | 1:5 |
|  |  | Installation |  |  |
|  |  | manuals |  |  |
|  |  | Trainer manuals | 1 pc | 1:25 |
|  |  | Trainee manuals | 25 pcs | 1:1 |
|  |  |  |  |  |
|  | **Learning Facilities & infrastructure** |  |  |  |
| 3. | Theory room | 60m2 | 1 | 1:25 |
| 4. | Workshop | 150m2 | 1 | 1:25 |
| 5. | Projector |  | 1 pc | 1:25 |
| 6. | Interactive display screen | 75 inches | 1 pc | 1:25 |
| 7. | Computers with internet access |  | 25 pcs | 1:25 |
| 8. | Directional control valves | 2/2, 3/2, 4/2, 5/2,  5/3 way for sizes 1/8", 1/4", 3/8",  1/2" | 25 pcs each category | 1:25 pcs each category |
| 9. | Pressure control valves | Pressure relief/ pressure reducing/pressure regulator for sizes 1/8", 1/4", 3/8", 1/2" of pressure range 0-  145 psi | 10 pcs each category | 1:2.5 pcs each category |
| 10. | Flow control valves | Needle valves, check valve | 10 pcs each  category | 1:2.5 pcs each category |
| 11. | Compressors | Reciprocating, rotary screw, rotary vane of power 1-500 HP and tank size 10-  500 liters, 230 V | 2 pcs | 1:12.5 |
| 12. | Solenoid valves | Direct-acting, pilot-operated of port sizes 1/8",  1/4", 3/8", 1/2" | 50 pcs | 2:1 |
| 13. | Pneumatic relays | Volume boosters, signal amplifiers of port sizes 1/8",  1/4", 3/8", 1/2" | 25 pcs | 1:1 |
| 14. | Pneumatic timers | On-delay, off-  delay of port  sizes 1/8", 1/4",  3/8", 1/2" | 25 pcs | 1:1 |
| 15. | Limit switches | Mechanical, optical, inductive,  capacitive | 25 pcs each category | 1:1 for each category |
| 16. | Industrial pressure sensors | Gauge, absolute,  differential | 10 pcs | 1:2.5 |
| 17. | Industrial temperature sensors | RTD,  thermocouple, thermistor | 10 pcs for each  category | 1:2.5 for each category |
| 18. | Single acting hydraulic cylinders | Tie-Rod Cylinder  Telescopic Cylinder  Compact Cylinder  High-Pressure Cylinder | 5 pcs for each  category | 1:5 |
| 19. | Double acting hydraulic cylinders | Tie-Rod Cylinder  Telescopic Cylinder  Compact Cylinder  High-Pressure Cylinder | 5 pcs for each  category | 1:5 |
| 20. | Hydraulic motors | Gear Motors  Piston Motors  Radial Piston Motors  Axial Piston Motors | 5 pcs for each  category | 1:5 |
| 21. | Hydraulic pipes | Steel pipes  Stainless steel pipes  Plastic pipes  Copper pipes  Aluminium pipes | 10m for each  category | 1.5 |
| 22. | Flow meters | 4-20mA, 0-10V,  RS485 | 10 pcs | 1:2.5 |
| 23 | Adjustable wrenches | Metric and  standard sizes | 10 pcs | 1:2.5 |
| 24. | Hydraulic torque wrench | Metric and  standard sizes | 5 pcs | 1:5 |
| 25. | Sets of combinational wrenches | Metric and  standard sizes | 5 sets | 1:5 |
| 26. | Assorted size socket wrenches | Metric and  standard sizes | 5 sets | 1:5 |
| 27. | Assorted sizes of screw drivers | Metric and  standard sizes | 5 sets | 1:5 |
| 28. | Assorted sizes of Allen keys | Metric and  standard sizes | 5 sets | 1:5 |
| 29. | Ball-pen hammers |  | 25 pcs | 1:1 |
| 30. | Rubber mallet hammers |  | 5 pcs | 1:5 |
| 31 | Claw hammers |  | 5 pcs | 1:5 |
| 32. | Tape measures | 8 m | 10 pcs | 1:2.5 |
| 33. | Utility knives |  | 10 pcs | 1:2.5 |
| 34. | Cordless drills | 16 V | 5 pcs | 1:5 |
| 35. | Angle grinders | Power: 500W to 2500W  Disc Diameter: 100mm (4"),  115mm (4.5"),  125mm (5"),  180mm (7"),  230mm (9")  Voltage: 220V | 5 pcs | 1:5 |
| 36. | Steel pipe benders | 1/4" to 2" pipe  diameter | 10 pcs | 1:2.5 |
| 37. | Hose cutters | Up to 2" (50mm)  outer diameter | 5 pcs | 1:5 |
|  | Digital multimeters |  | 25 pcs | 1:1 |
| 38. | Lifting jacks |  | 1 pc | 1:25 |
| 39. | Workbenches | With vices,  access top power and clamps | 10 pcs | 2:5 |
| 40. | Pneumatic system training panels |  | 10 panels | 2:5 |
| 41. | **Consumable materials** |  |  |  |
| 42. | Writing materials | Pens, pencils,  paper | Enough |  |
| 43. | Seals and O-rings for valves and fittings | Various diameters and  thicknesses, |  |  |
| 44. | Pneumatic steel pipes | 1/4" to 4" nominal diameter and wall thickness 1.5 mm  to 5 mm | 100m | 4:1 |
| 45. | Pneumatic fittings | Types: Quick- connect, barbed, threaded, push- to-connect  Port Sizes: 1/8", 1/4", 3/8", 1/2",  3/4", 1" | Enough |  |
| 46. | Pneumatic tubing | 4 mm to 12 mm outer diameter  and wall thickness 1 mm to 2 mm | 100m | 4:1 |
| 47. | First aid kit | Full kits | 5 pcs | 1:5 |

# **MODULE 4**

## WORK ETHICS AND PRACTICES

**UNIT CODE:** 0417 451 03B

**Relationship to Occupational Standards**

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

**Duration of Unit:** 40 Hours

**Unit Description**

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

**Summary of Learning Outcomes**

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

|  |  |  |
| --- | --- | --- |
| **S/NO** | **LEARNING OUTCOMES** | **DURATION(HOURS)** |
|  | Apply self-management skills | 10 |
|  | Promote ethical practices and values | 4 |
|  | Promote teamwork | 10 |
|  | Maintain professional and personal development | 10 |
|  | Apply problem-solving skills | 4 |
|  | Promote customer care. | 2 |
|  | **TOTAL HOURS** | **40** |

**Learning Outcomes, Content, and Suggested Assessment Methods**

| **Learning Outcome** | **Content** | **Suggested Assessment Methods** |
| --- | --- | --- |
| 1. Apply self-management skills | * 1. 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   8. Developing and maintaining high self-esteem   9. Developing and maintaining positive self-image   10. Time management   11. Setting performance targets   12. Monitoring and evaluating performance targets | 1. Written Assessment 2. Oral Questioning 3. Practical Assessment 4. Project 5. Third party report 6. Portfolio of evidence |
| 1. Promote ethical 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 | 1. Written Assessment 2. Oral Questioning 3. Practical Assessment 4. Project 5. Third party report 6. Portfolio of evidence |
| 1. Promote Teamwork | * 1. Types of teams   2. Team building   3. Individual responsibilities in a team   4. Determination of team roles and objectives   5. Team parameters and relationships   6. Benefits of teamwork   7. Qualities of a team player   8. Leading a team   9. Team performance and evaluation   10. Conflicts and conflict resolution   11. Gender and diversity mainstreaming   12. Developing Healthy workplace relationships   13. Adaptability and flexibility   14. Coaching and mentoring skills | 1. Written Assessment 2. Oral Questioning 3. Practical Assessment 4. Project 5. Third party report 6. Portfolio of evidence |
| 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   5. Assessing training needs   6. Mobilizing training resources   7. Licenses and certifications for professional growth and development   8. Pursuing personal and organizational goals   9. Managing work priorities and commitments   10. Dynamism and on-the-job learning | 1. Written Assessment 2. Oral Questioning 3. Practical Assessment 4. Project 5. Third party report 6. Portfolio of evidence |
| 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 | 1. Written Assessment 2. Oral Questioning 3. Practical Assessment 4. Project 5. Third party report 6. Portfolio of evidence |
| 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 | 1. Observation 2. Written assessment 3. Oral assessment 4. Third party reports 5. Portfolio of evidence |

**Suggested Delivery Methods**

* Demonstrations
* Simulation
* Role play
* Group Discussion
* Presentations
* Projects
* Case studies
* Assignments

**Recommended Resources for 25 Trainees**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S/No.** | **Category/Item** | **Description/**  **Specifications** | **Quantity** | **Recommended**  **Ratio**  (Item: Trainee) |
| **A** | **Learning Materials** |  |  |  |
|  | Textbooks | The 7 Habits of Highly Effective People by Stephen R. Covey.  The Courage to Meet the Demands of Reality by Dr. Henry Cloud.  The Five Dysfunctions of a Team by Patrick Lencioni.  Drive: The Surprising Truth About What Motivates Us by Daniel H. Pink | 10 pcs  10 pcs  10 pcs  10 pcs | 1:3  1:3  1:3  1:3 |
|  | Online resources | MindTools, Coursera, and LinkedIn | Online |  |
|  | Ethical guidelines | Industry-specific ethical guidelines and codes of conduct | 10 copies | 1:3 |
|  | Workplace etiquette manuals | Guides on professional behavior, dress code, punctuality, and communication in the workplace | 10 copies | 1:3 |
|  | Employee handbooks | Sample handbooks that outline expectations, policies, and procedures related to work ethics | 10 copies | 1:3 |
|  | Videos | Short films or documentaries on ethics | 25 samples | 1:1 |
|  | Podcasts | Episodes focused on work ethics | 5 samples | 1:5 |
| **B** | **Learning Facilities & infrastructure** |  |  |  |
|  | Lecture/theory room | 60m2 | 1 | 1:25 |
|  | Computer workshop | 160 m2 | 1 | 1:25 |
|  | Computers | Operating System: 64-bit Windows 11 or 10 version 1809 or above  Processor: 3 GHz (3+ GHz recommended),  Memory: 8 GB (32GB recommended)  Disk space: 10 GB  Display: 1920 x 1080 resolution  Display Card: 2 GB GPU (8 GB recommended) and DirectX 11 compliant (DirectX 12 recommended) | 25 pcs | 1:1 |
|  | Projector | high-resolution projectors with HDMI input | 1 | 1:25 |
|  | Smartboard/Smart TV | Specifications: 77-inch interactive whiteboard with touch and pen functionality. | 1 | 1:25 |
|  | Whiteboard | Traditional whiteboard | 1 | 1:25 |
|  | Printers | With Print, Copy, Scan and Fax | 2 | 1:13 |
| **C** | **Software** |  |  |  |
|  | Operating systems | Windows/Linux/Macintosh Operating System | Installed in 25 computers | 1:1 |
|  | Web Browsers | Chrome, Firefox, Edge, Safari | Installed in 25 computers | 1:1 |
|  | Ethical decision-making tools | Online simulations that present ethical dilemmas for trainees to navigate | Installed in 25 computers | 1:1 |
|  | Survey and Feedback Tools | Google Forms, SurveyMonkey | Installed in 25 computers | 1:1 |
| **D** | **Consumables** |  |  |  |
|  | Pens, pencils, rulers and paper | Whiteboard markers, 2H pencils, plastic rulers, A2 white papers | Enough |  |
|  | Printing papers | A4 and A3 | Enough |  |
|  | Flashcards | Assorted colours | Enough |  |
|  | Charts | Assorted colours | Enough |  |

## COMMUNICATION SKILLS

**UNIT CODE:** 0031 451 02B

**Relationship to 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 communication skills, non-verbal skills, oral communication skills and group communication skills.

**Summary of Learning Outcomes**

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

|  |  |  |
| --- | --- | --- |
| **S/NO** | **LEARNNG OUTCOMES** | **DURATION (HOURS)** |
|  | Apply communication channels. | 10 |
|  | Apply written communication skills. | 12 |
|  | Apply non-verbal skills. | 4 |
|  | Apply oral communication skills. | 4 |
|  | Apply group communication skills. | 10 |
|  | **TOTAL HOURS** | **40** |

**Learning Outcomes, Content, and Suggested Assessment Methods**

| **Learning Outcome** | **Content** | **Suggested Assessment Methods** |
| --- | --- | --- |
| 1. Apply communication channels. | * 1. 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 | 1. Written Assessment 2. Oral Questioning 3. Practical Assessment 4. Project 5. Third party report 6. Portfolio of evidence |
| 1. Apply written communication skills. | * 1. Types of written communication   2. Elements of communication   3. Organization requirements for written communication | 1. Written Assessment 2. Oral Questioning 3. Practical Assessment 4. Project 5. Third party report 6. Portfolio of evidence |
| 1. Apply non-verbal skills. | * 1. Utilize body language and gestures   2. Apply body posture   3. Apply workplace dressing code | 1. Oral assessment 2. Written assessment 3. Observation 4. Portfolio of Evidence 5. Practical assessment 6. Third party report |
| 1. Apply oral communication skills. | * 1. Types of oral communication pathways   2. Effective questioning techniques   3. Workplace etiquette   4. Active listening | 1. Oral assessment 2. Written assessment 3. Observation 4. Portfolio of Evidence 5. Practical assessment 6. Third party report |
| 1. Apply group communication skills. | * 1. Establishing rapport   2. Facilitating resolution of issues   3. Developing action plans   4. Group organization techniques   5. Turn-taking techniques   6. Conflict resolution techniques   7. Team-work | 1. Oral assessment 2. Written assessment 3. Observation 4. Portfolio of Evidence 5. Practical assessment |

**Suggested delivery methods**

* Discussion
* Roleplay
* Simulation
* Direct instruction
* Demonstration
* Field trips

**Recommended Resources for 25 trainees**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S/No.** | **Category/Item** | **Description/**  **Specifications** | **Quantity** | **Recommended**  **Ratio**  (Item: Trainee) |
| **A** | **Learning Materials** |  |  |  |
|  | Textbooks | Crucial Conversations: Tools for Talking When Stakes Are High by Kerry Patterson, Joseph Grenny, et al.  How to Win Friends and Influence People by Dale Carnegie.  The Art of Communicating by Thich Nhat Hanh  Talk Like TED: The 9 Public-Speaking Secrets of the World’s Top Minds by Carmine Gallo | 10 pcs  10 pcs  10 pcs  Online | 1:3  1:3  1:3 |
|  | Online resources | MindTools, Coursera, and LinkedIn  TED talks  YouTube channels  Webinars | Online  Online  Online  Online |  |
| **B** | **Learning Facilities & infrastructure** |  |  |  |
|  | Lecture/theory room | 60m2 | 1 | 1:25 |
|  | Computer workshop | 160 m2 | 1 | 1:25 |
|  | Computers | Operating System: 64-bit Windows 11 or 10 version 1809 or above  Processor: 2.5 GHz (3+ GHz recommended),  Memory: 8 GB (32GB recommended)  Disk space: 10 GB  Display: 1920 x 1080 resolution  Display Card: 2 GB GPU (8 GB recommended) and DirectX 11 compliant (DirectX 12 recommended) | 25 pcs | 1:1 |
|  | Projector | high-resolution projectors with HDMI input | 1 | 1:25 |
|  | Smartboard/Smart TV | Specifications: 77-inch interactive whiteboard with touch and pen functionality. | 1 | 1:25 |
|  | Whiteboard | Traditional whiteboard | 1 | 1:25 |
|  | External storage media | USB flash drives (32GB), External HDD/SSD | 25 pcs | 1:1 |
|  | Webcams | HD (1080p) | 25 pcs | 1:1 |
|  | Microphones | Wireless | 5 pcs | 1:5 |
|  | Printers | With Print, Copy, Scan and Fax | 2 | 1:13 |
|  | Over-ear headphones | Large diaphragm | 25 pcs | 1:1 |
| **C** | **Software** |  |  |  |
|  | Operating systems | Windows/Linux/Macintosh Operating System | For 25 computers | 1:1 |
|  | Presentation software | Microsoft power point, Prezi, Google slides | For 25 computers | 1:1 |
|  | Speech practice Tools | Orai or Ummo | For 25 computers | 1:1 |
|  | Writing tools | Microsoft word, Grammarly, Hemingway editor | For 25 computers | 1:1 |
|  | Survey tools | Google Forms, SurveyMonkey | For 25 computers | 1:1 |
|  | Video conferencing tools | Zoom, Microsoft Teams, Google Meet | For 25 computers | 1:1 |
|  | Web Browsers | Chrome, Firefox, Edge, Safari | For 25 computers | 1:1 |
| **D** | **Consumables** |  |  |  |
|  | Pens, pencils, rulers and paper | Whiteboard markers, 2H pencils, plastic rulers, A2 white papers | Enough |  |
|  | Printing papers | A4 and A3 | Enough |  |
|  | Flashcards | Assorted colours | Enough |  |

## ENTREPRENEURIAL SKILLS

**UNIT CODE:** 0413 451 04B

**Relationship to Occupational Standards**

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

**Duration of Unit:** 40 Hours.

**Unit Description**

This unit covers the competencies required to apply entrepreneurial skills. It involves applying financial literacy, entrepreneurial concepts, identifying entrepreneurship opportunities, applying business legal aspects, innovating business strategies and developing a business plan.

**Summary of Learning Outcomes**

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

|  |  |  |
| --- | --- | --- |
| **S/NO** | **LEARNING OUTCOME** | **DURATION (HOURS)** |
|  | Apply financial literacy | 6 |
|  | Apply the entrepreneurial concept | 4 |
|  | Identify entrepreneurship opportunities | 6 |
|  | Apply business legal aspects | 6 |
|  | Innovate Business Strategies | 6 |
|  | Develop a business plan | 12 |
|  | **TOTAL HOURS** | 40 |

**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 | 1. Written Assessment 2. Oral Questioning 3. Practical Assessment 4. Project 5. Third party report 6. Portfolio of evidence |
| 1. Apply the 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 | 1. Written Assessment 2. Oral Questioning 3. Practical Assessment 4. Project 5. Third party report 6. Portfolio of evidence |
| 1. Identify entrepreneurship opportunities | * 1. Sources of business ideas   2. Factors to consider when evaluating business opportunity   3. Business life cycle | 1. Written Assessment 2. Oral Questioning 3. Practical Assessment 4. Project 5. Third party report 6. Portfolio of evidence |
| 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 | 1. Written Assessment 2. Oral Questioning 3. Practical Assessment 4. Project 5. Third party report 6. Portfolio of evidence |
| 1. Innovate Business Strategies | * 1. Creativity in business   2. Innovative business strategies   3. Entrepreneurial Linkages   4. ICT in business growth and development | 1. Written Assessment 2. Oral Questioning 3. Practical Assessment 4. Project 5. Third party report 6. Portfolio of evidence |
| 1. Develop a 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 | 1. Written Assessment 2. Oral Questioning 3. Practical Assessment 4. Project 5. Third party report 6. Portfolio of evidence |

**Suggested Delivery Methods**

* Case studies
* Field trips
* Group Discussions
* Demonstration
* Team training
* Guest speakers

**Recommended Resources for 25 Trainees**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S/No.** | **Category/Item** | **Description/**  **Specifications** | **Quantity** | **Recommended**  **Ratio**  (Item: Trainee) |
| **A** | **Learning Materials** |  |  |  |
|  | Textbooks | The Lean Startup by Eric Ries.  Zero to One by Peter Thiel  Start with Why by Simon Sinek | 10 pcs  10 pcs  10 pcs | 1:3  1:3  1:3 |
| **B** | **Learning Facilities & infrastructure** |  |  |  |
|  | Lecture/theory room | 60m2 | 1 | 1:25 |
|  | Computer workshop | 160 m2 | 1 | 1:25 |
|  | Computers | Operating System: 64-bit Windows 11 or 10 version 1809 or above  Processor: 2.5 GHz (3+ GHz recommended),  Memory: 8 GB (32GB recommended)  Disk space: 10 GB  Display: 1920 x 1080 resolution  Display Card: 2 GB GPU (8 GB recommended) and DirectX 11 compliant (DirectX 12 recommended) | 25 pcs | 1:1 |
|  | Projector | high-resolution projectors with HDMI input | 1 | 1:25 |
|  | Smartboard/Smart TV | Specifications: 77-inch interactive whiteboard with touch and pen functionality. | 1 | 1:25 |
|  | Whiteboard | Traditional whiteboard | 1 | 1:25 |
|  | Printers | With Print, Copy, Scan and Fax | 2 | 1:13 |
| **C** | **Software** |  |  |  |
|  | Operating systems | Windows/Linux/Macintosh Operating System | Installed in 25 computers | 1:1 |
|  | Web Browsers | Chrome, Firefox, Edge, Safari | Installed in 25 computers | 1:1 |
|  | Software for business planning | LivePlan, Bizplan | Installed in 25 computers | 1:1 |
|  | Market research tools | Google Trends or SurveyMonkey or Statista | Installed in 25 computers | 1:1 |
|  | Marketing platforms | Google Ads or Hootsuite | Installed in 25 computers | 1:1 |
|  | Graphic design software | Adobe creative cloud or canva | Installed in 25 computers | 1:1 |
| **D** | **Consumables** |  |  |  |
|  | Pens, pencils, rulers and paper | Whiteboard markers, 2H pencils, plastic rulers, A2 white papers | Enough |  |
|  | Printing papers | A4 and A3 | Enough |  |

## BASIC MATHEMATICS

**UNIT CODE:** 0541 451 05A

**Relationship to Occupational Standards**

This unit addresses the unit of competency: Apply engineering mathematics.

**Duration of Unit:** 80 Hours

**Unit Description**

This unit covers the competencies required to apply basic mathematics. It involves applying number system, algebra, matrices, statistics, and trigonometry.

**Summary of Learning Outcomes**

By the end of this unit, the learner should be able to

|  |  |  |
| --- | --- | --- |
| **S/NO** | **LEARNING OUTCOMES** | **DURATION (HOURS)** |
|  | Apply number systems | 8 |
|  | Apply algebra | 12 |
|  | Apply matrices | 20 |
|  | Apply Statistics | 20 |
|  | Apply Trigonometry | 20 |
|  | **TOTAL HOURS** | **80** |

**Learning Outcomes, Content and Suggested Assessment Methods**

|  |  |  |
| --- | --- | --- |
| **Learning Outcome** | **Content** | **Suggested Assessment Methods** |
| 1. Apply number systems | * 1. Types of number systems: Number system conversions and properties      + 1. Natural Numbers        2. Whole Numbers        3. Integers        4. Rational Numbers        5. Irrational Numbers        6. Real Numbers        7. Percentages   2. GCD and LCM   3. Arithmetic operations on integers      1. The number line      2. Addition and Subtraction of Integers         1. Rules for adding and subtracting positive and negative integers.         2. Practice problems.      3. Multiplication and Division of Integers      4. Order of Operations         1. Applying the BODMAS rule         2. Powers and roots.      5. Squares and square roots   4. Fractions      1. Proper, improper fractions and mixed numbers      2. Operations on fractions   5. Decimals      1. Fractions and decimals      2. Decimal places      3. Standard form      4. Operations on decimals      5. Real life problems involving decimals | 1. Written Assessment 2. Oral Questioning 3. Practical Assessment 4. Project 5. Third party report 6. Portfolio of evidence |
| 1. Apply algebra | * 1. Indices and logarithms      1. Indices         1. Define Base and index         2. Laws of indices         3. Indicial equations      2. Logarithms         1. Laws of logarithm         2. Logarithmic equations         3. Conversion of bases      3. Use of log tables      4. Use of calculator      5. Applications of logarithms         1. Multiplication         2. Division         3. Finding roots   2. Algebra      1. General Algebraic expressions      2. Algebraic expressions with fractions      3. Simplification of algebraic expressions      4. Factorization by grouping      5. Removal of brackets      6. Substitution and evaluation      7. Problem solving in real situation   3. Linear Equations      1. Definition and standard form.      2. Simultaneous equations      3. Methods of solving: Graphical, substitution, and elimination methods.      4. Applications in engineering problems.   4. Quadratic expressions and Equations      1. Definition and standard form of quadratic expressions      2. Expansion of algebraic expressions      3. The three quadratic identities      4. Using the three quadratic identities      5. Methods of solving: Factoring, completing the square, and quadratic formula.      6. Real-world engineering applications.   5. Algebraic functions and graph      1. Types of functions         1. Linear, quadratic, polynomial, rational, and exponential functions         2. Characteristics and properties of each function type.      2. Graphing Functions         1. Cartesian coordinate system.         2. Plotting and interpreting graphs of algebraic functions.         3. Using graphs to solve engineering problems. | 1. Written Assessment 2. Oral Questioning 3. Practical Assessment 4. Project 5. Third party report 6. Portfolio of evidence |
| 1. Apply matrices | * 1. Introduction to matrices      1. Definition of a matrix.      2. Different types of matrices: row, column, square, rectangular, diagonal, identity, zero.      3. Notation and elements of a matrix.      4. Basic operations: addition, subtraction, scalar multiplication.      5. Special Matrices         1. Identity matrix,   diagonal matrix, symmetric matrix, skew-symmetric matrix.   * 1. Matrix Multiplication      1. Rules and properties of matrix multiplication.      2. Properties of Matrix Multiplication         1. Associative,   distributive, and commutative properties.   * + - 1. Transpose of a   matrix and properties.   * 1. Determinants and Inverses      1. Calculating determinants for 2x2 matrices.      2. Adjoint method to find the inverse      3. Conditions for the existence of an inverse.   2. Solving Systems of Linear Equations      1. Representation of linear systems using matrices      2. Using the inverse determinant method to solve simultaneous equations | 1. Written Assessment 2. Oral Questioning 3. Practical Assessment 4. Project 5. Third party report 6. Portfolio of evidence |
| 1. Apply Statistics | * 1. Introduction to Statistics      1. Definition of Statistics      2. Types of Data and applications         1. Qualitative (Categorical) Data         2. Quantitative (Numerical) Data         3. Discrete and continuous data.      3. Scales of Measurement         1. Nominal Scale         2. Ordinal Scale         3. Interval Scale         4. Ratio Scale      4. Applications of Statistics in engineering   2. Data Collection and Organization      1. Data Collection Methods         1. Primary Data Collection         2. Secondary Data Collection.      2. Data Organization         1. Frequency Distribution         2. Graphs and Charts * Bar Charts * Histograms * Pie Charts * Line Graphs * Pictograms * Frequency polygon * Ogive   + - 1. Organize and represent data collected from a sample survey or experiment.   1. Measures of Central Tendency      1. Mean (Arithmetic Average)      2. Median         1. Definition, steps to calculate the median in a data set.         2. Handling even and odd numbers of data points.         3. Examples and practice problems.      3. Mode         1. Definition and calculation of mode.         2. Identification of unimodal, bimodal, and multimodal data sets.         3. Examples and practice problems.   2. Measures of Dispersion      1. Range      2. Variance and Standard Deviation      3. Interquartile Range (IQR)   3. Interpretation of Statistical Data Interpretation      1. Understanding data trends and patterns.      2. Making inferences from data sets.   4. Hypothesis Testing      1. Basic concepts of null and alternative hypotheses.      2. Understanding p-values and significance levels.      3. Application of hypothesis testing in decision-making.      4. Case studies showing the use of statistics in decision-making processes in engineering field | 1. Written Assessment 2. Oral Questioning 3. Practical Assessment 4. Project 5. Third party report 6. Portfolio of evidence |
| 1. Apply Trigonometry | * 1. Importance of trigonometry in engineering.   2. Trigonometric Ratios and Functions      1. Definitions of sine, cosine, tangent, cosecant, secant, and cotangent.      2. Evaluating trigonometric rations of angles      3. Fractional and surd forms of trigonometric Ratios      4. Unit circle and angle measurement         1. Degrees and radians         2. Graphs of trigonometric functions.   3. Trigonometric Identities      1. Fundamental identities         1. Pythagorean         2. Reciprocal         3. Quotient identities      2. Co-function identities and even-odd properties.      3. Sum and difference formulas, double-angle, and half-angle formulas.   4. Solving Trigonometric Equations      1. Basic Trigonometric Equations         1. Solving equations involving basic trigonometric functions.         2. Using identities to simplify and solve equations.      2. Inverse Trigonometric Functions         1. Inverse sine, Inverse cosine and Inverse tangent.         2. Solving equations using inverse trigonometric functions.      3. Applications of Trigonometric Equations         1. Engineering problems involving periodic functions and waveforms.   5. Trigonometry in Triangles      1. Right-Angle Triangles         1. Solving for sides and angles using trigonometric ratios.         2. Applications in engineering problems: inclined planes and forces.      2. Non-Right-Angle Triangles         1. Law of Sines and Law of Cosines.         2. Solving oblique triangles.         3. Hero’s formula         4. Applications in engineering fields of structural analysis and navigation. | 1. Written Assessment 2. Oral Questioning 3. Practical Assessment 4. Project 5. Third party report 6. Portfolio of evidence |

**Suggested Delivery Methods**

* Demonstration
* Discussions
* Direct instruction

**List of Recommended Resources for 25 trainees**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S/No.** | **Category/Item** | **Description/**  **Specifications** | **Quantity** | **Recommended**  **Ratio**  (Item: Trainee) |
| **A** | **Learning Materials** |  |  |  |
|  | Textbooks | Engineering Mathematics by K.A. Stroud  Advanced Engineering Mathematics by Erwin Kreyszig | 5 pcs  5 pcs | 1:5  1:5 |
| **B** | **Learning Facilities & infrastructure** |  |  |  |
|  | Lecture/theory room | 60m2 | 1 | 1:25 |
|  | Computer | Operating System: 64-bit Windows 11 or 10 version 1809 or above  Processor: 2.5 GHz (3+ GHz recommended),  Memory: 8 GB (32GB recommended)  Disk space: 10 GB  Display: 1920 x 1080 resolution  Display Card: 2 GB GPU (8 GB recommended) and DirectX 11 compliant (DirectX 12 recommended) | 25 pcs | 1:1 |
|  | Projector |  | 1 | 1:25 |
|  | Interactive screen | Specifications: 77-inch interactive whiteboard with touch and pen functionality. | 1 | 1:25 |
| **C** | **Software** |  |  |  |
|  | MATLAB | License: Educational licenses available.  Features: Matrix manipulations, plotting of functions and data, implementation of algorithms, creation of user interfaces, interfacing with programs in other languages. | Installed in 25 computers | 1:1 |
|  | GeoGebra | License: Free educational software.  Interactive geometry, algebra, statistics, and calculus applications | Installed in 25 computers | 1:1 |
| **D** | **Consumables** |  |  |  |
|  | Pens, pencils, rulers and paper | Whiteboard markers, 2H pencils, plastic rulers, A2 white papers | Enough |  |

## LOGIC CONTROLLERS’ INSTALLATION

**UNIT CODE:** 0714 451 17A

**Relationship to Occupational Standards**

This unit addresses the unit of competency: Install logic controllers.

**Duration of Unit:** 120 Hours

**Unit Description**

This unit covers the competencies required to install logic controllers. It involves conducting logic controllers site survey, installing logic controller hardware, interfacing logic controller hardware, installing logic controller software, performing logic controller programming, and testing and commissioning logic controller system.

**Summary of Learning Outcomes**

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

|  |  |  |
| --- | --- | --- |
| **S/NO** | **LEARNING OUTCOMES** | **DURATION(HOURS)** |
|  | Conduct logic controllers site survey | **10** |
|  | Install logic controller hardware | **25** |
|  | Interface logic controller hardware | **10** |
|  | Install logic controller software | **20** |
|  | Perform logic controller programming | **35** |
|  | Perform logic controller system Test and commissioning | **20** |
|  | **TOTAL** | **120** |

**Learning Outcomes, Content and Suggested Assessment Methods**

|  |  |  |
| --- | --- | --- |
| **Learning Outcome** | **Content** | **Suggested Assessment Methods** |
| 1. Conduct logic controllers site survey | 1. Health and safety procedures: 2. PPEs 3. IEC 61131 4. Logic controller system site survey. 5. Gathering preliminary information. 6. Planning site survey 7. site survey checklist 8. Site conditions 9. Temperature 10. Humidity 11. Distance 12. Dust 13. Light Intensity 14. Pressure 15. Logic controllers Installation Layout Considerations 16. Accessibility 17. Environmental conditions 18. Power supply 19. Grounding 20. Ventilation 21. Cable routing 22. Safety 23. Logic controllers Installation layouts 24. Centralized control panel 25. Distributed control system (DCS) 26. Field-mounted controllers 27. Logic controllers Layout measurements 28. Controller dimensions 29. Power supply dimensions 30. Enclosure dimensions 31. Mounting surface 32. Mounting dimensions 33. Weight capacity 34. Clearances 35. Emergency stop buttons 36. Grounding points 37. Site survey report 38. System objectives 39. System description 40. Environmental conditions 41. Layout 42. Measurement records 43. Material take-off list | 1. Written Assessment 2. Oral Questioning 3. Practical Assessment 4. Project 5. Third party report 6. Portfolio of evidence |
| 1. Install logic controller hardware | * 1. PLC and microcontroller system installation Safety and compliance  1. Safety standards and regulations (IEC 61131) 2. Potential hazards and risk mitigation    1. Introduction to PLCs 3. Terminologies used in PLCs and microcontrollers. 4. PLC and microcontrollers Architecture 5. Power supply unit, 6. CPU. 7. Applications 8. Merits and demerits.    1. Logic Controller Hardware Selection Considerations 9. Processing Power 10. Communication Capabilities 11. Environmental Factors 12. Safety and Reliability 13. Scalability 14. Cost     1. Logic Controller Mounting Methods 15. DIN Rail Mounting 16. Panel Mounting 17. Rack Mounting 18. Wall Mounting 19. Portable Enclosure     1. Power Supply Connection for Logic Controllers: 20. AC (alternating current) 21. DC (direct current)     1. Types of Logic Controller Hardware I/O Modules 22. Digital I/O modules 23. Analog I/O modules 24. Specialized I/O modules     1. I/O Module Selection Considerations 25. I/O type 26. Number of channels 27. Signal range 28. Compatibility     1. Logic controller hardware installation 29. Hardware installation specifications 30. System design drawings 31. Equipment installation manuals 32. Mounting enclosures and equipment     1. Logic controller hardware termination 33. Laying of trunking and conduits 34. Cable routing 35. Wiring selection 36. Wiring compliance to regulation 37. Power supply wiring and termination 38. I/O modules wiring and termination     1. Logic Controller Hardware Configuration: 39. Communication settings 40. I/O assignments 41. Control program 42. Parameters     1. Logic Controller Hardware Testing: 43. Hardware diagnostics 44. I/O module testing 45. Communication testing | 1. Written Assessment 2. Oral Questioning 3. Practical Assessment 4. Project 5. Third party report 6. Portfolio of evidence |
| 1. Interface logic controller hardware | * 1. Logic Controller Hardware I/O Module Selection Factors  1. I/O type 2. Number of channels 3. Signal range 4. Accuracy 5. Isolation 6. Environmental conditions 7. Compatibility    1. Logic Controller Hardware Input Devices 8. Sensors 9. Switches 10. Encoders 11. Analog input cards     1. Logic Controller Hardware Output Devices 12. Solenoids 13. Motors 14. Pumps 15. Heaters 16. Lights     1. Methods to Connect I/O Modules to Logic Controllers 17. Backplane bus 18. Expansion modules 19. Fieldbus networks | 1. Written Assessment 2. Oral Questioning 3. Practical Assessment 4. Project 5. Third party report 6. Portfolio of evidence |
| 1. Install logic controller software | * 1. Logic Controller PC Software Selection Factors  1. Compatibility 2. Features 3. Ease of use 4. Cost    1. Logic Controller Pc Software Installation Steps    2. Run Logic Controller Software    3. Configuration Of Logic Controller Software    4. Testing Logic Controller Software    5. Programming software documentation 5. System requirements 6. Software licences 7. Updates and patches 8. Support resources | 1. Written Assessment 2. Oral Questioning 3. Practical Assessment 4. Project 5. Third party report 6. Portfolio of evidence |
| 1. Perform logic controller programming | * 1. Process requirements identification  1. Identification of control objectives 2. Identification of input and output requirements 3. Selecting control algorithms 4. Developing control flow charts    1. Logic controller programming languages    2. PLC programming languages 5. Ladder diagrams (LD) 6. Instruction list (IL) 7. Functional block diagrams (FBD) 8. Structured text (ST) 9. Sequential function chart (SFC)    1. Basic logic controller programming elements: 10. Normally closed contact 11. Normally open contact. 12. Coil 13. Timers 14. Counters 15. Mathematical functions 16. Logic operation     1. logic controller program code development     2. Logic controller program code simulation     3. Logic controller program code simulation     4. logic controller program code testing and debugging     5. Installing/downloading compiled program to logic controller | 1. Written Assessment 2. Oral Questioning 3. Practical Assessment 4. Project 5. Third party report 6. Portfolio of evidence |
| 1. Perform logic controller system Test and commissioning | * 1. Logic controller systems electrical tests  1. Continuity test 2. Polarity test 3. Earth loop impedance test 4. Insulation resistance test 5. Earth electrode resistance test    1. Logic controller system functionality test 6. Pre-test Inspections 7. Component sequence 8. Component verification 9. Firmness 10. Correct labelling 11. Correct component termination. 12. Functional testing 13. Performance test 14. Safety tests     1. Project handover and need for end user training     2. Commissioning documents 15. Commissioning plan 16. Test procedures and checklist 17. Instrumentation data sheet 18. Calibration certificate 19. Start up and shutdown procedures 20. Safety documentation 21. Training materials 22. Commissioning reports 23. Handover report 24. Test results 25. As-built drawings | 1. Written Assessment 2. Oral Questioning 3. Practical Assessment 4. Project 5. Third party report 6. Portfolio of evidence |

**Suggested Delivery Methods**

* Trainer demonstration
* Simulation
* Discussions
* Direct instruction

List of Recommended Resources for 25 trainees

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S/No.** | **Category/Item** | **Description/ Specifications** | **Quantity** | **Recommended Ratio**  (Item: Trainee) |
| **A** | **Learning**  **Materials** |  |  |  |
| 1. | Textbooks | *McMillan K. Gregory,* Process/industrial instruments and controls handbook, fifth edition  *W. BOLTON, programmable logic controllers, sixth edition.* | Online | 1:1 |
| 2. | Installation manuals | PLC systems. Manuals for Siemens, Allen-Bradley, Mitsubishi, Omron and Schneider | 5 pcs | 1:5 |
| **B** | **Learning Facilities & infrastructure** |  |  |  |
| 3. | Lecture/theory  room | 60m2 | 1 | 1:25 |
| 4. | Workshop | 150m2 | 1 | 1:25 |
| 5. | Projector |  | 1 pc | 1:25 |
| 6. | Interactive display  screen | 75 inches | 1 pc | 1:25 |
| 7. | Computers with internet access | Processor: Intel Core i5/i7 or equivalent  RAM: 8GB or higher  Storage: 256GB SSD or higher | 25 pcs | 1:25 |
| 8. | PLC | Logo/Siemens (S7-1500) /Mitsubishi FX5U/Omron CP2E/Modicon M262 | 5 pcs/5 pcs/5  pcs/5 pcs | 1:5 for each category |
| 9. | Microcontroller | ATMEL328P/CORTEX-M3/INTEL-8051 | 25 pcs for each category | 1:1 for each category |
| 9. | HMI panels | Siemens/Mitsubishi/Omron/Schneider | 5 pcs/5 pcs/5  pcs/5 pcs | 1:5 for each category |
| 10. | Limit switches | Mechanical, optical, inductive, capacitive | 25 pcs each  category | 1:1 for each category |
| 11. | Industrial pressure  sensors | 0-10 bar, 4-20mA output | 25 pcs | 1:1 |
| 12. | Proximity sensors | NPN/PNP, 10-30V DC | 25 pcs | 1:1 |
| 13. | Industrial  temperature sensors | RTD/PT100, -50 to 200°C | 25 pcs | 1:1 |
| 14. | Flow sensors | 4-20mA, 0-10V, RS485 | 25 pcs | 1:1 |
| 15. | Level sensor | Ultrasonic 4-20mA, 0-10V | 25 pcs | 1:1 |
| 16. | Power supply units | Output Voltage: 24V DC  Output Current: 5A or higher Input Voltage: 220V AC | 10 pcs | 1:2.5 |
| 17. | Adjustable  wrenches | Metric and standard sizes | 10 pcs | 1:2.5 |
| 18. | Sets of  combinational wrenches | Metric and standard sizes | 5 sets | 1:5 |
| 19. | Assorted size socket  wrenches | Metric and standard sizes | 5 sets | 1:5 |
| 20. | Assorted sizes of  screw drivers | Insulated, flathead | 5 sets | 1:5 |
| 21. | Assorted sizes of  Allen keys | Metric and standard sizes | 5 sets | 1:5 |
| 22. | Wire Strippers | Suitable for 0.5 mm² to 4 mm² wires | 10 pcs | 1:2 |
| 23. | Ball-pen hammers |  | 25 pcs | 1:1 |
| 24. | Tape measures | 8 m | 10 pcs | 1:2.5 |
| 25. | Utility knives |  | 10 pcs | 1:2.5 |
| 26. | Cordless drills | 16 V | 5 pcs | 1:5 |
| 27. | Relays | 24V DC coil, 10A contacts | 25 pcs | 1:1 |
| 28. | Solenoid valves | 24V DC, 1/4" or 1/2" connections | 25 pcs | 1:1 |
| 29. | Motor starters | 24V DC control voltage, suitable for  1 HP motors | 25 pcs | 1:1 |
| 30. | Contactors | Voltage:24V DC coil/230V AC coil Number of Poles: 3-pole or 4-pole Auxiliary Contacts: 1 NO + 1 NC  Mounting: DIN rail or panel mount | 25 pcs | 1:1 |
| 31. | Push buttons | Voltage:24V DC coil/230V AC coil Contact Configuration: 1 NO or 1 NC Illumination: Non-illuminated or LED illuminated  Color Options: Red, Green, Yellow,  Blue, Black | 100 pcs | 1:4 |
| 32. | Select switches | Voltage:24V DC coil/230V AC coil Contact Configuration: 2 NO, 2 NC,  or 1 NO + 1 NC  Positions: 2-position or 3-position Illumination: Non-illuminated or LED illuminated  Color Options: Black, Red, Green | 100 pcs | 1:4 |
| 33. | Digital multimeters | With voltage, current, and resistance  measurement | 25 pcs | 1:1 |
| 34. | Terminal Blocks | 2.5 mm² to 10 mm² | 50 pcs | 1:2 |
| 35. | DIN Rails | Standard 35 mm | 50 m | 2m:1 |
| 36. | Workstations | Custom-built or pre-configured workstations  Mounting space for PLCs, HMIs, and power supplies  Integrated wiring channels and terminals  Built-in safety features such as circuit  breakers | 25 stations | 1:1 |
| 37. | Network switches | Cisco 24 ports | 2 | 1:12.5 |
| 38. | Routers | TP link | 10 | 1:2.5 |
| **C** | **Consumable**  **materials** |  |  |  |
| 39. | Writing materials | Pens, pencils, paper | enough |  |
| 40. | Signal cables | 0.5 mm² to 1.5 mm², shielded | 200  metres for  each category | 50m:1 for each category |
| 41. | Power cables | 1.5 mm² to 4 mm² | 200  metres for each  category | 50m:1 for each category |
| 42. | Communication  cables | Cat6 Ethernet cables | 200 m | 50m:1 |
| 43. | Control wires | 18 AWG Twisted pairs/22 AWG Multi-conductor control cable/ 20 WG flexible control cable (19/32) | 200  metres for  each category | 50m:1 for each category |
| 44. | Safety Glasses | ANSI Z87.1 compliant | 25 pcs | 1:1 |
| 45. | Gloves | Insulated, suitable for electrical work | 25 pairs | 1:1 |
| 46. | Ear Protection | Noise reduction rating (NRR) of 25  dB or higher | 25 pcs | 1:1 |
| 47. | First aid kit | Full kits | 5 pcs | 1:5 |
| **D** | **Software** |  |  |  |
| 48. | Programming  and simulation software | TIA Portal, GX Works3, CX-  programmer or Sysmac Studio, Eco Structure Machine Expert, Logo soft, Arduino IDE | Installed  in 25 Computers | 1:1 |
| 49. | Human Machine interface software | Siemens WinCC, GT Designer3, Omron NB series/Vijeo Designer | Installed  in 25 Computers | 1:1 |

## ELECTRICAL MACHINES INSTALLATION

**UNIT CODE:** 0713 451 20A

**Relationship to Occupational Standards**

This unit addresses the unit of competency: Install electrical machines.

**Duration of Unit:** 120 Hours

**Unit Description**

This unit covers the competencies required to install electrical machines. It involves installing electrical machines, testing electrical machine installations, and maintaining electrical machine installations.

**Summary of Learning Outcomes**

By the end of this unit, the learner should be able to

|  |  |  |
| --- | --- | --- |
| **S/NO** | **LEARNING OUTCOMES** | **DURATION (HOURS)** |
|  | Install electrical machine | **72** |
|  | Test electrical machine installation | **30** |
|  | Maintain electrical machine installation | **18** |
|  | **TOTAL HOURS** | **120** |

**Learning Outcomes, Content and Suggested Assessment Methods:**

|  |  |  |
| --- | --- | --- |
| **Learning Outcome** | **Content** | **Suggested Assessment Methods** |
| 1. Install electrical machine | * 1. Wiring diagrams   2. Materials, tools and equipment’s   3. Types of machine layout e.g.      1. Fixed position layout      2. Product layout      3. Process layout      4. Combinational   4. Mounting techniques of electrical machines   5. Construction of machine support   6. Types of electrical machines and applications:      1. DC motors      2. DC generators      3. AC single phase motors      4. AC three phase machines:         1. Induction         2. Synchronous      5. Transformer   7. Calculations involving electrical machines   8. Electrical machine control gear      1. Contactors      2. Overload Relays      3. Circuit Breakers      4. Motor Starters         1. DOL         2. Star delta         3. Forward reverse      5. Push Buttons & Switches      6. Manual control (start/stop)      7. Timers      8. Sensors and Relays      9. Variable Speed Drives (VSDs)   9. Mounting structures/housing      1. Structural strength      2. Size   10. Conduits, trunks, and enclosures installation   11. Cables and conductor installation.   12. Cabling in machine       1. Current capacity       2. Type of the cable   13. Cable termination   14. Cables labelling   15. IET Electrical machine installation regulations   16. Installation route       1. Surface       2. Underground       3. Concealed   17. Installation conditions e.g. temperature, humidity, moisture, dust   18. Housekeeping practices.       1. Disposal of waste       2. Cleaning       3. Tools storage | 1. Written Assessment 2. Oral Questioning 3. Practical Assessment 4. Project 5. Third party report 6. Portfolio of evidence |
| 1. Test electrical machine installation | * 1. Types of tests on electrical machines      1. Visual inspection      2. Insulation resistance test      3. Continuity test      4. Earth continuity and earth loop impedance test      5. Polarity test      6. Functional (on-load/off-load) test      7. Open circuit test      8. Short circuit test   2. Testing tools      1. Multimeter      2. Insulation resistance tester      3. Earth electrode resistance tester      4. Ohmmeter   3. Visual inspection procedures      1. Checking cable terminations and routing      2. Verifying protection devices and labeling      3. Ensuring compliance with IET color codes and IP ratings      4. Identifying signs of damage, corrosion, or loose connections   4. Mechanical and structural checks      1. Verifying mounting bolts, frames, and enclosures for firmness      2. Checking vibration isolation measures      3. Ensuring alignment of couplings and drive systems   5. Continuity tests   6. Earthing and bonding tests      1. Compliance with IET earth fault protection requirements   7. On-load and off-load tests      1. Motor no-load run test      2. Full-load current and voltage measurements      3. Functional checks (rotation direction, speed, temperature rise)      4. Vibration and noise checks   8. Documentation and reporting:      1. Recording test results using standard forms      2. Use of inspection and test certificates      3. Interpreting results and recommending actions | 1. Written Assessment 2. Oral Questioning 3. Practical Assessment 4. Project 5. Third party report 6. Portfolio of evidence |
| 1. Maintain electrical machine installation | * 1. Maintenance schedules   2. System maintenance check list   3. Maintenance tools and equipment   4. Inspection and tests   5. Fault diagnosis   6. Fault rectification   7. Reports preparation | 1. Written Assessment 2. Oral Questioning 3. Practical Assessment 4. Project 5. Third party report 6. Portfolio of evidence |

**Suggested Methods of Instruction**

* Practical
* Projects
* Demonstrations
* Group Discussions
* Field trips
* On-job-training

**Recommended Resources for 25 trainees**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S/No.** | **Category/Item** | **Description/ Specifications** | **Quantity** | **Recommended Ratio**  (Item: Trainee) |
| **A** | **Learning Materials** |  |  |  |
|  | Textbooks | V.K Mehta Principles of Electrical Machines  B. Scaddan Electrical installation work  J. Hyde Electrical Installation Principles and Practices | 5 pcs | 1:5 |
|  | Installation manuals | Electrical machine manuals | 5 pcs | 1:5 |
|  | Charts | Single line diagram  Motor starting circuits  Circuit diagrams  Colour codes | 1 pcs for each | 1:25 |
|  | Power point presentations | For trainer’s use | 1 | 1:25 |
| **B** | **Learning Facilities & infrastructure** |  |  |  |
|  | Lecture/theory room | 60m2 | 1 | 1:25 |
|  | Workshop | 150m2 | 1 | 1:25 |
|  | Site |  |  |  |
| **C** | **Consumable materials** |  |  |  |
|  | Electrical wires | 1.5mm2(red, black green) | 5 rolls | 1:5 |
| 2.5mm2(red, black green) | 5 rolls | 1:5 |
| 4.0 mm2(red, black green) | 3 rolls | 1:10 |
| 6.0 mm2(red, black green) | 2 rolls | 1:12 |
| 10 mm2(red, black green) | 2 rolls | 1:12 |
|  | Insulation tapes |  | 25 pcs | 1:1 |
|  | Accessories | Push buttons, relays, Timers, contactors, Thermo overloads, DIN rail, Circuit breakers, TPN | 25 pcs | 1:1 |
|  | Pipes and trunkings | PVC conduits, Steel conduits, Mini trunking | 25 pcs | 1:1 |
| **D** | **Tools and Equipment** |  |  |  |
|  | 3-Phase motors | Power range (e.g., 1/2 HP to 5 HP), voltage rating (e.g., 230V, 415V), RPM, frame size | 5 pcs | 1:5 |
|  | Synchronous Motors | Power range, voltage rating, RPM, synchronous speed, excitation method. <br> Example: 3-phase synchronous motor, 2 HP, 415V, 1800 RPM | 5 pcs | 1:5 |
|  | Single Phase motors | Power range (e.g., 1/4 HP to 1 HP), voltage rating (e.g., 230V), type (e.g., split-phase, capacitor-start), RPM | 5 pcs | 1:5 |
|  | Electric Generator | Power output (e.g., 5 kVA), voltage output (e.g., 230V), frequency (e.g., 50 Hz), type (e.g., gasoline, diesel). | 5 pcs | 1:5 |
|  | DC motors | Voltage rating (e.g., 12V, 24V), power rating, RPM, type (e.g., brushed, brushless) | 5 pcs | 1:5 |
|  | Hacksaws | Hacksaws with adjustable blades for cutting various materials (e.g., metal, PVC). | 25 pcs | 1:1 |
|  | Striping knives | Wire stripping knives with adjustable blades for various wire gauges. | 25 pcs | 1:1 |
|  | Side cutters | Diagonal cutting pliers with hardened jaws for clean cuts on wires. | 25 pcs | 1:1 |
|  | Pliers | Combination pliers with long nose and cutting edges. | 25 pcs | 1:1 |
|  | Tape measure | Retractable tape measure with metric and imperial markings. | 25 pcs | 1:1 |
|  | Try Square | Metal try square for checking and marking right angles. | 25 pcs | 1:1 |
|  | Spirit level | Pocket-sized spirit level with vials for checking horizontal and vertical surfaces. | 25 pcs | 1:1 |
|  | Assorted Screw driver | Set of screw drivers with various tip sizes (Phillips and flathead) and lengths. | 25 pcs each | 1:1 |
|  | Assorted hammers | Claw hammers for driving nails and other fasteners. | 25 pcs each | 1:1 |
|  | Crimping tools | Crimping tools for various connector types (e.g., terminal blocks, cable lugs). | 5 pcs each | 1:5 |
|  | PPEs | Safety glasses, safety gloves, safety shoes, hard hats. | 25 pcs each | 1:1 |
|  | Multimeters | Digital multimeters for measuring voltage, current, resistance, and continuity. | 5 pcs | 1:5 |
|  | Clamp meters | Clamp-on ammeters for measuring AC/DC current without breaking the circuit. | 5 pcs | 1:5 |
|  | Earth resistance meter | Megger for measuring earth ground resistance. | 5 pcs | 1:5 |
|  | Stocks & Dies | Thread cutting tools for creating internal and external threads. | 5 pcs | 1:5 |
|  | Vices | Bench vices for holding workpieces during cutting, bending, and other operations. | 5 pcs | 1:5 |
|  | Oscilloscope | Dual-channel oscilloscope for analyzing electrical signals (optional for advanced troubleshooting). | 5 pcs | 1:5 |
|  | Pipe bending Machine | Hydraulic or mechanical pipe bender for bending conduit and pipes. | 5 pcs | 1:5 |
|  | Bending spring | Pipe bending springs to prevent pipe collapse during bending. | 5 pcs | 1:5 |
|  | Drilling machines | Benchtop drill presses for drilling holes in various materials. | 5 pcs | 1:5 |
|  | Work stations | Individual workbenches with features like tool holders and storage. | 25 | 1:1 |
|  | Installation boards | Training boards simulating real-world electrical installations (e.g., lighting circuits, motor control circuits). | 13 pcs | 1:2 |

# **MODULE 5**

## ENGINEERING TECHNICIAN MATHEMATICS

**UNIT CODE:** 0541 551 10A

**Relationship to Occupational Standards**

This unit addresses the unit of competency: Apply Engineering technician mathematics.

**Duration of Unit:** 100 Hours

**Unit Description**

This unit covers the competencies required to apply engineering technician mathematics. It involves applying complex numbers, calculus, Laplace transforms, and vector theorem.

**Summary of Learning Outcomes**

By the end of this unit, the learner should be able to

|  |  |  |
| --- | --- | --- |
| **S/NO** | **Learning Outcomes** | **DURATION(HOURS)** |
|  | Apply complex numbers | 15 |
|  | Apply calculus | 30 |
|  | Apply Laplace transforms | 20 |
|  | Apply vector theorem | 15 |
|  | **TOTAL HOURS** | **100** |

**Learning Outcomes, Content and Suggested Assessment Methods**

|  |  |  |
| --- | --- | --- |
| **Learning Outcome** | **Content** | **Suggested Assessment Methods** |
| 1. Apply complex numbers | * 1. Introduction to Complex Numbers      1. Definition of a complex number      2. Real and imaginary parts.      3. Complex numbers represented on Argand diagrams   2. Conversion from rectangular to polar and vice versa   3. Operations involving complex numbers   4. De Moivre’s theorem      1. Compute powers and roots of complex numbers.      2. Solve trigonometric identities using complex numbers.   5. Applications of complex numbers in AC circuit analysis. | 1. Written assessment 2. Oral assessment 3. Practical 4. Portfolio of evidence |
| 1. Apply calculus | * 1. Definition of derivatives of a function   2. Differentiation from fist principle   3. Tables of some common derivatives   4. Rules of differentiation      1. Sum and difference rule      2. Product rule      3. Quotient rule      4. Chain rule      5. Parametric differentiation      6. Implicit differentiation   5. Rate of change and small change   6. Stationery points of functions of two variables   7. Definition of integration   8. Indefinite and definite integral   9. Methods of integration application of integration.      1. Substitution      2. Reduction formula      3. By parts      4. Partial fractions   10. Integrals of hyperbolic and inverse functions   11. Application of integration | 1. Written Assessment 2. Oral Questioning 3. Practical Assessment 4. Portfolio of evidence |
| 1. Apply Laplace transforms | * 1. Solution to Laplace transforms using initial and final value theorems      1. Conditions for existence of Laplace transforms      2. Common Laplace transforms         1. unit step         2. exponential         3. sine         4. cosine      3. Initial value theorem:      4. Final value theorem      5. Application to check behaviour of systems at t=0 and t=∞.   2. Solution to inverse Laplace transforms using partial fractions:      1. Definition of inverse Laplace transform      2. Use of standard Laplace transform tables      3. Decomposition of rational functions into partial fractions      4. Solving for coefficients using substitution or the cover-up method      5. Finding time-domain function f(t) from F(s)      6. Application to time responses in control systems   3. Solution to differential equations using Laplace transforms      1. Formulation of first- and second-order linear differential equations from physical systems i.e., electrical      2. Solving algebraic equation in the s-domain      3. Applying inverse Laplace to find solution in time domain      4. Interpretation of solutions in context of system response such as step or impulse input. | 1. Oral Questioning 2. Written Assessment 3. Practical Assessment 4. Portfolio of evidence |
| 1. Apply vector theorem | * 1. Vectors and scalar in two and three dimensions   2. Operations on vectors:      1. Addition      2. Subtraction   3. Scalar and vector of vectors      1. Dot product      2. Cross product   4. Vector field      1. Introduction to vector fields      2. Solutions of problems involving vector fields   5. Gradient, Divergence and curl      1. Solutions of involving Gradient, Divergence and curl   6. Application of vectors | 1. Oral Questioning 2. Written Assessment 3. Practical Assessment 4. Portfolio of evidence |

**Suggested Delivery Methods**

* Demonstration
* Discussions
* Practical
* Project work
* Direct instruction

**List of Recommended Resources for 25 trainees**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S/No.** | **Category/Item** | **Description/**  **Specifications** | **Quantity** | **Recommended**  **Ratio**  (Item: Trainee) |
| **A** | **Learning Materials** |  |  |  |
|  | Textbooks | Engineering Mathematics by K.A. Stroud  Advanced Engineering Mathematics by Erwin Kreyszig | 5 pcs  5 pcs | 1:5  1:5 |
| **B** | **Learning Facilities & infrastructure** |  |  |  |
|  | Lecture/theory room | 60m2 | 1 | 1:25 |
|  | Computer | Operating System: 64-bit Windows 11 or 10 version 1809 or above  Processor: 2.5 GHz (3+ GHz recommended),  Memory: 8 GB (32GB recommended)  Disk space: 10 GB  Display: 1920 x 1080 resolution  Display Card: 2 GB GPU (8 GB recommended) and DirectX 11 compliant (DirectX 12 recommended) | 25 pcs | 1:1 |
|  | Projector |  | 1 | 1:25 |
|  | Interactive screen | Specifications: 77-inch interactive whiteboard with touch and pen functionality. | 1 | 1:25 |
| **C** | **Software** |  |  |  |
|  | MATLAB | License: Educational licenses available.  Features: Matrix manipulations, plotting of functions and data, implementation of algorithms, creation of user interfaces, interfacing with programs in other languages. | Installed in 25 computers | 1:1 |
|  | GeoGebra | License: Free educational software.  Interactive geometry, algebra, statistics, and calculus applications | Installed in 25 computers | 1:1 |
| **D** | **Consumables** |  |  |  |
|  | Pens, pencils, rulers and paper | Whiteboard markers, 2H pencils, plastic rulers, A2 white papers | Enough |  |

## ADVANCED ELECTRONICS CIRCUIT FABRICATION

**UNIT CODE:** 0714 551 08A

**UNIT DURATION: 100 Hours**

**Relationship to Occupational Standards**

This unit addresses the unit of competency: Fabricate advanced electronics circuit.

**Unit Description**

This unit describes competences required to fabricate advanced electronics circuit. It involves applying Boolean algebra concepts, advanced digital logic and converter circuits, transistors, special semiconductor devices, amplifiers and opto-electronics.

**Summary of Learning Outcomes**

|  |  |  |
| --- | --- | --- |
| **S/NO** | **LEARNING OUTCOMES** | **DURATION (HOURS)** |
|  | Apply Boolean algebra concepts | 20 |
|  | Apply knowledge of advance digital logic and converter circuits | 15 |
|  | Apply transistors. | 25 |
|  | Apply special semiconductor devices. | 15 |
|  | Apply amplifiers. | 30 |
|  | Apply opto-electronics | 15 |
|  | **TOTAL HOURS** | **120** |

**Learning Outcomes, Content and Suggested Assessment Methods**

|  |  |  |
| --- | --- | --- |
| **Learning Outcome** | **Content** | **Suggested Assessment Methods** |
| 1. Apply Boolean algebra concepts | 1. Principles of logic gates 2. Logic families 3. Laws of Boolean algebra 4. Logic expressions simplification 5. K-MAPS | * Practical test * Project * Third Party Report * Portfolio of evidence * Written test * Oral questioning |
| 1. Apply knowledge of advance digital logic and converter circuits | * 1. Principles of operation of shift registers      1. data storage      2. serial communication      3. sensor interfacing such as digital I/O expansion in PLCs or microcontrollers   2. Operation principles of synchronous and asynchronous counters      1. frequency counting      2. event counting      3. digital timing in process control systems.   3. Operation principles of digital converters circuits      1. ADCs      2. DACs   4. Interpretation of manufacturer’s datasheets and timing diagrams | * Practical test * Project * Third Party Report * Portfolio of evidence * Written test * Oral questioning |
| 1. Apply transistors. | * 1. Bipolar junction transistors (BJTs)      1. Types of BJTs      2. Operation and characteristics of BJTs   2. BJT configurations   3. BJT load line analysis      1. DC load line      2. AC load line   4. BJT transistor biasing methods   5. Field Effect Transistors (FETs)      1. Types of JFET & MOSFET      2. Operation and characteristics of FETs   6. Biasing techniques of FETs   7. Application of FETs | * Practical test * Project * Third Party Report * Portfolio of evidence * Written test * Oral questioning |
| 1. Apply special semiconductor devices. | * 1. Special semiconductor devices      1. SCR      2. LASCR      3. TRIAC      4. DIAC      5. SCS      6. UJT   2. Operation principle of special semiconductor devices   3. Schematic symbols of special semiconductor devices   4. Application of special semiconductor devices | * Practical test * Project * Third Party Report * Portfolio of evidence * Written test * Oral questioning |
| 1. Apply amplifiers. | * 1. Classification of amplifiers based on;      1. Stages      2. Coupling method      3. Frequency   2. Types of amplifiers      1. RC coupled amplifiers      2. Power amplifiers      3. Tuned amplifiers   3. Feedback      1. Principle of feedback      2. Positive feedback      3. Negative feedback   4. Operational amplifiers (OPAMPs)      1. Construction of opamps      2. Characteristics of the ideal and practical opamps      3. Opamp configurations         1. Inverting Amplifier         2. Non-Inverting Amplifier         3. Voltage Follower (Buffer)         4. Summing Amplifier         5. Differential Amplifier         6. Instrumentation Amplifier         7. Integrator         8. Differentiator   5. Application of Amplifiers | * Practical test * Project * Third Party Report * Portfolio of evidence * Written test * Oral questioning |
| 1. Apply opto-electronics | * 1. Opto-electronic devices      1. LEDs      2. OLED      3. LASER diode      4. Photo transistors      5. Photo diodes      6. Optocoupler      7. LASCR   2. Liquid crystal displays      1. Dynamic scattering LCDs      2. Field effect scattering LCDs   3. LASERs and MASERs   4. Drive requirements for displays   5. Applications of optoelectronics | * Practical test * Project * Third Party Report * Portfolio of evidence * Written test * Oral questioning |

**Suggested Methods of Instruction**

* Role playing
* Viewing of related videos
* Discussion
* Direct Instruction

**Recommended Resources for 25 Trainees**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S No.** | **Category Item** | **Description Specifications** | **Quantity** | **Recommended Ratio**  (Item: Trainee) |
| **A** | **Learning Materials** |  |  |  |
|  | Reference books | 1. Digital Electronics: Principles, Devices and Applications 2. By Anil K. Maini | 5 pcs | 1:5 |
|  | Installation manuals | Assorted Systems component Manufacturer’s manuals and data sheets  Instrumentation Handbooks | 5 pcs | 1:5 |
|  | Charts | Assorted Circuit diagrams  charts | 1 pcs for each | 1:25 |
|  | Software | Assorted simulation software  e.g Deeds, | 25 | 1:1 |
|  | Audio visual presentations | Projector | 1 | 1:25 |
| **B** | **Learning Facilities & infrastructure** |  |  |  |
|  | Lecture theory room | 60m2 | 1 | 1:25 |
|  | Workshop | 150m2 | 1 | 1:25 |
|  | Computer laboratory | 100m2 | 1 | 1:25 |
| **C** | **Consumable materials** |  |  |  |
|  | Assorted electronics components | ICs, resistors, capacitors | 25 pcs | 1:1 |
| **D** | **Tools and Equipment** |  |  |  |
|  | Assorted tools and equipment | Side cutters, Side cutters, Pliers, Screw driver, Multi-meter, Oscilloscope, Solder guns, breadboards | 25 pcs | 1:1 |
|  | PPEs | Safety boots, overall | 25 pcs | 1:1 |
|  | Function generator |  | 5 pcs | 1:5 |
|  | Variable power supply |  | 5 pcs | 1:5 |
|  | Trainers kit | Assorted logic gate, combinational circuits trainer kits with component Manufacturer’s manuals and data sheets | 5 pcs | 1:5 |
|  | Hot air gun |  | 5 pcs | 1:5 |
|  | Work stations |  | 25 | 1:1 |

## ELECTRICAL MEASUREMENT AND FAULT DIAGNOSIS

**UNIT CODE:** 0713 551 09A

**Relationship to Occupational Standards**

This unit addresses the unit of competency: Perform electrical measurements and fault diagnosis.

**Duration of Unit:** 60 Hours

**Unit Description**

This unit covers the competencies required to monitor control and instrumentation systems. It involves applying electrical measurement instruments, waveform analyzing instruments, sensors and transducers and calibrating measurement instruments.

**Summary of Learning Outcomes**

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

|  |  |  |
| --- | --- | --- |
| **S/NO** | **LEARNING OUTCOMES** | **DURATION(HOURS)** |
|  | Apply electrical measurement instruments | 15 |
|  | Apply waveform analysing instruments, | 18 |
|  | Apply sensors and transducers | 12 |
|  | Calibrate measurement instruments. | 15 |
|  | **TOTAL** | **60** |

| **Learning Outcome** | **Content** | **Suggested Assessment Methods** |
| --- | --- | --- |
| 1. Apply electrical measurement instruments | * 1. Health and safety procedures e.g. PPEs, Hazards, Accidents etc.   2. Electrical Quantities e.g.      1. AC/DC Current      2. AC/DC Voltage      3. Power      4. Resistance      5. Capacitance      6. Inductance   3. Electrical Units e.g.      1. Amperes      2. Volts      3. Watts      4. Ohms      5. Farads      6. Henrys   4. Measurement Standards      1. International      2. Primary      3. Secondary      4. Working   5. Electrical Measuring Instruments e.g.      1. Voltmeter      2. Ammeters      3. Ohmmeter      4. Multimeter etc   6. Converters e.g. Analogue to Digital converters, Digital to Analogue converters etc.   7. Measurement presentation mechanisms e.g. Display, Recording   8. Performance characteristics      1. Static characteristics e.g. precision, resolution repeatability, reproducibility, drift etc      2. Dynamic characteristics e.g. fidelity, measuring lag, measuring error etc | 1. Written tests 2. Observation 3. Oral questioning |
| 1. Apply waveform analyzing instruments | * 1. Health and safety procedures: ppes and hazards.   2. Types of waveforms:   sinusoidal wave, step, ramp, impulse.   * 1. Waveform analysis instruments      1. Type’s e.g. oscilloscope spectrum analysis, wave analysers etc      2. Construction of waveform analysis equipment   2. Operation of waveform analysis instruments   3. Analysis of performance of waveform analysis instruments | 1. Written tests 2. Observation 3. Oral questioning |
| 1. Apply sensors and transducers | * 1. Definition of terms   2. Transducers/Sensors      1. Types/principles of operation transducers/sensors: restive, capacitive      2. Sensors/transducer e.g. displacement, force, flow pressure etc.   3. Signal processors      1. Definition of terms      2. Importance      3. Methods of processing: amplification, attenuation filtration      4. Applications of signal processors   4. Data analysis and documentation   5. Signal presentation | 1. Written tests 2. Observation 3. Oral questioning |
| 1. Calibrate measurement instruments | * 1. Measurement and recording of initial values   2. Integration of measuring instrument into calibrating instrument: compatibility, settings configuration   3. Measuring instrument physical variables from calibrator   4. Measurement error calculation: parallax, relative, environmental, instrumental, random etc.   5. Resetting the readings of calibrated instrument to zero error/span error   6. Calibration documentation      1. Traceability table      2. Repeatability table      3. Calibration Certificate      4. Equipment tag | 1. Observation 2. Oral questioning 3. Written tests |

**Suggested Methods of Instruction**

* Demonstrations
* Simulation
* Role play
* Group Discussion
* Presentations
* Projects
* Case studies
* Assignments

**Recommended Resources for 25 trainees**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S/No.** | **Category/Item** | **Description/ Specifications** | **Quantity** | **Recommended Ratio**  (Item: Trainee) |
| **A** | **Learning Materials** |  |  |  |
|  | Textbooks | A Course in Electrical and Electronic Measurements and Instrumentation by A.K. Sawhney, Puneet Sawhney, | 5 pcs | 1:5 |
|  | User manuals |  | 5 pcs | 1:5 |
|  | Measuring instruments manuals | Voltmeter  Multimeters Ammeters  Megaohmeter | 5pcs | 1:5 |
|  | Charts | Single line diagram  Circuit diagrams  Colour codes | 1 pc for each | 1:25 |
|  | Power point presentations | For trainer’s use | 1 | 1:25 |
| **B** | **Learning Facilities & infrastructure** |  |  |  |
|  | Lecture/theory room | 60m2 | 1 | 1:25 |
|  | Workshop | 160m2 | 1 | 1:25 |
|  | Site |  |  |  |
| **C** | **Consumable materials** |  |  |  |
|  | Electrical wires | 1.5mm2(red, black green) | 5 rolls | 1:5 |
| 2.5mm2(red, black green) | 5 rolls | 1:5 |
| 4.0 mm2(red, black green) | 3 rolls | 1:10 |
| 6.0 mm2(red, black green) | 2 rolls | 1:12 |
| 10 mm2(red, black green) | 2 rolls | 1:12 |
|  | Insulation tapes |  | 25 pcs | 1:1 |
|  | Accessories | Breadboard, strip board, resistors, capacitors, inductors, transformers, power supply units, function generator, signal tracers, diagnostic software, sensors etc | 25 pcs each | 1:1 |
| **D** | **Tools and Equipment** |  |  |  |
|  | Striping knives |  | 25 pcs | 1:1 |
|  | Side cutters |  | 25 pcs | 1:1 |
|  | Pliers |  | 25 pcs | 1:1 |
|  | Tape measure |  | 25 pcs | 1:1 |
|  | Try Square |  | 25 pcs | 1:1 |
|  | Assorted Screw driver |  | 25 pcs | 1:1 |
|  | Assorted hammers |  | 25 pcs | 1:1 |
|  | Crimping tools |  | 5 pcs | 1:5 |
|  | PPEs |  | 25 pcs | 1:1 |
|  | Work stations |  | 25 | 1:1 |
|  | Installation boards |  | 13 pcs | 1:2 |

## CONTROL AND INSTRUMENTATION SYSTEMS MONITORING

**UNIT CODE:** 0714 551 21A

**Relationship to Occupational Standards**

This unit addresses the unit of competency: Monitor control and instrumentation systems.

**Duration of Unit:** 120 Hours

**Unit Description**

This unit covers the competencies required to monitor control and instrumentation systems. It involves conducting control and instrumentation monitoring site survey, installing control and instrumentation monitoring systems, testing and commissioning instrumentation systems. **Summary of Learning Outcomes**

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

|  |  |  |
| --- | --- | --- |
| **S/NO** | **LEARNING OUTCOMES** | **DURATION(HOURS)** |
|  | To conduct control and instrumentation monitoring site survey | **32** |
|  | To install control and instrumentation monitoring system | **54** |
|  | To test and commission instrumentation system | **34** |
|  | **TOTAL** | **120** |

**Learning Outcomes, Content and Suggested Assessment Methods**

|  |  |  |
| --- | --- | --- |
| **Learning Outcome** | **Content** | **Suggested Assessment Methods** |
| 1. Conduct Control and instrumentation monitoring site survey | 1. Safety procedures and hazard Identification    * 1. Electrical hazards      2. Chemical hazards      3. Physical hazards      4. Biological hazards      5. Ergonomic hazards 2. Site conditions    * 1. temperature      2. humidity      3. distance      4. dust      5. light intensity      6. pressure 3. Visit 4. Risk Assessment 5. Control Measures    * + 1. Engineering controls        2. Administrative controls 6. Site Survey Procedures    * + 1. Lockout/Tagout        2. Confined Space Entry        3. Hot Work Permits        4. PPE Use        5. Safe Work Practices 7. Emergency Preparedness    * + 1. First aid and medical assistance        2. Fire safety        3. Evacuation procedures 8. Post-Survey Procedures    * + 1. Incident Reporting        2. Debriefing        3. Documentation 9. Site condition evaluation 10. Temperature 11. Distance 12. Dust 13. Light intensity 14. Pressure 15. Instrumentation systems layouts 16. Pressure system 17. Flow system 18. Level system 19. Temperature system 20. Monitor instrumentation measurements 21. Pressure measurements 22. Flow measurements 23. Level measurements 24. Temperature measurements 25. Optical measurements 26. Installation of monitoring systems 27. Interpretation of technical reports 28. Manuals 29. Technical drawings 30. Site survey reports | 1. Written tests 2. Oral Questioning 3. Practical assessment 4. Project 5. Third party report 6. Portfolio of evidence |
| 1. Install Control and instrumentation monitoring system | 1. Health and safety procedures 2. Types of working drawings 3. Schematic diagram 4. Wiring diagram 5. Line diagram 6. Control and instrumentation monitoring system Tools 7. Measuring tools 8. Marking tool 9. Cutting tools 10. Fastening tools 11. Fixing tools 12. Crimping tool 13. Monitoring system instruments 14. Sensors 15. Transducers 16. Data loggers 17. Controllers 18. HMIs 19. Remote monitoring systems 20. Types of instrumentation wiring systems 21. Conduit wiring 22. Batten wiring 23. Metallic conduits 24. Cable trays 25. Ducts 26. Trunkings 27. Fixing and termination of monitoring instruments 28. Pressure gauge 29. Tachometer 30. Loadcells 31. Piezometer 32. Strain gauge 33. Multimeter 34. Thermo couple 35. Cable laying, lugging and tagging 36. Termination of monitoring system cables 37. Power cable 38. Signal cable | * + 1. Written tests     2. Oral Questioning     3. Practical assessment     4. Project     5. Third party report     6. Portfolio of evidence |
| 1. Test and commission instrumentation system | 1. Importance of instrumentation system testing 2. Meaning of terms 3. Inspection 4. Testing 5. Types of tests e.g. 6. Electrical tests 7. Functionality tests    * + 1. Test Signal Conditioning Elements        2. Test Signal Processing elements        3. Test Data presentation elements 8. Testing tools and equipment 9. Multimeter 10. Insulation resistance tester 11. Signal generators 12. Troubleshooting techniques 13. Performance characteristics 14. Statics and dynamics 15. Error and loading effects 16. Accuracy 17. Precision 18. Linearity 19. Sensitivity 20. Resolution 21. Response time 22. Drift 23. Calibration 24. Functional integration 25. Need for end user training 26. Commissioning documents 27. Start up and shutdown procedures 28. Safety documentation 29. Handover report | 1. Written tests 2. Oral Questioning 3. Practical assessment 4. Project 5. Third party report 6. Portfolio of evidence |

**Suggested Methods of Instruction**

* Demonstrations
* Simulation
* Role play
* Group Discussion
* Presentations
* Projects
* Case studies
* Assignments

**Recommended Resources for 25 trainees**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S/No.** | **Category/Item** | **Description/ Specifications** | **Quantity** | **Recommended Ratio**  (Item: Trainee) |
| **A** | **Learning Materials** |  |  |  |
|  | Reference books | A.K Sawhney  Electrical and Electronic Measurement and Instrumentation.  Arun. K Ghoshi  Introduction to Measurements and Instrumentation 2nd edition  R.K Rajput  Electrical Measurements and Instrumentation 2nd edition | 5 pcs | 1:5 |
|  | Installation manuals | Assorted Systems component Manufacturer’s manuals and data sheets  Instrumentation Handbooks | 5 pcs | 1:5 |
|  | Charts | Assorted Circuit diagrams  P& ID charts | 1 pcs for each | 1:25 |
|  | Software | Assorted simulation software  e.g Circuit wizard, Auto CAD | 25 | 1:1 |
|  | Audio visual presentations | Projector | 1 | 1:25 |
| **B** | **Learning Facilities & infrastructure** |  |  |  |
|  | Lecture/theory room | 60m2 | 1 | 1:25 |
|  | Workshop | 150m2 | 1 | 1:25 |
|  | Computer laboratory | 100m2 | 1 | 1:25 |
| **C** | **Consumable materials** |  |  |  |
|  | Installation materials | Insulation tape,cables | 25 pcs | 1:1 |
|  | Assorted electrical components | Contactors, transformer, overload relays, timers | 25 pcs | 1:1 |
|  | Assorted instrumentation components | Sensors, transducers, actuators | 25 | 1:5 |
| **D** | **Tools and Equipment** |  |  |  |
|  | Assorted tools and equipment | Side cutters, Side cutters, Pliers, Screw driver, Crimping tools, Mult-meter, Oscilloscope, Solder guns | 25 pcs | 1:1 |
|  | PPEs | Safety boots,overall | 25 pcs | 1:1 |
|  | Function generator |  | 5 pcs | 1:5 |
|  | Variable power supply |  | 5 pcs | 1:5 |
|  | Trainers kit | Digital electronics, PWM kit | 5 pcs | 1:5 |
|  | PCB prototyping machine |  | 2 | 1:13 |
|  | Hot air gun |  | 5 pcs | 1:5 |
|  | Drilling machines |  | 5 pcs | 1:5 |
|  | Work stations |  | 25 | 1:1 |

# **MODULE 6**

## CONTROL SYSTEMS

**UNIT CODE:** 0714 551 12A

**Relationship to Occupational Standards**

This unit addresses the unit of competency: Apply control systems.

**Duration of Unit:** 120 Hours.

**Unit Description**

This unit covers the competencies required to apply control systems. It involves applying basic concepts of control systems, system modelling, performance, compensation and servo systems.

**Summary of Learning Outcomes**

By the end of this unit, the learner should be able to

|  |  |  |
| --- | --- | --- |
| **S/NO** | **LEARNING OUTCOMES** | **DURATION(HOURS)** |
|  | Apply basic concepts of control systems | 20 |
|  | Apply system modelling | 25 |
|  | Apply system performance | 30 |
|  | Apply system compensation | 25 |
|  | Apply servo systems | 20 |
|  | **TOTAL HOURS** | **120** |

**Learning Outcomes, Content and Suggested Assessment Methods**

|  |  |  |
| --- | --- | --- |
| **Learning Outcome** | **Content** | **Suggested Assessment Methods** |
| * + - 1. Apply basic concepts of control systems | * 1. Types of control systems      1. Man-made system      2. Natural system      3. Hybrid system      4. Controlled variable   2. Open and closed loop systems   3. Feedback      1. Positive feedback      2. Negative feedback      3. Effects of feedback on overall gain, sensitivity, stability and noise.   4. Block diagrams      1. Basic elements of block diagram      2. Block diagram representation of electrical systems      3. Block diagram algebra         1. Series connection         2. Parallel connection         3. Feedback connection   5. Simplification of block diagrams      1. Canonical forms      2. Transfer functions      3. Superposition   6. Signal flow graphs      1. Basic elements of signal flow graphs      2. Construction of signal flow graphs   7. Simplification of system loops      1. Masons rule      2. Complex loop      3. Loop reduction   8. Conversion of block diagrams to signal flow graphs      1. Nodes      2. Sinks | * Practical * Portfolio of evidence * Third party report * Oral questioning * Written tests |
| * + - 1. Apply system modelling | * 1. Need for modelling   2. Mathematical models      1. Differential equation model      2. Transfer function model      3. State space model   3. Derivation of transfer functions for simple networks      1. Electrical      2. Mechanical      3. Laplace transforms, jω, D-operations   4. Electrical-mechanical analogy      1. Force- Voltage      2. Force – current      3. Translational vs Rotational   5. Modelling of practical systems      1. Generators      2. Temperature control systems      3. Calculations | * Practical * Portfolio of evidence * Third party report * Oral questioning * Written tests |
| 1. Apply system performance | * 1. Time response analysis      1. Transient response      2. Steady state response   2. Test signals      1. Unit step      2. Unit ramp      3. Unit parabolic      4. Unit impulse   3. Dynamic response for 1st and 2nd order systems      1. Response terms      2. Standard 2nd order equation      3. Response graphs      4. Derivation of dimensionless 2nd order equation   4. Damping methods      1. Velocity feedback      2. Error rate      3. Viscous friction damping      4. Effects of damping ratio      5. Calculation of limiting values   5. Time domain specifications      1. Delay time      2. Rise time      3. Peak time      4. Peak overshoot      5. Settling time   6. Types of system stability      1. Relative stability      2. Absolute stability      3. Asymptotic Stability      4. Marginal Stability      5. Bounded input-bounded output   7. System stability analysis methods      1. Routh’s stability criterion      2. Nyquist diagrams      3. Bode plots      4. Nichol’s chart      5. Root locus   8. Process control strategies      1. Proportional (P),      2. Integral (I),      3. Derivative (D),      4. Proportional plus Integral (PI),      5. Proportional plus Derivative (PD),      6. Proportional plus Integral plus Derivative (PID) | * Practical * Portfolio of evidence * Third party report * Oral questioning * Written tests |
| 1. Apply system compensation | * 1. Need for compensation   2. Compensating networks transfer functions      1. Lead compensator      2. Lag compensator      3. Lead-lag compensator   3. Designing a Bode compensator   4. Compensation using 3-term controller | * Practical * Portfolio of evidence * Third party report * Oral questioning * Written tests |
| 1. Apply servo systems | * 1. Servo mechanisms      1. Position      2. Speed      3. Acceleration   2. AC and DC Servo amplifiers      1. Linear      2. Pulse-width modulation      3. Digital   3. Operation of stepper motors      1. Construction      2. Control circuits      3. Calculations      4. Interfacing      5. Applications   4. Characteristics curves of ac and dc servo motors      1. Torque Vs Speed curve      2. Torque Vs Current curve      3. Efficiency Vs Load curve      4. Calculations | * Practical * Portfolio of evidence * Third party report * Oral questioning * Written tests |

**Suggested Methods of Instruction**

* Projects
* Practical
* Demonstration
* Group Discussions
* Direct Instruction
* Illustration

**Recommended Resources for 25 trainees**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S/No.** | **Category/Item** | **Description/ Specifications** | **Quantity** | **Recommended Ratio**  (Item: Trainee) |
| **A** | **Learning Materials** |  |  |  |
|  | Textbooks | S.K.B Pearson Control Systems Theory and Application  Control systems by Yousef Zadek | 5 pcs of each | 1:5 |
|  | Installation manuals | Electrical machine manuals | 5 pcs | 1:5 |
|  | Charts | Single line diagram  Motor starting circuits  Circuit diagrams  Colour codes | 1 pcs for each | 1:25 |
|  | Softwares | PLC software  Arduino IDE  Matlab |  |  |
|  | Projector and screen | For trainer’s use | 1 | 1:25 |
| **B** | **Learning Facilities & infrastructure** |  |  |  |
|  | Lecture/theory room | 60m2 | 1 | 1:25 |
|  | Workshop | 150m2 | 1 | 1:25 |
|  | Computer Laboratory | 100m2 | 1 | 1:25 |
| **C** | **Consumable materials** |  |  |  |
|  | Electrical wires | 1.5mm2(red, black green) | 1 rolls | 1:5 |
| 2.5mm2(red, black green) | 5 rolls | 1:5 |
| 4.0 mm2(red, black green) | 3 rolls | 1:10 |
| 6.0 mm2(red, black green) | 2 rolls | 1:12 |
| 10 mm2(red, black green) | 2 rolls | 1:12 |
|  | Cables | USB, Ethernet, UART, 4-20mA current loop cable | 5 pcs | 1:5 |
|  | Insulation tapes |  | 25 pcs | 1:1 |
|  | Accessories | Sensors, Actuators, Limit switches, Push buttons, Timers, Relays, input/output modules, keyboard | 25 pcs | 1:1 |
|  | Pipes and trunkings | PVC conduits, Mini trunking | 25 pcs | 1:1 |
| **D** | **Tools and Equipment** |  |  |  |
|  | PLC module |  | 5 | 1:5 |
|  | Microcontroller tool kit |  | 5 | 1:5 |
|  | PPEs |  | 25 pcs | 1:1 |
|  | Multimeter |  | 5 pcs | 1:5 |
|  | Oscilloscope |  | 5 pcs | 1:5 |
|  | Servomotors |  | 5 pcs | 1:5 |

## RESEARCH METHODS

**UNIT CODE:** 0111 551 11A

**Relationship to Occupational Standards**

This unit addresses the unit of competency: Apply research methods.

**Duration of Unit:** 60 Hours

**Unit Description**

This unit covers the competencies required to apply research methods. It involves identifying research problems, conducting literature review, developing research methodology, analyze collected data, and prepare research report.

**Summary of Learning Outcomes**

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

|  |  |  |
| --- | --- | --- |
| **S/NO** | **LEARNING OUTCOMES** | **DURATION(HOURS)** |
|  | Identify research problem | **8** |
|  | Conduct literature review | **10** |
|  | Develop Research Methodology | **12** |
|  | Analyse collected data | **14** |
|  | Prepare research report | **16** |
|  | **TOTAL** | **60** |

**Learning Outcomes, Content and Suggested Assessment Methods**

|  |  |  |
| --- | --- | --- |
| **Learning Outcome** | **Content** | **Suggested Assessment Methods** |
| 1. Identify research problem | * 1. Methods of identifying research problem   2. Gathering background information   3. Research variables   4. Research objectives   5. Formulating research questions   6. Significance of research   7. Establishment of scope of study | 1. Interview 2. Observation 3. Supervised exercises 4. Third party reports 5. Written texts |
| 1. Conduct literature review | * 1. Sources of literature review      1. Primary      2. Secondary   2. Keywords and phrases   3. Ethical research guidelines on referencing and citation   4. Organization and reporting of collected literature | 1. Interview 2. Observation 3. Supervised exercises 4. Third party reports 5. Written texts |
| 1. Develop research Methodology | * 1. Types of research designs      1. Descriptive      2. Correlational      3. Experimental      4. Longitudinal      5. Cross-sectional   2. Identification of study population   3. Sampling techniques      1. Simple random      2. Systematic      3. Stratified      4. Clustered   4. Research proposal guidelines and requirements   5. Budget preparation | 1. Interview 2. Observation 3. Supervised exercises 4. Third party reports 5. Written texts |
| 1. Analyze collected data | * 1. Methods of data collection      1. Surveys and questionnaires      2. Interviews      3. Focus groups      4. Observations      5. Case studies   2. Research guidelines on data collection   3. Data cleaning   4. Data analysis tools      1. Statistical software      2. Qualitative analysis software      3. Spreadsheet software   5. Data presentation      1. Data visualization tools      2. Presentation software | 1. Interview 2. Observation 3. Supervised exercises 4. Third party reports 5. Written texts |
| 1. Prepare research report | * 1. Discussion of research findings   2. Drawing of conclusions based on findings   3. Recommendations   4. Referencing systems      1. APA      2. MLA      3. Havard      4. IEEE   5. Appendices   6. Research report presentation | 1. Interview 2. Observation 3. Supervised exercises 4. Third party reports 5. Written texts |

**Suggested Methods of Instruction**

* Practical
* Lab and field projects
* Demonstrations
* Group discussions
* Direct instructions
* Role playing
* Interactive lectures
* Individual assignments
* Viewing of related videos

**Recommended Resources for 25 Trainees**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S/No.** | **Category/Item** | **Description/ Specifications** | **Quantity** | **Recommended Ratio**  (Item: Trainee) |
| **A** | **Learning Materials** | | | |
|  | Reference books | * Research Methodology: A Step-by-Step Guide for Beginners by Ranjit Kumar * Research Methodology: Tools And Techniques   By Dr. Prabhat Pandey  and Dr. Meenu Mishra Pandey | 5 pcs | 1:5 |
|  | Charts | Research design flow chart | 1 pc for each | 1:25 |
|  | Software | Data analysis software i.e SPSS, Microsoft Excel  Data presentation software i.e. Microsoft powerpoint, Tableau, Canva, Microsoft Excel.  Planning and management software. i.e. Google Calendar | 25 | 1:1 |
|  | Audio visual presentations | Projector | 1 | 1:25 |
| **B** | **Learning Facilities & infrastructure** | | | |
|  | Lecture/theory room | 60m2 | 1 | 1:25 |
|  | Computer laboratory | 100m2 | 1 | 1:25 |
|  | Research Centre | 100m2 | 1 | 1:25 |
| **C** | **Consumable materials** | | | |
|  | Field research materials | Sampling supplies i.e. soil, bags, notebook, battery and fuel | 25 pcs | 1:1 |
|  | Social research materials | Surveys and questionnaires | 25 pcs | 1:1 |
|  | Laboratory research materials | Chemical reagents, glassware and plastic ware | 25 | 1:5 |
| **D** | **Tools and Equipment** | | | |
|  | Assorted research and data collection tools and equipment | Camera, Digital storage device, computer, | 25 pcs | 1:1 |

## INDUSTRIAL MEASUREMENT INSTRUMENTS CALIBRATION

**UNIT CODE:** 0714 551 22A

**Relationship to Occupational Standards**

This unit addresses the unit of competency: Calibrate industrial measurement instruments.

**Duration of Unit:** 120 Hours

**Unit Description**

This unit covers the competencies required to calibrate industrial measurement instruments. It involves preparing industrial measurement instruments, performing industrial measurements, testing industrial measuring instruments and adjusting industrial measurement to pre-set value.

**Summary of Learning Outcomes**

By the end of this unit, the learner should be able to

|  |  |  |
| --- | --- | --- |
| **S/NO** | **Learning Outcomes** | **DURATION(HOURS)** |
|  | To prepare industrial measurement instruments | **31** |
|  | To perform industrial measurements | **42** |
|  | To test industrial measuring instruments | **27** |
|  | To adjust industrial measurement to pre-set value | **20** |
|  | **TOTAL HOURS** | **120** |

**Learning Outcomes, Content and Suggested Assessment Methods**

|  |  |  |
| --- | --- | --- |
| **Learning Outcome** | **Content** | **Suggested Assessment Methods** |
| * + - 1. Prepare industrial measurement instruments | 1. Health and safety procedures 2. Industrial measurement Quantities 3. Flow meter 4. Load cells 5. Pressure transmitters 6. Level Transmitters 7. Temperature transmitters 8. Piezo Electric sensors 9. Calibration and alignment 10. Calibration procedure 11. Industrial measurement instrument is disengagement 12. Safety procedures 13. Instruments manufacture manuals | 1. Written tests  2. Oral Questioning  3. Practical assessment  4. Project  5. Third party report  6. Portfolio of evidence |
| * + - 1. Perform industrial measurements | 1. Industrial measurement Quantities 2. Flow rate 3. Pressure 4. Temperature 5. Level 6. Mass 7. Time 8. Frequency 9. Speed 10. Energy 11. Measuring instruments 12. Pressure gauges 13. tachometer 14. multimeter 15. thermocouple 16. energy meter 17. flow meter 18. Units of measurements 19. pascal 20. volts 21. amperes 22. degree Celsius 23. watts 24. meter cube per second 25. Measurement analysis and recording | 1. Written tests  2. Oral Questioning  3. Practical assessment  4. Project  5. Third party report  6. Portfolio of evidence |
| * + - 1. Test industrial measuring instruments | 1. Measuring instrument initial values:    * 1. Identification of the instrument type: pressure, temperature, flow, or level      2. Observation of pre-calibration values      3. Check response and output stability      4. Recording initial readings in logbooks or calibration forms 2. Integration of measuring instrument with calibration instrument:    * 1. Selection of appropriate calibration instruments         1. Electrical (multimeter, loop calibrator, multifunction calibrator)         2. Pressure (dead weight tester, digital pressure calibrator)         3. Temperature (dry block calibrator, thermocouple simulator)      2. Matching signal types and measurement ranges:         1. 4–20 mA loops, 0–10 V signals, RTD or thermocouple inputs      3. Correct connection procedures:      4. Instrument isolation:         1. Disconnecting from live processes         2. Bypassing control systems if necessary 3. Sourcing of Physical Variable from Calibrator    * 1. Setting calibrator to generate the required physical variable:      2. Application of variable in defined steps or continuous sweep      3. Maintaining accuracy and stability during source application      4. Using software-controlled calibrators where applicable      5. Observing environmental effects on physical variable delivery 4. Calibration documentations    * 1. Traceability table      2. Repeatability table      3. Calibration Certificate      4. Equipment tag | 1. Written tests  2. Oral Questioning  3. Practical assessment  4. Project  5. Third party report  6. Portfolio of evidence |
| * + - 1. Adjust industrial measurement to pre-set value | 1. Error calculation 2. Industrial measuring instruments value adjustments to zero and span error 3. Calibration Documentations 4. Instrument types 5. Calibration frequency 6. Calibration standards 7. Accuracy requirements 8. Documentation requirements | 1. Written tests  2. Oral Questioning  3. Practical assessment  4. Project  5. Third party report  6. Portfolio of evidence |

**Suggested Delivery Methods**

* + - Demonstrations
    - Simulation
    - Role play
    - Group Discussion
    - Presentations
    - Projects
    - Case studies
    - Assignments

**List of Recommended Resources for 25 trainees**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S/No.** | **Category/Item** | **Description/ Specifications** | **Quantity** | **Recommended Ratio**  (Item: Trainee) |
| **A** | **Learning**  **Materials** |  |  |  |
| 1. | Textbooks | *McMillan K. Gregory,* Process/industrial instruments and controls handbook, fifth edition  *W. BOLTON, programmable logic controllers, sixth edition.* | Online | 1:1 |
| 2. | Installation manuals | PLC systems. Manuals for Siemens, Allen-Bradley, Mitsubishi, Omron and Schneider | 5 pcs | 1:5 |
| **B** | **Learning Facilities & infrastructure** |  |  |  |
| 3. | Lecture/theory  room | 60m2 | 1 | 1:25 |
| 4. | Workshop | 150m2 | 1 | 1:25 |
| 5. | Projector |  | 1 pc | 1:25 |
| 6. | Interactive display  screen | 75 inches | 1 pc | 1:25 |
| 7. | Computers with internet access | Processor: Intel Core i5/i7 or equivalent  RAM: 8GB or higher  Storage: 256GB SSD or higher | 25 pcs | 1:25 |
| 8. | Handheld Calibrators | * Yokogawa HART Communicator * Emerson AMS Device Manager * ABB FieldXpert * Honeywell DTM+ * Endress+Hauser FieldCare | 1 pc | 1:25 |
| **C** | **Consumable**  **materials** |  |  |  |
| 39. |  |  |  |  |
| **D** | **Software** |  |  |  |

## INSTRUMENTATION AND CONTROL SYSTEM SUPERVISION

**UNIT CODE:** 0714 551 23A

**Relationship to Occupational Standards**

This unit addresses the unit of competency: Supervise instrumentation and control systems.

**Duration of Unit:** 120 Hours

**Unit Description**

This unit covers the competencies required to supervise instrumentation and control systems. It involves preparing instrumentation and control systems installation work plans, allocating instrumentation and control systems personnel duties, controlling instrumentation and control systems material usage, inspecting instrumentation and control systems installation work and commissioning instrumentation and control systems installation work.

**Summary of Learning Outcomes**

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

|  |  |  |
| --- | --- | --- |
| **S/NO** | **LEARNING OUTCOMES** | **DURATION(HOURS)** |
|  | To prepare instrumentation and control systems installation work plans | 20 |
|  | To allocate instrumentation and control systems personnel duties | 15 |
|  | To control instrumentation and control systems Material usage | 35 |
|  | To inspect instrumentation and control systems installation work | 30 |
|  | To commission Instrumentation and control system installation work | 20 |
|  | **TOTAL HOURS** | **120** |

**Learning Outcomes, Content and Suggested Assessment Methods**

|  |  |  |
| --- | --- | --- |
| **Learning Outcome** | **Content** | **Suggested Assessment Methods** |
| 1. Prepare instrumentation and control systems installation work plans | 1. Introduction to instrumentation and control systems installation work plans 2. Creation of an instrumentation and control system work plan 3. Documentation of the scope of Instrumentation and control system installation. 4. Preparation of Instrumentation and control system installation project timelines 5. Bar charts 6. Gantt charts 7. Assembling of Tools and equipment Instrumentation and control system installation project | 1. Written tests  2. Oral Questioning  3. Practical assessment  4. Project  5. Third party report  6. Portfolio of evidence |
| 1. Allocate instrumentation and control system personnel duties | 1. Classification of project tasks for instrumentation and control system installation project 2. Pre-Project Planning 3. Design and engineering 4. Procurement and logistics 5. Site Preparation and civil works 6. Equipment installation 7. Configuration and integration 8. Testing and Quality assurance 9. Commissioning and handover 10. Post-Installation support 11. Assign instrumentation and control system installation project tasks to personnel 12. Project Manager 13. Site engineer 14. Field technicians/installers 15. Engineer (network, civil, electrical instrumentation and control system s design) 16. Safety officer 17. Procurement specialist 18. Quality Assurance (QA) Engineer 19. Environmental officer (Optional, for larger projects) 20. Client/Stakeholder representative 21. Commissioning engineer 22. Distribution of instrumentation and control system installation project tools and equipment | 1. Written tests  2. Oral Questioning  3. Practical assessment  4. Project  5. Third party report  6. Portfolio of evidence |
| 1. Control instrumentation and control system installation material usage | 1. Identification of Instrumentation and control system installation materials 2. Terminology on control of Instrumentation and control system installation material usage 3. Material management 4. Inventory management 5. Bill of Materials (BOM 6. Supply Chain Management 7. Inspection Compliance 8. Usage Rate 9. Cost Variance 10. Waste Management 11. Material Handling 12. Assembling the materials for Instrumentation and control system installation 13. Procedure of Issuance of Instrumentation and control system installation materials 14. Material Requisition 15. Review and Approval 16. Material Preparation and Documentation 17. Issuance of Materials 18. Material Delivery to Site 19. Usage and Tracking 20. Return of Excess or Unused Materials 21. Record Keeping and Auditing 22. Final Material Reconciliation | 1. Written tests  2. Oral Questioning  3. Practical assessment  4. Project  5. Third party report  6. Portfolio of evidence |
| 1. Inspect Instrumentation and control system installation work | 1. Identification of Instrumentation and control system installation project tools and equipment 2. Physical Inspection of instrumentation and control system 3. Functional Testing of Installed Systems 4. Correct Equipment Installation 5. Cable Management 6. Proper Grounding and Bonding 7. Environmental Conditions (temperature, humidity) 8. Surge Protection and Shielding 9. Mounting and Support Structures Stability 10. Adherence to Safety Standards 11. Adherence to Industry Regulations and Standards 12. Equipment Accessibility for Maintenance 13. Site Cleanliness and Orderliness 14. Testing of Communication Links (performance and quality) 15. Compliance with Design Specifications 16. Integrity of Cable Connections and Terminations 17. Labelling of Equipment and Cables 18. Power Supply and Backup Systems 19. Technical inspection of instrumentation and control system 20. Compliance with Technical Specifications 21. Data Transmission Speeds 22. Electrical Testing (voltage, current, grounding) 23. System Configuration and Software Settings 24. Proper Functionality of Network systems 25. Documentation of inspection report | 1. Written tests  2. Oral Questioning  3. Practical assessment  4. Project  5. Third party report  6. Portfolio of evidence |
| 1. Commission instrumentation and control system installation work | 1. Assembly of instrumentation and control installation project tools and equipment 2. Pre-commissioning activities    * 1. Visual inspection of wiring, piping, and instrument mounting      2. Checking for proper termination, grounding, and shielding      3. Power-on checks (input power, fuses, signal integrity)      4. Ensuring all process isolation and safety procedures are in place      5. Use of pre-commissioning checklist 3. Functional testing    * 1. Testing instruments for correct input-output behavior      2. Verification of alarm set points, range settings, and scaling      3. Testing PLC/DCS input-output (I/O) response      4. Testing interlocks and control logic (manual and auto modes)      5. Simulating process conditions for device response      6. Troubleshooting and resolving non-functional components      7. Documenting test outcomes in functional test reports 4. Performance testing    * 1. Comparing system performance with design specifications      2. Checking process accuracy, response time, stability, and repeatability      3. Verifying integrated operation of sensors, actuators, and controllers      4. Stress-testing system under normal and peak operating conditions      5. Recording all test data and deviations      6. Generating performance test reports and obtaining client/project approval | 1. Written tests  2. Oral Questioning  3. Practical assessment  4. Project  5. Third party report  6. Portfolio of evidence |

**Suggested Methods of Delivery**

* Demonstrations
* Simulation
* Role play
* Group Discussion
* Presentations
* Projects
* Case studies
* Assignments

**Recommended Resources for 25 trainees**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S/No.** | **Category/Item** | **Description/ Specifications** | **Quantity** | **Recommended Ratio**  (Item: Trainee) |
| **A** | **Learning Materials** |  |  |  |
|  | Installation manuals |  | 5 pcs | 1:5 |
|  | Charts |  | 1 pc for each | 1:25 |
| **B** | **Learning Facilities & infrastructure** |  |  |  |
|  | Lecture/theory room | 60m2 | 1 | 1:25 |
|  | Workshop | 160m2 | 1 | 1:25 |
|  | Laboratory | 100m2 | 1 | 1:25 |
| **C** | **Consumable materials** |  |  |  |
|  | Electrical wires | 1.5mm2(red, black green) | 5 rolls | 1:5 |
| 2.5mm2(red, black green) | 5 rolls | 1:5 |
| 4.0 mm2(red, black green) | 3 rolls | 1:10 |
| 6.0 mm2(red, black green) | 2 rolls | 1:12 |
| 10 mm2(red, black green) | 2 rolls | 1:12 |
|  | Insulation tapes |  | 25 pcs | 1:1 |
|  | Accessories | Switches, sockets, Junction boxes, Consumer units, Lamp holders, Patrice boxes, Circuit breakers | 25 pcs | 1:1 |
|  | Mounting racks |  | 10 | 1:3 |
|  | Pipes and trunkings | PVC conduits, Steel conduits, Mini trunking | 25 pcs | 1:1 |
| **D** | **Tools and Equipment** |  |  |  |
|  | Hacksaws |  | 25 pcs | 1:1 |
|  | Striping knives |  | 25 pcs | 1:1 |
|  | Side cutters |  | 25 pcs | 1:1 |
|  | Pliers |  | 25 pcs | 1:1 |
|  | Tape measure |  | 25 pcs | 1:1 |
|  | Try Square |  | 25 pcs | 1:1 |
|  | Spirit level |  | 25 pcs | 1:1 |
|  | Assorted Screw driver |  | 25 pcs | 1:1 |
|  | Assorted hammers |  | 25 pcs | 1:1 |
|  | Crimping tools |  | 5 pcs | 1:5 |
|  | PPEs |  | 25 pcs | 1:1 |
|  | Multimeters |  | 5 pcs | 1:5 |
|  | Clamp meters |  | 5 pcs | 1:5 |
|  | Earth resistance meter |  | 5 pcs | 1:5 |
|  | Stocks & Dies |  | 5 pcs | 1:5 |
|  | Vices |  | 5 pcs | 1:5 |
|  | Oscilloscope |  | 5 pcs | 1:5 |
|  | Pipe bending Machine |  | 5 pcs | 1:5 |
|  | Bending spring |  | 5 pcs | 1:5 |
|  | Drilling machines |  | 5 pcs | 1:5 |
|  | Work stations |  | 25 | 1:1 |
|  | Installation boards |  | 13 pcs | 1:2 |
|  | Hydrometer |  | 5 pcs | 1:5 |
|  | Solar irradiance meter |  | 1 pc | 1:25 |
|  | Grid tie Synchroniser |  | 1 | 1:25 |
|  | Battery capacity tester |  | 1 | 1:25 |