

**THE REPUBLIC OF KENYA**

**COMPETENCY-BASED MODULAR CURRICULUM**

**FOR**

**TELECOMMUNICATION TECHNOLOGY**

**KNQF LEVEL 6**

**PROGRAMME ISCED 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 Telecommunication 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.

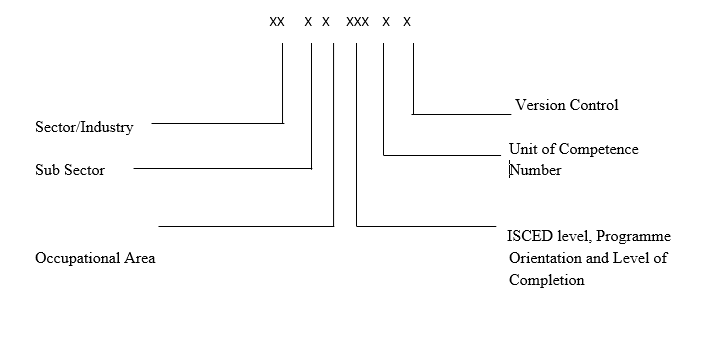
I recognize with appreciation the role of the National Sector Skills Committee (NSSC) in ensuring that competencies required by the industry are addressed in the curriculum. I also thank all stakeholders in the Telecommunication sector for their valuable input and everyone who participated in developing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

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

# ACRONYMS AND ABBREVIATIONS

| **Abbreviation** | **Meaning** |
| --- | --- |
| AC | Alternating Current |
| ACL | Access Control List |
| ADC | Analog-to-Digital Converter |
| ADSS | All-Dielectric Self-Supporting (Fiber Optic Cable) |
| AF | Audio Frequency |
| ALU | Arithmetic Logic Unit |
| AM | Amplitude Modulation |
| AND | Logical AND (Boolean Operation) |
| ANSI | American National Standards Institute |
| AP | Access Point |
| ARM | Advanced RISC Machine (Processor Architecture) |
| ASK | Amplitude Shift Keying |
| AT | Attention Command (Modem Command) |
| ATE | Automated Test Equipment |
| ATSC | Advanced Television Systems Committee |
| AVR | Automatic Voltage Regulator |
| BER | Bit Error Rate |
| BERT | Bit Error Rate Test |
| BJT | Bipolar Junction Transistor |
| BNC | Bayonet Neill-Concelman (Connector) |
| BOM | Bill of Materials |
| BS | Base Station |
| BSC | Base Station Controller |
| BSS | Base Station Subsystem |
| BTS | Base Transceiver Station |
| BUC | Block Upconverter |
| BW | Bandwidth |
| CAD | Computer-Aided Design |
| CAK | Carrier Aggregation Key |
| CAP | Carrierless Amplitude Phase Modulation |
| CAT | Category (e.g., CAT5, CAT6 cables) |
| CBET | Continuous Broadcast Enhancement Transmission |
| CD | Carrier Detect |
| CFP | C Form-Factor Pluggable (Transceiver) |
| CIRCUIT | Electrical Pathway |
| CNC | Computer Numerical Control |
| CPR | Common Public Radio Interface |
| CPU | Central Processing Unit |
| CT | Current Transformer |
| CV | Coefficient of Variation |
| DAC | Digital-to-Analog Converter |
| DC | Direct Current |
| DD | Data Dictionary |
| DHCP | Dynamic Host Configuration Protocol |
| DMM | Digital Multimeter |
| DNS | Domain Name System |
| DRC | Design Rule Check |
| DSL | Digital Subscriber Line |
| DSO | Digital Storage Oscilloscope |
| DVB | Digital Video Broadcasting |
| DVD | Digital Versatile Disc |
| DVI | Digital Visual Interface |
| EEPROM | Electrically Erasable Programmable Read-Only Memory |
| EHF | Extremely High Frequency |
| EIA | Electronic Industries Alliance |
| EIGRP | Enhanced Interior Gateway Routing Protocol |
| EMC | Electromagnetic Compatibility |
| EMCA | ElectroMagnetic Compatibility Assessment |
| EMF | Electromotive Force |
| EMI | Electromagnetic Interference |
| EPA | Environmental Protection Agency |
| ERC | Error Correction |
| ESD | Electrostatic Discharge |
| ESH | Environmental, Safety, and Health |
| FC | Fiber Channel |
| FET | Field-Effect Transistor |
| FIBER | Optical Fiber |
| FIFO | First In, First Out |
| FM | Frequency Modulation |
| FR | Frame Relay |
| FSK | Frequency Shift Keying |
| FSM | Finite State Machine |
| FTP | File Transfer Protocol |
| FTTH | Fiber to the Home |
| GB | Gigabyte |
| GH | Gigahertz |
| GIMP | GNU Image Manipulation Program |
| GNS | Global Navigation Satellite |
| GNSS | Global Navigation Satellite System |
| GPS | Global Positioning System |
| GPU | Graphics Processing Unit |
| GSM | Global System for Mobile Communications |
| HB | High Bandwidth |
| HC | High Current |
| HD | High Definition |
| HDD | Hard Disk Drive |
| HDMI | High-Definition Multimedia Interface |
| HEPA | High-Efficiency Particulate Air |
| HF | High Frequency |
| HPA | High Power Amplifier |
| HTTP | HyperText Transfer Protocol |
| HVAC | Heating, Ventilation, and Air Conditioning |
| IAM | Identity and Access Management |
| IC | Integrated Circuit |
| ICD | Interface Control Document |
| ICT | Information and Communication Technology |
| IDE | Integrated Development Environment |
| IEC | International Electrotechnical Commission |
| IEEE | Institute of Electrical and Electronics Engineers |
| IF | Intermediate Frequency |
| IP | Internet Protocol |
| IPC | Inter-Process Communication |
| IRF | Infrared Frequency |
| ISDN | Integrated Services Digital Network |
| ISO | International Organization for Standardization |
| ISR | Integrated Services Router |
| IT | Information Technology |
| ITU | International Telecommunication Union |
| JFET | Junction Field-Effect Transistor |
| JK | JK Flip-Flop (Digital Logic Circuit) |
| KCE | Key Circuit Element |
| KCL | Kirchhoff’s Current Law |
| KCSE | Kenya Certificate of Secondary Education |
| KNQF | Kenya National Qualifications Framework |
| KPI | Key Performance Indicator |
| KVL | Kirchhoff’s Voltage Law |
| LAN | Local Area Network |
| LC | Logical Circuit |
| LCD | Liquid Crystal Display |
| LCR | Logic Control Relay |
| LED | Light-Emitting Diode |
| LEO | Low Earth Orbit |
| LF | Low Frequency |
| LIFO | Last In, First Out |
| LM | Linear Modulation |
| LMR | Land Mobile Radio |
| LNA | Low Noise Amplifier |
| LNB | Low Noise Block Downconverter |
| LOS | Line of Sight |
| LOTO | Lockout/Tagout |
| LTE | Long-Term Evolution (Mobile Network) |
| LTS | Long-Term Support |
| MAN | Metropolitan Area Network |
| MATLAB | Matrix Laboratory (Software) |
| MC | Microcontroller |
| MCB | Miniature Circuit Breaker |
| MCCB | Molded Case Circuit Breaker |
| MEO | Medium Earth Orbit |
| MF | Medium Frequency |
| MH | Megahertz |
| MI | Modulation Index |
| MMF | Multimode Fiber |
| MOSFET | Metal-Oxide-Semiconductor Field-Effect Transistor |
| MP | Modulation Protocol |
| MPO | Multi-Fiber Push On Connector |
| MSC | Mobile Switching Center |
| MSP | Managed Service Provider |
| MTP | Multi-Fiber Termination Push-On Connector |
| NAT | Network Address Translation |
| NE | Network Element |
| NEC | National Electrical Code |
| NP | Network Processor |
| NPN | Negative-Positive-Negative (Transistor) |
| NSS | Network Switching Subsystem |
| NTP | Network Time Protocol |
| ODF | Optical Distribution Frame |
| OLT | Optical Line Terminal |
| OM | Optical Module |
| ONT | Optical Network Terminal |
| OPGW | Optical Ground Wire |
| OPM | Optical Power Meter |
| OPNET | Optimized Network Engineering Tools |
| OSHA | Occupational Safety and Health Administration |
| OSI | Open Systems Interconnection |
| OSRF | Open Shortest Path First |
| OTDR | Optical Time-Domain Reflectometer |
| PABX | Private Automatic Branch Exchange |
| PBX | Private Branch Exchange |
| PCB | Printed Circuit Board |
| PCI | Peripheral Component Interconnect |
| PCM | Pulse Code Modulation |
| PF | Power Factor |
| PFC | Power Factor Correction |
| PIC | Programmable Interface Controller |
| PIN | Personal Identification Number |
| PLD | Programmable Logic Device |
| PM | Power Management |
| PN | Positive-Negative (Diode) |
| PON | Passive Optical Network |
| POTS | Plain Old Telephone Service |
| PPE | Personal Protective Equipment |
| PWM | Pulse Width Modulation |
| QAM | Quadrature Amplitude Modulation |
| RAM | Random Access Memory |
| RF | Radio Frequency |
| RFID | Radio Frequency Identification |
| RJ | Registered Jack |
| ROM | Read-Only Memory |
| RTOS | Real-Time Operating System |
| SC | Subscriber Connector (Fiber) |
| SD | Secure Digital |
| SFP | Small Form-factor Pluggable |
| TCP | Transmission Control Protocol |
| UPS | Uninterruptible Power Supply |
| VLAN | Virtual Local Area Network |
| VPN | Virtual Private Network |
| WAN | Wide Area Network |
| WLAN | Wireless Local Area Network |
| WPA | Wi-Fi Protected Access |

**KEY TO UNIT CODE**



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# COURSE OVERVIEW

This course is designed to equip a Telecommunication Technician Level 6 with competences required to perform electrical installation, install computer networks, install fiber optical networks, maintan communication systems, fabricate electronic circuits, install broadcasting communication systems, install wireless transmission links, install specialized power systems, fabricate embedded and RF circuits, install telephony systems and install enterprise computer networks.

|  |  |  |  |
| --- | --- | --- | --- |
| **UNITS OF LEARNING** | | | |
| **UNIT CODE** | **UNIT TITLE** | **CREDIT HOURS** | **CREDIT FACTOR** |
| **BASIC UNITS OF LEARNING** | | | |
| 0611 451 01B | Digital Literacy | 40 | 4 |
| 0031 441 02B | Communication skills | 40 | 4 |
| 0417 441 03B | Apply work ethics and practices | 40 | 4 |
| 0413 441 04B | Entrepreneurial skills | 40 | 4 |
| **SUB TOTAL** | | **160** | **16** |
| **COMMON UNITS OF LEARNING** | | | |
| 0541 441 05A | Engineering technician mathematics | 240 | 24 |
| 0732 441 06A | Engineering drawing | 100 | 10 |
| 0713 441 07A | Electrical principles | 190 | 19 |
| 0714 541 08A | Telecommunication principles | 80 | 8 |
| **SUB TOTAL** | | **610** | **61** |
| **CORE UNITS OF LEARNING** | | | |
| 0714 451 09a | Electrical installation | 200 | 20 |
| 0612 451 10a | Computer networks installation | 160 | 16 |
| 0612 551 11a | Fiber optical networks installation | 150 | 15 |
| 0714 551 12a | Communication systems maintenance | 120 | 12 |
| 0714 451 13A | Electronic circuits fabrication | 180 | 18 |
| 0714 551 14A | Broadcasting communication systems installation | 160 | 16 |
| 0714 551 15A | Wireless tranmission links installation | 140 | 14 |
| 0714 451 16A | Specialized power systems installation | 190 | 19 |
| 0714 551 17A | Embedded and rf circuits fabrication | 230 | 23 |
| 0714 551 18A | Telephony systems installation | 180 | 18 |
| 0612 551 19A | Enterprise computer networks | 200 | 20 |
| **SUB TOTAL** | | **2720** | **272** |
| **INDUSTRIAL ATTACHMENT** | | **480** | **48** |
| **TOTAL** | | **3160** | **316** |

# MODULAR UNIT SUMMARY

The Telecommunication Technology Level 6 curriculum has been structured to be implemented in six (6) modules as shown on the table below.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **MODULE** | **UNITS** | | | |
| **UNIT CATEGORY** | **UNIT CODE** | **UNIT NAME** | **DURATION(Hours)** |
| **ONE (I)** | CORE | 0714 451 09A | Electrical Installation | 200 |
| COMMON | 0732 441 06A | Engineering Drawing | 100 |
| BASIC | 0611 451 01A | Digital Literacy | 40 |
|  |  |  | **Total 340 HRS** |
| **TWO (2)** | COMMON | 0541 441 05A | Engineering Technician Mathematics | 240 |
| CORE | 0714 451 16A | Specialized Power Systems Installation | 190 |
|  |  |  | **Total 460 HRS** |
| **THREE (3)** | CORE | 0612 451 10A | Computer Networks Installation | 160 |
| BASIC | 0417 441 03B | Apply Work Ethics and Practices | 40 |
| COMMON | 0713 441 07A | Electrical Principles | 190 |
|  |  |  | **Total 400 HRS** |
| **FOUR (4)** | CORE | 0714 451 13A | Electronic Circuits Fabrication | 180 |
| BASIC | 0413 441 04A | Entrepreneurial Skills | 40 |
| BASIC | 0031 441 02A | Communication Skills | 40 |
|  |  |  | **Total 280 HRS** |
| **FIVE (5)** | COMMON | 0714 541 08A | Telecommunication Principles | 80 |
| CORE | 0714 551 17A | Embedded and RF Circuits Fabrication | 230 |
|  |  |  | **Total 310 HRS** |
| **SIX (6)** | CORE | 0714 551 18A | Telephony Systems Installation | 180 |
| CORE | 0714 551 14A | Broadcasting Communication Systems Installation | 160 |
| CORE | 0714 551 15A | Wireless Transmission Links Installation | 140 |
|  |  |  | **Total 480 HRS** |
| **SEVEN (7)** | CORE | 0612 551 19A | Enterprise Computer Networks | 200 |
| CORE | 0714 551 12A | Communication Systems Maintenance | 120 |
|  | CORE | 0612 551 11A | Fiber Optical Networks Installation | 150 |
|  |  |  |  | **Total 470 HRS** |
|  | CORE |  | Industrial Attachment | **Total 480 HRS** |
| **TOTAL HOURS** | | | | **3160** |

The total duration of the course is **3160** hours.

**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**

1. Completion of Telecommunication Technology level 5.

**Or**

1. Any other qualification equivalent to that of Telecommunication Technology level 5 as determined by Technical and Vocational Education Training Authority (TVETA)

**Industrial attachment**

An individual enrolled in this course will be required to undergo an industrial attachment for a minimum period of 480 hours in the telecommunication technology sector.

**Trainer qualification**

A trainer for any of the Units of Competency in this course must:

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

**Assessment Requirements**

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 shall be as follows;
5. 30:70 for units in modules I to IV.
6. 40:60 for units in module V to VII
7. Formative and summative assessments shall be weighted at 60% and 40% respectively in the overall unit of learning score

For a candidate to be declared competent in a unit of competency, the candidate must meet the following conditions:

1. Obtained at least 40% in theory assessment in formative and summative assessments.
2. Obtained at least 60% in practical assessment in formative and summative assessment where applicable.
3. 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.
4. Assessment performance rating for each unit of competency shall be as follows:

|  |  |
| --- | --- |
| **MARKS** | **COMPETENCE RATING** |
| 80 -100 | Mastery |
| 65 – 79 | Proficiency |
| 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 Certificate of Competency in Telecommunication Technology level 6.
2. The assessors and verifiers must be registered by TVETA.

**Certification**

An individual will be awarded a Certificate of Competency on demonstration of competence in a core unit of competency. To be awarded Kenya National certificate in Telecommunication Technology Level 6, an individual must demonstrate competence in all the units of competency in this qualification pack.

The qualification certificates in Telecommunication Technology Level 6 will be awarded and issued by **The QAI**.

# MODULE ONE

## DIGITAL LITERACY

**UNIT CODE:** 0611 451 01B

**Relationship to Occupational Standards**

This unit addresses the Unit of Competency: Apply Digital Literacy

**Duration of Unit:** 40 Hours

**Unit Description:** This unit covers the competencies required to demonstrate digital literacy. It involves operating computer devices, solving tasks using the Office suite, accessing online/offline data and information, performing online communication and collaboration, applying cybersecurity skills and performing jobs online. It also involves applying job entry techniques.

**Summary of Learning Outcomes**

By the end of the unit the trainee 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** | **40** |

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

| **Learning Outcome** | **Content** | **Suggested**  **Assessment Methods** |
| --- | --- | --- |
| 1. Operate Computer Devices | * 1. Meaning and importance of digital literacy   2. Functions and Uses of Computers   3. Classification of computers   4. Components of a computer system   5. Computer Hardware      1. The System Unit E.g. Motherboard, CPU, casing      2. Input Devices e.g. Pointing, keying, scanning, voice/speech recognition, direct data capture devices.      3. Output Devices e.g. hardcopy output and softcopy output      4. Storage Devices e.g. main memory e.g. RAM, secondary storage (Solid state devices, Hard Drives, CDs & DVDs, Memory cards, Flash drives      5. Computer Ports e.g. HDMI, DVI, VGA, USB type C etc.   6. Classification of computer software   7. Operating system functions   8. Procedure for turning/off a computer   9. Mouse use techniques   10. Keyboard Parts and Use Techniques   11. Desktop Customization   12. File and Files Management using an operating system   13. Computer Internet Connection Options       1. Mobile Networks/Data Plans       2. Wireless Hotspots       3. Cabled (Ethernet/Fiber)       4. Dial-Up       5. Satellite   14. Computer external devices management       1. Device connections       2. Device controls (volume controls and display properties) | 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 |  |

## ELECTRICAL INSTALLATION

**UNIT CODE:** 0714 451 08A

**Relationship to Occupational Standards**

This unit addresses the unit of competency: Perform Electrical Installation

**Duration of Unit:** 200 hours

**Unit Description**

This unit specifies competencies required for installing electrical installation for telecommunication systems and facilities. These include preparing power supply electrical drawings, performing electrical installation system sizing, setting up telecommunication mains utility power supply system, and testing electrical power supply system

**Summary of Learning Outcomes**

By the end of the unit the trainee should be able to:

|  |  |  |
| --- | --- | --- |
| **S/NO** | **LEARNING OUTCOME** | **DURATION (HRS)** |
|  | Prepare power supply electrical drawings | 30 |
|  | Perform Electrical installation system sizing | 20 |
|  | Set up Telecommunication mains utility power supply system | 130 |
|  | Test electrical power supply system | 20 |
|  | **TOTAL HOURS** | **200** |

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

|  |  |  |
| --- | --- | --- |
| **Learning Outcome** | **Content** | **Suggested Assessment Methods** |
| 1. Prepare power supply electrical drawings | * 1. Power Supply Site Survey      1. Purpose of a Power Supply Site Survey      2. Pre-Survey Planning         1. Review of project specifications and requirements         2. Gathering necessary equipment and tools         3. Obtaining permits and clearances      3. Safety Considerations         1. Electrical safety precautions         2. Personal protective equipment (PPE)         3. Hazard identification and risk assessment      4. Site Assessment and Data Collection         1. Site Inspection  1. Visual inspection of the site 2. Identifying existing power infrastructure 3. Assessing site accessibility and terrain 4. Evaluating environmental factors (temperature, humidity, weather)    * + 1. Data Collection 5. Measuring distances and elevations 6. Recording existing power supply conditions 7. Collecting data on load requirements 8. Documenting site photos and sketches    * 1. Site Survey Report Writing         1. Report Structure 9. Executive summary 10. Site description 11. Power load analysis 12. Power supply options and recommendations 13. Cost estimates 14. Appendices (data sheets, maps, photos)     * + 1. Report Writing Guidelines 15. Clear and concise language 16. Accurate data presentation 17. Professional formatting 18. Adherence to industry standards     1. Electrical Design and Drawing Preparation        1. Electrical Design Principles           1. Load Calculation and Power Factor Correction           2. Voltage Drop Calculations           3. Short Circuit Current Calculations           4. Earthing System Design           5. Lighting Design        2. Electrical Drawing Standards           1. Single-Line Diagrams           2. Three-Line Diagrams           3. Wiring Diagrams           4. Control Schematics           5. Panel Layouts        3. CAD Software           1. AutoCAD Basics           2. Electrical Symbol Libraries           3. Drawing Creation and Editing           4. Dimensioning and Annotation           5. Printing and Plotting | 1. Written assessment 2. Oral assessment 3. Practical 4. Project 5. Third party report 6. Portfolio of evidence |
| 1. Perform Electrical installation system sizing | * 1. Power distribution systems      1. Types Power Supply Sources         1. Grid power         2. Generator power         3. Solar power         4. Battery backup         5. Hybrid power systems         6. Uninterruptible Power Supply (UPS)      2. Factors in Selecting a Power Supply Source      3. Electrical loads         1. Load Types and Characteristic  1. Resistive, Inductive, and Capacitive Loads 2. Motor Loads 3. Lighting Loads 4. Heating and Cooling Load    * + 1. Load Estimation Techniques 5. Load diversity factor 6. Demand factor 7. Load growth projections    * 1. Power Factor Correction         1. Importance of Power Factor         2. Calculation of Power Factor         3. Methods of Power Factor Correction         4. Capacitor Bank Sizing    1. Cable Sizing and Selection       1. Cable Types and Construction          1. Copper and Aluminum Conductors          2. Cable Insulation Materials          3. Cable Ratings (Voltage, Current, Temperature)       2. Cable Sizing Standards          1. IEC Standards          2. NEC Standards          3. Importance of cable sizing       3. Cable Sizing Calculations          1. Factors affecting cable sizing          2. Voltage Drop Calculations          3. Current Carrying Capacity          4. Cable Derating Factor    2. Protection devices selection       1. Circuit Breaker Types          1. Molded Case Circuit Breakers (MCCBs)          2. Miniature Circuit Breakers (MCBs)          3. Circuit Breaker Ratings (Ampere, Voltage, Interrupting Capacity)       2. Fuse Types          1. Cartridge Fuses          2. Plug Fuses          3. Fuse Ratings (Ampere, Voltage, Interrupting Rating)       3. Circuit Breaker and Fuse Selection Criteria          1. Short-Circuit Current Rating          2. Overload Protection          3. Selective Coordination          4. Protection system principles: discrimination and redundancy       4. Surge protection devices       5. Overload relays    3. Transformer Sizing and Selection       1. Transformer Types          1. Single-Phase and Three-Phase Transformers          2. Core-Type and Shell-Type Transformers       2. Transformer Ratings          1. Voltage Rating          2. Current Rating          3. Power Rating          4. Efficiency          5. Impedance       3. Transformer Sizing Calculations          1. Load Calculation          2. Voltage Drop Calculation          3. Transformer Efficiency and Losses    4. Earthing Systems       1. Types of Earthing Systems          1. TN-S          2. TN-C-S          3. TT          4. IT Systems       2. Earthing system sizing    5. Sizing of Electrical Panels and Distribution Boards       1. Panelboard Components          1. Main Busbar          2. Circuit Breakers          3. Neutral Busbar          4. Ground Busbar          5. Enclosure       2. Distribution Board Components          1. Incoming Feeder          2. Outgoing Circuits          3. Circuit Breakers or Fuses          4. Enclosure       3. Panelboard and distribution board Layout          1. Incoming Feeder          2. Outgoing Circuits          3. Circuit Breaker or Fuse Arrangement          4. Wiring Layout          5. Grounding and Bonding       4. Panelboard and distribution board Sizing          1. Load Calculation          2. Short-Circuit Current Calculation          3. Voltage Drop Calculation          4. Board Rating Selection          5. Busbar Sizing          6. Allowance for Future Expansion       5. Code Compliance and Standards          1. NEC code          2. IEC standards | 1. Written assessment 2. Oral assessment 3. Practical 4. Project 5. Third party report 6. Portfolio of evidence |
| 1. Set up Telecommunication mains utility power supply system | * 1. Tools, Equipment, and Material Preparation      1. Tool Selection and Usage         1. Screwdrivers         2. Pliers         3. Wire Strippers         4. Cable Cutters         5. Cable Pullers         6. Drilling Machines      2. Equipment Selection and Usage:         1. Voltage Testers         2. Multimeters         3. Megger         4. Cable Fault Locators      3. Material Selection and Preparation         1. Cables (PVC, XLPE, armored)         2. Conduits and Fittings         3. Cable Trays and Accessories         4. Circuit Breakers and Fuses         5. Distribution Boards and Panels         6. Earthing and Bonding Materials   2. Utility Distribution Panel and Board Installation      1. Panel Selection         1. Choosing the Right Panel Type: indoor, outdoor, weatherproof         2. Panel Rating and Configuration      2. Panel Installation         1. Mounting the Panel         2. Installing Busbars and Circuit Breakers         3. Wiring the Panel         4. Grounding and Bonding      3. Distribution Board Installation         1. Mounting the Board         2. Installing Circuit Breakers or Fuses         3. Wiring the Board         4. Grounding and Bonding   3. Cable Laying and Termination      1. Cable Laying Techniques         1. Trenching and Cable Laying         2. Cable Tray and Conduit Installation         3. Cable Bending and Routing      2. Cable Termination Techniques         1. Stripping and Tinning Cable Ends         2. Crimping Connectors         3. Lug Termination         4. Cable Glanding and Sealing      3. Terminating metering units      4. Terminating control relays and conductors   4. Earthing and Bonding Installation      1. Installing Earth Electrodes         1. Earth rod         2. Earth pits      2. Connecting Equipment to the Earthing System      3. Bonding Conductive Parts   5. Testing and Commissioning      1. Pre-Commissioning Tests         1. Insulation Resistance Test         2. Continuity Test         3. Earth Resistance Test      2. Commissioning Procedures         1. Energizing the System         2. Load Testing         3. Protection System Testing      3. Handover Procedures         1. Preparing Documentation  1. As-built drawings 2. Test reports | 1. Written assessment 2. Oral assessment 3. Practical 4. Project 5. Third party report 6. Portfolio of evidence |
| 1. Test electrical power supply system | * 1. Electrical Safety      1. Safety Regulations and Standards: NEC, IEC      2. Personal Protective Equipment (PPE)      3. Electrical Shock Hazards      4. Lockout/Tagout Procedures   2. Test Equipment      1. Multimeter      2. Clamp Meter      3. Megger      4. Power Quality Analyzer      5. Oscilloscope   3. Electrical tests      1. Visual inspection: purpose and procedure      2. Insulation Resistance Test         1. Purpose and Significance         2. Test Procedure         3. Interpretation of Results      3. Continuity Test         1. Purpose and Significance         2. Test Procedure         3. Interpretation of Results      4. Earth Resistance test         1. Purpose and Significance         2. Test Procedure         3. Interpretation of Results      5. Voltage and Current Measurements         1. Measuring Voltage and Current Levels         2. Verifying Phase Sequence         3. Power Factor      6. Protection System Testing         1. Testing Overcurrent and Overvoltage Protection         2. Response of protection systems         3. Testing Earth Fault Protection      7. Transformer Testing         1. Voltage Ratio Test         2. Winding Resistance Test         3. Insulation Resistance Test         4. Load Test      8. Cable Testing         1. Cable Fault Location         2. Cable Impedance Measurement         3. Cable Insulation      9. Functional Testing      10. Documentation and Reporting of electrical tests          1. Importance of tests documentation          2. Test checklists          3. Creating Test Report | 1. Written assessment 2. Oral assessment 3. Practical 4. Project 5. Third party report 6. Portfolio of evidence |

**Suggested Methods of delivery**

* + 1. Practical
    2. Project
    3. Demonstration
    4. Group discussion
    5. Direct instruction
    6. Field visits
    7. Industry visits
    8. Case studies

**Recommended Resources for 25 trainees**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S No.** | **Item** | **Specifications for Purchase** | **Quantity** | **Recommended Ratio (Item: Trainee)** |
| **A** | **Tools & Equipment** |  |  |  |
| 1 | Laptops/Desktop Computers | 8GB RAM, 256GB SSD, CAD software compatible | 10 pcs | 1:3 |
| 2 | Drawing Tools | Includes T-squares, protractors, rulers | 25 sets | 1:1 |
| 3 | Plotter/Printer | Wide-format, high-resolution for CAD prints | 2 pcs | 1:13 |
| 4 | Digital Multimeters | Auto-ranging, backlit display | 5 pcs | 1:5 |
| 5 | Power Factor Meters | Measures 0.5-1.0 power factor | 5 pcs | 1:5 |
| 6 | Cable Cutters | Insulated, ergonomic handle | 10 pcs | 1:3 |
| 7 | Cable Strippers | Adjustable for different wire gauges | 10 pcs | 1:3 |
| 8 | Crimping Tools | High-quality, suitable for insulated terminals | 10 pcs | 1:3 |
| 9 | Torque Wrenches | Adjustable torque range, calibrated | 2 sets | 1:13 |
| 10 | Spanners and Socket Sets | Includes standard and metric sizes | 2 sets | 1:13 |
| **B** | **Reference Materials** |  |  |  |
| 11 | Electrical Symbols Reference Charts | Comprehensive symbols for schematic reference | 25 pcs | 1:1 |
| 12 | Paper and Pencils/Erasers | For drafting, includes erasers and HB pencils | 25 sets | 1:1 |
| 13 | Whiteboard and Markers | Magnetic whiteboard, assorted color markers | 1 set | 1 per class |
| **C** | **Electrical Materials** |  |  |  |
| 14 | Cables and Wires | Assorted gauges for electrical training | As needed | As needed |
| 15 | Electrical Panels and Enclosures | Weatherproof, lockable | 5 sets | 1:5 |
| 16 | Conduit and Trunking | Assorted sizes for wire management | As needed | As needed |
| 17 | Cable Ties, Connectors, and Lugs | Variety pack for secure electrical connections | As needed | As needed |
| 18 | Safety Labels and Tags | Assorted electrical hazard labels | 25 pcs | 1:1 |
| 22 | Scaffolding | Modular, adjustable height for safe access | 2 sets | 1:13 |
| **D** | **Testing & Measurement** |  |  |  |
| 23 | Multimeters | Digital, auto-ranging with multiple test functions | 10 pcs | 1:3 |
| 24 | Projector | High-resolution for presentations | 1 pc | 1 per class |
| 25 | Insulation Resistance Testers | 500V, accurate insulation resistance measurement | 5 pcs | 1:5 |
| 26 | Distribution Boards | With circuit breakers for demonstration purposes | 5 pcs | 1:5 |
| 27 | Switchgear | Assorted for learning different control methods | As needed | As needed |
| 28 | Power Meters | Monitors electrical parameters | 5 pcs | 1:5 |
| 32 | Ladders | Adjustable, anti-slip steps | 5 pcs | 1:5 |
| 34 | Power Distribution Units | With surge protection | 5 pcs | 1:5 |
| 36 | Racks/Cabinets | Secure storage for equipment | As needed | As needed |
| **E** | **Documentation** |  |  |  |
| 40 | Manufacturer’s Catalogues | Latest catalogs of electrical components | 5 pcs | 1:5 |
| 41 | Electrical Design Standards | Includes IEEE, IEC guidelines | 5 pcs | 1:5 |
| 42 | Electrical Codebooks | National Electrical Code, BS7671 | 5 pcs | 1:5 |
| 43 | EMCA Act | Environmental guidelines for electrical installations | 5 pcs | 1:5 |
| 44 | OSHA | Safety guidelines for electrical systems | 5 pcs | 1:5 |
| 45 | Cable Sizing Charts | For selecting correct cable gauge | 5 pcs | 1:5 |
| 46 | Cable Specification Catalogs | Specifications for different cable types | 5 pcs | 1:5 |
| 47 | Electrical Load Data Sheets | Load calculations and examples | 5 pcs | 1:5 |
| 48 | Specification Sheets | Manufacturer’s specs for key components | 5 pcs | 1:5 |
| 49 | Electrical Utility Standards | Guidelines from utility providers | 5 pcs | 1:5 |
| 50 | Site Layout Diagrams | Electrical schematics for practice | 5 sets | 1:5 |

## ENGINEERING DRAWINGS

**UNIT CODE:** 0732 451 05A

**Relationship to Occupational Standards**

This unit addresses the unit of competency: Prepare Engineering drawings

**Unit duration**: 100 hours.

**Unit Description:** This unit covers competences required to prepare technical drawings. Competences include preparing drawing equipment and materials, producing plane geometry drawings, managing basic operations in AutoCAD, developing 2D Drawings in AutoCAD and Producing pictorial and orthographic drawings of components.

**Summary of Learning Outcomes**

By the end of the unit the trainee should be able to:

|  |  |  |
| --- | --- | --- |
| **S/NO** | **LEARNING OUTCOME** | **DURATION (HRS)** |
|  | Prepare drawing equipment and materials | 10 |
|  | Produce plane geometry drawings | 10 |
|  | Manage basic operations in AutoCAD | 10 |
|  | Develop 2D Drawings in AutoCAD | 40 |
|  | Produce pictorial and orthographic drawings of components | 30 |
|  | **TOTAL HOURS** | **100** |

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

|  |  |  |
| --- | --- | --- |
| **Learning Outcome** | **Content** | **Suggested Assessment Methods** |
| 1. Prepare drawing equipment and materials | * 1. Introduction to engineering Drawing      1. Importance of technical drawing in engineering and design.      2. Types of engineering technical drawings         1. Orthographic         2. Isometric         3. Perspective   2. Identifying Technical Drawing Tools and Equipment      1. Tools Overview         1. Drawing board, T-square, set squares, protractor.         2. Compass and dividers.         3. Scale rulers (linear, diagonal, isometric).         4. Drafting pencils and mechanical pencils.         5. Erasers and erasing shields.         6. Drawing paper and tracing sheets.      2. Equipment Overview         1. Adjustable drafting tables.         2. Lighting for technical drawing   3. Using Technical Drawing Tools      1. Drawing Lines and Shapes      2. Angles and Measurements      3. Creating Circles and Arcs      4. Lettering and Dimensioning   4. Care and Maintenance of Technical Drawing Tools      1. Cleaning and storing tools      2. Sharpening and handling drafting pencils and compasses.      3. Preventing rust or damage to metal tools.   5. Safety Practices in engineering drawing | 1. Written assessment 2. Oral assessment 3. Practical 4. Project 5. Third party report 6. Portfolio of evidence |
| 1. Produce plane geometry drawings | * 1. Introduction to Plane Geometry      1. Overview of plane geometry concepts         1. Points         2. Lines         3. Angles         4. Polygons         5. Circles      2. Real-life applications of plane geometry drawings   2. **Constructing Geometric** Shapes      1. Drawing and labelling         1. Freehand printing         2. Borderlines ad tittle blocks         3. Points and straight lines.         4. Angles: acute, right, obtuse, and reflex.         5. Basic shapes: triangles, squares, rectangles, parallelograms and circles.         6. Bisection of different angles and lines      2. Using tools for precision         1. Measuring lengths and angles accurately.         2. Using compasses for circles and arcs.      3. Constructing other geometric **shapes**         1. Drawing polygons: pentagons, hexagons, and octagons.         2. Pyramids         3. Conic sections         4. Prisms         5. Inscribing and circumscribing polygons within circles.         6. Drawing tangents and chords on circles.         7. Patterns development      4. Standards and conventions in drawing         1. Dimensioning: specifying lengths, angles, and radii.         2. Line types and their meanings Title blocks, scales, and annotations. | 1. Written assessment 2. Oral assessment 3. Practical 4. Project 5. Third party report 6. Portfolio of evidence |
| 1. Manage basic operations in AutoCAD | * 1. **Introduction** to 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 assessment 3. Practical 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    * + 1. Surface development        2. Simpe floor plans        3. Electrical drawings 3. Block diagram 4. Schematic diagram 5. Line and wiring circuits    1. Drawing Precision in CAD       1. Using object snap overrides       2. Polar tracking at angles       3. Object snap tracking       4. Drawing with snap and grid    2. 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    3. 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    4. Adding dimensions to drawings       1. Dimensioning concepts       2. Adding linear dimensions       3. Adding radial and angular dimensions       4. Editing dimensions    5. 2D drawings documentation       1. Printing concepts       2. Printing layouts       3. Print and plot settings | 1. Written assessment 2. Oral assessment 3. Practical 4. Project 5. Third party report 6. Portfolio of evidence |
| 1. Produce pictorial and orthographic drawings of components | * 1. Difference between 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 assessment 3. Practical 4. Project 5. Third party report 6. Portfolio of evidence |

**Suggested Delivery Methods**

* Demonstration
* Discussions
* Practical
* Project
* 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 | 5 pcs  5 pcs  5 pcs | 1:5  1:5  1:5 |
|  | Installation manuals | AutoCAD software 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 |
|  | Solid works licenses | Solid works 2024 Standard version licenses | 25 | 1:1 |
|  | AutoCAD licenses | AutoCAD 2025 licenses | 25 | 1:1 |

# MODULE TWO

## ENGINEERING TECHNICIAN MATHEMATICS

**UNIT CODE:** 0541 441 04A

**Relationship to Occupational Standards**

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

**Unit duration**: 240 hours.

**Unit Description:** This unit describes the competencies required by a technician in order to apply technician mathematics. It enables the learner to; apply algebra, apply trigonometry and hyperbolic functions, apply complex numbers perform coordinates geometry, carry out mensuration, applying calculus, carrying out binomial expansion, applying vector theory, applying statistics and probability and applying matrices.

**Summary of Learning Outcomes**

By the end of the unit the trainee should be able to:

|  |  |  |
| --- | --- | --- |
| **S/NO** | **LEARNING OUTCOME** | **DURATION (HRS)** |
|  | Apply algebra | 20 |
|  | Apply Trigonometry and hyperbolic functions | 20 |
|  | Apply complex numbers | 20 |
|  | Perform coordinate geometry | 20 |
|  | Apply Calculus | 60 |
|  | Carry out binomial expansion | 20 |
|  | Apply vector theory | 20 |
|  | Apply Statistics and probability | 20 |
|  | Apply matrices | 20 |
|  | **TOTAL HOURS** | **240** |

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

|  |  |  |
| --- | --- | --- |
| **Learning Outcome** | **Content** | **Suggested Assessment Methods** |
| 1. Apply algebra | * 1. Importance of algebra in engineering   2. 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 calculator   3. Linear Equations      1. Definition and standard form.      2. Methods of solving: Graphical, substitution, and elimination methods.      3. Applications in engineering problems.   4. Quadratic Equations      1. Definition and standard form.      2. Methods of solving: Factoring, completing the square, and quadratic formula.      3. 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 assessment 3. Practical 4. Project 5. Third party report 6. Portfolio of evidence |
| 1. Apply trigonometry and hyperbolic functions | * 1. Importance of trigonometry in engineering.   2. Trigonometric Ratios and Functions      1. Definitions of sine, cosine, tangent, cosecant, secant, and cotangent.      2. 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. Definition and properties.         2. Solving equations using inverse trigonometric functions.      3. Applications of Trigonometric Equations         1. Engineering problems involving periodic functions and waveforms.         2. Harmonic motion and oscillations in mechanical systems.   5. Trigonometry in Triangles      1. Right-Angle Triangles         1. Solving for sides and angles using trigonometric ratios.         2. Applications in engineering problems such as inclined planes and forces.      2. Non-Right-Angle Triangles         1. Law of Sines and Law of Cosines.         2. Solving oblique triangles.         3. Applications in engineering fields of structural analysis and navigation.   6. Introduction to Hyperbolic Functions      1. Definitions of hyperbolic sine, cosine, tangent, and their reciprocals.      2. Graphs and properties of hyperbolic functions.   7. Hyperbolic Identities      1. Fundamental identities         1. Pythagorean-like identities      2. Sum and difference formulas, double-angle, and half-angle formulas.   8. Solving Hyperbolic Equations      1. Basic Hyperbolic Equations         1. Solving equations involving basic hyperbolic functions.         2. Using identities to simplify and solve equations.      2. Inverse Hyperbolic Functions         1. Definition and properties.         2. Solving equations using inverse hyperbolic functions.      3. Applications of Hyperbolic Functions in Engineering | 1. Written assessment 2. Oral assessment 3. Practical 4. Project 5. Third party report 6. Portfolio of evidence |
| 1. Apply complex numbers | * 1. Introduction to Complex Numbers      1. Definition of a complex number      2. Real and imaginary parts.      3. Complex plane: Argand diagram   2. Arithmetic Operations      1. Addition, subtraction, multiplication, and division of complex numbers.      2. Conjugate of a complex number.   3. Polar and Exponential Forms      1. Polar form of a complex number.      2. Conversion between Cartesian and polar forms.      3. Exponential form using Euler’s formula.   4. Complex Number Operations      1. Powers and Roots         1. Powers of complex numbers using De Moivre’s Theorem.         2. Finding roots of complex numbers.      2. Complex Exponential Functions         1. Definition and properties.         2. Applications in solving differential equations.   5. Solving Equations Using Complex Numbers      1. Quadratic Equations      2. Solving quadratic equations with complex coefficients.      3. Nature of roots         1. Real and complex      4. Systems of Linear Equations         1. Using complex numbers to solve linear systems.         2. Applications in AC circuit analysis. | 1. Written assessment 2. Oral assessment 3. Practical 4. Project 5. Third party report 6. Portfolio of evidence |
| 1. Perform coordinates geometry | * 1. Polar equations      1. Definition of polar coordinates      2. Definition and examples of polar equations.      3. Representing curves using polar equations.   2. Cartesian equation      1. Definition of Cartesian coordinates.      2. Definition of a point in cartesian coordinates      3. Relationship between Cartesian and polar coordinates.      4. Definition and examples of Cartesian equations.      5. Representing lines, circles, parabolas, ellipses, and hyperbolas using Cartesian equations.      6. Conversion Between Polar and Cartesian Equations.   3. Graphs of polar equations      1. Plotting Polar Equations         1. Definition of a point in polar coordinates         2. Steps to graph polar equations.         3. Using symmetry and periodicity in polar graphs.      2. Analyzing Polar Graphs         1. Identifying key features intercepts, maxima, minima      3. Applications in engineering   4. Normal and tangents      1. Tangents to Curves         1. Definition of a tangent line.         2. Finding the slope of a tangent to a curve at a given point.      2. Normals to Curves         1. Definition of a normal line.         2. Finding the equation of a normal to a curve at a given point.      3. Tangents and Normals in Polar Coordinates         1. Techniques for finding tangents and normals to curves defined by polar equations.   5. Loci      1. Introduction to Loci         1. Definition of Locus         2. Understanding the concept of a locus.         3. Importance of loci in engineering.      2. Locus in Relation to a Circle         1. Equations and properties of loci relative to circles.         2. Common loci problems involving circles      3. Applications in Engineering         1. Using loci to solve engineering problems: robotic arm movement         2. Analyzing Loci of Points: tracing the path of a point on a rotating arm         3. Using loci to optimize mechanical systems: designing cams, robotic path planning. | 1. Written assessment 2. Oral assessment 3. Practical 4. Project 5. Third party report 6. Portfolio of evidence |
| 1. Carry out binomial expansion | * 1. Basic concepts of binomial theorem      1. Binomial expressions and notation.      2. Factorials and their use in binomial coefficients.      3. Binomial Coefficients         1. Definition and calculation using combinations (nCr).         2. Pascal’s Triangle as a tool for finding binomial coefficients.   2. Binomial Expansion  1. General form of the binomial expansion expression 2. Binomial Expansion of where 3. Special cases    * + 1. When        2. Negative and fractional binomial expansions using the binomial series    1. Applications of Binomial Expansion       1. Simplifying algebraic expressions using binomial expansion.       2. Solving polynomial equations.    2. Engineering Applications    3. Estimating values in engineering calculations. | 1. Written assessment 2. Oral assessment 3. Practical 4. Project 5. Third party report 6. 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 assessment 3. Practical 4. Project 5. Third party report 6. Portfolio of evidence |
| 1. Apply statistics and probability | * 1. Measures of central tendency mean, mode and median   2. Measures of dispersion   3. Variance and standard deviation   4. Definition of probability   5. Laws of probability   6. Expectation variance and SD   7. Calculations involving discrete and continuous random variables.   8. Types of distributions      1. Binomial      2. Poisson      3. Normal   9. Mean, variance and SD of probability distributions   10. Application of probability distributions |  |
| 1. Apply vector theorem | * 1. Vectors and scalar in two and three dimensions   2. Operations on vectors: Addition and subtraction   3. Position vectors   4. Resolution of vectors   5. Scalar and vector product | 1. Written assessment 2. Oral assessment 3. Practical 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.   2. Matrix Multiplication      1. Rules and properties of matrix multiplication.      2. Properties of Matrix Multiplication         1. Associative, distributive, and commutative properties.         2. Transpose of a matrix and properties.   3. Determinants and Inverses      1. Calculating determinants for 2x2 and 3x3 matrices.      2. Methods to find the inverse (adjoint method, Gauss-Jordan elimination).      3. Conditions for the existence of an inverse.   4. Solving Systems of Linear Equations      1. Representation of linear systems using matrices.      2. Application of Cramer's rule for solving systems of linear equations.      3. Using the inverse matrix inverse method to solve linear systems.   5. Using the inverse determinant method to solve linear systems. | 1. Written assessment 2. Oral assessment 3. Practical 4. Project 5. Third party report 6. 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 |  |

## SPECIALIZED POWER SYSTEMS INSTALLATION

**UNIT CODE:** 0714 451 15A

**Relationship to Occupational Standards**

This unit addresses the unit of competency: Install Specialized Power Systems.

**Duration of Unit:** 190 hours

**Unit Description**

This unit specifies competences required for installing specialized power systems. These include preparing power supply electrical drawings, performing electrical installation system sizing, setting up telecommunication mains utility power supply system, setting up telecommunication solar power supply system, setting up telecommunication ups system and testing electrical power supply system

**Summary of Learning Outcomes**

By the end of the unit the trainee should be able to:

|  |  |  |
| --- | --- | --- |
| **S/NO** | **LEARNING OUTCOME** | **DURATION (HRS)** |
|  | Install Solar power supply systems | 40 |
|  | Set up Telecommunication UPS systems | 30 |
|  | Install Power Factor Correction Systems | 30 |
|  | Install HVAC systems | 60 |
|  | Test electrical power supply system | 20 |
|  | **TOTAL HOURS** | **190** |

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

|  |  |  |
| --- | --- | --- |
| **Learning Outcome** | **Content** | **Suggested Assessment Methods** |
| 1. Set up Telecommunication Solar power supply system | * 1. Solar Power Fundamental Concepts      1. Solar Radiation      2. Photovoltaic Effect      3. Solar Panel Characteristics      4. Solar Inverter Operation   2. Preparing Solar Power Supply Equipment and Materials      1. Solar Panel Selection         1. Understanding Solar Panel Ratings: Watts, Voltage, Amperes         2. Choosing the Right Solar Panel Type: monocrystalline, polycrystalline, amorphous      2. Solar Inverter Selection         1. Understanding Inverter Ratings: Watts, Voltage, Frequency         2. Choosing the Right Inverter Type: on-grid, off-grid, hybrid      3. Battery Bank Selection         1. Understanding Battery Bank Capacity (Ah, kWh)         2. Choosing the Right Battery Type: lead-acid, lithium-ion      4. Cable Selection         1. Choosing the Right Cable Type         2. Cable Sizing based on Load Requirements and Voltage Drop      5. Mounting Structure Selection:         1. Choosing the Right Mounting Structure: roof-mounted, ground-mounted         2. Tracking Systems: Single-Axis Tracker, Dual-Axis Tracker         3. Erection of Support Structures         4. Inclination and Orientation         5. Determining Optimal Tilt Angle and Azimuth         6. Adjusting the Mounting Structure   3. Installing Solar Panels      1. Securing Solar Panels with Clamps and Bolts      2. Weatherproofing      3. Interconnecting Solar Panels         1. Connecting Solar Panels in Series and Parallel         2. Using MC4 Connectors         3. Cable Laying and Termination      4. Cable Routing         1. Planning Cable Routes procedures         2. Securing Cables      5. Cable Termination         1. Stripping and Tinning Cable Ends         2. Crimping Connectors         3. Connecting Cables to Solar Panels, Inverters, and Batteries      6. Installing Solar Panel Combiner Boxes      7. Combiner Box Selection: Box Size and Rating         1. Combiner Box Installation         2. Mounting the Combiner Box         3. Connecting Solar Panels to the Combiner Box         4. Connecting the Combiner Box to the Inverter   4. Installing Solar System Protection Systems      1. Sizing and installation of DC Circuit Breakers and Fuses      2. Surge Protection Devices (SPDs)   5. Installing Solar System Inverters and Battery Banks      1. Connecting Batteries in Series and Parallel      2. Ventilation and Cooling systems      3. Connecting the Inverter to Solar Panels, Batteries, and AC Load      4. Configuring Inverter Settings   6. Solar Power System Testing      1. Pre-Commissioning Tests         1. Insulation Resistance Test         2. Continuity Test         3. Earth Resistance Test         4. Open-circuit tests         5. Short-circuit tests         6. Voltage and current tests      2. Commissioning Procedures         1. Energizing the System         2. Load Testing         3. Performance Monitoring   7. Preparing Documentation      1. As-built drawings      2. Test reports | 1. Written assessment 2. Oral assessment 3. Practical 4. Project 5. Third party report 6. Portfolio of evidence |
| 1. Set up Telecommunication UPS system | * 1. Introduction to UPS Systems      1. Definition and purpose of a UPS system.      2. Importance in telecommunication systems      3. Types of UPS System         1. Standby (offline), Line-interactive, and Online double conversion UPS systems.         2. Application cases for each in telecommunications.   2. Telecommunication system power requirements      1. Power Supply Systems in Telecommunication         1. AC vs. DC power in telecom systems.         2. Voltage and current considerations      2. Load Analysis         1. Calculating total load requirements         2. UPS sizing   3. UPS System Components      1. UPS Unit         1. Inverter, rectifier, and battery charger functions.         2. Power capacity rating (kVA or kW).      2. Batteries         1. Types: Lead-acid, Lithium-ion, or Nickel-Cadmium (NiCd).         2. Battery banks and their configuration.         3. Battery runtime and backup capacity calculations.      3. Monitoring and Control Interfaces         1. LCD display         2. Alarms         3. Network interfaces for remote monitoring.   4. Installing the UPS System      1. UPS Placement         1. Factors to consider when choosing an optimal UPS location         2. Rack-mounting and standalone installations.      2. Electrical Connections         1. Main AC supply to UPS termination.         2. System load termination         3. Grounding UPS system      3. Battery bank Installation         1. Battery banks configurations.         2. Verification of battery bank health.   5. Testing and Commissioning      1. Initial System Checks         1. Verification of input voltage, load capacity, and system settings.         2. UPS Error codes and warnings.      2. Load Testing         1. Simulated power failure test         2. Load performance and battery discharge rates.      3. System Configuration         1. Remote monitoring and alert settings configuration         2. UPS integration to existing telecom network management systems   6. Maintenance and Troubleshooting      1. Routine Maintenance         1. Battery health monitoring.         2. Cleaning Ventilation.      2. Troubleshooting Common Issues         1. UPS not switching to battery mode.         2. Overload and temperature warnings.         3. Degraded battery performance.   7. Documentation and Reporting      1. Installation Report      2. Maintenance Logs         1. Tracking performance         2. Service dates         3. Battery replacements. | 1. Written assessment 2. Oral assessment 3. Practical 4. Project 5. Third party report 6. Portfolio of evidence |
| 1. Install Power Factor Correction Systems | * 1. Fundamentals of Power Factor & PFC Systems      1. Introduction to Power Factor         1. Understanding real, reactive, and apparent power         2. Definition and importance of power factor (PF)         3. Causes and effects of poor power factor         4. Effects of low power factor on electrical systems         5. Power factor measurement methods         6. Industrial and commercial applications      2. Power Factor Correction (PFC) Concepts         1. Types of power factor correction: passive, active, hybrid         2. Components of PFC systems: capacitor banks, reactors, controllers         3. Fixed vs. automatic PFC         4. Harmonic distortion and filtering techniques         5. Selection criteria for PFC systems      3. Safety Procedures & Compliance         1. Electrical safety regulations (IEC, IEEE, NEC)         2. PPE and handling high-voltage capacitors         3. Lockout/Tagout (LOTO) and earthing procedures   2. Power Factor Correction System Installation      1. Site Survey & System Sizing         1. Load analysis and reactive power calculation         2. Selection of capacitor banks based on demand         3. Harmonics analysis and mitigation techniques      2. Installation of PFC Equipment         1. Mounting capacitor banks and reactors         2. Wiring capacitor bank         3. Electrical wiring and busbar connections         4. Integrating controllers and protection devices      3. Testing & Initial Commissioning         1. Checking voltage, current, and power factor levels         2. Verifying automatic switching of capacitor banks         3. Identifying and troubleshooting installation issues   3. Maintenance & Troubleshooting      1. Detecting capacitor degradation and failures      2. Identifying harmonic interference problems      3. Ensuring long-term reliability of PFC systems | 1. Written assessment 2. Oral assessment 3. Practical 4. Project 5. Third party report 6. Portfolio of evidence |
| 1. Install HVAC systems | * 1. Fundamentals of HVAC Systems      1. Introduction to HVAC Systems         1. Basics of heating, ventilation, and air conditioning  1. Psychrometric principles 2. Heat transfer mechanisms    * + 1. Types of HVAC systems: split, packaged, VRF, ductless        2. Applications in residential, commercial, and industrial setups      1. HVAC Components & Working Principles         1. Refrigeration cycle overview         2. Compressors, condensers, evaporators, expansion valves         3. Types of Ducts, air handling units, filters, fans         4. Refrigerants and their environmental impact      2. Safety Procedures & Regulations         1. Personal protective equipment (PPE)         2. Handling refrigerants & compliance with EPA guidelines         3. Electrical safety and lockout/tagout (LOTO) procedures    1. HVAC Installation Techniques       1. Reading blueprints and schematics       2. Selecting appropriate HVAC units       3. Mounting indoor and outdoor units    2. Ductwork & Piping       1. Designing and installing duct systems       2. Leak testing and vacuuming procedures       3. Insulation and sealing techniques       4. Copper tubing, pipe bending, and brazing       5. Charging refrigerants and pressure testing    3. Electrical Wiring & Controls       1. Electrical Connections          1. Wiring diagrams and control circuit installation          2. Connecting thermostats and relay and sensors          3. Checking voltage, current, and electrical continuity       2. Ventilation & Air Balancing          1. Adjusting airflows and testing pressure differences          2. Filter installation and replacement          3. Identifying airflow obstructions and fixing leaks    4. System Testing & Commissioning       1. System Start-up & Performance Testing          1. Checking operational efficiency          2. Troubleshooting common startup issues          3. Analyzing system parameters and making adjustments       2. HVAC Troubleshooting & Repairs          1. Diagnosing electrical, mechanical, and refrigerant issues          2. Common fault codes and diagnostic tools          3. Fixing airflow, compressor, and coil problems       3. Documentation & Customer Handover          1. Creating HVAC installation reports          2. Explaining system operation to clients          3. Maintenance best practices and service scheduling | 1. Written assessment 2. Oral assessment 3. Practical 4. Project 5. Third party report 6. Portfolio of evidence |
| 1. Test electrical power supply system | * 1. Electrical Safety      1. Safety Regulations and Standards: NEC, IEC      2. Personal Protective Equipment (PPE)      3. Electrical Shock Hazards      4. Lockout/Tagout Procedures   2. Test Equipment      1. Multimeter      2. Clamp Meter      3. Megger      4. Power Quality Analyzer      5. Oscilloscope   3. Electrical tests      1. Visual inspection: purpose and procedure      2. Insulation Resistance Test         1. Purpose and Significance         2. Test Procedure         3. Interpretation of Results      3. Continuity Test         1. Purpose and Significance         2. Test Procedure         3. Interpretation of Results      4. Earth Resistance test         1. Purpose and Significance         2. Test Procedure         3. Interpretation of Results      5. Voltage and Current Measurements         1. Measuring Voltage and Current Levels         2. Verifying Phase Sequence         3. Power Factor      6. Protection System Testing         1. Testing Overcurrent and Overvoltage Protection         2. Response of protection systems         3. Testing Earth Fault Protection      7. Transformer Testing         1. Voltage Ratio Test         2. Winding Resistance Test         3. Insulation Resistance Test         4. Load Test      8. Cable Testing         1. Cable Fault Location         2. Cable Impedance Measurement         3. Cable Insulation      9. Functional Testing      10. Documentation and Reporting of electrical tests          1. Importance of tests documentation          2. Test checklists          3. Creating Test Report | 1. Written assessment 2. Oral assessment 3. Practical 4. Project 5. Third party report 6. Portfolio of evidence |

**Suggested Methods of delivery**

* + 1. Practical
    2. Project
    3. Demonstration
    4. Group discussion
    5. Direct instruction
    6. Field visits
    7. Industry visits
    8. Case studies

**Recommended Resources for 25 trainees**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S No.** | **Item** | **Specifications for Purchase** | **Quantity** | **Recommended Ratio (Item: Trainee)** |
| **A** | **Tools & Equipment** |  |  |  |
| 1 | Laptops/Desktop Computers | 8GB RAM, 256GB SSD, CAD software compatible | 10 pcs | 1:3 |
| 2 | Drawing Tools | Includes T-squares, protractors, rulers | 25 sets | 1:1 |
| 3 | Plotter/Printer | Wide-format, high-resolution for CAD prints | 2 pcs | 1:13 |
| 4 | Digital Multimeters | Auto-ranging, backlit display | 5 pcs | 1:5 |
| 5 | Power Factor Meters | Measures 0.5-1.0 power factor | 5 pcs | 1:5 |
| 6 | Cable Cutters | Insulated, ergonomic handle | 10 pcs | 1:3 |
| 7 | Cable Strippers | Adjustable for different wire gauges | 10 pcs | 1:3 |
| 8 | Crimping Tools | High-quality, suitable for insulated terminals | 10 pcs | 1:3 |
| 9 | Torque Wrenches | Adjustable torque range, calibrated | 2 sets | 1:13 |
| 10 | Spanners and Socket Sets | Includes standard and metric sizes | 2 sets | 1:13 |
| **B** | **Reference Materials** |  |  |  |
| 11 | Electrical Symbols Reference Charts | Comprehensive symbols for schematic reference | 25 pcs | 1:1 |
| 12 | Paper and Pencils/Erasers | For drafting, includes erasers and HB pencils | 25 sets | 1:1 |
| 13 | Whiteboard and Markers | Magnetic whiteboard, assorted color markers | 1 set | 1 per class |
| **C** | **Electrical Materials** |  |  |  |
| 14 | Cables and Wires | Assorted gauges for electrical training | As needed | As needed |
| 15 | Electrical Panels and Enclosures | Weatherproof, lockable | 5 sets | 1:5 |
| 16 | Conduit and Trunking | Assorted sizes for wire management | As needed | As needed |
| 17 | Cable Ties, Connectors, and Lugs | Variety pack for secure electrical connections | As needed | As needed |
| 18 | Safety Labels and Tags | Assorted electrical hazard labels | 25 pcs | 1:1 |
| 19 | DC Cables | Proper gauge for low voltage applications | As needed | As needed |
| 20 | Battery Banks | Rechargeable, assorted capacities | 5 sets | 1:5 |
| 21 | Solar Panel Mounts and Brackets | Adjustable for solar panel installation | 5 sets | 1:5 |
| 22 | Scaffolding | Modular, adjustable height for safe access | 2 sets | 1:13 |
| **D** | **Testing & Measurement** |  |  |  |
| 23 | Multimeters | Digital, auto-ranging with multiple test functions | 10 pcs | 1:3 |
| 24 | Projector | High-resolution for presentations | 1 pc | 1 per class |
| 25 | Insulation Resistance Testers | 500V, accurate insulation resistance measurement | 5 pcs | 1:5 |
| 26 | Distribution Boards | With circuit breakers for demonstration purposes | 5 pcs | 1:5 |
| 27 | Switchgear | Assorted for learning different control methods | As needed | As needed |
| 28 | Power Meters | Monitors electrical parameters | 5 pcs | 1:5 |
| 29 | Solar Irradiance Meter | Measures solar panel exposure accurately | 5 pcs | 1:5 |
| 30 | DC Disconnect Switch | Safety switch for DC power | 5 pcs | 1:5 |
| 31 | Battery Tester | Measures voltage and charge level | 5 pcs | 1:5 |
| 32 | Ladders | Adjustable, anti-slip steps | 5 pcs | 1:5 |
| 33 | UPS Units | Backup power, 1000VA capacity | 5 pcs | 1:5 |
| 34 | Power Distribution Units | With surge protection | 5 pcs | 1:5 |
| 35 | Batteries | Assorted types for various testing needs | As needed | As needed |
| 36 | Racks/Cabinets | Secure storage for equipment | As needed | As needed |
| 37 | Inverters | 1000W, pure sine wave | 5 pcs | 1:5 |
| 38 | Solar Panels | Assorted, rated 200W or higher | As needed | As needed |
| 39 | Charge Controllers | For battery charging regulation | 5 pcs | 1:5 |
| **E** | **Documentation** |  |  |  |
| 40 | Manufacturer’s Catalogues | Latest catalogs of electrical components | 5 pcs | 1:5 |
| 41 | Electrical Design Standards | Includes IEEE, IEC guidelines | 5 pcs | 1:5 |
| 42 | Electrical Codebooks | National Electrical Code, BS7671 | 5 pcs | 1:5 |
| 43 | EMCA Act | Environmental guidelines for electrical installations | 5 pcs | 1:5 |
| 44 | OSHA | Safety guidelines for electrical systems | 5 pcs | 1:5 |
| 45 | Cable Sizing Charts | For selecting correct cable gauge | 5 pcs | 1:5 |
| 46 | Cable Specification Catalogs | Specifications for different cable types | 5 pcs | 1:5 |
| 47 | Electrical Load Data Sheets | Load calculations and examples | 5 pcs | 1:5 |
| 48 | Specification Sheets | Manufacturer’s specs for key components | 5 pcs | 1:5 |
| 49 | Electrical Utility Standards | Guidelines from utility providers | 5 pcs | 1:5 |
| 50 | Site Layout Diagrams | Electrical schematics for practice | 5 sets | 1:5 |
| 51 | Solar Power System Sizing Guides | Guides for sizing solar installations | 5 pcs | 1:5 |
| 52 | Battery Storage Design Manuals | Guidelines for setting up battery storage | 5 pcs | 1:5 |

# MODULE THREE

## COMPUTER NETWORKS INSTALLATION

**UNIT CODE:** 0713 441 09A

**Relationship to Occupational Standards**

This unit addresses the unit of competency: Install Computer Networks

**Duration of Unit:** 160 hours

**Unit Description**

This unit specifies competencies required for installing computer networks. These include: conducting computer network site preparation, preparing computer network technical drawing, carrying out computer network structured cabling and installing SOHO networks

**Summary of Learning Outcomes**

By the end of the unit the trainee should be able to:

|  |  |  |
| --- | --- | --- |
| **S/NO** | **LEARNING OUTCOME** | **DURATION (HRS)** |
|  | Conduct Computer Network Site preparation | 10 |
|  | Prepare Computer Network Technical Drawings | 40 |
|  | Carry out Computer Network Structured Cabling | 60 |
|  | Install SOHO networks | 50 |
|  | **TOTAL HOURS** | **160** |

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

|  |  |  |
| --- | --- | --- |
| **Learning Outcome** | **Content** | **Suggested Assessment Methods** |
| 1. Conduct Computer Network Site preparation | * 1. Introduction to network types      1. LAN      2. MAN      3. WAN   2. Introduction to site survey      1. Definition of site survey      2. Terms used in site survey         1. Site Survey         2. Network Topology         3. Coverage Area         4. Bandwidth         5. Latency      3. Components of site survey         1. Physical Layout Assessment         2. Coverage Area Analysis         3. Capacity Planning         4. Power and Cabling Requirements         5. Security      4. Tools and equipment required during site survey         1. Basic tools:  1. Cable strippers, 2. crimping tool, 3. wire cutter, 4. screwdriver set, 5. pliers, 6. cable tester    * + 1. Network installation tools: 7. Cable puller, 8. fish tape, 9. cable labels and markers, 10. cable ties, 11. punch down tool     * + 1. Network testing equipment: 12. Network analyzer, 13. power meter, 14. protocol analyzer     1. Network site preparation and planning        1. Site requirements assessment           1. Number of workstations and devices           2. Required bandwidth and data rates           3. Security requirements           4. Future expansion plans | 1. Practical assessment 2. Project 3. Written assessment 4. Observation 5. Oral questioning 6. Portfolio of evidence 7. Third party report |
| 1. Prepare Computer Network Technical Drawings | * 1. Network topology diagram      1. Types of network topology:         1. Star         2. Bus         3. Ring         4. Mesh         5. Hybrid      2. Components of network topology:         1. Routers         2. Workstations         3. Switches         4. Hubs         5. Access point.         6. Servers      3. Physical and logical topology   2. Site floor plan and layout   3. Cabling diagram      1. Structure cabling representation      2. Cable routing         1. Horizontal         2. Vertical      3. Patch panel and wall jack mapping      4. Cabling diagram components:         1. Ethernet cables,         2. Fiber optic cable         3. Coaxial cables         4. Patch panel         5. Wall jacks         6. conduits      5. Rack elevation diagram:         1. Arrangement of equipment in rack         2. Labelling and color code standards | 1. Practical assessment 2. Project 3. Written assessment 4. Observation 5. Oral questioning 6. Portfolio of evidence 7. Third party report |
| 1. Carry out Computer Network Structured Cabling | * 1. Computer network structured cabling      1. Definition of Structured Cabling      2. Components of structured cabling         1. Patch Panels         2. Cable Trays         3. Conduits and raceways         4. Switches & Routers         5. Network Cabinets and racks         6. Patch cords and jumpers   2. Introduction to Network media      1. Analog and Digital data      2. Analog and Digital Signals      3. Line Coding      4. Multiplexing      5. Types of network cables and their capacities         1. Twisted pair  1. UTP 2. STP    * + 1. Coaxial cable 3. RG 6, 4. RG 11 5. RG 59    * + 1. Fibre optic cable 6. single mode 7. multimode    * 1. Cable standards and application         1. Ethernet cable standards         2. Coaxial cable standards         3. Fiber optic cable standards    1. Cable installation techniques       1. Cable routing and management       2. Cable path planning       3. Distance limitation       4. Securing and protecting cables       5. Environmental consideration    2. Termination Techniques       1. Twisted Pair Cable Termination          1. Attaching RJ45 connectors using crimping tools.          2. Terminating cables on patch panels and keystone jacks       2. Fiber Optic Termination          1. Fusion splicing and mechanical splicing.          2. Attaching fiber connectors (LC, SC).       3. Patch panel and Equipment Termination          1. Connecting terminated cables to patch panels and switches.          2. Routing and securing within cabinets.          3. Labeling standards and documentation       4. Introduction to IP addressing       5. IPv4 and IPv6       6. Sub-netting       7. Private and public IP addressing       8. DHCP and static IP | 1. Practical assessment 2. Project 3. Written assessment 4. Observation 5. Oral questioning 6. Portfolio of evidence 7. Third party report |
| 1. Install SOHO network | * 1. Install SOHO network      1. Introduction to network models         1. OSI model         2. TCP/IP model         3. Comparison of network models.      2. Introduction to network protocols         1. TCP/IP protocol         2. UDP protocol         3. HTTP protocol         4. FTP protocol         5. SMTP         6. DNS         7. Roles of protocols in network communication      3. Definition of SOHO      4. Components of a SOHO network         1. Router         2. Modem         3. Switch         4. Ethernet         5. Firewall      5. Steps in installing SOHO network         1. Setting up internet access         2. Configuring router         3. Setting up wired and wireless connections         4. Testing and troubleshooting network connectivity         5. Documentation | 1. Practical assessment 2. Project 3. Written assessment 4. Observation 5. Oral questioning 6. Portfolio of evidence 7. Third party report |

**Suggested Methods of Instruction**

* + 1. Practical
    2. Project
    3. Demonstration
    4. Group discussion
    5. Direct instruction
    6. Field trips

**Recommended Resources for 25 trainees**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S/No.** | **Category/Item** | **Description/**  **Specifications** | **Quantity** | **Recommended**  **Ratio**  (Item: Trainee) |
| **A** | **Learning Materials** |  |  |  |
|  | Training Manuals | Manuals on network installation, covering topology, configuration, and testing. | 5 copies | 1:5 |
|  | Networking Simulators | Software such as Cisco Packet Tracer or GNS3 | Enough | - |
|  | Network Configuration Guides | Documentation for setting up routers, switches, and firewalls. | 5 copies | 1:5 |
|  | Topology Diagrams | Pre-designed network layout diagrams for training exercises. | 5 copies | 1:5 |
|  | Safety Guidelines | OSHA-compliant guidelines for handling electrical and networking equipment safely. | 5 copies | 1:5 |
|  | Reference Books | Books such as Networking All-in-One For Dummies or CompTIA Network+ Certification Guide. | Online access | - |
|  | Tutorial Videos | Step-by-step video tutorials on cable termination, network setup, and troubleshooting. | Enough | - |
|  | Power point presentations | For trainer’s use | Enough | - |
| **C** | **Learning Facilities & infrastructure** |  |  |  |
|  | Lecture/theory room | 60m2 | 1 | 1:25 |
|  | Workshop | 160m2 | 1 | 1:25 |
|  | Computers and laptop with internet access | Processor: Intel Core i5/i7 or equivalent  RAM: 8GB or higher  Storage: 256GB SSD or higher | 10 pcs | 1:3 |
|  | Projectors | At least 3000 lumens  With HDMI and VGA ports | 1 | 1:25 |
| **D** | **Materials, tools and equipment** |  |  |  |
|  | Ethernet Cables | Cat6a cables | 200 m | 8 m:1 |
|  | Patch Cords | Pre-terminated patch cables with RJ45 connectors, Cat6 standard, lengths from 0.5m to 5m. | 50 pcs each category | 2:1 |
|  | Cable Management Supplies | Velcro straps, cable ties, cable sleeves | Enough | - |
|  | RJ45 Connectors | Compatible with Cat5e/Cat6 cables. | 1000 pcs | 40:1 |
|  | Keystone Jacks | Ethernet jacks for wall plate installation; Cat6 or higher standard. | 500 pcs | 20:1 |
|  | Network Racks | 9U and 12U network racks with mounting brackets and lockable glass doors. | 5 pcs | 1:5 |
|  | Faceplates | Single and dual-port wall plates for Ethernet jack installation. | 200 pcs each category | 8:1 |
|  | Labeling Supplies | Label tapes and markers. | 2 pcs | 1:13 |
|  | Network Switches | Managed and unmanaged switches, 8-port and 24-port models with Gigabit Ethernet. | 4 pcs each category | 1:6.25 |
|  | Routers | Wireless and wired routers with dual-band (2.4 GHz/5 GHz) support and firewall capabilities. | 10 pcs | 1:3 |
|  | Access Points | Wi-Fi 6 or Wi-Fi 5 APs with PoE support for wireless network coverage. | 5 pcs | 1:5 |
|  | Servers | Entry-level servers for network hosting, with Intel Xeon processors and at least 16GB RAM. | 1 pc | 1:25 |
|  | Network Interface Cards | PCIe-based Ethernet adapters supporting Gigabit or 10Gbps speeds. | 5 pcs | 1:5 |
|  | Patch Panels | 24-port and 48-port Cat6 patch panels for central cable management. | 10 pcs | 1:3 |
|  | Modems | DSL, cable, or fiber modems for internet access. | 5 pcs | 1:5 |
|  | UPS Units | Uninterruptible power supplies with minimum 500VA capacity for backup power. | 1 pc | 1:25 |
|  | Crimping Tool | Compatible with RJ45 connectors. | 5 pcs | 1:5 |
|  | Cable Tester | Multi-function cable tester with capability to verify continuity, pin configuration, and speed compatibility. | 5 pcs | 1:5 |
|  | Punch-Down Tool | Capable of terminating wires into keystone jacks and patch panels; includes spare blades. | 5 pcs | 1:5 |
|  | Wire Stripper | Adjustable stripper for Ethernet cables, supporting Cat5e, Cat6, and Cat6a. | 5 pcs | 1:5 |
|  | Label Printer | Portable printer. | 2 pcs | 1:13 |
|  | Multimeter | Digital multimeter capable of testing voltage, current, and continuity of network power supplies. | 10 pcs | 1:3 |
|  | Fiber Optic Splicing Kit | Includes fusion splicer, cleaver, and cleaning tools for fiber optic cable preparation and installation. | 2 pcs | 1:13 |

## ELECTRICAL PRINCIPLES

**UNIT CODE:** 0713 441 06A

**Relationship to Occupational Standards**

This unit addresses the unit of competency: Apply electrical principles

**Unit duration**: 190 hours

**Unit Description:** This unit describes the competencies required by a technician in order to apply Electrical principles in their work. It involves Applying Electrical quantities, using cells and batteries, Apply Concepts of DC circuit, Applying Electrostatics principles, applying magnetism and electromagnetism, applying AC circuits and performing electrical measurements.

**Summary of Learning Outcomes**

By the end of the unit the trainee should be able to:

|  |  |  |
| --- | --- | --- |
| **S/NO** | **LEARNING OUTCOME** | **DURATION (HRS)** |
|  | Apply Electrical quantities | 10 |
|  | Use cells and batteries | 10 |
|  | Apply Concepts of DC circuit | 40 |
|  | Apply Electrostatics principles | 30 |
|  | Apply magnetism and electromagnetism | 40 |
|  | Apply AC circuits | 30 |
|  | Perform electrical measurements | 30 |
|  | **TOTAL HOURS** | **190** |

**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  1. Voltmeters 2. Ammeters 3. Ohmmeters 4. Multimeters 5. Power meters 6. Oscilloscope | 1. Written assessment 2. Oral assessment 3. Practical 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. Nickel-Cadmium (NiCd) Batteries         1. Advantages and disadvantages         2. Applications      3. Nickel-Metal Hydride (NiMH) Batteries         1. Advantages and disadvantages         2. Applications      4. Lithium-Ion (Li-ion) Batteries         1. Advantages and disadvantages         2. Applications      5. Lithium-Polymer (Li-Po) Batteries         1. Advantages and disadvantages         2. Applications   6. Battery Maintenance and Safety | 1. Written assessment 2. Oral assessment 3. Practical 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 assessment 3. Practical 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         5. Filters using capacitors         6. Power factor correction      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 assessment 3. Practical 4. Project 5. Third party report 6. Portfolio of evidence |
| 1. Apply magnetism and electromagnetism | * 1. Introduction to Magnetism      1. Definition of terms         1. Magnetism         2. Magnetic field         3. Magnetic field lines         4. Magnetic field strength units         5. Magnetization   2. Magnetism and magnetic fields      1. Types of Magnetic Materials:         1. Ferromagnetic         2. Paramagnetic         3. Diamagnetic.         4. 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         1. Ampere’s Law         2. Faraday’s Law of Electromagnetic Induction         3. Lenz’s Law         4. Magnetic Flux      6. Applications of Electromagnetism         1. Transformers         2. Electric Motors and Generators         3. Relays and Solenoids         4. Magnetic Storage   4. Magnetic Circuits and Permeability      1. Introduction to Magnetic Circuits         1. Definition and components of magnetic circuits.         2. Difference between magnetic and electric circuits.         3. Overview of magnetic flux, MMF, reluctance, and permeability.      2. Magnetic Flux and MMF         1. Magnetic flux calculation and interpretation.         2. Concepts of magnetomotive force (MMF) and its importance in magnetic circuits.         3. Introduction to magnetic field strength (H) and flux density (B).      3. Permeability and Reluctance         1. Definition of permeability and how it affects magnetic materials.         2. Reluctance calculation and role in magnetic circuits.      4. Ohm’s Law for Magnetic Circuits         1. Application of Ohm’s Law analogy to magnetic circuits.         2. Calculation exercises​.         3. Analyzing magnetic circuit diagrams.      5. Transformer and Motor Magnetic Circuits         1. Components of a Transformer  1. Primary windings 2. Secondary windings 3. Core materials    * + 1. Application of magnetic circuits in transformers.        2. Overview of DC and AC motor magnetic circuits        3. Operational principles of DC and AC motor magnetic circuits.      1. Inductors         1. Magnetic circuits in inductors         2. Relationship between inductance, flux linkage, and stored energy.         3. Hands-on inductor circuit building and testing.         4. Applications of inductors 4. Filter circuits 5. 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. Practical 2. Project 3. Third party report 4. Portfolio of evidence 5. Written tests 6. Oral questioning |
| 1. Apply AC circuits | 1. Introduction to AC Circuits 2. Definitions and characteristics of AC vs. DC 3. Historical context and significance of AC power 4. Applications of AC in modern technology 5. Fundamental Concepts of AC 6. Waveforms: Sinusoidal, square, triangular, and sawtooth 7. Frequency, period, amplitude, and phase 8. Phasors: Representation of AC signals, phasor addition 9. Complex Numbers and Phasor Analysis 10. Basics of complex numbers 11. Impedance, reactance, and resistance in AC circuits 12. Converting between time domain and phasor domain 13. Circuit Elements in AC 14. Resistors, inductors, and capacitors in AC 15. Impedance calculations for R, L, and C 16. Series and parallel combinations of RLC circuits 17. AC Circuit Analysis Techniques 18. Ohm's Law in AC circuits 19. Kirchhoff's laws for AC circuits 20. Nodal and mesh analysis in AC circuits 21. Thevenin's and Norton's Theorems in AC analysis 22. Power in AC Circuits 23. Real, reactive, and apparent power calculations 24. Power factor and its significance 25. Power factor correction 26. Three-phase AC systems: Delta and wye connection 27. Frequency Response and Resonance 28. Resonance in RLC circuits 29. Bandwidth and quality factor (Q) 30. Series and parallel resonance 31. Applications of resonance in tuning circuits 32. Transformers 33. Principles of operation 34. Turns ratio and voltage transformation 35. Efficiency and losses in transformers 36. Applications of transformers in AC circuits 37. AC Circuit Theorems and Calculations 38. Superposition theorem in AC circuits 39. Maximum power transfer theorem 40. AC circuit simplification techniques 41. Measurement Techniques 42. Instruments for measuring AC voltage and current (multimeters, oscilloscopes) 43. Phase measurement and power factor meters 44. Harmonics and distortion analysis in AC systems 45. Applications of AC Circuits 46. Electric power generation and distribution 47. AC motors and generators 48. Audio and communication systems 49. Switch-mode power supplies and inverters | 1.Practical  2.Project  3.Third party report  4.Portfolio of evidence  5.Written tests  Oral questioning |
| 1. Perform electrical measurements | * 1. Introduction to Electrical Measurements      1. Importance of Electrical Measurements         1. Role in system maintenance and troubleshooting.         2. Applications in industrial telecommunication and electrical systems.      2. Overview of Measurement Quantities         1. Voltage, current, resistance, power, energy, frequency, phase and RMS values.         2. Difference between AC and DC         3. Waveforms: sine, square, triangular   2. Metering Circuits      1. Basic meter movement         1. PMMC         2. Moving iron         3. Electrodynamometer      2. D'Arsonval meter movement      3. Series and shunt resistance connections   3. Electrical Measuring Instruments      1. Classification of Instruments         1. Analog vs. Digital instruments.         2. Absolute and secondary instruments.      2. Analog Meters         1. PMMC meters         2. Moving iron meters         3. Electrodynamometer meters         4. Multimeters      3. Digital Meters         1. Digital multimeter (DMM)         2. Basic meter movement         3. Digital storage oscilloscope (DSO)         4. Clamp meter         5. Power analyzer      4. Specialized Instruments         1. LCR meter         2. Frequency counter         3. Function generator      5. Electrical instruments selection Criteria      6. Instrument Calibration         1. Calibration Standards  1. Primary and secondary standards 2. Calibration procedures    * 1. Measuring instrument range extension Methods         1. Shunts and Multipliers 3. Principle and design. 4. Application in extending current and voltage ranges.    * + 1. Use of Current Transformers (CTs) and Potential Transformers (PTs).    1. Electrical Measurements Techniques       1. Voltage          1. Using voltmeters (analog and digital)          2. Voltage divider circuits       2. Current          1. Using ammeters (analog and digital)          2. Current shunt       3. Resistance          1. Using ohmmeters          2. Wheatstone bridge       4. Power          1. Wattmeter method          2. Two-wattmeter method       5. Frequency          1. Using frequency counters       6. Phase angle measurements          1. Using oscilloscopes and phase meters    2. Measurement Errors       1. Types of errors          1. Systematic errors: Instrument, environmental, and observational.          2. Random errors.          3. Gross errors.       2. Sources of Errors in measuring instruments       3. Error Mitigation Techniques       4. Calculations Involving Instruments and Errors          1. Measurement of unknown quantities using known resistances, voltages, and currents.          2. Scaling factors for extended ranges.          3. Absolute error, relative error, and percentage error.    3. Propagation of errors in measurement systems | 1. Written assessment 2. Oral assessment 3. Practical 4. Project 5. Third party report 6. Portfolio of evidence |

**Suggested Delivery Methods**

* Practical
* Project
* 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 |

## WORK ETHICS AND PRACTICES

**UNIT CODE:** 0417 441 03B

**Duration of Unit:** 40 hours

**Relationship to Occupational Standards**

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

**UNIT DESCRIPTION**

This unit covers competencies required to demonstrate employability skills. It involves the ability to: conduct self-management, promote ethical work practices and values, promote teamwork, manage workplace conflicts, maintain professional and personal development, apply problem-solving, and promote customer care.

**Summary of Learning Outcomes**

By the end of this unit the trainee 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 |  |

# MODULE FOUR

## ELECTRONIC CIRCUITS FABRICATION

**UNIT CODE:** 0714 451 12A

**Relationship to Occupational Standards**

This unit addresses the unit of competency: Fabricate Electronic Circuits

**Unit duration**: 180 Hours

**Unit Description:** This unit covers the competencies required in fabrication of electronic circuits. These competencies include; preparing electronic components, fabricating digital logic circuits, fabricating analogue circuits and fabricating PCB circuits.

**Summary of Learning Outcomes**

By the end of the unit the trainee should able to:

|  |  |  |
| --- | --- | --- |
| **S/NO** | **LEARNING OUTCOME** | **DURATION (HRS)** |
|  | Prepare Electronic Components | 20 |
|  | Fabricate analog circuits | 60 |
|  | Fabricate digital logic circuits | 60 |
|  | Fabricate PCB circuits | 40 |
|  | **TOTAL HOURS** | **180** |

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

|  |  |  |
| --- | --- | --- |
| **Learning Outcome** | **Content** | **Suggested Assessment Methods** |
| 1. Prepare Electronic Components | * 1. Introduction to Electronic Communication Systems      1. Overview of basic electronic components and their characteristics         1. Resistors         2. Capacitors         3. Inductors         4. Diodes         5. Transistors         6. ICs: Op-amps, counters, multivibrators, amplifiers      2. Reading component values      3. Polarity-sensitive components      4. ESD precautions and component storage      5. Active and passive components      6. Power suppliers      7. Linear      8. Switching   2. Radio frequency fundamentals      1. Introduction to radio frequency (RF) signals         1. Definition of Electromagnetic waves         2. Frequency spectrum concepts         3. Significance of Impedance matching      2. Role of RF components         1. Antennas         2. Filters and their applications.         3. Amplifiers | 1. Written assessment 2. Oral assessment 3. Practical 4. Project 5. Third party report 6. Portfolio of evidence |
| 1. Fabricate digital logic circuits | * 1. Introduction to Digital Logic      1. Number Systems and Codes      2. Boolean Algebra and Logic Gates      3. K-map      4. Logic Gates Implementation         1. Transistor-level         2. ICs   2. Combinational Circuit Design      1. Multiplexers and Demultiplexers      2. Encoders and Decoders      3. Adders and Subtractors      4. Arithmetic Logic Units (ALUs)      5. Combinational Circuit Design and Analysis Techniques      6. Introduction to Programmable Logic Devices (PLDs)   3. Sequential Circuit Design      1. Latches and Flip-Flops (SR, D, JK, T)      2. Registers      3. Counters: Asynchronous and Synchronous      4. Shift Registers      5. Finite State Machines (FSMs)      6. Sequential Circuit Design and Analysis Techniques   4. Digital Logic Circuit Design and Simulation Tools      1. Introduction to a specific CAD tool: EAGLE, Logisim      2. Basic operations: project creation, file management, simulation setup      3. Introduction to Circuit Simulation Software: SPICE, LTSpice      4. Producing Printed Circuit Boards (PCBs   5. Digital Logic Circuit Implementation      1. Breadboarding Techniques      2. Prototyping Boards and Kits      3. Soldering techniques      4. Introduction to PCB Design      5. Using Digital Logic ICs      6. Interfacing with Microcontrollers and   6. Digital electronic circuit tests      1. Importance of testing      2. Types of digital circuit tests         1. Functional testing         2. Input/Output Verification         3. Truth Table Testing         4. Sequential Logic Testing      3. Reporting and Documentation         1. Results, and observations | 1. Written assessment 2. Oral assessment 3. Practical 4. Project 5. Third party report 6. Portfolio of evidence |
| 1. Fabricate Analog circuits | * 1. Foundational Concepts      1. Semiconductor Physics         1. Energy bands, doping, PN junctions         2. Diode characteristics, applications         3. Bipolar Junction Transistors (BJTs): structure, operation, biasing         4. Field-Effect Transistors (FETs): MOSFETs, JFETs, operation, biasing      2. Operational Amplifiers (Op Amps)         1. Ideal op-amp model         2. Inverting, non-inverting, and summing amplifiers         3. Differential amplifiers         4. Filters: low-pass, high-pass, band-pass         5. Oscillators         6. Comparators      3. Signal Analysis         1. Signal types: DC, AC, sinusoidal, square, triangular         2. Noise sources and their effects   2. Analog Circuit Design      1. Amplifier Design         1. Small-signal amplifiers: common emitter, common source         2. Power amplifiers: class A, B, AB         3. Feedback amplifiers         4. Stability and oscillation      2. Filter Design         1. Active filters: using op-amps         2. Passive filters: using RLC components         3. Switched-capacitor filters      3. Data Converters         1. Analog-to-Digital Converters (ADCs): sampling, quantization, resolution         2. Digital-to-Analog Converters (DACs)      4. Oscillator Design         1. LC oscillators         2. Crystal oscillators   3. Testing and Measurement      1. Measurement Instruments         1. Oscilloscope         2. Function generator         3. Multimeter         4. Spectrum analyzer         5. Network analyzer      2. Testing Procedures         1. DC and AC measurements         2. Noise and distortion measurements         3. Frequency response measurements         4. Troubleshooting techniques         5. Automated test equipment (ATE) | 1. Written assessment 2. Oral assessment 3. Practical 4. Project 5. Third party report 6. Portfolio of evidence |
| 1. Fabricate PCB circuits | * 1. PCB Materials & Components      1. Types of boards and copper cladding         1. Single-sided, double-sided, multilayer         2. Overview of fabrication steps      2. Identifying electronic components      3. Understanding datasheets and packaging types   2. Tools and Equipment      1. Soldering iron, desoldering pump, hot air station      2. Magnifier, tweezers, multimeter, test jigs      3. Safety gear and ESD protection   3. PCB Material Preparation      1. Handling blank PCBs      2. Cleaning PCBs before assembly      3. Applying solder mask      4. Silkscreen usage   4. Assembly Process      1. Through-hole mounting techniques      2. Surface mount (SMD) techniques      3. Using tweezers, magnifiers, and reflow stencils      4. Reflow soldering overview      5. Wire harnessing and header alignment   5. Soldering & Rework Techniques      1. Lead and lead-free solder differences      2. Temperature control & tip care      3. Manual and hot-air soldering      4. Soldering fine-pitch ICs and connectors      5. Heat-sensitive component handling      6. Desoldering and component replacement      7. Preventing cold solder joints & solder bridges      8. Desoldering and rework best practices   6. Assembly of Full Circuit Boards      1. Interpreting BOM (Bill of Materials) and layout      2. Populating and assembling a functional circuit   7. Inspection & Testing      1. Cleaning agents and techniques      2. Visual inspection standards (IPC-A-610 basic intro)      3. Electrical continuity and functionality testing   8. Maintenance & Troubleshooting      1. Diagnosing common fabrication faults      2. Replacing and re-soldering components      3. Record keeping and quality logs | 1. Written assessment 2. Oral assessment 3. Practical 4. Project 5. Third party report 6. Portfolio of evidence |

**Suggested Delivery Methods**

* Practical
* Project
* 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 | Digital Design by M. Morris Mano and Michael D. Ciletti  Digital Fundamentals by Thomas L. Floyd | 5 pcs  5 pcs | 1:5  1:5 |
| **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  1:2.5 |
|  | 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 | 25 pcs | 1:1 |
|  | PCB prototyping machine | Specifications: CNC router for PCB, precision ±0.01mm, spindle speed 20,000 RPM | 1 pc | 1:25 |
|  | Printed Circuit Boards | Single-sided, double-sided, and multi-layer PCBs  Specifications: FR4 material, 1.6mm thickness, copper thickness 1oz | 100 pcs each category | 4:1 |
|  | 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 | 1:2.5 |
|  | Power supply | Specifications: Dual output, 0-30V, 0-5A, adjustable | 10 pcs | 1:2.5 |
|  | Component tester | Specifications: Test resistors, capacitors, inductors, diodes, transistors | 5 pcs | 1:5 |
|  | Microscope | Specifications: 10x - 40x magnification, LED illumination | 5 pcs | 1:5 |
|  | Magnifying lamps | Specifications: 5x magnification, adjustable arm | 25 pcs | 1:1 |
|  | PCB etching tank | Specifications: 300mm x 200mm, temperature control, bubble agitation | 5 pcs | 1:5 |
|  | Etching solution | Specifications: Ferric chloride or sodium persulfate | 20 litres | 1:1.25 |
|  | Drilling machine | Specifications: Precision PCB drill, drill bits 0.8mm - 1.5mm | 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 | 1:2.5 |
|  | Wrist straps | Specifications: Adjustable, grounding cord with 1MΩ resistor | 25 pcs | 1:1 |
|  | Logic analyzer | Specifications: 16 channels, 100MHz sampling rate, USB interface | 5 pcs | 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 |
|  | Strip boards |  | 200 | 1:8 |
|  | Logic gates ICs | Specifications: 74HC series (7400, 7402, 7404, 7408, 7432) | 100 pcs each category | 4:1 |
|  | 100 Light Emitting Diodes | Red/yellow/green/white | 100 pcs each category | 4:1 |
|  | Flip-flops IC | Specifications: 74HC series (7474, 7476) | 100 pcs each category | 4:1 |
|  | Counters and register ICs | Specifications: 74HC series (7490, 7493, 74161, 74164) | 100 pcs each category | 4:1 |
|  | Multiplexers and demultiplexers ICs | Specifications: 74HC series (74151, 74154) | 100 pcs each category | 4:1 |
|  | Encoders and Decoders ICs | Specifications: 74HC series (74138, 74147) | 100 pcs each category | 4:1 |
|  | Analog-to-digital converters | Specifications: 8-bit, 10-bit, 12-bit resolution, various interfaces (I2C, SPI) | 50 pcs each category | 2:1 |
|  | Digital-to-analog converters | Specifications: 8-bit, 10-bit, 12-bit resolution, various interfaces (I2C, SPI) | 50 pcs each category | 2:1 |
|  | Microcontrollers | Specifications: 8-bit (ATmega328), 16-bit (MSP430), 32-bit (ARM Cortex-M) | 25 pcs each category | 1:1 |
|  | Development boards | Specifications: Arduino, Raspberry Pi, STM32 Nucleo, including necessary accessories (sensors, shields) | 25 sets each category | 1:1 |
| **D** | **Software** |  |  |  |
|  | PCB design software | Eagle, KiCad, Altium Designer  Specifications: Ability to design schematic diagrams and PCB layouts | Installed in 25 computers | 1:1 |
|  | Simulation software | LTSpice, Proteus and Multisim  Specifications: Simulate electronic circuits, support for various components and models | Installed in 25 computers | 1:1 |
|  | Programming tools  Arduino IDE | Specifications: Integrated development environment for Arduino boards | Installed in 25 computers | 1:1 |
|  | Keil uVision | Specifications: IDE for ARM microcontroller programming | Installed in 25 computers | 1:1 |

## COMMUNICATION SKILLS

**UNIT CODE:** 0031 441 02B

**Duration of Unit:** 40 hours

**Relationship to Occupational Standards**

This unit addresses the Unit of Competency: Apply Communication Skills

**UNIT DESCRIPTION**

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

**Summary of Learning Outcomes**

By the end of the unit the trainee 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 441 04B

**Duration of unit:** 40 hours

**Relationship to occupational standards**

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

**UNIT DESCRIPTION**

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

**Summary of Learning Outcomes**

By the end of the unit the trainee 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 |  |

# MODULE FIVE

## TELECOMMUNICATION PRINCIPLES

**UNIT CODE:** 0714 441 07A

**Relationship to Occupational Standards**

This unit addresses the unit of competency: Apply telecommunication principles

**Unit duration**: 80 hours

**Unit Description:**

This unit covers the competencies required to apply knowledge of allocation of frequency and measuring instruments, apply transmission line principles and apply antennas principles.

**Summary of Learning Outcomes**

By the end of the unit the trainee should be able to:

|  |  |  |
| --- | --- | --- |
| **S/NO** | **LEARNING OUTCOME** | **DURATION (HRS)** |
|  | Apply knowledge of allocation of frequency and measuring instruments | 20 |
|  | Apply transmission line principles | 20 |
|  | Apply antennas principles | 40 |
|  | **TOTAL HOURS** | **80** |

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

|  |  |  |
| --- | --- | --- |
| **Learning Outcome** | **Content** | **Suggested Assessment Methods** |
| 1. Apply knowledge of allocation of frequency and measuring instruments | * 1. Logarithmic units      1. Reasons for using logarithmic units      2. Analysis of various logarithmic units         1. The decibel (dB)         2. Reference levels: The dBm, dBr, dBW, dBuV         3. The Neper   2. Measuring instruments      1. Telecommunication measuring instruments         1. The network analyser         2. The spectrum analyser         3. The frequency counter         4. The RF power meter         5. OTDR         6. RF and AF signal generators         7. Bit Error Rate Tester (BERT)         8. Level meter   3. Practical Application and Measurement Techniques      1. Measuring Signal Levels in Telecommunication Systems      2. Troubleshooting Telecommunication Networks Using Measurements      3. Calibrating Telecommunication Instruments   4. Concept of Frequency allocation and licensing      1. Reasons for radio frequency allocation      2. Radio-frequency bands and their applications: VLF, LF, MF, HF, VHF, UHF, SHF, EHF   5. Regulatory bodies      1. ITU      2. CAK      3. Roles of CAK and ITU | 1. Practical 2. Project 3. Third party report 4. Portfolio of evidence 5. Written tests 6. Oral questioning |
| 1. Apply transmission line principles | * 1. Introduction to Transmission Lines      1. Definition of transmission lines.      2. Importance in telecommunication systems.      3. Types of transmission media: copper, fiber optics, coaxial cables, wireless transmission   2. Basic Components of Transmission Lines      1. Conductors, insulation, dielectric materials.      2. Structure and design of telecommunication transmission lines.   3. Types of Transmission Lines in Telecommunications      1. Twisted Pair Cables      2. Coaxial Cables      3. Fiber Optic Cables      4. Wireless Transmission Lines   4. Transmission Line Characteristics      1. Impedance Matching         1. Importance of matching impedance.         2. Reflection and standing waves      2. Attenuation and Signal Loss         1. Factors affecting signal loss in transmission lines         2. Calculation of attenuation over distance.         3. Methods to minimize signal degradation.      3. Capacitance and Inductance         1. Impact of capacitance and inductance on signal transmission.         2. Role of capacitance and inductance in signal distortion and phase shifting.   5. Transmission Line Performance and Testing      1. Bandwidth and Data Rate         1. Relationship between transmission line bandwidth and data-carrying capacity.         2. Calculating data rate based on bandwidth and signal type (analog vs. digital).      2. Line Testing and Fault Diagnosis         1. Tools for testing transmission lines: time-domain reflectometer (TDR), network analyzer.         2. Identifying faults: short circuits, open circuits, signal loss.      3. Signal Integrity and Noise Management         1. Noise types: external interference, thermal noise, cross-talk.         2. Techniques to maintain signal integrity: shielding, grounding, proper termination.   6. Applications of Transmission Lines in Modern Telecommunication Systems      1. Transmission Lines in Telephony      2. Transmission Lines in Data Communication      3. Transmission Lines in Broadcasting         1. Role in distributing TV, radio, and satellite signals.         2. Application in transmitting signals to base stations in broadcasting systems.   7. Future Trends in Telecommunication Transmission Lines      1. Advances in Fiber Optics         1. New materials and technologies for faster data transmission.         2. Impact of 5G and fiber optics in future telecommunication networks.      2. Integration of Wireless Technologies         1. Role of transmission lines in supporting wireless infrastructure         2. Wireless backhaul and its dependence on transmission line infrastructure. | 1. Practical 2. Project 3. Third party report 4. Portfolio of evidence 5. Written tests 6. Oral questioning |
| 1. Apply antennas principles | * 1. Radio wave propagation modes      1. Introduction to radio wave propagation modes         1. Definition of radio waves         2. Fundamentals of electromagnetic wave propagation         3. Importance of propagation modes in communication      2. Types of Radio Wave Propagation         1. Ground Wave Propagation  1. Characteristics and applications 2. Surface waves and their behaviour 3. Factors affecting ground wave transmission    * + 1. Sky Wave Propagation 4. Reflection and refraction in the ionosphere 5. Layers of the ionosphere (D, E, F1, F2) 6. Daytime vs. nighttime propagation effects 7. Skip distance and critical frequency 8. Applications in long-distance communication    * + 1. Space Wave Propagation 9. Line-of-sight (LOS) communication 10. Tropospheric refraction and ducting 11. Use in VHF, UHF, and satellite communication     * 1. Factors Affecting Radio Wave Propagation          1. Atmospheric conditions: temperature, humidity, pressure          2. Terrain and obstacles          3. Frequency and wavelength considerations          4. Interference and signal attenuation     1. Introduction to Antennas        1. Definition of Antenna        2. Antenna as a Transducer        3. Basic Structure           1. Dipole           2. Parabolic Reflector           3. Yagi-Uda Antenna     2. Key antenna parameters        1. Radiation Pattern        2. Directivity        3. Bandwidth        4. Beamwidth        5. Gain        6. Polarization        7. Impedance matching        8. Effective aperture        9. Antenna efficiency        10. Standing wave ratio (SWR)     3. Types of Antennas        1. Omnidirectional Antennas:        2. Directional Antennas        3. Yagi-Uda Antenna        4. Parabolic Dish Antenna        5. Horn Antennas        6. Patch/ Microstrip Antennas        7. Log-Periodic Antenna     4. Antenna Frequency spectrum concepts        1. Antenna resonant Frequency        2. Antenna Length           1. Dipole Antenna           2. Monopole Antenna        3. Antenna Frequency Range        4. Application           1. Antenna tunning: Length vs operating frequency     5. Types of Antenna Feeders        1. Coaxial Cable           1. Advantages           2. Applications           3. Types: 50 Ω and 75 Ω Coaxial Cables        2. Twisted Pair           1. Advantages           2. Applications        3. Balanced Feeders (Twin-lead)           1. Advantages           2. Applications        4. Waveguides           1. Advantages           2. Applications        5. Fiber Optic Cable           1. Advantages           2. Applications     6. Key Considerations for Antenna Feeders        1. Impedance Matching           1. Importance           2. Mismatch Consequences        2. Losses           1. Definition           2. Factors Influencing Losses: Frequency, Feeder Length, Feeder Quality           3. Mitigation        3. Velocity factor     7. Applications of Antenna Feeders        1. Broadcasting systems        2. Satellite Systems.        3. Wi-Fi Networks | 1. Practical 2. Project 3. Third party report 4. Portfolio of evidence 5. Written tests 6. Oral questioning |

**Suggested Delivery Methods**

* Practical
* Project work
* Demonstration
* Discussions
* Direct instruction
* Field visits
* Case studies

**List Recommended Resources for 25 trainees**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S/No.** | **Category/Item** | **Description/**  **Specifications** | **Quantity** | **Recommended**  **Ratio**  (Item: Trainee) |
| **A** | **Learning Materials** |  |  |  |
|  | Textbooks | Telecommunication Systems Engineering by Roger Freeman or equivalent detailed coverage of telecommunication principles. | 5 pcs | 1:5 |
|  | Posters and Diagrams | Visual aids for fiber optic cable structures, modulation types, network topologies, and RF spectrum allocation | Enough | - |
|  | Simulation Software | MATLAB, Simulink, or OPNET | - | - |
|  | Standards Documents | ITU-T and IEEE standards for telecommunication protocols, cabling, and signal integrity. | Enough | - |
|  | Power point presentations | For trainer’s use | 1 | 1:25 |
|  | **Learning Facilities & infrastructure** |  |  |  |
|  | Lecture/theory room | 60m2 | 1 | 1:25 |
|  | General fitting workshop  (Equipped with tools, equipment and consumables indicated in C and D) | 160m2 | 1 | 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 |
| **B** | **Tools and Equipment** |  |  |  |
|  | Spectrum Analyzer | Measuring frequency ranges up to 3 GHz for RF and microwave signal analysis. | 2 pcs | 1:13 |
|  | Network Analyzers | Handheld network analyzers | 2 pcs | 1:13 |
|  | Signal Generators | RF signal generators with adjustable frequencies from 1Hz to 1GHz for testing and calibration | 5 pcs | 1:5 |
|  | Time Domain Reflectometer (TDR) | Cable faults and measuring cable lengths. | 2 pcs | 1:13 |
|  | Cable Testers | With capability for continuity, attenuation, and signal integrity testing in coaxial, twisted-pair, and fiber. | 5 pcs | 1:5 |
|  | Crimping Tools | Capable of terminating RJ45, RJ11, and coaxial connectors. | 5 pcs | 1:5 |
|  | Wire Stripper | Adjustable strippers for coaxial, twisted-pair, and fiber optic cables. | 5 pcs | 1:5 |
|  | Punch Down Tools | Capable of terminating cables into patch panels and telephone jacks. | 5 pcs | 1:5 |
|  | Screwdrivers | Insulated sets | 2 sets | 1:13 |
|  | Multimeter | Digital multimeter capable of measuring voltage, current, resistance, and frequency. | 5 pcs | 1:5 |
|  | Oscilloscopes | Digital oscilloscopes with bandwidth up to 100MHz for signal analysis. | 5 pcs | 1:5 |
| **C** | **Consumable materials** |  |  |  |
|  | Coaxial Cables | RG6 and RG58 cables for RF signal transmission | 100 m each category | 4m:1 |
|  | Twisted Pair Cables | CAT5e and CAT6 UTP and STP cables for Ethernet and voice transmission | 300 m | 12m:1 |
|  | Transmission line training kits | * Frequency range: DC to 2 GHz. * Line types: Coaxial, twin-wire, and microstrip line samples. * Includes SWR meter, signal source, and TDR module. * Visual representation of reflection coefficients and impedance mismatches. | 5 pcs | 1:5 |
|  | Antenna training kit | * Antenna Types: Yagi-Uda, patch, horn, parabolic, and dipole antennas. * Frequency range: 100 MHz to 10 GHz. * Gain: 3 dBi to 15 dBi depending on antenna type. * Includes mounting kits and rotation mechanisms | 5 pcs | 1:5 |

## EMBEDDED AND RF CIRCUIT FABRICATION

**UNIT CODE:** 0714 551 16A

**Relationship to Occupational Standards**

This unit addresses the unit of competency: Fabricate Embedded and RF Circuits

**Unit duration**: 230 Hours

**Unit Description:** This unit covers the competencies required in Fabrication of Embedded and RF circuits. These competencies include; designing Printes Circuit Boards, constructing Microcontroller-based systems, fabricating RF communication circuits and maintaining electronic circuits

**Summary of Learning Outcomes**

By the end of the unit the trainee should able to:

|  |  |  |
| --- | --- | --- |
| **S/NO** | **LEARNING OUTCOME** | **DURATION (HRS)** |
|  | Design Printed Circuit Boards | 60 |
|  | Construct Microcontroller-based systems | 80 |
|  | Fabricate RF Communication Circuits | 80 |
|  | Maintain electronic circuits | 10 |
|  | **TOTAL HOURS** | **230** |

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

|  |  |  |
| --- | --- | --- |
| **Learning Outcome** | **Content** | **Suggested Assessment Methods** |
| 1. Design Printed Circuit Boards | * 1. Fundamentals of PCB Design      1. Introduction to PCB Design         1. Purpose and application of PCBs         2. PCB types: Single-layer, double-layer, multilayer         3. Understanding PCB stack-up and materials      2. Electronic Schematics         1. Reading and creating circuit diagrams         2. Electronic symbols and net connections         3. Using schematic capture tools      3. Component Libraries & Footprints         1. Creating and managing component libraries         2. Assigning footprints to schematic symbols         3. Common footprint standards (IPC - 7351)      4. Design Rules & Constraints         1. Trace width, clearance, via size         2. Net class assignment         3. Electrical and mechanical design constraints      5. PCB Design Tools Introduction         1. Overview of PCB CAD software: KiCad / Eagle / Altium         2. Schematic to PCB layout process         3. User interface walkthrough   2. PCB Layout & Routing      1. Board Outline & Layer Setup         1. Creating the board shape         2. Layer stack configuration         3. Ground and power planes      2. Component Placement Strategies         1. Best practices for analog/digital separation         2. Placement for signal integrity and thermal performance         3. Design for testability and assembly      3. Signal Routing Techniques         1. Manual and auto-routing         2. Routing single-sided and double-sided boards         3. Differential pair and impedance matching basics      4. Power Distribution & Grounding         1. Ground loops, star grounding         2. Power planes and decoupling capacitors         3. High current trace design      5. Design Validation & DRC Checks         1. Design Rule Check (DRC) and Electrical Rule Check (ERC)         2. Gerber file generation         3. Bill of Materials (BOM) creation      6. MI/EMC Considerations         1. Shielding, filtering, and layout strategies         2. Controlled impedance design         3. Avoiding crosstalk and noise      7. Thermal Management         1. Heat sink layout         2. Thermal vias         3. Placement for heat-sensitive components   3. PCB Design Project      1. Complete design of a simple functional circuit         1. Power supply         2. Motor controller      2. Walkthrough from schematic to Gerber | 1. Written assessment 2. Oral assessment 3. Practical 4. Project 5. Third party report 6. Portfolio of evidence |
| 1. Construct Microcontroller-based systems | * 1. Introduction to Microcontrollers      1. Definition and key components: CPU, memory, peripherals      2. Comparison with microprocessors      3. Applications in various domains: industrial, automotive, consumer electronics      4. Microcontroller Architectures         1. Memory organization: ROM, RAM, EEPROM         2. Interrupts and interrupt handling   2. Microcontroller Selection and Development Tools      1. Selecting Microcontroller         1. Factors to consider         2. Microcontroller families: Arduino, Raspberry Pi, PIC, AVR, STM32      2. Development Tools         1. Integrated Development Environments (IDEs)         2. Compilers, assemblers, debuggers         3. In-circuit debuggers (ICDs) and emulators         4. Programmers and development boards   3. Programming Microcontrollers      1. C/C++ programming for microcontrollers         1. Data types, variables, operators, control flow         2. Functions, pointers, structures, and unions         3. Writing and debugging C/C++ programs for microcontroller      2. Interfacing with Peripherals         1. Digital I/O: input and output pins         2. Analog-to-Digital Converters (ADCs)         3. Digital-to-Analog Converters (DACs)         4. Timers/Counters         5. Serial Communication (UART, SPI, I2C)         6. Pulse Width Modulation (PWM)         7. Interrupts and interrupt service routines (ISRs)   4. Microcontroller-Based System Design      1. System Design Process         1. Requirements analysis and specification         2. Block diagram and system architecture         3. Hardware and software design considerations         4. Prototyping and iteration      2. Hardware Design         1. Circuit schematics and PCB layout         2. Component selection and placement         3. Power supply design         4. Sensor and actuator interfacing   5. Fabrication and Testing      1. Fabrication Techniques         1. PCB fabrication methods         2. Soldering techniques         3. Assembly and testing of prototypes      2. Testing and Debugging         1. Hardware testing: using Multimeter, oscilloscopes, logic analyzers         2. Software debugging         3. Troubleshooting techniques   6. Modern trends in microcontroller systems      1. Wireless Communication         1. Bluetooth, Wi-Fi, Zigbee, LoRa         2. Implementing wireless communication in microcontroller-based systems      2. Embedded Systems         1. Real-time operating systems (RTOS)         2. Networked embedded systems         3. Industrial control systems      3. Internet of Things (IoT)         1. IoT concepts and architectures         2. Microcontrollers in IoT applications         3. Cloud connectivity for IoT devices | 1. Written assessment 2. Oral assessment 3. Practical 4. Project 5. Third party report 6. Portfolio of evidence |
| 1. Fabricate RF Communication Circuits | * 1. Fundamentals of Radio Frequency (RF)      1. RF Components         1. Passive components: resistors, capacitors, inductors at RF frequencies         2. Transmission lines: microstrip, coaxial, waveguide         3. Resonant circuits: LC circuits, cavity resonators         4. Active components: RF transistors, diodes      2. RF Measurements**.**         1. Basic RF measurement techniques: power, frequency, impedance         2. RF measurement instruments: spectrum analyzers, network analyzers, power meter   2. RF Circuit Design      1. Amplifier Design      2. Oscillator Design         1. LC oscillators (Colpitts, Hartley)         2. Crystal oscillators         3. Voltage-Controlled Oscillators (VCOs)      3. Mixer Design         1. Frequency mixing principles         2. Diode mixers         3. Balanced mixers      4. Filter Design         1. RF filters (low-pass, high-pass, band-pass)         2. Filter design techniques (Butterworth, Chebyshev)      5. Antenna Fundamentals         1. Basic antenna types: dipole, monopole, patch         2. Antenna parameters: gain, directivity, impedance         3. Antenna matching and impedance transformation   3. RF Circuit Fabrication      1. Printed Circuit Board (PCB) Design for RF         1. High-frequency PCB design considerations         2. Grounding and shielding techniques         3. Impedance control techniques (microstrip lines)      2. RF Module Assembly         1. Soldering RF PCB circuits         2. Surface Mount Technology (SMT) for RF components         3. Shielding and grounding techniques for RF modules         4. Testing and troubleshooting RF assemblies   4. RF System Applications      1. Wireless Communication Systems         1. Cellular networks (GSM, LTE, 5G)         2. Wi-Fi and Bluetooth         3. Radio and television broadcasting      2. Radar Systems      3. Satellite Communication   5. RF Testing and Measurement      1. RF Test Equipment         1. Spectrum analyzers, network analyzers, power meter         2. Signal generators, noise sources      2. RF Test Procedures         1. Gain measurements         2. Noise figure measurements         3. Intermodulation distortion measurements         4. Impedance matching measurements         5. Antenna measurements | 1. Written assessment 2. Oral assessment 3. Practical 4. Project 5. Third party report 6. Portfolio of evidence |
| 1. Maintain electronic circuits | * 1. Importance of electronic circuit maintenance   2. Electronic circuits troubleshooting      1. Common electronic circuit faults         1. Open circuit         2. Short circuit         3. Thermal failure         4. Component faults         5. Soldering issues         6. Power supply problems         7. Broken traces         8. Incorrect wiring         9. Loose connections         10. Aging and wear      2. Troubleshooting Procedures         1. Interpreting schematics         2. Visual checks         3. Power supply check         4. Signal tracing         5. Component testing         6. Faulty component replacement   3. Electronic circuit general maintenance tasks      1. Inspection      2. Component replacement      3. Cleaning      4. Component testing      5. Temperature monitoring      6. Solder joint repair      7. Testing circuit performance   4. Maintenance documentation      1. Importance of maintenance reports      2. Maintenance logs      3. Component replacement record      4. Keeping schematics, datasheets and user manuals | 1. Written assessment 2. Oral assessment 3. Practical 4. Project 5. Third party report 6. Portfolio of evidence |

**Suggested Delivery Methods**

* Practical
* Project
* 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 | Digital Design by M. Morris Mano and Michael D. Ciletti  Digital Fundamentals by Thomas L. Floyd | 5 pcs  5 pcs | 1:5  1:5 |
| **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  1:2.5 |
|  | 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 | 25 pcs | 1:1 |
|  | PCB prototyping machine | Specifications: CNC router for PCB, precision ±0.01mm, spindle speed 20,000 RPM | 1 pc | 1:25 |
|  | Printed Circuit Boards | Single-sided, double-sided, and multi-layer PCBs  Specifications: FR4 material, 1.6mm thickness, copper thickness 1oz | 100 pcs each category | 4:1 |
|  | 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 | 1:2.5 |
|  | Power supply | Specifications: Dual output, 0-30V, 0-5A, adjustable | 10 pcs | 1:2.5 |
|  | Component tester | Specifications: Test resistors, capacitors, inductors, diodes, transistors | 5 pcs | 1:5 |
|  | Microscope | Specifications: 10x - 40x magnification, LED illumination | 5 pcs | 1:5 |
|  | Magnifying lamps | Specifications: 5x magnification, adjustable arm | 25 pcs | 1:1 |
|  | PCB etching tank | Specifications: 300mm x 200mm, temperature control, bubble agitation | 5 pcs | 1:5 |
|  | Etching solution | Specifications: Ferric chloride or sodium persulfate | 20 litres | 1:1.25 |
|  | Drilling machine | Specifications: Precision PCB drill, drill bits 0.8mm - 1.5mm | 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 | 1:2.5 |
|  | Wrist straps | Specifications: Adjustable, grounding cord with 1MΩ resistor | 25 pcs | 1:1 |
|  | Logic analyzer | Specifications: 16 channels, 100MHz sampling rate, USB interface | 5 pcs | 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 |
|  | Strip boards |  | 200 | 1:8 |
|  | Logic gates ICs | Specifications: 74HC series (7400, 7402, 7404, 7408, 7432) | 100 pcs each category | 4:1 |
|  | 100 Light Emitting Diodes | Red/yellow/green/white | 100 pcs each category | 4:1 |
|  | Flip-flops IC | Specifications: 74HC series (7474, 7476) | 100 pcs each category | 4:1 |
|  | Counters and register ICs | Specifications: 74HC series (7490, 7493, 74161, 74164) | 100 pcs each category | 4:1 |
|  | Multiplexers and demultiplexers ICs | Specifications: 74HC series (74151, 74154) | 100 pcs each category | 4:1 |
|  | Encoders and Decoders ICs | Specifications: 74HC series (74138, 74147) | 100 pcs each category | 4:1 |
|  | Analog-to-digital converters | Specifications: 8-bit, 10-bit, 12-bit resolution, various interfaces (I2C, SPI) | 50 pcs each category | 2:1 |
|  | Digital-to-analog converters | Specifications: 8-bit, 10-bit, 12-bit resolution, various interfaces (I2C, SPI) | 50 pcs each category | 2:1 |
|  | Microcontrollers | Specifications: 8-bit (ATmega328), 16-bit (MSP430), 32-bit (ARM Cortex-M) | 25 pcs each category | 1:1 |
|  | Development boards | Specifications: Arduino, Raspberry Pi, STM32 Nucleo, including necessary accessories (sensors, shields) | 25 sets each category | 1:1 |
| **D** | **Software** |  |  |  |
|  | PCB design software | Eagle, KiCad, Altium Designer  Specifications: Ability to design schematic diagrams and PCB layouts | Installed in 25 computers | 1:1 |
|  | Simulation software | LTSpice, Proteus and Multisim  Specifications: Simulate electronic circuits, support for various components and models | Installed in 25 computers | 1:1 |
|  | Programming tools  Arduino IDE | Specifications: Integrated development environment for Arduino boards | Installed in 25 computers | 1:1 |
|  | Keil uVision | Specifications: IDE for ARM microcontroller programming | Installed in 25 computers | 1:1 |

# MODULE SIX

## TELEPHONY SYSTEMS INSTALLATION

**UNIT CODE:** 0612 551 17A

**Relationship to Occupational Standards**

This unit addresses the of competency: Install Telephony System

**Unit duration**: 180 hours

**Unit Description**

This unit specifies competences required for Conducting Telephone System Site survey, Preparing Telephone System Technical Drawings, Preparing Telephone System Equipment, Installing PABX systems, Installing VoIP systems and Installing mobile Communication Systems.

**Summary of Learning Outcomes**

By the end of the unit the trainee should be able to:

|  |  |  |
| --- | --- | --- |
| **S/NO** | **LEARNING OUTCOME** | **DURATION (HRS)** |
|  | Conduct telephone system site survey | 10 |
|  | Prepare telephone systems technical drawings | 40 |
|  | Prepare telephone System Equipment | 10 |
|  | Install PABX systems | 40 |
|  | Install VoIP systems | 40 |
|  | Install mobile Communication Systems | 40 |
|  | **TOTAL HOURS** | **180** |

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

|  |  |  |
| --- | --- | --- |
| **Learning Outcome** | **Content** | **Suggested Assessment Methods** |
| 1. Conduct Telephone System Site survey | 1. Telephone System Components    * 1. Antennas (Types, Gain, Polarization)      2. Transceivers      3. Cables and Connectors      4. Power Supplies 2. Site Survey Planning and Preparation    * 1. Importance of Telephone System site survey      2. Site Survey Tools and Equipment         1. RF Site Survey Equipment: Spectrum Analyzers, Signal Generators, Power Meters         2. GPS Devices         3. Cameras         4. Safety Equipment: Hard Hats, Safety Vests, Safety Boots 3. RF Site Survey Techniques    * 1. RF Signal Strength Measurements         1. Using RF Meters and Spectrum Analyzers         2. Identifying Signal Sources and Strengths      2. Interference Analysis         1. Identifying Interference Sources         2. Analyzing Interference Impact on System Performance         3. Identification of obstacles and reflections      3. Building Penetration Loss Measurements         1. Using RF Signal Strength Measurements Inside and Outside Buildings         2. Evaluating Building Materials and Construction Impact on Signal Propagation    1. Site Selection Criteria       1. Factors Affecting Site Selection       2. Site Selection Guidelines          1. Maximizing Signal Coverage and Capacity          2. Minimizing Interference          3. Ensuring Safety and Security          4. Optimizing Cost and Time    2. Data collection and documentation       1. Data Collection          1. Recording Site Information: location, coordinates, elevation          2. Collecting RF Signal Strength Measurements          3. Capturing Photographs and Videos       2. Data Analysis and Reporting          1. Analyzing RF Data to Identify Coverage Gaps and Interference          2. Preparing Site Survey Reports          3. Providing Recommendations for System Design and Deployment | 1. Written assessment 2. Oral assessment 3. Practical 4. Project 5. Third party report 6. Portfolio of evidence |
| 1. Prepare Telephone System Technical Drawings | * 1. Technical Drawing Standards and Symbols      1. Industry Standards         1. IEEE         2. TIA/EIA         3. IEC      2. Common Symbols and Notations         1. Electronic Components         2. Antennas         3. Cables and Connectors         4. Power Supplies         5. Grounding and Shielding      3. CAD Software Basics         1. Introduction to CAD Software  1. AutoCAD 2. Visio    * + 1. Basic CAD Operations 3. Drawing Creation and Editing 4. Layer Management 5. Dimensioning and Annotation 6. Printing and Plotting    1. Block Diagrams       1. Purpose of Block Diagrams       2. Creating Block Diagrams          1. Selecting symbols          2. Arranging blocks and connecting them with lines          3. Adding labels and annotations    2. Schematic Diagrams       1. Purpose of Schematic Diagrams       2. Creating Schematic Diagrams          1. Using standard electrical symbols          2. Drawing circuit components and interconnections          3. Adding component values and ratings          4. Using hierarchical design for complex systems    3. Wiring Diagrams       1. Purpose of Wiring Diagrams       2. Creating Wiring Diagrams          1. Using cable symbols and connectors          2. Indicating cable lengths and types          3. Labelling cable terminals and connectors          4. Using cable tray and conduit symbols    4. Layout Drawings       1. Purpose of Layout Drawings       2. Creating Layout Drawings          1. Using floor plans and site maps          2. Placing equipment symbols and cable trays          3. Indicating power and grounding connections          4. Adding dimensions and annotations    5. Documenting Technical Drawings       1. Adding titles, revision history, and author information       2. Including a drawing index       3. Providing clear and concise annotations    6. Adhering to Standards       1. Industry standards for symbols, notations, and formatting       2. Clarity and consistency in drawings | 1. Written assessment 2. Oral assessment 3. Practical 4. Project 5. Third party report 6. Portfolio of evidence |
| 1. Prepare Telephone System Equipment | * 1. Prepare Telephone System Equipment      1. Identification of Key Broadcasting Systems components         1. Telephone Handset         2. Mobile Phones         3. PABX Phones         4. VoIP Phones      2. Identification of Key GSM System components         1. Base transceiver stations (BTS)         2. Network and switching subsystem         3. Antennas         4. Switches         5. Tower         6. Transmission Lines and waveguides         7. Transceivers   2. Equipment Sourcing and Procurement      1. Factors to consider in Sourcing and Procurement of equipment      2. Equipment Pre-installation Testing and Calibration      3. Planning equipment logistics and storage | 1. Written assessment 2. Oral assessment 3. Practical 4. Project 5. Third party report 6. Portfolio of evidence |
| 1. Install PABX systems | * 1. Introduction to PABX Systems      1. Definition and function of PABX      2. History and Evolution of PBX (Analog → Digital → VoIP)      3. Types of PABX Systems:         1. Analog PABX         2. Digital PABX         3. IP PABX (VoIP-based)         4. Cloud PABX   2. Analog PBX Systems      1. Operation of Analog PABX      2. Components of an Analog PABX System:         1. PABX Control Unit         2. POTS (Plain Old Telephone Service) Lines         3. Extension Phones         4. Trunk Lines      3. Call Routing in Analog PABX      4. Features of Analog PABX:         1. Call Transfer         2. Voicemail         3. Hold         4. Conference      5. Limitations of Analog PABX      6. Digital PABX vs. Analog PABX      7. Digital Signalling         1. TDM         2. ISDN      8. Integrating Analog Phones with Digital PABX   3. PABX Installation & Configuration      1. Setting Up an Analog PABX System      2. Wiring and Connecting Extensions & Trunks   4. PABX Security & Maintenance      1. Security Risks in PABX Systems (Toll Fraud, Hacking, Eavesdropping)      2. Best Practices for Securing PABX Systems      3. Troubleshooting Common PABX Issues      4. Backup & Disaster Recovery for PABX      5. Upgrading from Analog PABX to VoIP | 1. Written assessment 2. Oral assessment 3. Practical 4. Project 5. Third party report 6. Portfolio of evidence |
| 1. Install VoIP systems | 1. Fundamental Concepts of VoIP systems    * 1. Features of VoIP systems:         1. Cost Savings         2. Scalability         3. Flexibility         4. Advanced Features         5. Integration      2. Types of VoIP systems:         1. On-Premises VoIP         2. Cloud-Based VoIP (Hosted PBX)         3. Hybrid VoIP      3. Components of a VoIP System:         1. VoIP Phones         2. Session Initiation Protocol (SIP)         3. Gateways         4. Network Infrastructure      4. Considerations when selecting a VoIP System:         1. Internet Connection Quality         2. Compatibility         3. Security    1. Setup mini–SIP Server    2. Connect local users to mini–SIP Server    3. Connect mini–SIP Server to VoIP providers' network    4. Deploy network services    5. Test, commission and run installed VoIP system    6. Document installed VoIP system | 1. Written assessment 2. Oral assessment 3. Practical 4. Project 5. Third party report 6. Portfolio of evidence |
| 1. Install Mobile Communication Systems | * 1. Fundamental Concepts of GSM System      1. GSM System Architecture         1. Base Station Subsystem (BSS)         2. Network and Switching Subsystem (NSS)         3. Core Network      2. GSM Protocols         1. Layer 1 (Physical Layer)         2. Layer 2 (Data Link Layer)         3. Layer 3 (Network Layer)   2. Installation Site Planning      1. Site Selection Criteria         1. Population Density         2. Terrain and Topography         3. Interference Sources         4. Power Supply Availability         5. Regulatory Considerations      2. Site Planning         1. Antenna Mounting and Orientation         2. Cable Routing         3. Power Distribution         4. Installation Safety Considerations   3. Base Transceiver Station (BTS) Installation      1. BTS Components         1. Transceiver Modules         2. Antenna Systems         3. Power Supplies         4. Control Units      2. BTS Installation         1. Mounting Antennas         2. Installing Transceiver Modules         3. Connecting Power Supplies and Cables         4. Configuring BTS Parameters: Frequency, Power, Modulation   4. Base Station Controller (BSC) Installation and Configuration      1. BSC Functions      2. BSC Installation         1. Rack Mounting         2. Cable Connections         3. Power Supply Connection      3. BSC Configuration         1. Network Parameters         2. Alarm Thresholds         3. Performance Monitoring   5. Transmission and Distribution Network      1. Transmission Media         1. Fiber Optic Cables         2. Microwave Links      2. Transmission Network Design         1. Network Topology         2. Link Budget         3. Network Redundancy      3. Transmission Equipment Installation         1. Fiber Optic Splicing         2. Microwave Antenna Alignment         3. Power Supply Connection   6. System Integration and Testing      1. System Integration         1. Connecting BTSs to the BSC         2. Integrating the GSM Network with the Core Network         3. Configuring Interfaces: SS7, IP      2. System Testing         1. Drive Tests         2. Performance Measurement: Call Drop Rate, BER         3. Interference Analysis         4. Handover Testing   7. Operation and Maintenance      1. Network Monitoring         1. Real-time Monitoring Tools         2. Performance Metrics         3. Fault Detection and Alarm Handling      2. Network Optimization         1. Cell Planning and Optimization         2. Frequency Planning         3. Power Control      3. Maintenance Procedures         1. Preventive Maintenance         2. Corrective Maintenance | 1. Written assessment 2. Oral assessment 3. Practical 4. Project 5. Third party report 6. Portfolio of evidence |

**Suggested Methods of Instruction**

* + 1. Practical
    2. Project
    3. Demonstration
    4. Group discussion
    5. Direct instruction
    6. Case studies
    7. Field visits
    8. Industry visits

**List of Recommended Resources for 25 Trainees**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S/No.** | **Category/Item** | **Description/**  **Specifications** | **Quantity** | **Recommended**  **Ratio**  (Item: Trainee) |
| **A** | **Learning Materials** |  |  |  |
|  | Training Manuals | Detailed manuals on GSM system installation, configuration, and troubleshooting.  Step-by-step guides specific to broadcast communication systems | 5 copies of each | 1:5 |
|  | Safety Procedures | Guidelines for electrical safety and working at heights | 5 copies | 1:5 |
|  | Tutorial Videos | For trainer’s use | Enough | - |
|  | 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 |
|  | Computers with internet access | Processor: Intel Core i5/i7 or equivalent  RAM: 8GB or higher  Storage: 256GB SSD or higher | 25 pcs | 1:25 |
| **C** | **Consumable materials** |  |  |  |
|  | Coaxial Cables | RG-6, RG-11, and RG-59 coaxial cables with connectors like F-type and BNC. | 100 m each category | 4 m:1 |
|  | Connectors and Adapters | BNC, SMA, N-type, and UHF connectors for different cable types. | 10 pcs each category | 1:2.5 |
|  | Antenna Mounts | Adjustable and weather-resistant mounts. | 5 pcs | 1:5 |
|  | Cable Clips and Ties | UV-resistant cable ties and clips | Enough | - |
|  | Lightning Arresters | Surge protectors designed for RF systems, handling frequencies up to 3 GHz. | 5 pcs | 1:5 |
|  | Fiber Optic Cables | Multimode and single-mode cables | 100 m | 4 m:1 |
|  | RJ45 and RJ11 Cables | Cat5e and Cat6 cables. | 200 m | 8 m:1 |
|  | RF Cables | Low-loss RF cables (LMR-400) | 100 m | 4 m:1 |
|  | Base Station Antennas | Omni-directional and sector antennas for GSM signal broadcasting; frequency range 800 MHz to 2600 MHz. | 1 pc | 1:25 |
|  | Repeater Systems | RF repeaters for extending GSM coverage in weak signal areas. | 1 pc | 1:25 |
| **D** | **Equipment and tools** |  |  |  |
|  | Oscilloscope | Digital or analog oscilloscope with bandwidth of 50 MHz or higher for signal analysis. | 2 pcs | 1:12.5 |
|  | Multimeter | Digital multimeter with capability to measure voltage, current, resistance, and continuity. | 10 pcs | 1:2.5 |
|  | RF Signal Generators | Generating RF signals from 100 kHz to 1 GHz. | 5 pcs | 1:5 |
|  | Spectrum Analyzer | Frequency range of 9kHz to 3GHz for analyzing RF signals. | 2 pcs | 1:12.5 |
|  | Field Strength Meter | Handheld | 2 pcs | 1:12.5 |
|  | Access to BTS (Base Transceiver Station) | GSM base stations for signal transmission and reception; power output and frequency configuration options. | 1 pc | 1:25 |
|  | Access to MSC (Mobile Switching Center) | Managing call routing and switching. | 1 pc | 1:25 |
|  | Access to RF Test Equipment | Includes network analyzers, signal generators, and site master tools for system verification. | 1 pc | 1:25 |
|  | Access to Power Amplifiers | Amplifiers for boosting GSM signal transmission; frequency range 900 MHz to 1800 MHz. | 1 pc | 1:25 |
|  | Access to GPS Synchronizers | Devices for synchronizing GSM base stations. | 1 pc | 1:25 |
|  | Battery Backup Systems | UPS units and battery banks for power redundancy. | 1 pc | 1:25 |
|  | Soldering Iron Kit | Soldering tools for connecting cables and components; 25W to 60W adjustable temperature range. | 5 pcs | 1:5 |
|  | Drill Machine | Cordless or corded drills with bits suitable for antenna and mount installation. | 2 pcs | 1:12.5 |
|  | Crimping Tools | Capable of crimping RF connectors like BNC and SMA. | 5 pcs | 1:5 |
|  | Coaxial Cable Strippers | Adjustable | 5 pcs | 1:5 |

## BROADCASTING COMMUNICATION SYSTEMS INSTALLATION

**UNIT CODE:** 0714 551 13A

**Relationship to Occupational Standards**

This unit addresses the of competency: Install Broadcasting Communication systems

**Unit duration**: 160 hours

**Unit Description**

This unit specifies competences required for installing communication systems. These include: apply radio frequency broadcasting concepts, conduct communication system site survey, prepare communication system technical drawings and set-up broadcasting communication systems.

**Summary of Learning Outcomes**

By the end of the unit the trainee should be able to:

|  |  |  |
| --- | --- | --- |
| **S/NO** | **LEARNING OUTCOME** | **DURATION (HRS)** |
|  | Apply radio frequency broadcasting concepts | 60 |
|  | Conduct communication system Site survey | 10 |
|  | Prepare Communication System Technical Drawings | 20 |
|  | Set up Broadcasting Communication Systems | 70 |
|  | **TOTAL HOURS** | **160** |

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

|  |  |  |
| --- | --- | --- |
| **Learning Outcome** | **Content** | **Suggested Assessment Methods** |
| 1. Apply radio frequency broadcasting concepts | * 1. Radio Frequency Transmitters and Receivers      1. Definition of RF Transmitters and RF Receivers      2. General RF transmitter and RF receiver block diagrams      3. Radio Frequency (RF) Transmitters         1. Block diagram and Operation of AM and FM transmitters         2. Applications of AM and FM transmitters   2. Signal Modulation principles      1. Reasons for modulation      2. Amplitude Modulation (AM)         1. AM waveform and derivation of AM equation         2. Modulation index and bandwidth         3. Applications         4. Demonstration of AM         5. Advantages and disadvantages      3. Angle modulation         1. Introduction to angle modulation         2. FM and PM equations         3. FM frequency spectrum         4. FM Power distribution         5. Narrow band FM vs Wideband FM         6. Applications         7. Demonstration of FM         8. Advantages and disadvantages      4. Concepts of digital signal modulation schemes         1. ASK         2. FSK         3. PSK         4. QAM      5. Pulse code modulation         1. PCM concepts  1. Sampling 2. Quantization 3. Encoding    * + 1. Advantages and disadvantages of PCM        2. Applications of PCM 4. Telephony systems 5. Audio Recording 6. Broadcasting 7. Data Transmission    1. Radio Receivers       1. Block diagram and operation of FM receivers          1. Superheterodyne Receiver          2. Direct Conversion Receiver          3. FM receivers Circuits       2. AM Receivers          1. TRF (Tuned Radio Frequency) Receiver          2. Regenerative Receiver          3. Super regenerative Receiver       3. Receiver Parameters          1. Sensitivity          2. Selectivity          3. Noise Figure          4. Dynamic Range    2. Applications of RF broadcasting systems       1. Broadcast Radio systems          1. Advantages and disadvantages of AM broadcasting          2. Advantages and disadvantages of FM broadcasting          3. Shortwave Radio Broadcasting       2. TV broadcast systems          1. Key components of television transmitters and receivers          2. Video signal generation and transmission          3. Digital television broadcasting (DVB, ATSC)          4. Terrestrial Transmission          5. Satellite Transmission coverage.          6. Antenna systems for television reception       3. Two-Way Radio          1. Simplex, half-duplex, and full-duplex operation          2. Frequency allocation and channel selection          3. Types of Two-Way Radios: Mobile radios, Portable radios, Base stations and repeaters          4. Applications of Two-Way Radio       4. Military Communication systems          1. Types of Military Communication Systems 8. HF/VHF/UHF radios 9. Satellite communication system | 1. Written assessment 2. Oral assessment 3. Practical 4. Project 5. Third party report 6. Portfolio of evidence |
| 1. Conduct broadcasting communication system Site survey | * 1. Communication System Components      1. Antennas (Types, Gain, Polarization)      2. Transceivers      3. Cables and Connectors      4. Power Supplies   2. Site Survey Planning and Preparation   3. Importance communication system site survey   4. Site Survey Tools and Equipment      1. RF Site Survey Equipment: Spectrum Analyzers, Signal Generators, Power Meters      2. GPS Devices      3. Cameras      4. Safety Equipment: Hard Hats, Safety Vests, Safety Boots   5. RF Site Survey Techniques      1. RF Signal Strength Measurements         1. Using RF Meters and Spectrum Analyzers         2. Identifying Signal Sources and Strengths      2. Interference Analysis         1. Identifying Interference Sources         2. Analyzing Interference Impact on System Performance         3. Identification of obstacles and reflections      3. Building Penetration Loss Measurements         1. Using RF Signal Strength Measurements Inside and Outside Buildings         2. Evaluating Building Materials and Construction Impact on Signal Propagation   6. Site Selection Criteria      1. Factors Affecting Site Selection      2. Site Selection Guidelines         1. Maximizing Signal Coverage and Capacity         2. Minimizing Interference         3. Ensuring Safety and Security         4. Optimizing Cost and Tim   7. Data collection and documentation      1. Data Collection         1. Recording Site Information: location, coordinates, elevation         2. Collecting RF Signal Strength Measurements         3. Capturing Photographs and Videos   8. Data Analysis and Reporting      + 1. Analyzing RF Data to Identify Coverage Gaps and Interference        2. Preparing Site Survey Reports        3. Providing Recommendations for System Design and Deployment | 1. Written assessment 2. Oral assessment 3. Practical 4. Project 5. Third party report 6. Portfolio of evidence |
| 1. Prepare Communication System Technical Drawings | * 1. Technical Drawing Standards and Symbols      1. Industry Standards         1. IEEE         2. TIA/EIA         3. IEC      2. Common Symbols and Notations         1. Electronic Components         2. Antennas         3. Cables and Connectors         4. Power Supplies         5. Grounding and Shielding      3. CAD Software Basics         1. Introduction to CAD Software  1. AutoCAD 2. Visio    * + 1. Basic CAD Operations 3. Drawing Creation and Editing 4. Layer Management 5. Dimensioning and Annotation 6. Printing and Plotting    1. Block Diagrams       1. Purpose of Block Diagrams       2. Creating Block Diagrams          1. Selecting symbols          2. Arranging blocks and connecting them with lines          3. Adding labels and annotations    2. Schematic Diagrams       1. Purpose of Schematic Diagrams       2. Creating Schematic Diagrams          1. Using standard electrical symbols          2. Drawing circuit components and interconnections          3. Adding component values and ratings          4. Using hierarchical design for complex systems    3. Wiring Diagrams       1. Purpose of Wiring Diagrams       2. Creating Wiring Diagrams          1. Using cable symbols and connectors          2. Indicating cable lengths and types          3. Labelling cable terminals and connectors          4. Using cable tray and conduit symbols    4. Layout Drawings       1. Purpose of Layout Drawings       2. Creating Layout Drawings          1. Using floor plans and site maps          2. Placing equipment symbols and cable trays          3. Indicating power and grounding connections          4. Adding dimensions and annotations    5. Documenting Technical Drawings       1. Adding titles, revision history, and author information       2. Including a drawing index       3. Providing clear and concise annotations    6. Adhering to Standards       1. Industry standards for symbols, notations, and formatting       2. Clarity and consistency in drawings | 1. Written assessment 2. Oral assessment 3. Practical 4. Project 5. Third party report 6. Portfolio of evidence |
| 1. Set up Broadcasting Communication Systems | * 1. Installation Site Planning      1. Antenna Mounting and Orientation      2. Cable Routing      3. Power Distribution      4. Installation Safety Considerations   2. Transmitter Installation and Configuration      1. Transmitter Selection      2. Power Output      3. Frequency Range      4. Modulation Type      5. Transmitter Installation         1. Mounting the Transmitter         2. Connecting Power Supply and Antenna         3. Configuring Transmitter Parameters: Frequency, Power, Modulation.      6. RF Power Amplifier Installation         1. Mounting the Amplifier         2. Connecting to the Transmitter and Antenna         3. Configuring Amplifier Parameters: Gain, Power Output   3. Antenna Installation and Alignment      1. Antenna Selection considerations         1. Antenna Type: Dipole, Yagi-Uda, Parabolic, horn         2. Gain         3. Beamwidth         4. Polarization         5. Radiation pattern      2. Antenna Installation         1. Mounting broadcasting Antenna         2. Adjusting Antenna Tilt and Azimuth         3. Connecting the Antenna to the Transmission Line      3. Antenna Alignment         1. Using Field Strength Meter         2. Optimizing Antenna Pattern         3. Minimizing Interference   4. Transmission Line Installation and Termination      1. Transmission Line Selection:         1. Type: Coaxial Cable, Waveguide         2. Impedance         3. Attenuation      2. Transmission Line Installation:         1. Cable Routing and Support         2. Cable Termination: Connectors, Terminators         3. Impedance Matching   5. Studio Equipment Setup and Configuration      1. Audio Equipment         1. Microphones         2. Mixers         3. Audio Processors         4. Amplifiers      2. Video Equipment:         1. Cameras         2. Video Mixers         3. Video Processors      3. Studio Layout and Acoustics:         1. Soundproofing         2. Cable Management         3. Lighting   6. System Testing and Commissioning      1. RF Signal Measurements         1. Field Strength Measurements         2. Signal-to-Noise Ratio         3. Carrier-to-Noise Ratio      2. Audio and Video Quality Testing         1. Distortion Measurement         2. Frequency Response         3. Signal-to-Noise Ratio      3. System Integration and Optimization         1. Fine-tuning Transmitter and Receiver Settings         2. Adjusting Antenna Alignment         3. Optimizing Audio and Video Signal Levels   7. Documentation and Commissioning      1. Recording test results      2. Coverage area verification      3. Submission of documentation for regulatory approval. | 1. Written assessment 2. Oral assessment 3. Practical 4. Project 5. Third party report 6. Portfolio of evidence |

**Suggested Methods of Instruction**

* + 1. Practical
    2. Project
    3. Demonstration
    4. Group discussion
    5. Direct instruction
    6. Case studies
    7. Field visits
    8. Industry visits

**List of Recommended Resources for 25 Trainees**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S/No.** | **Category/Item** | **Description/**  **Specifications** | **Quantity** | **Recommended**  **Ratio**  (Item: Trainee) |
| **A** | **Learning Materials** |  |  |  |
|  | Training Manuals | Detailed manuals on Broadcasting system installation, configuration, and troubleshooting.  Step-by-step guides specific to broadcast communication systems | 5 copies of each | 1:5 |
|  | Safety Procedures | Guidelines for electrical safety and working at heights | 5 copies | 1:5 |
|  | Tutorial Videos | For trainer’s use | Enough | - |
|  | 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 |
|  | Computers with internet access | Processor: Intel Core i5/i7 or equivalent  RAM: 8GB or higher  Storage: 256GB SSD or higher | 25 pcs | 1:25 |
| **C** | **Consumable materials** |  |  |  |
|  | Coaxial Cables | RG-6, RG-11, and RG-59 coaxial cables with connectors like F-type and BNC. | 100 m each category | 4 m:1 |
|  | Waveguides | Rectangular and circular waveguides | 10 pcs each category | 1:3 |
|  | Connectors and Adapters | BNC, SMA, N-type, and UHF connectors for different cable types. | 10 pcs each category | 1:3 |
|  | Antenna Mounts | Adjustable and weather-resistant mounts. | 5 pcs | 1:5 |
|  | Cable Clips and Ties | UV-resistant cable ties and clips | Enough | - |
|  | Lightning Arresters | Surge protectors designed for RF systems, handling frequencies up to 3 GHz. | 5 pcs | 1:5 |
|  | Fiber Optic Cables | Multimode and single-mode cables | 100 m | 4 m:1 |
|  | RJ45 and RJ11 Cables | Cat5e and Cat6 cables. | 200 m | 8 m:1 |
|  | RF Cables | Low-loss RF cables (LMR-400) | 100 m | 4 m:1 |
| **D** | **Equipment and tools** |  |  |  |
|  | Oscilloscope | Digital or analog oscilloscope with bandwidth of 50 MHz or higher for signal analysis. | 2 pcs | 1:13 |
|  | Multimeter | Digital multimeter with capability to measure voltage, current, resistance, and continuity. | 10 pcs | 1:3 |
|  | Broadcast Transmitters | FM/AM transmitters with adjustable power output, frequency range of 88 MHz to 108 MHz for FM. | 1 pc | 1:25 |
|  | Antenna Systems | Yagi, parabolic, and log-periodic antennas | 1 pc | 1:25 |
|  | Audio Processors | Supporting analog and digital inputs. | 1 pc | 1:25 |
|  | RF Signal Generators | Generating RF signals from 100 kHz to 1 GHz. | 5 pcs | 1:5 |
|  | Spectrum Analyzer | Frequency range of 9kHz to 3GHz for analyzing RF signals. | 2 pcs | 1:13 |
|  | Field Strength Meter | Handheld | 2 pcs | 1:13 |
|  | Access to RF Test Equipment | Includes network analyzers, signal generators, and site master tools for system verification. | 1 pc | 1:25 |
|  | Battery Backup Systems | UPS units and battery banks for power redundancy. | 1 pc | 1:25 |
|  | Antenna Alignment Tools | Digital inclinometers and compasses. | 5 pcs each category | 1:5 |
|  | Soldering Iron Kit | Soldering tools for connecting cables and components; 25W to 60W adjustable temperature range. | 5 pcs | 1:5 |
|  | Drill Machine | Cordless or corded drills with bits suitable for antenna and mount installation. | 2 pcs | 1:13 |
|  | Crimping Tools | Capable of crimping RF connectors like BNC and SMA. | 5 pcs | 1:5 |
|  | Coaxial Cable Strippers | Adjustable | 5 pcs | 1:5 |
|  | Network Switches | Managed Computer network switches | 5 pcs | 1:5 |

## WIRELESS TRANSMISSION LINKS INSTALLATION

**UNIT CODE:** 0714 551 14A

**Relationship to Occupational Standards**

This unit addresses the unit of competency: Install Wireless Transmission Links

**Duration of Unit:** 140 hours

**Unit Description**

This unit specifies competences required for installing wireless transmission links. These include conducting wireless transmission link site survey, preparing transmission link technical drawings, preparing transmission link equipment, installing microwave transmission link, installing satellite transmission link and installing Radar systems.

**Summary of Learning Outcomes**

By the end of the unit the trainee should be able to:

|  |  |  |
| --- | --- | --- |
| **S/NO** | **LEARNING OUTCOME** | **DURATION (HRS)** |
|  | Conduct wireless transmission link site survey | 10 |
|  | Prepare wireless transmission link technical drawings | 20 |
|  | Prepare wireless transmission link equipment | 10 |
|  | Install Microwave Transmission Link | 30 |
|  | Install Satellite Transmission Link | 30 |
|  | Install Radar System | 40 |
|  | **TOTAL HOURS** | **140** |

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

|  |  |  |
| --- | --- | --- |
| **Learning Outcome** | **Content** | **Suggested**  **Assessment**  **Methods** |
| 1. Conduct wireless transmission link Site survey | * 1. Introduction to wireless transmission Link      1. Wireless transmission Link Types         1. Microwave         2. Satellite      2. Characteristics and applications of each type      3. Factors influencing link performance         1. Distance         2. Frequency         3. Attenuation         4. Interference         5. Environmental factors (terrain, weather)   2. Communication link site survey      1. Importance of communication link Site Survey      2. Site Survey Equipment and Techniques         1. Survey Equipment  1. GPS/GNSS receivers 2. Theodolites/Total stations 3. Compass 4. Measuring tapes/wheels 5. Cameras 6. Laptop/Tablet with data collection software 7. Signal analyzers 8. Spectrum analyzers 9. Interference detectors 10. RF power meters 11. Satellite signal strength meters     * + 1. Survey Techniques 12. Site Reconnaissance 13. Data Collection 14. Path Profiling 15. Interference Analysis     1. Microwave Link Site Survey considerations        1. Microwave Link Path Profile           1. Fresnel Zone clearance analysis           2. Path loss calculations           3. Effects of terrain and foliage        2. Interference Analysis           1. Identification of potential interference sources           2. Measurement of interference levels           3. Potential challenges        3. Performance requirements        4. Client requirements     2. Satellite Link Site Survey        1. Satellite Visibility Analysis           1. Satellite elevation and azimuth calculations           2. Obstruction analysis (trees, buildings)           3. Rain fade and other atmospheric effects        2. Identification of potential interference sources        3. Performance requirements        4. Client requirements     3. Data Analysis and Reporting        1. Data Analysis           1. Processing and analysis of collected data           2. Link budget calculations           3. Performance predictions           4. Identification of potential problems and mitigation strategies        2. Report Preparation           1. Site survey report documentation 16. Introduction 17. Findings 18. Recommendations 19. Costing 20. Risks and mitigations     * + 1. Maps and diagrams         2. Data tables and graphs         3. Conclusions and recommendations     1. Health and Safety Considerations        1. Working at Heights           1. Fall protection measures           2. Safe climbing and rigging techniques        2. Electrical Safety           1. Working with high voltages           2. Grounding and bonding procedures        3. Radiation Safety           1. RF radiation exposure limits           2. Safety precautions when working with RF equipment | 1. Written assessment 2. Oral assessment 3. Practical 4. Project 5. Third party report 6. Portfolio of evidence |
| 1. Prepare wireless Transmission Link Technical Drawings | * 1. Introduction to Technical Drawing      1. Principles of Technical Drawing         1. Purpose and importance of technical drawings in telecommunications         2. Basic drawing conventions and standards: ISO, ANSI         3. Dimensioning and tolerancing         4. Use of layers and colors   2. Specific Transmission Link Drawings      1. Microwave Links         1. Drawing antenna towers and mounts         2. Representing microwave dishes and waveguide runs         3. Illustrating Fresnel zones and path profiles         4. Creating RF interference maps      2. Satellite Links         1. Drawing satellite ground stations and antennas         2. Representing satellite orbits and coverage areas         3. Illustrating satellite elevation and azimuth angles         4. Creating obstruction analysis diagrams   3. Creation and Management of Drawings      1. Data Collection and Analysis         1. Gathering data from site surveys, design documents, and other sources         2. Analyzing data to determine drawing requirements         3. Creating a drawing plan      2. Drawing Creation Process         1. Creating basic shapes and lines         2. Adding dimensions and annotations         3. Inserting symbols and blocks         4. Creating layers and organizing drawing elements         5. Checking drawings for accuracy and completeness      3. Drawing Management         1. Version control and revision history         2. Archiving and retrieval of drawings         3. Sharing drawings with other team members and stakeholders      4. 3D Modeling         1. Creating 3D models of transmission link components and structures         2. Using 3D modeling software: SolidWorks/Inventor | 1. Written assessment 2. Oral assessment 3. Practical 4. Project 5. Third party report 6. Portfolio of evidence |
| 1. Prepare wireless Transmission Link Equipment | * 1. Introduction to Transmission Link Equipment      1. Microwave Transmission Links equipment         1. Microwave Radio         2. Antennas (Dish, Horn)         3. Waveguides         4. Feedhorns         5. LNA (Low Noise Amplifier)         6. Power Amplifiers         7. Filters         8. Diplexers         9. Frequency Converters         10. Spectrum Analyzer         11. Signal Generator      2. Satellite Transmission Links equipment         1. Satellite Antennas (Dish, Parabolic).         2. Low Noise Block Downconverters (LNBs)         3. High-Power Amplifiers (HPAs)         4. Modems         5. Demodulators         6. Tracking Receivers         7. Uplink Converters         8. Downlink Converters         9. Spectrum Analyzers         10. Signal Generators      3. Equipment Handling and Storage         1. Importance of proper equipment handling and storage         2. Environmental factors affecting equipment: temperature, humidity, vibration         3. Packaging and labeling procedures         4. Planning for Storage facilities and conditions   2. Assembling Tools and Equipment      1. Tool Identification and Usage         1. Common tools used in transmission link installations: wrenches, screwdrivers, torque wrenches, multimeters         2. Safety procedures for handling tools         3. Proper tool usage and maintenance      2. Equipment Inspection and Testing         1. Pre-installation equipment checks         2. Visual inspection for damage or defects         3. Basic functional tests: power-on self-tests, signal checks         4. Calibration and maintenance procedures   3. Tools, Equipment and material Documentation and Record Keeping      1. Importance of effective inventory management      2. Inventory methods         1. First-In, First-Out (FIFO)         2. Last-In, First-Out (LIFO)      3. Inventory Tracking and Record Keeping         1. Automated tracking systems: RFID and Barcodes         2. Inventory cards and sheets | 1. Written assessment 2. Oral assessment 3. Practical 4. Project 5. Third party report 6. Portfolio of evidence |
| 1. Install Microwave Transmission Link | * 1. Introduction to Microwave Transmission Systems      1. Overview of Microwave Transmission         1. Characteristics of microwave signals.         2. Applications of microwave systems in:  1. Telecommunications 2. Broadcasting 3. Data communication    * 1. Components of Microwave Systems         1. Antennas 4. Parabolic 5. Horn    * + 1. Waveguides and cables 6. Types of waveguides and cables 7. Operating principles of waveguides 8. Advantages of waveguides    * + 1. Feedhorns        2. Filters        3. Transmitters and receivers.        4. Power amplifiers        5. Grounding and shielding equipment        6. Supporting structures 9. Towers 10. Mounts     1. Mounting of Microwave Transmission Equipment        1. Antenna Installation           1. Mounting antennas on towers or poles.           2. Aligning antennas for maximum signal strength.           3. Torqueing bolts and fasteners to specifications        2. Waveguide and Cable Installation           1. Connecting waveguides between antennas and transmitters.           2. Securing cables to prevent physical damage and signal loss.        3. Transmitter and Receiver Setup           1. Installing and connecting transmitters and receivers.           2. Ensuring proper grounding and power connections.     2. System Alignment and Testing        1. Antenna Alignment           1. Using alignment tools 11. Sighting compasses 12. Signal meters.     * + 1. Fine-tuning for maximum signal quality and strength.       1. Performance Testing          1. Conducting signal strength tests using spectrum analyzers.          2. Measuring latency, throughput, and error rates.       2. Troubleshooting          1. Identifying common installation issues.          2. Rectifying alignment and connectivity problems.     1. Safety and Compliance        1. Safety Protocols           1. Fall protection and PPE for working at heights.           2. Handling microwave radiation hazards.        2. Compliance Standards           1. Adhering to local and international telecommunication regulations.           2. Maintaining proper documentation for audits.     2. Documentation and Handover        1. Documentation           1. Creating installation checklists and test reports.        2. Handover Process           1. Demonstrating system functionality to clients.           2. Explaining operational and maintenance requirements. | 1. Written assessment 2. Oral assessment 3. Practical 4. Project 5. Third party report 6. Portfolio of evidence |
| 1. Install Satellite Transmission Link | * 1. Introduction to Satellite Transmission Systems      1. Overview of Satellite Communication         1. Satellite orbits  1. Geostationary 2. LEO 3. MEO    * + 1. Satellite frequency bands: C, Ku, Ka, X, L-band        2. Applications of satellites in: 4. Broadcasting 5. Telecommunications 6. Data transfer    * 1. Components of Satellite Communication systems         1. Antennas 7. Parabolic dish 8. Flat panel    * + 1. LNB (Low-Noise Block Downconverter) and BUC (Block Upconverter).        2. Satellite modems and power supplies.        3. Mounting structures and cables.        4. Frequency converters        5. High-Power Amplifiers      1. Understanding Satellite Signals & Link Budgets         1. Uplink and downlink concepts         2. Signal propagation and path loss         3. Link budget analysis    1. Pre-Installation Planning       1. Site Survey and Analysis          1. Tools for site survey 9. GPS 10. Spectrum analyzers 11. Inclinometer     * + 1. Evaluating line-of-sight to satellites.         2. Identifying potential interference sources.       1. Environmental and Structural Considerations          1. Site accessibility and stability for mounting equipment.          2. Weather factors affecting installation and operation.       2. System Layout Planning          1. Equipment positioning based on site constraints.          2. Power and cable routing.     1. Installation of Satellite Transmission Equipment        1. Satellite System antenna Assembly & Alignment           1. Dish mounting and stability           2. Azimuth, elevation, and polarization alignment           3. Using satellite finders and spectrum analyzers        2. RF Equipment Installation           1. Low Noise Block (LNB) and Block Upconverter (BUC) installation           2. Waveguide, coaxial cable, and fiber-optic connections           3. Power supply and grounding requirements        3. Initial Testing & System Calibration           1. Checking signal strength and quality           2. Cross-pol alignment and fine-tuning           3. Troubleshooting common installation issues     2. Configuration & Integration        1. Modem & Network Configuration           1. VSAT modem setup and IP configuration           2. Point-to-multipoint and mesh network setups        2. Integrating with Terrestrial Networks           1. Connecting satellite links to LAN/WAN           2. VPNs and secured satellite communication        3. System Optimization & Troubleshooting           1. Identifying and resolving interference           2. Spectrum analysis and noise filtering           3. Diagnosing component failures (LNB, BUC, modem)           4. Handling rain fade and signal degradation     3. Safety and Compliance        1. Safety Measures           1. PPE and safe working practices.           2. Avoiding RF radiation exposure.        2. Regulatory Compliance           1. Licensing and frequency allocation.           2. Documentation requirements for satellite installations.     4. Documentation and System Handover        1. Documentation           1. Preparing site readiness and installation checklists.           2. Recording test results and system configurations.        2. Client Handover           1. Demonstrating system functionality.           2. Training clients or operators on system use and maintenance. | 1. Written assessment 2. Oral assessment 3. Practical 4. Project 5. Third party report 6. Portfolio of evidence |
| 1. Install radar system | * 1. Fundamentals of Radar Technology      1. Introduction to Radar Systems         1. Principles of radar operation         2. Radar system components and functions         3. Types and classification of radar  1. Pulse Radar 2. Continuous Wave Radar 3. Doppler Radar 4. Phased array    * + 1. Applications of radar in different industries        2. Radar frequency bands    1. Installation site Selection and Planning       1. Site Selection Criteria          1. Terrain and Topography          2. Interference Sources          3. Power Supply Availability          4. Regulatory Considerations       2. Site Planning          1. Antenna Mounting and Orientation          2. Cable Routing          3. Power Distribution       3. RF radiation safety and mitigation       4. Compliance with aviation and maritime regulations    2. Radar Hardware and Equipment Installation       1. Radar Antenna Installation          1. Mounting and securing the antenna          2. Aligning for optimal signal reception          3. Using GPS and leveling tools for positioning       2. Radar Transmitter & Receiver Setup          1. Power supply, grounding and cabling requirements          2. Waveguide, RF amplifier, and duplexer installation          3. Receiver sensitivity adjustments    3. Radar System Configuration       1. Aligning antennas and signal calibration       2. Configuring Transmitter Parameters          1. Configuring range          2. Frequency settings          3. Power          4. Pulse Repetition Frequency       3. Integration with Communication Systems          1. Radar data transmission and remote monitoring          2. Securing radar data against cyber threats    4. Signal Processor and Display Unit       1. Signal Processor function          1. Pulse Compression          2. Doppler Filtering          3. Target Tracking       2. Display Unit          1. Radar Display Types: A-scope, B-scope, C-scope, PPI          2. Range and Bearing Scales          3. Target Identification and Tracking    5. System Testing       1. Range and Angle Accuracy       2. Sensitivity       3. Resolution       4. Interference Rejection       5. False Alarm Rate    6. Operation and Maintenance       1. Routine Maintenance          1. Equipment Inspection          2. Cleaning Antennas and Equipment          3. Replacing Faulty Components       2. System Calibration          1. Periodic Calibration of Range, Angle, and Velocity Measurements          2. Adjusting System Parameters for Optimal Performance | 1. Written assessment 2. Oral assessment 3. Practical 4. Project 5. Third party report 6. Portfolio of evidence |

**Suggested Methods of delivery**

* + 1. Practical
    2. Project
    3. Demonstration
    4. Group discussion
    5. Site visits
    6. Industry visits
    7. Case studies

**Recommended Resources for 25 Trainees**

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| --- | --- | --- | --- | --- |
| **S No.** | **Item** | **Specifications for Purchase** | **Quantity** | **Recommended Ratio (Item: Trainee)** |
| **A** | **Tools** |  |  |  |
| 1 | GPS Devices | High-accuracy GPS for fieldwork, supports multiple satellites | 5 pcs | 1:5 |
| 2 | Rangefinder | Digital, accurate to at least 500 meters | 5 pcs | 1:5 |
| 3 | Digital Camera | Minimum 12 MP, GPS tagging capability | 5 pcs | 1:5 |
| 4 | Laser Distance Meter | Measures up to 100 meters, backlit display | 5 pcs | 1:5 |
| 5 | Communication Signal Strength Meter | Measures GSM/4G/5G signal strength | 5 pcs | 1:5 |
| 6 | Cable Tester | Multi-functional, suitable for coaxial and Ethernet cables | 5 pcs | 1:5 |
| 7 | Crimping Tool | Ergonomic, for coaxial and network cables | 5 pcs | 1:5 |
| 8 | Audio and Video Signal Tester | Compatible with HDMI, SDI, and analog signals | 5 pcs | 1:5 |
| 9 | RF Power Meter | Measures RF power accurately across multiple frequencies | 5 pcs | 1:5 |
| 10 | GSM Signal Tester | Supports GSM 900/1800/1900 MHz | 5 pcs | 1:5 |
| 11 | Oscilloscope | Digital, 100 MHz bandwidth | 5 pcs | 1:5 |
| **B** | **Materials and Supplies** |  |  |  |
| 12 | Coaxial Cables and Splitters | Assorted lengths, 75 Ohm impedance | As needed | As needed |
| 13 | Transmitters and Receivers | Frequency-matched for testing signal strength | As needed | As needed |
| 14 | Waveguides and Feedhorns | For specific frequency bands (S, C, Ku bands) | As needed | As needed |
| 15 | Modulators/Demodulators | Compatible with various modulation schemes | As needed | As needed |
| 16 | GSM Base Stations (BTS) | For signal transmission experiments | As needed | As needed |
| 17 | SIM Cards for Testing | Includes multiple carrier networks | As needed | As needed |
| 18 | Antennas for GSM Frequencies | Covers common bands like 900/1800 MHz | As needed | As needed |
| 19 | Grounding System Supplies | Copper rods, clamps, and cables for grounding | As needed | As needed |
| **C** | **Equipment** |  |  |  |
| 20 | Plotter Printer | High-resolution, compatible with CAD and mapping software | 1 pc | 1 per class |
| 21 | Multimeter | Auto-ranging, digital with backlit display | 10 pcs | 1:3 |
| 22 | Network Analyzer | Frequency range up to 3 GHz, for RF and communication networks | 5 pcs | 1:5 |
| 23 | Antennas | Covers different bands (GSM, UHF, VHF) | 5 pcs | 1:5 |
| 24 | Spectrum Analyzer | Covers a range up to 6 GHz | 5 pcs | 1:5 |
| 25 | Satellite Dishes | Fixed or motorized for receiving satellite signals | 5 pcs | 1:5 |
| 26 | Broadcasting Monitors | High-definition, multiple inputs including HDMI | 2 pcs | 1:13 |
| 27 | Frequency Synthesizers | Covers frequency range 100 MHz to 6 GHz | 5 pcs | 1:5 |
| 28 | Antenna Towers and Mounts | Adjustable height, secure foundation | As needed | As needed |
| 29 | RF Amplifiers | Amplification up to 10 dB | 5 pcs | 1:5 |
| 30 | GSM Modems | Supports multiple GSM bands | 5 pcs | 1:5 |
| 31 | Power Supplies and UPS | 1000VA or higher, stable output for equipment | 5 pcs | 1:5 |
| 32 | Antenna Towers or Mast | High-quality steel, weather-resistant | 5 pcs | 1:5 |
| **D** | **Reference Materials** |  |  |  |
| 33 | Manufacturer’s Catalogues | Latest catalogs for communication equipment | 5 pcs | 1:5 |
| 34 | Frequency Allocation Guides | Lists of allocated frequencies by region | 5 pcs | 1:5 |
| 35 | Licensing Documents | As required by local regulations | 5 pcs | 1:5 |
| 36 | Installation Guides for Transmitters | Step-by-step setup guides | 5 pcs | 1:5 |
| 37 | Working Drawings | Sample layouts and schematics for setup | 5 sets | 1:5 |
| 38 | EMCA Act | Environmental guidelines for communication installations | 5 pcs | 1:5 |
| 39 | OSHA | Safety standards for communication installations | 5 pcs | 1:5 |

# MODULE SEVEN

## FIBER OPTICAL NETWORKS INSTALLATION

**UNIT CODE:** 0612 551 10A

**Relationship to Occupational Standards**

This unit addresses the unit of competency: Install Fiber Optical Networks

**Duration of Unit:** 150 hours

**Unit Description**

This unit specifies competencies required for installing fiber optical networks. These include:

Conduct fiber optic network site survey, preparing fiber optic network technical drawings, laying fiber optic cables, terminating fiber optic cables, configuring fiber optic network devices and testing fiber optic network

**Summary of Learning Outcomes**

By the end of the unit the trainee should be able to:

|  |  |  |  |
| --- | --- | --- | --- |
| **S/NO** | **LEARNING OUTCOME** | | **DURATION (HRS)** |
|  | Conduct fiber transmission link Site survey | 10 | | |
|  | Prepare fiber optic network technical Drawings | 20 | | |
|  | Lay Fibre Optic cables | 20 | | |
|  | Terminate fiber optic cables | 40 | | |
|  | Configure fiber optic network devices | 40 | | |
|  | Test fiber optic network | 20 | | |
|  | **TOTAL HOURS** | **150** | | |

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

|  |  |  |
| --- | --- | --- |
| **Learning Outcome** | **Content** | **Suggested**  **Assessment**  **Methods** |
| 1. Conduct fiber optic network site survey | * 1. Introduction to Fiber Optic Communication      1. Overview of Fiber Optics         1. Basics of light transmission and refraction.         2. Structure of fiber optic cable  1. Core fibers 2. Cladding 3. Buffer tube 4. Strength member 5. Outer jacket    * + 1. Types of fiber optic cables 6. Single-mode 7. Multi-mode    * + 1. Advantages of fiber optic communication over traditional cabling      1. Key Components of fiber optic system         1. Optical fibers, connectors, and patch panels.         2. Optical transceivers and termination boxes.         3. Optical distribution frames (ODF) and splitters.      2. Characteristics and applications of fiber optic link      3. Factors influencing link performance         1. Distance         2. Frequency         3. Attenuation         4. Interference         5. Environmental factors: terrain, weather    1. Fiber optical link site survey       1. Importance of Fiber link Site Survey       2. Site Survey Equipment and Techniques          1. Optical Time Domain Reflectometer (OTDR)          2. Optical Power Meter          3. Light Source          4. Interference detectors          5. Survey Techniques 8. Site Reconnaissance 9. Data Collection 10. Path Profiling 11. Interference Analysis     1. Fiber Optic Link Site Survey        1. Path mapping        2. Approval and permits        3. Performance requirements        4. Client requirements        5. Potential challenges     2. Data Analysis and Reporting        1. Data Analysis           1. Processing and analysis of collected data           2. Link budget calculations           3. Performance predictions           4. Identification of potential problems and mitigation strategies        2. Report Preparation           1. Site survey report documentation 12. Introduction 13. Findings 14. Recommendations 15. Costing 16. Risks and mitigations     * + 1. Maps and diagrams         2. Data tables and graphs         3. Conclusions and recommendations | 1. Written assessment 2. Oral assessment 3. Practical 4. Project 5. Third party report 6. Portfolio of evidence |
| 1. Prepare Fiber optical network Technical Drawings | * 1. Introduction to Technical Drawing      1. Principles of Technical Drawing         1. Purpose and importance of technical drawings in telecommunications         2. Basic drawing conventions and standards: ISO, ANSI         3. Dimensioning and tolerancing         4. Use of layers and colors   2. Fiber optical network Drawings      + 1. Drawing symbols for fiber optic components: cables, connectors, splices, equipment        2. Representing fiber optic routes on maps and plans        3. Detailing splice closures and manholes        4. Creating cable layout diagrams   3. Creation and Management of Drawings      1. Data Collection and Analysis         1. Gathering data from site surveys, design documents, and other sources         2. Analyzing data to determine drawing requirements         3. Creating a drawing plan      2. Drawing Creation Process         1. Creating basic shapes and lines         2. Adding dimensions and annotations         3. Inserting symbols and blocks         4. Creating layers and organizing drawing elements         5. Checking drawings for accuracy and completeness      3. Drawing Management         1. Version control and revision history         2. Archiving and retrieval of drawings         3. Sharing drawings with other team members and stakeholders | 1. Written assessment 2. Oral assessment 3. Practical 4. Project 5. Third party report 6. Portfolio of evidence |
| 1. Lay fiber optic cables | * 1. Laying fiber optic cables      1. Cable Installation Methods         1. Choice of cable installation method         2. Overhead Installation         3. Underground Installation.         4. Indoor Cable Routing      2. Pre-installation Planning         1. Site Survey.         2. Route Marking and Permissions.         3. Material and Equipment Checklist   2. Overhead Fiber Cable Installation      1. Techniques for Overhead Installation         1. Use of Aerial Cables  1. ADSS (All-Dielectric Self-Supporting) 2. OPGW (Optical Ground Wire).    * + 1. Sag and Tension Calculation (slack management)        2. Bend Radius Compliance        3. Attachment Hardware 3. Brackets 4. Suspension Clamps 5. Insulators 6. Guide wires 7. messenger cables    * + 1. Use of pulleys and winches        2. Securing and Protecting Cables 8. Lightning protection 9. Vibration dampers    * + 1. Tension and alignment verification      1. Advantages and challenges of overhead installations      2. Safety Considerations         1. Working at Heights         2. Electrical Hazards    1. Underground Cable Installation       1. Techniques for Underground Installation          1. Trenching and Direct Burial          2. Duct and Conduit Systems          3. Micro-trenching          4. Cable Pulling and Blowing          5. Bend Radius Compliance          6. Pulling Tension Limits and slack management          7. Using lubrication to minimize friction in Duct and Conduit Installations          8. Backfilling and Restoration       2. Protective Measures          1. Marker Tapes and Warning Labels          2. Manhole and Handhole Installation       3. Advantages and challenges of underground installations       4. Safety Considerations          1. Personal protective equipment          2. Underground utilities safety    2. Indoor fiber optic cabling       1. Structured cabling concepts and standards          1. TIA/EIA 568          2. ISO/IEC 11801       2. Techniques for installing cables in walls, ceilings, and conduits       3. Labeling and organizing cables       4. Minimizing signal loss          1. Bend radius management          2. Cable Routing       5. Indoor Cable management systems    3. Fiber Cable Installation Equipment       1. Cable Rollers and Trailers       2. Cable Blowing Machines          1. Pneumatic systems          2. Hydraulic systems       3. Winches and Capstans       4. Cable Cutting Tools    4. Safety Procedures       1. Personal Protective Equipment (PPE)          1. Hard hats, safety glasses, gloves, and high-visibility clothing.          2. Proper footwear       2. Hazard Identification and Risk Mitigation          1. Electrical Safety          2. Sharp Fiber End          3. Chemical Safety: lubricants and cleaning solutions       3. Site Safety Measures          1. Traffic Management for street installation          2. Emergency Response Plan: First aid and evacuation procedures.       4. Regulatory Compliance          1. Local laws and standards for fiber optic installations          2. Maintaining records 10. Safety checks 11. Incident reports | 1. Written assessment 2. Oral assessment 3. Practical 4. Project 5. Third party report 6. Portfolio of evidence |
| 1. Terminate fiber optic cables | * 1. Fiber Optic Termination Components      1. Types Fiber Optic Connectors         1. SC, LC, ST, FC, MTP/MPO         2. Applications of each connector type      2. Understanding pigtails and patch cords      3. Adapter panels, patch panels, and enclosures      4. Role of ferrules and connector boots      5. Fiber optic materials and their impact on performance         1. Ceramic         2. Plastic         3. Metal   2. Fiber Optic Termination Techniques      1. Cleaving and cleaning fibers for termination      2. Fusion splicing         1. Equipment overview (fusion splicers).         2. Steps for achieving high-quality splices.         3. Protecting spliced joints with heat-shrink sleeves.      3. Mechanical splicing         1. Reasons and applications for mechanical splicing.         2. Aligning fibers and securing with index-matching gel.      4. Connectorization         1. Direct termination of connectors.         2. Polishing techniques for high-quality connections      5. Hands-on practice         1. Cleaving, fusion splicing and polishing optical fibers.         2. Termination in Fiber Optic Splice Closures  1. Dome-Type Splice Closures 2. Inline Splice Closures 3. Outdoor and indoor enclosures    * + 1. Termination in Fiber Optic Patch Panels 4. Rack-Mount Patch Panels 5. Wall-Mount Patch Panels    * + 1. Termination in Optical Distribution Frames (ODF)        2. Fiber Optic Termination Boxes        3. Termination in fiber splice trays        4. Termination in Optical Network Terminals (ONT) and Optical Line Terminals (OLT)        5. Termination in Splitter Modules I in FTTH and PON networks    1. Fiber Optic Equipment Configuration       1. Purpose of Configuration       2. Optical Transceivers configuration          1. Setting operating wavelengths          2. Adjusting transmission power for the required distance.          3. Integrating transceivers into SFP (Small Form-factor Pluggable) ports.       3. Optical Amplifiers          1. Configuring gain          2. Setting amplifier thresholds       4. Optical Switches and Routers          1. VLAN (Virtual LAN) setup for network segmentation.          2. Assigning IP addresses.          3. Configuring routing protocols          4. Prioritizing traffic with Quality of Service (QoS).       5. Setting up backup links for failover support.       6. Configuring load balancing for distributed traffic.       7. Setting bandwidth limits and ensuring SLA compliance.       8. Media Converters          1. Link to copper-based systems          2. Compatibility of protocols and data rates | 1. Written assessment 2. Oral assessment 3. Practical 4. Project 5. Third party report 6. Portfolio of evidence |
| 1. Configure fiber optic network devices | * 1. Fiber optic network devices      1. Optical line terminals      2. Optical network units      3. Switches      4. Routers   2. Fiber Optic Transceivers      1. SFP      2. QSFP      3. CFP   3. Setting Up of fiber optic network devices   4. Insertion of fiber optic transceivers   5. Assigning IP addresses   6. Setting up optical power level | 1. Written assessment 2. Oral assessment 3. Practical 4. Project 5. Third party report 6. Portfolio of evidence |
| 1. Test fiber optic network | * 1. Fiber Optic Performance Parameters      1. Signal-to-noise ratio (SNR)      2. Bit error rate (BER)      3. Power budget calculations   2. Fiber Test tools and Equipment      1. Optical Power Meter (OPM)         1. Measuring signal strength and loss.      2. Optical Time-Domain Reflectometer (OTDR)         1. Operation         2. Calibration         3. Fault detection      3. Visual Fault Locator (VFL)      4. Light sources      5. Fiber Inspection Microscopes   3. Practical Testing      1. End-to-end testing using OTDR         1. Measuring attenuation, splices, and connector losses.         2. Identifying faults, such as breaks or high-loss splices.      2. Continuity testing with a VFL      3. Insertion loss and return loss testing procedure         1. Definition of Insertion loss         2. Definition of return loss      4. Troubleshooting with OTDR      5. Testing for Dispersion and Polarization      6. Network Performance Validation against design specifications         1. Validating fiber optic networks against industry standards: TIA/EIA.         2. Bandwidth and signal-to-noise ratios         3. Testing for bit error rates (BER) in active networks         4. Benchmarking network performance under load conditions   4. Documentation of Fiber Optic Tests      1. Key Elements of Fiber Optic Test Documentation         1. Test Overview         2. Fiber Optic Network Details         3. Test Parameters         4. Test Results         5. Test Report         6. Sign-Off      2. Documentation Format         1. Manual Reports         2. Digital Reports         3. Cloud-Based Systems | 1. Written assessment 2. Oral assessment 3. Practical 4. Project 5. Third party report 6. Portfolio of evidence |

**Suggested Delivery Methods**

* Practical
* Project work
* Demonstration
* Discussions
* Research
* Direct instruction
* Industry visits
* Case study

**List of Recommended Resources for 25 Trainees**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S/No.** | **Category/Item** | **Description/**  **Specifications** | **Quantity** | **Recommended**  **Ratio**  (Item: Trainee) |
| **A** | **Learning Materials** |  |  |  |
|  |  |  |  |  |
|  | Textbooks | Fiber Optic Communications by Joseph C. Palais  Fiber Optic Network Design and Implementation by Thomas L. Floyd  The Fiber Optic Technician's Manual by Jim Hayes  Introduction to Fiber Optics by John C. Bellamy  Fiber Optic Communications: Fundamentals and Applications by K. T. Iyyer  Optical Fiber Communications by Gerd Keiser | Online access | - |
|  | Fiber Optic Simulation Software | FiberSim or OptiSystem that help in visualizing and designing fiber optic network layouts | Enough | - |
|  | Fiber Optic System Identification Guides | Manuals or online resources offering descriptions and images of various fiber optic components, including connectors, splices, and active equipment like transmitters and receivers. | Enough | - |
| **C** | **Learning Facilities & infrastructure** |  |  |  |
|  | Lecture/theory room | 60m2 | 1 | 1:25 |
|  | Workshop | 160m2 | 1 | 1:25 |
|  | Computers and laptop with internet access | Processor: Intel Core i5/i7 or equivalent  RAM: 8GB or higher  Storage: 256GB SSD or higher | 10 pcs | 1:3 |
|  | Projectors | At least 3000 lumens  With HDMI and VGA ports | 1 | 1:25 |
| **D** | **Materials, tools and equipment** |  |  |  |
|  | Fiber Optic Cables | Single-mode and multi-mode fiber cables  OM1, OM2, OM3, OM4, OM5 cables for different transmission distances and data rates. | 200 m | 8 m:1 |
|  | Fiber Optic Connectors (SC, LC, ST, MTP) | Compatible with SC, LC, ST, MTP connectors; low insertion loss, precision engineered for efficient signal transfer. | 50 pcs each category | 2:1 |
|  | Network Racks | 9U and 12U network racks with mounting brackets and lockable glass doors. | 5 pcs | 1:5 |
|  | Fiber Optic Cable Splice Trays | Suitable for SMF and MMF, can hold multiple fibers, and made of durable plastic or metal. | 5 pcs | 1:5 |
|  | Cable Drum/Reel | Specifications: Must accommodate the fiber optic cable's length and diameter, with smooth unwinding capabilities. | 1 | 1:25 |
|  | Fiber Optic Cable Pulling Lubricant | Silicone-based, non-abrasive, and compatible with both single-mode and multi-mode fibers. | Enough | - |
|  | Cable Pulling Tools (Cable Pulling Grip, Tensioner) | Tensioner capable of maintaining proper pulling force; cable grips for secure installation. | 2 pcs | 1:13 |
|  | Cable Trays and Conduits | Metal or PVC construction | 200 m each category | 8m:1 |
|  | Network Switches | Managed, unmanaged switches, and PoE switches 8-port and 24-port models with Gigabit Ethernet. | 4 pcs each category | 1:6 |
|  | Fiber Optic Switch | Support high-speed data transmission (10Gbps, 100Gbps) and be compatible with SMF and MMF. | 2 pcs | 1:13 |
|  | Routers | Wireless and wired routers with dual-band (2.4 GHz/5 GHz) support and firewall capabilities.  Wi-Fi 6 or Wi-Fi 6E standards. | 10 pcs | 1:3 |
|  | Access Points | Wi-Fi 6 or Wi-Fi 5 APs with PoE support for wireless network coverage. | 5 pcs | 1:5 |
|  | Patch Panels | 24-port and 48-port Cat6 patch panels for central cable management. | 10 pcs | 1:3 |
|  | Fiber Optic Splicing Kit | Includes fusion splicer, cleaver, and cleaning tools for fiber optic cable preparation and installation. | 2 pcs | 1:13 |
|  | Fusion Splice Protectors | Protective sleeves with various fiber diameters (125µm core diameter), heat-shrinkable for proper protection. | 1000 pcs | 40:1 |
|  | Fiber Optic Connectors (SC, LC, MTP) | SC, LC, or MTP styles; low insertion loss, precision-engineered for low-loss connections. | 500 pcs | 20:1 |
|  | OTDR (Optical Time Domain Reflectometer) | Wavelength range of 1310nm and 1550nm, dynamic range of >40dB, capable of measuring both SMF and MMF. | 2 pcs | 1:13 |
|  | Power Meter | Wavelength range (850nm to 1650nm) and compatible with both single-mode and multi-mode fibers. | 2 pcs | 1:13 |
|  | Light Source (LED/VCSEL) | Wavelength options like 850nm, 1310nm, 1550nm for different types of fiber. | 2 pcs | 1:13 |
|  | Visual Fault Locator (VFL) | Output power of at least 5mW, visible red laser, compatible with SMF and MMF. | 2 pcs | 1:13 |
|  | Fiber Optic Cleaning Kit | Should include lint-free wipes, cleaning pens, alcohol solutions, and fiber cleaning swabs. | 2 pcs | 1:13 |
|  | Fiber Optic Polishing Film | Abrasive films of varying grits (3μm, 5μm, 0.3μm) for different connector types. | Enough | - |
|  | Fiber Optic Cable Splice Enclosures | Waterproof, dustproof, and UV resistant with multiple ports for fiber entry and exit. | 5 pcs | 1:5 |
|  | Underground Manholes | Reinforced concrete, precast concrete, fiberglass, steel, polymer concrete.Diameter: 600mm to 1200mm; Depth: 1.5m to 3m, customizable based on requirements | 5 pcs | 1:5 |

## ENTERPRISE COMPUTER NETWORKS

**UNIT CODE:** 0714 551 18A

**Relationship to Occupational Standards**

This unit addresses the unit of competency: Install Enterprise Computer Networks.

**Duration of Unit:** 200 hours

**Unit Description**

This unit specifies competencies required for installing communication network. These include: Configure enterprise computer network, conduct enterprise computer network risk assessment and planning, set up Network Security Controls, Deploy Cyber-security Solutions, set up computer network firewalls, set up computer network monitoring tools, Set up computer network backup and disaster recovery.

**Summary of Learning Outcomes**

By the end of the unit the trainee should be able to:

|  |  |  |
| --- | --- | --- |
| **S/NO** | **LEARNING OUTCOME** | **DURATION (HRS)** |
|  | Configure enterprise computer network | 60 |
|  | Conduct enterprise computer network risk assessment and planning | 10 |
|  | Set up Network Security Controls | 20 |
|  | Deploy Cybersecurity Solutions | 30 |
|  | Set up computer network firewalls | 20 |
|  | Set up computer network monitoring tools | 40 |
|  | Set up computer network backup and disaster recovery | 20 |
|  | **TOTAL HOURS** | **200** |

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

|  |  |  |
| --- | --- | --- |
| **Learning Outcome** | **Content** | **Suggested Assessment Methods** |
| 1. Configure enterprise computer network | * 1. Configure enterprise computer network      1. Definition of enterprise computer network      2. Components of an enterprise network         1. Servers         2. Cores witches         3. routers         4. Workstations         5. Storage      3. Types of enterprise networks         1. 5 Local Area Network (LAN)         2. Wide Area Network (WAN)         3. Metropolitan Area Network (MAN)   2. Configuring network infrastructure      1. IP addressing and sub-netting         1. Ip addressing review: ipv4 and ipv6         2. Subnetting and VSLM (Variable Length Subnet Mask)         3. Ip scheme design         4. IP address planning      2. VLAN configuration   1.2.2.1. VLAN creation and port assignment on managed switches  1.2.2.2. inter-VLAN routing  1.2.2.3. VLAN trunking protocol (VTP)   * + 1. Router and switch configuration        1. Static vs Dynamic Routing: RIP, OSPF, EIGRP        2. Configuring default gateway and routing tables        3. Spanning Tree Protocol (STP) basics        4. Link aggregation and redundancy     2. Network Security Policies        1. Configuring access control lists (ACLs)        2. Setting up firewalls and NAT        3. Secure switch and router configurations        4. Network segmentation for security     3. Network Services Configuration        1. DHCP Server setup and scope assignment        2. DNS Configuration        3. NTP (Network Time Protocol) setup        4. Syslog and SNMP for monitoring     4. Enterprise Wireless Setup WLAN        1. design for large-scale deployment        2. Access Point configuration and placement        3. Wireless security: WPA2-Enterprise, 802.1X        4. Guest and staff SSID separation     5. Cloud network integration        1. Types of clouds networks  1. Public Cloud 2. Private Cloud 3. Hybrid Cloud 4. Multi-Cloud    * + 1. Cloud connectivity methods 5. Direct connect 6. VPN tunneling 7. Cloud-based SD-WAN solutions | 1. Practical assessment 2. Project 3. Written assessment 4. Observation 5. Oral questioning 6. Portfolio of evidence 7. Third party report |
| 1. Conduct enterprise computer network risk assessment and planning | * 1. Introduction to Network Risk Assessment      1. Definition of risk assessment in networking      2. Importance of risk management      3. Common network risks         1. Hardware Failures         2. Software Vulnerabilities         3. Unauthorized Access         4. Insider Threats         5. Natural Disasters         6. Data Breaches         7. Service Downtime         8. Cloud Misconfiguration   2. Risk Assessment Process      1. Asset Identification      2. Threat Identification      3. Vulnerability Analysis      4. Risk Evaluation      5. Risk Treatment   3. Tools Used in Risk Assessment      1. Network Vulnerability Scanners      2. Penetration Testing Tools      3. Security Information and Event Management (SIEM) Tools      4. Network Monitoring Tools   4. Risk Mitigation Strategies      1. Implementing network segmentation      2. Enforcing access control policies      3. Developing incident response plans | 1. Practical assessment 2. Project 3. Written assessment 4. Observation 5. Oral questioning 6. Portfolio of evidence 7. Third party report |
| 1. Set up Network Security Controls | * 1. Definition of network security controls   2. Types of Network Security Controls      1. Preventive      2. Detective      3. Corrective      4. Administrative   3. Security Policy Implementation components      + 1. Risk Mitigation        2. Compliance        3. Consistency        4. Accountability   4. Steps in Network Security Control      1. Assess the network and risks      2. Define security requirements      3. Select and deploy controls      4. Integrate monitoring and logging      5. Test the controls      6. Train users      7. Maintain and update controls | 1. Practical assessment 2. Project 3. Written assessment 4. Observation 5. Oral questioning 6. Portfolio of evidence 7. Third party report |
| 1. Deploy Cyber-security Solutions | * 1. Cyber-security fundamentals      1. Definition of cyber-security solutions      2. Cyber security implementation         1. Antivirus and anti-malware deployment         2. Zero Trust security model         3. Identity and Access Management (IAM)         4. Security Information and Event Management (SIEM) | 1. Practical assessment 2. Project 3. Written assessment 4. Observation 5. Oral questioning 6. Portfolio of evidence 7. Third party report |
| 1. Set up computer network firewalls | * 1. Computer network firewall      1. Introduction to firewall         1. Definition and purpose of firewalls         2. Types of firewalls  1. hardware 2. software 3. cloud-based    * 1. Firewall configuration         1. Setting up firewall rules and policies         2. Implementing firewall filtering techniques         3. Monitoring firewall activity | 1. Practical assessment 2. Project 3. Written assessment 4. Observation 5. Oral questioning 6. Portfolio of evidence 7. Third party report |
| 1. Set up computer network monitoring tools | * 1. Introduction to Network Monitoring tools      + 1. Definition and importance of network monitoring        2. Types of network monitoring tools  1. SNMP, 2. NetFlow 3. Wireshark    * + 1. Firewall configuration    1. Implementation of network monitoring tools       * 1. Configuring network performance monitors         2. Real-time threat detection         3. Generating network reports and alerts | 1. Practical assessment 2. Project 3. Written assessment 4. Observation 5. Oral questioning 6. Portfolio of evidence 7. Third party report |
| 1. Set up computer network backup and disaster recovery | * 1. Introduction to Backup and Disaster Recovery      1. Definition of backup and disaster recovery      2. Importance of backup strategies   2. Backup strategies      1. Types of backups         1. Full backup         2. Incremental backup         3. Differential backup      2. Cloud vs. on-premise backup solutions      3. Backup scheduling and automation   3. Disaster recovery planning      1. Identifying critical network resources      2. Implementing failover mechanisms      3. Disaster recovery testing and documentation | 1. Practical assessment 2. Project 3. Written assessment 4. Observation 5. Oral questioning 6. Portfolio of evidence 7. Third party report |

**Suggested Methods of Instruction**

* + 1. Practical
    2. Project
    3. Demonstration
    4. Group discussion
    5. Direct instruction
    6. Field trips

**Recommended Resources for 25 trainees**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S/No.** | **Category/Item** | **Description/**  **Specifications** | **Quantity** | **Recommended**  **Ratio**  (Item: Trainee) |
| **A** | **Learning Materials** |  |  |  |
|  | Training Manuals | Manuals on network installation, covering topology, configuration, and testing. | 5 copies | 1:5 |
|  | Networking Simulators | Software such as Cisco Packet Tracer or GNS3 | Enough | - |
|  | Network Configuration Guides | Documentation for setting up routers, switches, and firewalls. | 5 copies | 1:5 |
|  | Topology Diagrams | Pre-designed network layout diagrams for training exercises. | 5 copies | 1:5 |
|  | Safety Guidelines | OSHA-compliant guidelines for handling electrical and networking equipment safely. | 5 copies | 1:5 |
|  | Reference Books | Books such as Networking All-in-One For Dummies or CompTIA Network+ Certification Guide. | Online access | - |
|  | Tutorial Videos | Step-by-step video tutorials on cable termination, network setup, and troubleshooting. | Enough | - |
|  | Power point presentations | For trainer’s use | Enough | - |
| **C** | **Learning Facilities & infrastructure** |  |  |  |
|  | Lecture/theory room | 60m2 | 1 | 1:25 |
|  | Workshop | 160m2 | 1 | 1:25 |
|  | Computers and laptop with internet access | Processor: Intel Core i5/i7 or equivalent  RAM: 8GB or higher  Storage: 256GB SSD or higher | 10 pcs | 1:3 |
|  | Projectors | At least 3000 lumens  With HDMI and VGA ports | 1 | 1:25 |
| **D** | **Materials, tools and equipment** |  |  |  |
|  | Ethernet Cables | Cat6a cables | 200 m | 8 m:1 |
|  | Patch Cords | Pre-terminated patch cables with RJ45 connectors, Cat6 standard, lengths from 0.5m to 5m. | 50 pcs each category | 2:1 |
|  | Cable Management Supplies | Velcro straps, cable ties, cable sleeves | Enough | - |
|  | RJ45 Connectors | Compatible with Cat5e/Cat6 cables. | 1000 pcs | 40:1 |
|  | Keystone Jacks | Ethernet jacks for wall plate installation; Cat6 or higher standard. | 500 pcs | 20:1 |
|  | Network Racks | 9U and 12U network racks with mounting brackets and lockable glass doors. | 5 pcs | 1:5 |
|  | Faceplates | Single and dual-port wall plates for Ethernet jack installation. | 200 pcs each category | 8:1 |
|  | Labeling Supplies | Label tapes and markers. | 2 pcs | 1:13 |
|  | Network Switches | Managed and unmanaged switches, 8-port and 24-port models with Gigabit Ethernet. | 4 pcs each category | 1:6.25 |
|  | Routers | Wireless and wired routers with dual-band (2.4 GHz/5 GHz) support and firewall capabilities. | 10 pcs | 1:3 |
|  | Access Points | Wi-Fi 6 or Wi-Fi 5 APs with PoE support for wireless network coverage. | 5 pcs | 1:5 |
|  | Servers | Entry-level servers for network hosting, with Intel Xeon processors and at least 16GB RAM. | 1 pc | 1:25 |
|  | Network Interface Cards | PCIe-based Ethernet adapters supporting Gigabit or 10Gbps speeds. | 5 pcs | 1:5 |
|  | Patch Panels | 24-port and 48-port Cat6 patch panels for central cable management. | 10 pcs | 1:3 |
|  | Modems | DSL, cable, or fiber modems for internet access. | 5 pcs | 1:5 |
|  | UPS Units | Uninterruptible power supplies with minimum 500VA capacity for backup power. | 1 pc | 1:25 |
|  | Crimping Tool | Compatible with RJ45 connectors. | 5 pcs | 1:5 |
|  | Cable Tester | Multi-function cable tester with capability to verify continuity, pin configuration, and speed compatibility. | 5 pcs | 1:5 |
|  | Punch-Down Tool | Capable of terminating wires into keystone jacks and patch panels; includes spare blades. | 5 pcs | 1:5 |
|  | Wire Stripper | Adjustable stripper for Ethernet cables, supporting Cat5e, Cat6, and Cat6a. | 5 pcs | 1:5 |
|  | Label Printer | Portable printer. | 2 pcs | 1:13 |
|  | Multimeter | Digital multimeter capable of testing voltage, current, and continuity of network power supplies. | 10 pcs | 1:3 |
|  | Fiber Optic Splicing Kit | Includes fusion splicer, cleaver, and cleaning tools for fiber optic cable preparation and installation. | 2 pcs | 1:13 |

## COMMUNICATION SYSTEMS MAINTENANCE

**UNIT CODE:** 0714 451 11A

**Relationship to Occupational Standards**

This unit addresses the unit of competency: Maintain Communication Systems

**Duration of Unit:** 120 hours

**Unit Description**: This unit specifies competences required for maintaining Communication systems. These include applying workshop practice, preparing Telecommunication System maintenance schedule, performing Communication System routine maintenance and performing Telecommunication System corrective maintenance.

**Summary of Learning Outcomes**

By the end of the unit the trainee should be able to:

|  |  |  |
| --- | --- | --- |
| **S/NO** | **LEARNING OUTCOME** | **DURATION (HRS)** |
|  | Apply workshop practice | 40 |
|  | Prepare Telecommunication System maintenance schedule | 10 |
|  | Perform Communication System routine maintenance | 30 |
|  | Perform Telecommunication System corrective maintenance | 40 |
|  | **TOTAL HOURS** | **120** |

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

|  |  |  |
| --- | --- | --- |
| **Learning Outcome** | **Content** | **Suggested**  **Assessment**  **Methods** |
| 1. Apply workshop practice | * 1. Definition of terms      1. Hazards      2. Accidents   2. Workplace hazards      1. Categories of workplace hazards         1. Physical         2. Biological         3. Chemical         4. Ergonomics         5. Electrical   3. Personal Protective Equipment (PPE)      1. Types of PPE      2. Proper Selection and Use of PPE         1. Factors to consider when selecting PPE         2. Inspection and maintenance of PPE         3. Limitations of PPE   4. Safe work practices      1. Lockout/Tagout Procedures      2. Chemical Safety Practices      3. Electrical safety procedures      4. Ergonomic Practices   5. Occupational Health and Safety Regulations      1. General Industry Standards      2. Construction Industry Standards      3. Electrical Safety Standards      4. National electrical code      5. Local and international standards   6. Workplace hazards mitigation measures      1. Workplace accidents         1. Cuts and bleeds         2. Fracture         3. Fainting         4. Electric shock         5. Fire         6. Pinch      2. Workplace emergency plan         1. Implementing emergency plans         2. Evacuation procedures         3. Fire safety procedure  1. Classes of fire 2. Causes of fire 3. Methods of extinguishing fire    * + 1. Spill response drills      1. First Aid and CPR      2. Emergency Contacts and Reporting         1. Reporting accidents and incidents         2. Contacting emergency services    1. ESH       1. Definition of ESH       2. Importance of ESH       3. Key ESH concepts          1. Hazard identification and risk assessment          2. Control measures          3. Emergency response          4. Incident investigation and reporting    2. Environmental Management       1. Environmental Impact Assessment (EIA)          1. Purpose of EIA          2. Key components of an EIA          3. Mitigation measures       2. Pollution Prevention and Control          1. Air pollution          2. Water pollution          3. Noise pollution          4. Solid waste management       3. Environmental pollution control measures          1. Recycling          2. Zoning          3. Reusing          4. Effluent treatment       4. Resource Conservation          1. Energy efficiency          2. Water conservation          3. Waste reduction and recycling       5. Environmental Regulations and Standards          1. Local, national, and international regulations          2. Compliance monitoring and reporting    3. Tools and equipment calibration    4. Tools and equipment maintenance    5. Electrical Workshop Records Maintenance       1. Importance of Records Maintenance       2. Types of Records in Electrical Workshop          1. Inventory Records          2. Maintenance Records          3. Safety Records          4. Operational Records       3. Maintaining Records          1. Manual Systems          2. Digital Systems          3. Best practices in maintaining records       4. Common Challenges and Solutions in records maintenance    6. Storing Tools, Equipment, and Materials       1. Importance of Proper Storage       2. Organizing Storage Areas          1. By Category          2. By Usage          3. Labeling       3. Electrical workshop storage techniques          1. Use pegboards          2. Shelving units          3. Locked cabinets          4. Climate-controlled storage       4. Safety Considerations in storing tools, equipment and materials       5. Inventory Management methods          1. Use of barcodes systems          2. Use of RFID systems          3. Periodic stock checks          4. First in First out (FIFO) system    7. Electrical Workshop Housekeeping       1. Importance of Good Housekeeping       2. Daily Housekeeping Tasks       3. Weekly and Monthly Housekeeping Tasks       4. Electrical Workshop Waste Management       5. Electrical Workshop Housekeeping Best Practices    8. Evaluating Housekeeping Effectiveness | 1. Written assessment 2. Oral assessment 3. Practical 4. Project 5. Third party report 6. Portfolio of evidence |
| 1. Prepare Telecommunication System maintenance schedule | * 1. Introduction to Maintenance Planning and Scheduling      1. Importance of Planning and Scheduling      2. Key Concepts and Definitions         1. Preventive maintenance         2. Corrective maintenance         3. Predictive maintenance         4. Work order management   2. Assessing Telecommunication System maintenance needs      1. Common Telecommunication System Failures and Issues         1. Hardware failures: component malfunctions, equipment degradation         2. Software glitches and bugs         3. Connectivity problems: signal interference, cable cuts, connector issues         4. Security breaches and cyberattacks   3. Telecommunication System Equipment and devices Key Performance Indicators (KPIs) and monitoring      1. Importance of KPIs      2. Definition and measurement of KPIs         1. Service availability and uptime         2. Mean Time Between Failures         3. Mean Time to Repair         4. Performance: Network Latency, Network Throughput, jitter         5. Security incidents         6. Customer satisfaction levels         7. Signal strength and quality      3. Performance monitoring tools and techniques         1. Network Management Systems         2. Telemetry and remote monitoring         3. Log file analysis         4. Performance testing and benchmarking         5. Network traffic analysis      4. Data Collection and Analysis         1. Sources of maintenance data         2. Data visualization and reporting methods         3. Reasons for analyzing maintenance data   4. Developing a Maintenance Schedule      1. Prioritization Techniques         1. Criticality analysis         2. Risk-based prioritization         3. Pareto analysis         4. Economic justification      2. Scheduling Methods         1. Gantt charts         2. Critical path method         3. Scheduling software and tools      3. Risk Assessment and Mitigation         1. Identification of potential hazards and risks         2. Implementation of safety measures and procedures   5. Resource Allocation      1. Workforce Planning         1. Skill requirements and training needs analysis         2. Staffing levels and scheduling methods         3. Overtime and shift work considerations      2. Telecommunication System Inventory management         1. Spare parts and consumables         2. Inventory control systems         3. Equipment and devices tagging and tracking         4. Equipment and devices documentation best practices  1. Device information 2. Consistent format 3. Regular update 4. Regular audit | 1. Written assessment 2. Oral assessment 3. Practical 4. Project 5. Third party report 6. Portfolio of evidence |
| 1. Perform Communication System routine maintenance | * 1. Introduction to Telecommunication Systems & Maintenance      1. Importance of Routine Maintenance         1. Proactive vs. reactive maintenance         2. Benefits of scheduled maintenance         3. Methods of Identifying critical components and systems  1. Technical layout drawings 2. Schematics 3. Functional diagrams 4. Equipment manuals    * 1. Safety Procedures         1. Workplace safety guidelines         2. Electrical safety precautions         3. Working at heights and in confined spaces         4. Use of personal protective equipment (PPE)    1. Telecommunication System Components and Maintenance       1. Power Systems          1. UPS systems, generators, batteries          2. Battery testing and replacement          3. Power distribution and grounding       2. Environmental Control          1. Cooling systems (HVAC)          2. Temperature and humidity monitoring          3. Environmental controls for sensitive equipment       3. Cabling Infrastructure          1. Cable inspection and testing          2. Cable termination and connectivity          3. Fiber optic cable maintenance       4. Active Equipment          1. Routers, switches, servers, modems          2. Software upgrades and firmware updates          3. Basic troubleshooting and diagnostics    2. Routine Maintenance Procedures       1. Performing Maintenance Tasks          1. Cleaning and inspecting equipment          2. Tightening connections and replacing worn parts          3. Performing basic hardware and software checks          4. Inspect and test system monitoring equipment and software          5. Running diagnostic tests          6. Backups and disaster recovery checks       2. Documentation and Record Keeping          1. Completing maintenance records templates          2. Using computerized maintenance management systems | 1. Written assessment 2. Oral assessment 3. Practical 4. Project 5. Third party report 6. Portfolio of evidence |
| 1. Perform Telecommunication System corrective maintenance | * 1. Repair and Maintenance Procedures      1. Repair Technique         1. Component replacement and repair.  1. Printed circuit boards component replacement 2. Connector replacements    * + 1. Cable installation and termination. 3. Fiber 4. Copper    * + 1. Equipment alignment and calibration.      1. Documentation and Reporting         1. Repair reports and service tickets.         2. Maintaining equipment records.         3. Communicating with customers. | 1. Written assessment 2. Oral assessment 3. Practical 4. Project 5. Third party report 6. Portfolio of evidence |

**Suggested Methods of Instruction**

* + 1. Practical
    2. Project
    3. Demonstration
    4. Group discussion
    5. Direct instruction
    6. Case studies
    7. Field visits
    8. Industry visits

**List of Recommended Resources for 25 Trainees**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S/No.** | **Category/Item** | **Description/**  **Specifications** | **Quantity** | **Recommended**  **Ratio**  (Item: Trainee) |
| **Learning Materials** |  |  |  |  |
|  | Equipment Manuals | Telecommunication equipment installation, operation and configuration manuals | Enough copies | - |
|  | Safety Procedures | Guidelines for electrical safety and working at heights | 5 copies | 1:5 |
|  | Tutorial Videos | For trainer’s use | Enough | - |
|  | Power point presentations | For trainer’s use | 1 | 1:25 |
| **Learning Facilities & infrastructure** |  |  |  |  |
|  | Lecture/theory room | 60m2 | 1 | 1:25 |
|  | Workshop | 150m2 equipped with:  Tools, spares parts and consumable storage area.  Safety and emergency zone with extinguishers, first aid kits, and clearly marked exits.  Multiple power outlets (AC/DC) with surge protection  High-speed internet for accessing resources  Adequate lighting (preferably LED) for detailed work  15 Trainee workstations | 1 | 1:25 |
|  | Computers with internet access | Processor: Intel Core i5/i7 or equivalent  RAM: 8GB or higher  Storage: 256GB SSD or higher | 25 pcs | 1:25 |
| **C** | **Tools and Equipment** |  |  |  |
|  | Spectrum Analyzer | Used to measure and analyze the frequency spectrum of telecommunication signals. Frequency range: 9 kHz–3 GHz (or higher). Portable or bench-top models. | 5 pcs | 1:5 |
|  | Signal Generator | Produces calibrated signals for testing. Frequency range: 1 Hz–6 GHz. Supports amplitude and frequency modulation. | 5 pcs | 1:5 |
|  | Oscilloscope | Displays and analyzes signal waveforms. Bandwidth: 100 MHz or higher. Channels: 2 or more. Digital storage functionality. | 5 pcs | 1:5 |
|  | Multimeter | Measures voltage, current, and resistance. Digital models with auto-ranging capability preferred. | 5 pcs | 1:5 |
|  | Network Cable Tester | Verifies cable connectivity and identifies faults in Ethernet cables (e.g., Cat5e, Cat6). Can test wiremap, length, and continuity. | 5 pcs | 1:5 |
|  | VoIP Tester | Tests the performance and connectivity of VoIP systems. Capable of monitoring SIP traffic and voice quality metrics. | 5 pcs | 1:5 |
|  | Time Domain Reflectometer (TDR) | Locates faults in coaxial and twisted-pair cables. Measures the distance to faults like breaks or shorts. | 5 pcs | 1:5 |
|  | Crimping Tool | Used to terminate RJ45 and RJ11 connectors. Ergonomic design with replaceable blades. | 5 pcs | 1:5 |
|  | Wire Stripper | Strips insulation from cables. Adjustable for different wire gauges. | 5 pcs | 1:5 |
|  | Punch-Down Tool | Terminates wires on patch panels and keystone jacks. Spring-loaded impact mechanism for secure connections. | 5 pcs | 1:5 |
|  | Soldering Kit | Includes soldering iron (30-50W), solder wire, flux, and stand. Suitable for electronic repairs. | 5 kits | 1:5 |
|  | Screwdrivers and Pliers | Set of precision screwdrivers and needle-nose pliers. Non-conductive, insulated handles preferred. | 5 sets | 1:5 |
|  | Heat Gun | For shrink tubing and solder reflow. Adjustable temperature: 100–500°C. | 5 pcs | 1:5 |
|  | Fiber Optic Tester | Measures loss, power, and quality in fiber optic cables. Includes optical power meter and light source. | 5 pcs | 1:5 |
|  | Fiber Optic Splicing Kit | Includes fusion splicer, cleaver, and cleaning tools for fiber optic cable connections. | 2 pcs | 1:13 |
|  | Mobile Communication Components | Access to Base stations, antennas, and RF amplifiers for wireless communication training. | Enough | - |
|  | Signal Boosters | Enhances weak signals in telecommunication networks. Frequency range: 800–2600 MHz for GSM, 3G, or LTE. | 2 pcs | 1:13 |
| **Software** |  |  |  |  |
|  | Cisco Packet Tracer | Networking simulation tool for practice and design of telecommunication networks. | Installed in 10 computers | 1:3 |
|  | GNS3 | Open-source network simulation software for virtualizing routers and switches. | Installed in 10 computers | 1:3 |
|  | Wireshark | Packet analyzer for monitoring and troubleshooting network traffic. Supports protocols like TCP/IP, UDP, and SIP. | Installed in 10 computers | 1:3 |
|  | SolarWinds Network Monitor | Software for real-time network diagnostics and performance monitoring. | Installed in 10 computers | 1:3 |
| **Cables and Connectors** |  |  |  |  |
|  | Ethernet Cables | Cat5e and Cat6 cables for wired networks. Pre-terminated or roll with required connectors. | 300m | 12m:1 |
|  | Fiber Optic Cables | Single-mode and multimode cables with SC, LC, or ST connectors. Length: 10–50 meters. | 100 pcs | 4:1 |
|  | Coaxial Cables | Used for RF and TV signal transmission. RG6 and RG11 types preferred. | 100 pcs | 4:1 |
|  | RJ45 and RJ11 Connectors | Connectors for Ethernet and telephone cables. Pack of 50 or 100 connectors for training purposes. | 1000 pcs | 40:1 |
| **Personal Protective Equipment (PPE)** |  |  |  |  |
|  | Anti-static Wrist Straps | Protects sensitive electronic components from static discharge. Adjustable and reusable. | 25 pcs | 1:1 |
|  | Safety Glasses | Protects eyes during soldering or handling optical fibers. ANSI Z87.1-compliant. | 25 pcs | 1:1 |
|  | Insulated Gloves | Protects against electrical shocks. Rated for low- and high-voltage applications. | 25 pcs | 1:1 |
| **Documentation Tools** |  |  |  |  |
|  | Maintenance Logs | Templates for recording maintenance tasks, system configurations, and fault resolutions. | Enough | **-** |
|  | Network Diagrams | Tools like Microsoft Visio for creating and sharing network topology diagrams. | Enough | **-** |
| **Reference Materials** |  |  |  |  |
|  | Telecom Standards | ITU, IEEE, and ISO standard manuals for telecommunication system setup and maintenance. | 5 copies | 1:5 |
|  | Troubleshooting Guides | Comprehensive manuals detailing common faults, diagnostic methods, and solutions for telecom systems. | 5 copies | 1:5 |