RQFLEVEL 4

CSACE401

COMPUTER SYSTEM AND ARCHITECTURE

# Creation of Electronics Enclosure

*TRAINER'S MANUAL*

*October, 2024*

# CREATION OF ELECTRONICS ENCLOSURE

KOICA Korea International Cooperation Agency

TQUM TVET Quality Management Project

2024

# AUTHOR'S NOTE PAGE (COPYRIGHT)



*Copies available from:*

- *HQs: Rwanda TVET Board-RTB*
- *Web: www.rtb.gov.rw*
- **KIGALI-RWANDA**

Original published version: October 2024

# ACKNOWLEDGEMENTS

The publisher would like to thank the following for their assistance in the elaboration of this training manual:

Rwanda TVET Board (RTB) extends its appreciation to all parties who contributed to the development of the trainer's and trainee's manuals for the TVET Certificate IV in Computer System and Architecture, specifically for the module "**CSACE401: Creation of Electronics Enclosure".**

We extend our gratitude to KOICA Rwanda for its contribution to the development of these training manuals and for its ongoing support of the TVET system in Rwanda.

We extend our gratitude to the TQUM Project for its financial and technical support in the development of these training manuals.

We would also like to acknowledge the valuable contributions of all TVET trainers and industry practitioners in the development of this training manual.

The management of Rwanda TVET Board extends its appreciation to both its staff and the staff of the TQUM Project for their efforts in coordinating these activities.

This training manual was developed:

Under Rwanda TVET Board (RTB) guiding policies and directives

Under Financial and Technical support of

## COORDINATION TEAM

RWAMASIRABO Aimable

MARIA Bernadette M. Ramos

MUTIJIMA Asher Emmanuel

## PRODUCTION TEAM

### Authoring and Review

TWAGIRIMANA Onesphore

MWIZERWA Regis

### Validation

BANABADATA Jean Claude

KAGABA Gaspard

MUZIMANGANYE Jean Pierre

### Conception, Adaptation and Editorial works

HATEGEKIMANA Olivier

GANZA Jean Francois Regis

HARELIMANA Wilson

NZABIRINDA Aimable

DUKUZIMANA Therese

NIYONKURU Sylvestre

NIYONZIMA Augustin

### Formatting, Graphics, Illustrations, and infographics

YEONWOO Choe

SUA Lim

SAEM Lee

SOYEON Kim

WONYEONG Jeong

MANIRAKIZA Jean de Dieu

### Financial and Technical support

KOICA through TQUM Project

# TABLE OF CONTENT

# ACRONYMS

**3MF**: Manufacturing File

**CAD:** Computer Aided Design

**CBT:** Competency-Based Training

**EMC:** Electromagnetic Compatibility

**EMI:** Electromagnetic Interference

**GB:** Gigabyte

**GLB:** GL Transmission Format Binary file

**GLTF:** Graphics Library Transmission Format

**KOICA**: Korea International Cooperation Agency

**OBJ:** Wave front OBJ

**PCB:** Print Circuit Board

**PETG:** Polyethylene Terephthalate Glycol

**PLA:** Polylactic Acid

**PPE:** Personal Protective Equipment

**RAM:** Random Access Memory

**RTB:** Rwanda TVET Board

**STL:** Stereo lithography

**TQUM Project:** TVET Quality Management Project

# INTRODUCTION

This trainer's manual includes all the methodologies required to effectively deliver the module titled **"Creation of Electronics Enclosure."** Trainees enrolled in this module will engage in practical activities designed to develop and enhance their competencies.

The development of this training manual followed the Competency-Based Training and Assessment (CBT/A) approach, offering ample practical opportunities that mirror real-life situations.

The trainer's manual is organized into Learning Outcomes, which is broken down into indicative content that includes both theoretical and practical activities. It provides detailed information on the key competencies required for each learning outcome, along with the objectives to be achieved.

As a trainer, you will begin by asking questions related to the activities to encourage critical thinking and guide trainees toward real-world applications in the labor market. The manual also outlines essential information such as learning hours, didactic materials, and suggested methodologies.

This manual outlines the procedures and methodologies for guiding trainees through various activities as detailed in their respective trainee manuals. The activities included in this training manual are designed to offer trainees opportunities for both individual and group work. Upon completing all activities, you will assist trainees in conducting a formative assessment known as the end learning outcome assessment. Ensure that trainees review the key reading and the points to remember section.

## MODULE CODE AND TITLE: CSACE401 CREATION OF ELECTRONICS ENCLOSURE

| |
|---|
| **Learning Outcome 1: Create a conceptual model of electronics enclosure** |
| **Learning Outcome 2: Design 3D Model of electronics enclosure with CAD** |
| **Learning Outcome 3: Print electronics enclosure** |

# Learning Outcome 1: Create a Conceptual Model of Electronics Enclosure

**Indicative contents**

**1.1:Identification of enclosure modelling requirements**
**1.2:Identification of object modelling stages**
**1.3:Sketch the conceptual design of the object**

## Key Competencies for Learning Outcome 1 : Create a Conceptual Model of Electronics Enclosure

| Knowledge | Skills | Attitudes |
|---|---|---|
| • Description of electronics enclosure<br>• Description of System requirements<br>• Description of object modelling<br>• Description of various modelling stages | • Interpreting the electronic device diagrams<br>• Designing for EMI prevention/reduction<br>• Applying measurement of the object<br>• Developing 3D Conceptual model<br>• Drawing of conceptual model object | • Being innovative<br>• Being organizer<br>• Having flexibility<br>• Being problem Solver<br>• Having team work split<br>• Being hard worker |

**Duration: 15hrs**

**Learning outcome 1 objectives**:

By the end of the learning outcome, the trainees will be able to:

1. Introduce correctly electronicenclosure according to the concepts of enclosure
2. Identify properly system requirements based on the type of electronics being housed, and the specific design requirements
3. Interpret properly electronic circuitaccording to circuit board diagrams specifications.
4. Identify properly object-modelling stage according to the form factor of the electronic components.
5. Design properly EMI preventionaccording to their types
6. Perform correctly dimension of the object according to electronic circuit
7. Develop correctly3D conceptual design of the object according to circuit board diagrams specifications

**Resources**

| Equipment | Tools | Materials |
|---|---|---|
| • Computer<br>• Projector<br>• Drawing board<br>• Drawing table | • Drawing tool set | • Internet<br>• Electricity<br>• Pen and Paper |

**Advance Preparation:**

Before delivering this learning outcome, you are recommended to:

- Avail CAD software (SolidWorks)
- Avail workshop of electronic enclosure

## Indicative content 1.1: Identification of Enclosure Modelling Requirements

**Duration: 4 hrs**

### Theoretical Activity 1.1.1: Description of enclosure modelling requirements

**Notes to the trainer:**

- Trainer may use small group for describing 3Dmodel
- Trainer may use image, video of 3D model
- Avail electronic device diagrams

**Key steps:**

**While delivering this activity, pass through the following steps:**

**Step 1:** Introduce the activity and ask trainees to answer the following questions:

i. What do you understand by the term “Electronic enclosure”?
ii. Outline the purpose of electronics enclosure
iii. Distinguish between functional and non-functional system requirements.

**Step 2**: Ask trainees to write provided answers on flipchart/paper.

**Step 3:** Ask traineesto discuss on the provided answer and choose correct answers.

**Step 4:**Provide expert view and clarify ideas by using didactic materials.

**Step 5:** Address any questions or concerns.

**Step 6:** Ask trainees to read the key reading 1.1.1 in their manuals.

**Points to Remember**

- Definition: An electronic enclosure is a protective casing that safeguards electronic components from environmental factors like dust, moisture, and physical damage, and prevents electromagnetic interference.
- Purpose: Its main roles include providing protection, ensuring safety, minimizing EMI, managing heat, enhancing aesthetics, and complying with regulatory standards.
- Functional Requirements: The enclosure must be made from materials that withstand mechanical, electrical, thermal, and environmental stresses.
- Non-Functional Requirements: These focus on performance attributes, such as compatibility, portability, capacity, and reliability.
- Material Selection: The materials should exhibit strong resistance and remain undamaged under service conditions.
- System Architecture: It should consider the connections between subsystems for a functional final system

**Practical Activity 1.1.2:.Interpreting of Electronic Device Diagram**

**Notes to the trainer**

- Trainer may use electronic circuit diagrams representing circuit symbols of electronic devices.
- Trainer may use image, video of 3D model

**Key steps:**

**While delivering this activity, pass through the following steps:**

**Step 1:** Introduce the topic and ask trainees to perform the following task:

To better protect the electronic circuit, it is crucial to implement an electronics enclosure. You are requested to interpret the electronic circuit that will be implemented.

**Step 2:** Ask trainees to read the steps of interpreting electronics devices diagram in key readings 1.1.2 in their manuals.

**Step 3:** Conduct a demonstration on how to interpret the electronic circuit diagram by explaining each step.

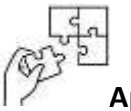
**Step 4:** Ask trainees to interpret the electronic circuit diagram.

**Step 5:** Ask trainees to present their work to the whole class.

**Step 6:** Facilitate them in presentation and provide a feedback

**Points to Remember**

- Diagram Elements: Understanding electronic diagrams involves recognizing symbols, conventions, and the layout used to represent components, connections, power, and ground in circuits.
- Key Steps in Interpretation: This includes familiarizing oneself with circuit symbols, identifying the power source, tracing the circuit path, and understanding component values and ground connections.
- Signal Flow and Feedback: Analyzing signal flow and locating feedback loops helps to comprehend circuit behavior, especially in active components like amplifiers.
- Diagram Considerations: When creating diagrams, ensure clear labeling, logical layout, inclusion of dimensions, and compliance with safety standards.
- Practical Approach: Using simulation tools and practicing with various circuit diagrams enhances understanding and interpretation skills



**Application of learning 1.1.**

XYZ company is a company that is specialized in developing electronic enclosures, as a staff member, company has chosen you to interpret an electronic device diagram to be protected; this diagram is sent by a client,you are asked to interpret that electronic device diagram and provide assistance in design of an enclosure.

**Checklist**

| SN | Criteria | Indicators | Observation | |
|---|---|---|---|---|
| | | | Yes | No |
| 1 | **Electronic device diagram are identified** | 1.1. Electronic circuit diagram is identified | | |
| | | 1.2. Electronic components symbols are identified | | |
| 2 | **Electronic device diagram is well interpreted** | 1.3. Power source are well interpreted | | |
| | | 1.4. Ground terminals are interpreted | | |

## Indicative content 1.2: Identification of Object Modeling Stages

**Duration: 7hrs**

### Theoretical Activity 1.2.1: Identification of object modelling stages

**Notes to the trainer:**

- Trainer may use small group for describing 3Dmodel
- Trainer may use image, video of 3D model

**Key steps:**

**While delivering this activity, pass through the following steps:**

**Step 1:** Introduce the activity and ask trainees to do the following questions:

a. What do you understand by the term “Object modelling stage”?
b. Outline the key factors to consider in designing electronic enclosure
c. Distinguish between EMI filter and EMI shielding design

**Step 2**: Ask trainees to write provided answers on flipchart/paper.

**Step 3:** Ask trainees to discuss on the provided answer and choose correct answers.

**Step 4:** Provide expert view and clarify ideas by using didactic materials.

**Step 5:** Address any questions or concerns.

**Step 6:** Ask trainees to read the key readings 1.2.1 in their manuals.

**Points to Remember**

- Object Modeling Stages: Involves systematic representation of the structure and behavior of electronic enclosures, often using UML.
- Key Considerations: Factors include compatibility, dimensional fit, thermal management, environmental protection, user ergonomics, aesthetics, and branding.
- Modularity and Customization: Modular designs allow for easy assembly and customization, catering to specific user requirements.

- Modeling Stages: Includes skeleton/thumbnails for initial design, sculpting for form refinement, texturing for surface finishes, rigging for component configuration, and animation for visualizing assembly.
- Environmental and Thermal Concerns: Ensuring protection against harsh conditions and effective heat management is crucial for device reliability.
- User-Centric Design: Emphasizes ergonomics, aesthetics, and brand identity for improved functionality and market appeal.

**Practical Activity 1.2.2: Designing EMI Prevention/Reduction**

**Notes to the trainer**

- Trainer may use image, video of 3D model

**Key steps:**

**While delivering this activity, pass through the following steps:**

**Step 1:** Introduce the topic and ask trainees to perform the following task:

You are requested to go in the computer lab to design EMI shielding for a workshop project to protect electronic circuits inside an enclosure from electromagnetic interference. Follow these steps:

a. Design an EMI shielding solution: Identify suitable materials and methods to shield the enclosure from both internal and external interference.
b. Develop grounding schemes: Plan and implement grounding strategies to minimize electromagnetic noise.
c. Create a basic PCB layout: Design a simple PCB layout that incorporates the EMI shielding and grounding techniques.

**Step 2:** Ask trainees to read the steps of interpreting electronics devices diagram in key readings 1.2.2 in their manuals.

**Step 3:** Conduct a demonstration on how to design EMI by explaining each step.

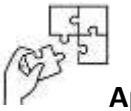
**Step 4:** Ask trainees to design EMI on their own pace.

**Step 5:** Ask trainees to present their work to the whole class.

**Step 6:** Facilitate them in presentation and provide a feedback

**Points to Remember**

- EMI Definition: Unwanted electromagnetic emissions or susceptibility that can disrupt electronic devices' operation.
- EMI Shielding: Uses manufacturing techniques and materials to protect signals from external interference and prevent internal signals from affecting nearby components.
- Grounding Schemes: Involves systematic ground connections to ensure safety, proper function, and electromagnetic compatibility.
- EMI Filters: Mitigate high-frequency electromagnetic noise on power and signal lines, improving device performance.
- PCB Layout Minimization: Optimizes PCB design by reducing size, complexity, and inductance loops to minimize EMI impact.



**Application of learning 1.2.**

XYZ Company is seeking a technician responsible for designing EMI shielding for device enclosures. As a computer system architecture technician, your role will involve designing EMI shielding to protect the electronic circuit boards within the enclosure from both internal and external electromagnetic interference.

**Checklist**

| SN | Criteria | Indicators | Yes | No |
|---|---|---|---|---|
| 1 | Equipment and Materials are selected | 1.1. Computer and software are identified | | |
| | | 1.2. Drawing tool set are selected | | |
| | | 1.3. Power and ground cables are identified | | |
| 2 | EMI Shield is correctly designed | 2.1. Connecting parts are well connected appropriately | | |
| | | 2.2. Testing and troubleshooting are well performed | | |

## Indicative content 1.3: Sketch the Conceptual Design of the Object

**Duration: 4hrs**

### Practical Activity 1.3.1: Sketching the conceptual design of the object

**Notes to the trainer**

Trainer may use small group for create a conceptual model of electronics enclosure

- Trainer may use image, video ofcreate a conceptual model of electronics enclosure

**Key steps:**

**While delivering this activity, pass through the following steps:**

**Step1:** Introduce the topic and ask trainees do the task described below:

> You are requested to go in workshop to interpret and applying the dimensions of an electronic circuit board diagram for a workshop project. Your objective is to design electronic circuits that fit seamlessly within an enclosure, ensuring compatibility with the enclosure's specifications.

**Step2:** Asks trainees to write provided answers on papers.

**Step3:** Asks Trainees to discuss the provided answer and choose correct answers.

**Step4:** Provide expert view and clarify ideas by using didactic materials**.**

**Step5:** Address any questions or concerns.

**Step6:** Ask trainees to read the key reading 1.3.1 in the trainee manual.

**Points to Remember**

- **Schematic Diagrams**: Essential for visualizing electronic circuits, using standardized symbols to represent components and connections.
- **Block Diagrams:** Simplified representations showing functional relationships between circuit parts with boxes and lines.
- **Assembly Drawings:** Provide physical layouts for beginners, detailing how to connect components on a printed circuit board (PCB).

- **Dimensioning:** Refers to the physical size of objects, crucial for accurate design and fitting.
- **AutoCAD Tools:** MEASUREGEOM command aids in precise measurements of area, distance, and angles for effective design.
- **Conceptual Models:** Sketching electronic enclosures helps visualize layout, ensuring both functionality and aesthetics are met**.**

**Application of learning 1.3**

A new small business, "Enclosure Solution," needs to design electronic enclosures to cover electronic circuit board diagram. You are tasked to perform the following tasks:

i. Interpret a circuit diagram and apply dimensioning to an object in design software
ii. Design electronic circuit board diagrams.
iii. Perform a conceptual model or ideation sketch

**Check list**

| **Criteria** | **Indicators** | **Score** | |
|---|---|---|---|
| | | Yes | No |
| **Interpretation of electronic device diagrams** | 1.1. Drawing diagrams are selected | | |
| | 1.2. Drawing board or drawing table is selected | | |
| | 1.3. Drawing tool set is selected | | |
| | Drawing steps are followed | | |

## Learning outcome 1 end assessment

**Theoretical assessment**

I. Read the following statements and choose the correct answer.

**1.** What do you understand by the term “Electronic enclosure”?

**a)** An electronic enclosure is a protective casing designed to house and safeguard electronic components and systems

**b)** Electronic devices and equipment is the use of manufacturing techniques and materials to protect signals from being disrupted by external electromagnetic signals

**c)** Architectural requirements are more descriptive of “connections” between the subsystems to form the final system

**Answer: a)**

**2.** Which purpose of electronics enclosure?

a) Converts signals between digital and analog
b) Inclusion of dimensions and mounting points for proper installation
c) Protection shields electronic components from environmental hazards like dust, moisture, and physical impact

**Answer: c)**

**3.** .What does the acronym EMI stand for?

a) Electrical machine interference
b) Electromagnetic Interference
c) Erasable memory interference
d) A and B is correct
e) All is correct

**Answer: b)**

4. Which function of ergonomics in electronic enclosures?

    a. Communications between electronic device
    b. To filter and control incoming and outgoing traffic
    c. To ensure that the end-users can interact with the device comfortably and efficiently.
    d. None

**Answer: c)**.

5. What is the purpose of grounding?

    a. To ensure proper functioning, safety, and compliance with electromagnetic compatibility (EMC) standards.
    b. Reducing the size and complexity of the PCB design to meet specific goals
    c. It allows you to draw and edit digital 2D and 3D designs more quickly and easily than you could by hand.
    d. None of the above

    **Answer: a)**.

II. Read the following statements, and Answer by TRUE if the statement is right or FALSE if it is wrong.

1. Electromagnetic compatibility is the system should not be affected by emissions from other systems or equipment such as electromagnetic fields created by other circuits. **Answer: TRUE**

2. Non-functional requirements are “how well” the system should perform in one or more areas. **Answer: TRUE**

3. User ergonomics is the monitoring and control of temperature produced by devices in electrical enclosures. **Answer: FALSE**

4. In the 3D modelling stage, you could create animated prototypes or simulations of the enclosure. **Answer: FALSE**

5. Brand is the unique identity, image, and reputation associated with a specific manufacturer or company that produces the enclosures. **Answer: TRUE**

## I. Match Indicators with corresponding functions

| Answer | Indicators | Functions |
|---|---|---|
| **1… b …** | 1.Skelton/Thumbnail | **a.** EMI Filters, or electromagnetic interference filters, also called RFI Filters or radio-frequency interference filters, are an electrical device / circuit that mitigate the high frequency Electromagnetic noise present on the power and signal lines |
| **2 … c …..** | **2.**Safety | **b.** Is a protective case for electronic components, and adding a skeleton or thumbnail design can enhance its aesthetics or functionality. |
| **3 …… a …** | **3.** EMI Filters | **c.**Is to prevents accidental contact with live electrical parts, reducing the risk of electric shock |
| | | e. Ensures that products meet safety and environmental regulations. |

**Practical assessment**

High Tech Company Ltd intends to hire you as a technical expert to design an electronic enclosure for its electronic devices. Youare asked to analyse devices and circuit diagrams, design to minimize electromagnetic interference (EMI), and ensuring accurate dimensions to produce a more efficient electronic enclosure.

**Checklist**

| SN | Criteria | Indicators | Score | |
|---|---|---|---|---|
| | | | Yes | No |
| 1 | Electronic Devices diagrams are well interpreted | 1.1. Drawing diagrams are selected | | |
| | | 1.2. Drawing circuit is interpreted and de | | |
| 2 | Dimensioning of Object is well done | 2.1. Dimensioning tools are selected | | |
| | | 2.2. Modelling object is well measured | | |
| 3 | EMI is properly designed | EMI is designed according to manufacturer's instructions. | | |
| 4 | Electronic enclosure is well designed | 4.1. Electronic enclosure is designed properly | | |
| | | 4.2. Electronic enclosure is perform appropriately | | |

## Further information to the trainer

***Skill-Lync.*** *(n.d.).* Week 6.1: Setting up a model electronic enclosure*. Retrieved November 4, 2024, from https://skill-lync.com/trainee-projects/week-6-1-setting-up-a-model-electronic-enclosure-20*

***Skill-Lync.*** *(n.d.).* Week 6.1: Setting up a model electronic enclosure*. Retrieved November 4, 2024, from https://skill-lync.com/trainee-projects/week-6-1-setting-up-a-model-electronic-enclosure-17*

***Ernst, G.*** *(2009).* Advances in electronic enclosure design*. Springer. Retrieved from https://link.springer.com/book/10.1007/978-3-642-03867-9*

# Learning Outcome 2: Design 3D Model of Electronics Enclosure with CAD

| Indicative contents |
|---|
| **2.1 Selection of tools, materials and equipment of 3D model**<br>**2.2Installation of CAD software**<br>**2.3 Apply a 3D model design**<br>**2.4 Perform a 3D animation** |

**Key Competencies for Learning Outcome 2 :Design 3D Model of Electronics Enclosure with CAD**

| Knowledge | Skills | Attitudes |
|---|---|---|
| • Description of3D model<br>• Description of hardware specification<br>• Explanation software tools(Solid works)<br>• Description common elements in 3D software design interface<br>• Explanation 3D file types<br>• Description 3D enclosure modelling considerations | • Installing CAD software<br>• Selecting tools, materials and equipment<br>• Applying a 3D model design<br>• Performing 3D animation | • Being innovative<br>• Being organization<br>• Being safety First<br>• Being flexibility<br>• Being problem Solving<br>• Being team work<br>• Being hard worker |

**Duration: 35hrs**

**Learning outcome 2 objectives**:

By the end of the learning outcome, the trainees will be able to:

1. Introduce clearly 3D model according to electronic enclosure
2. Identify properly the hardware specifications according to electronic enclosure
3. Identify properly elements of 3D software design according to their features.
4. Introduce clearly 3D file types according to electronic enclosure
5. Identify appropriately Tools, material and equipment based on 3D model
6. Perform correctly Installation of CAD software based on selection criteria
7. Design properly 3D model designs according to electronics enclosure

**Resources**

| Equipment | Tools | Materials |
|---|---|---|
| • Computer<br>• Projector | • CAD software (SolidWorks, Autodesk Maya, AutoCAD) | • Electricity<br>• Internet |

**Advance Preparation:**

Before delivering this learning outcome, you are recommended to:

- Prepare electronics enclosure tools, material and equipment of electronic device
- Have CAD software tools (SolidWorks)

## Indicative content 2.1: Selection of Tools, Materials and Equipment of 3D Model

**Duration: 3hrs**

**Theoretical Activity 2.1.1: Description of tools, material and equipment of 3Dmodel**of 3D model

**Notes to the trainer:**

- Trainer may use small group for describing 3Dmodel
- Trainer may use image, video of 3D model

**Key steps:**

**While delivering this activity, pass through the following steps:**

**Step 1:** Introduce the activity and ask trainees to answer the following questions:

i. Explain the purpose of SolidWorks and how it is used in 3D modeling.
ii. Outline the minimum required computer hardware specifications for 3D modeling and the key characteristics of a 3D model.
iii. Distinguish between the main features of AutoCAD and the best-known features of Autodesk Maya.

**Step2:** Ask trainees to write provided answers on papers.

**Step3:** Ask Trainees to discuss the provided answer and choose correct answers.

**Step4:** Address any questions or concerns.

**Step5:** Ask trainees to read the key reading 2.1.1 in the trainee manual.

**Points to Remember**

- **3D Modeling Definition**: The process of creating three-dimensional representations of objects using specialized software, representing physical bodies with geometric entities like triangles and curves.
- **Key Characteristics**: Important features include geometry (shape), textures (surface details), materials (light interaction), scalability (resizing), and interactivity (user engagement).
- **Angle Views**: Common projection methods include orthographic views (2D), isometric views (equal foreshortening), and perspective views (realistic distance portrayal).
- **Hardware Specifications**: Recommended specs include a multi-core CPU, 16-32 GB RAM, a dedicated GPU, and SSD storage for optimal performance.
- **Software Tools**: Essential tools for developers include SolidWorks for CAD, AutoCAD for 2D and 3D designs, and Autodesk Maya for advanced animation and visual effects.
- **3D Model Properties**: Main properties consist of faces (surfaces), edges (where faces meet), and vertices (corners), forming the foundational structure of 3D models

**Practical Activity 2.1.2: Selecting tools , materials and equipment for 3D**

**Notes to the trainer**

- Avail the computer lab with the required tools, materials and equipment required for installing CAD Software
- This activity of selecting tools ,materials and equipment required for installing CAD Software may be done individually

**Key steps:**

**While delivering this activity, pass through the following steps:**

**Step 1:** Introduce the topic by demonstrating the activity and explaining the following task:

Before Installing 3D model design software of an enclosure, you are requested to attend the workshop to select required tools, materials and equipment to perform this task.

**Step2**: Demonstrate the task and provide clear work instruction

**Step3.** Facilitate learners to understand the process ofSelecting tools, materials and equipments for 3Dmodel design software

**Step4**. Provide more explanations where necessary

**Step5.** Verify whether 3D model is well done according to the instructions.

**Step6.** For more clarification, read the key readings 2.1.2

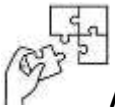
**Points to Remember**

- Below, I'll provide detailed guidance on selecting tools, materials, and equipment for creating a 3D model and printing a custom electronics enclosure.
- Here are the tools that can help with designing a 3D model of an electronics enclosure: CAD (Computer-Aided Design) Software
    - ✓ Fusion 360:
    - ✓ SolidWorks:
    - ✓ Tinkercad
    - ✓ FreeCAD:
    - ✓ Slicing Software

Key factors to consider when choosing materials include strength, thermal stability, electrical properties, and ease of printing, Common Materials for Electronics Enclosures:

- ✓ PLA (Polylactic Acid)
- ✓ Nylon
- ✓ Polycarbonate (PC)

- Conductive Materials (e.g., Conductive PLA or PETG)
  Choosing Based on Application:
- Equipment for 3D Printing Electronics Enclosures,The equipment you use can vary based on the complexity of the enclosure and the material selected.



**Application of learning 2.1**

As a trainee who studied the identification of tools, materials and equipment required for designing 3D Model, you are required to select all required resources

**Checklist**

| **Main points to check** | **Yes** | No |
|---|---|---|
| Fusion 360 is selected | | |
| SolidWorksis selected | | |
| Tinkercad is selected | | |
| FreeCAD is selected | | |
| Slicing Software is selected | | |

## Indicative content 2.2: Installation of CAD Software

**Duration: 10hrs**

### Theoretical Activity 2.2.1: Install CAD software

**Notes to the trainer:**

- Trainer may use small group for describing installation of CAD software

**Key steps:**

**While delivering this activity, pass through the following steps:**

**Step 1:**Introduce the activity and ask trainees to answer the following questions:

a. What are specific features should you look for in CAD software to meet your design needs?
b. Outline the key considerations for 3D enclosure modeling, including shape, size, and material choice.
c. Distinguish between the STL, OBJ, and 3MF file formats in terms of their suitability for 3D printing and data representation.

**Step2**. Ask trainees to write their findings to the flipcharts/Papers.
**Step3.** Ask Trainees to present their finding to the whole class.
**Step4.** Provide expert view and clarifications on asked questions.
**Step5.** Ask trainees to read the key readings 2.2.1 in their manuals.

**Points to Remember**

- **CAD Software Installation & Selection**: Choose CAD software based on its efficiency for specific product types, such as sheet metal parts, and ensure hardware compatibility for seamless operation.
- **Key Software Features**: Evaluate CAD programs for functionalities that aid in the creation, modification, and analysis of digital models, which are crucial for effective design workflows.

- **3D File Types**: Understand the differences between file formats like STL, OBJ, and 3MF; STL is geometry-focused, OBJ supports textures and complex shapes, and 3MF enhances 3D printing workflows.
- **3D Enclosure Design Considerations**: Focus on shape, size, wall thickness, and material selection, all of which significantly impact the functionality and aesthetics of the enclosure.
- **EMI Shielding & Branding**: Incorporate EMI shielding to protect electronic components while ensuring the enclosure's design aligns with aesthetic and branding goals for a cohesive product identity.

**Practical Activity 2.2.2: Installing CAD Software**

**Notes to the trainer**

- This activity should take place in computer lab where you are supposed to demonstrate trainees how to install CAD software. Remember you must ask them to perform this activity and facilitate them individually.
- The computer lab must be accessible
- Trainer may use small group in order to perform a practical activity
- Trainer may use image, video of 3D model

**Key steps:**

**While delivering this activity, pass through the following steps:**

**Step1:**Introduce the topic and ask trainees to perform the following task:

You are requested to go to the lab and install CAD software on the computers. Start by downloading the software from the provided link or source. Follow the installation steps carefully, ensuring all settings are configured correctly. Once the installation is complete, open the software and perform a quick check to verify it is running properly.

**Step 2:** Ask trainees to read the steps of installing 3D CAD software in key readings 2.2.1 in their manuals.

**Step 3:** Conduct a demonstration on how to install 3D CAD software by explaining each step.

**Step 4:** Ask trainees to present their work to the whole class.

**Step 5:** Facilitate them in presentation and provide a feedback

**Points to Remember**

- **Evaluate CAD software** based on its efficiency in creating specific products and ensure compatibility with other systems.
- **Focus on essential software features** that enhance design functionalities and user capabilities.
- **Downloading CAD software** involves obtaining it online and following the installation guide provided by the manufacturer.
- **Traditional 2D** CAD is often favored for smaller projects due to its simplicity and contract relevance.
- **Adhere to best practices** like layer organization and regular backups to improve workflow and design accuracy.

**Application of learning 2.2.**

The school has a computer lab with 30 computers, and CAD software needs to be installed on them. As a computer architecture technician, you have been assigned the task of installing this software, which will be used for designing electronic enclosures.

**Checklist**

| Criteria | Indicators | Score | |
|---|---|---|---|
| | | Yes | No |
| CAD software is well installed | 1.. Installation procedures are followed | | |
| | 2. Test software is running properly | | |

## Indicative content 2.3: Apply a 3D Model Design

**Duration: 20hrs**

### Practical Activity 2.3.1: Applying a 3D model design

**Notes to the trainer**

- Avail a computer lab
- Trainer may use individual presentation to perform this activity
- Trainer may use image, video of 3D model

**Key steps:**

**While delivering this activity, pass through the following steps:**

**Step1**: Introduce the topic and ask trainees to perform the following activity:

You are requested to go in lab to sketch a 3D model design for its electronic device. As a computer system architecture designer, your task is to interpret and design the appropriate 3D model design and rigging by using CAD software.

**Step 2.**Ask trainees to read the steps of designing a 3D model in key readings 2.3.1 in their manuals.

**Step 3.**Conduct a demonstration on how to design 3D model by explaining each step.

**Step 4.** Ask trainees to design 3D model on their own pace.

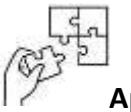
**Step 5.** Ask trainees to present their work to the whole class.

**Step 6.**Facilitate them in presentation and provide a feedback

**Points to Remember**

- **In 3D model design**, interpret conceptual models by extracting meaningful information and understanding the design's purpose and aesthetics.
- **Initial steps** involve researching the subject, sketching rough concepts, and collaborating with stakeholders for feedback.

- **3D modeling** uses software to create mathematical representations of objects, focusing on size, shape, and texture.
- **After grasping the conceptual model**, use tools like Blender or Maya to create detailed 3D representations with defined geometry and textures.
- **3D rigging** involves creating a skeleton for models, allowing movement through skeleton creation, skinning, and setting up animation controls.



**Application of learning 2.3**

Your manager asks you to create a 3D model of a custom gear system that can fit within a 10x10 cm space. The part should be easy to assemble and optimized for 3D printing, without overhangs that could complicate the process. Your goal is to ensure the part is functional, precise, and aligns with the sleek, modern look the company aims for.

**Checklist**

| SN | Criteria | Indicators | Score | |
|---|---|---|---|---|
| | | | Yes | No |
| 1 | 3D model is Interpreted | Interpretation is well done | | |
| 2 | 3D model object is designed | 2.1. 3D model is well created | | |
| | | 2.2. 3D model is functioning | | |
| | | 2.3. 3D model obeys dimensions | | |

## Indicative content 2.4: Perform a 3D animation

**Duration: 2hrs**

### Practical Activity 2.4.1: Performing 3D Animation

**Notes to the trainer**

- The computer lab must be accessible
- Trainer may use small group in order to perform a practical activity
- Trainer may use image, video of 3D model

**Key steps:**

**While delivering this activity, pass through the following steps:**

**Step 1:** Introduce the topic by demonstrating the activity and explaining the following task:

You are requested to go in computer lab to use CAD software for Pose Blocking**,** Timing**,** and Spacing in 3D animation. Pose blocking sets the key positions of an object, while timing and spacing control the speed and smoothness of its movement

**Step2**: Provide manual indicating the steps of the task and provide clear work instruction

**Step3.** Facilitate learners to understand the steps of designing 3D model.

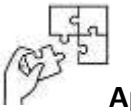
**Step4**. Provide more explanations where necessary

**Step5.**Verify whether 3D model is well done according to the instructions.

**Step6.**For more clarification, read the key readings 2.4.1

**Points to Remember**

- **Key framing** defines an object's initial and final states, reflecting changes in properties like position and color over time.
- **Pose blocking** creates key poses to establish timing and placement of characters and props, often called Stepped animation in 3D.
- **Each key frame marks** critical start or end points for movements or poses in the animation.
- **A timing** chart shows the number of frames between key frames, influencing movement speed.
- **Spacing** determines the distance between key frames, directly affecting the speed and acceleration of the animation.



**Application of learning 2.4.**

XYZ Company intends to design 3D model of electronic enclosures, and you have been selected to lead this activity. As the lead designer for this activity, your duties include installing the latest version of the CAD software, creating a 3D model, and implementing a 3D animation of the object.

**Checklist**

| SN | Criteria | Indicators | Score | |
|---|---|---|---|---|
| | | | Yes | No |
| 1 | Software tool and hardware devices are well identified | 1.1. Software tool with current version is well selected | | |
| | | 1.2. Hardware device are well selected | | |
| 2 | CAD software is installed properly | 2.1. Installation steps are followed | | |
| | | 2.2. CAD software is well functioning | | |
| 3 | 3D model well created | 3.1. Interpretation of an object is correct | | |
| | | 3.2. 3Dobject of electronic enclosure is well drawn | | |
| | | 3.3.. 3D object animation is running properly | | |

## Learning outcome 2 end assessment

**Theoretical assessment**

**I. Multiple Choice Questions**

1. What do you understand by the term “3D model”?
   a) Is a set of computer programs that are used by the developers to create, maintain, debug
   b) Represent a physical body using a collection of points in 3D space, connected by various geometric entities such as triangles, lines, curved surfaces
   c) Ability of different CAD programs or versions to work together seamlessly

**Answer: b**

2. What are thetypes of view angles for 3D models
   a) First angle projection and third angle projection
   b) Orthographic Views and Isometric Views
   c) Storage

**Answer: b**

3. What are th eminimum computer hardware specifications for 3D modelling
   a) RAM Memory: 8GB
   b) SSD Memory: 256GB or HDD Memory: 500GB
   c) Isometric Views
   d) 3D file

**Answer: a and b**

4. What is SolidWorks used for
   a) Is 3D CAD software that provide collaboration, analysis, and product data management
   b) Representations from multiple angles without perspective distortion.
   c) Is used for creating a three-dimensional representation of an object using specialized software

**Answer: a**

**II. Read the following statements, and Answer by TRUE if the statement is right or FALSE if it is wrong**

a. Wall thickness refers to the distance between one surface of your model and the opposite sheer surface
   **Answer: True**
b. 3D design is the process of using software to create a geometrical representation of a 3-dimensional object or shape
   **Answer: True**
c. Keyframing is the simplest form of animating an object based on the notion that an object has a beginning state
   **Answer: True**

**III.Match with corresponding description**

| **Answer** | **Indicators** | **Description** |
|---|---|---|
| **1…c..** | 1. 3D Manufacturing File(.3MF) | **a)** It enables users to represent complex or irregularly shaped objects by dividing their surface into small, triangular "tiles." |
| **2…b..** | 2. Stereolithography(.STL) | b) Using to express colour or textures is impossible because it is only concerned with surface geometry and forms. It is suitable for use in specific circumstances when complex CAD data is not required |
| **3…a..** | 3. Wavefront OBJ(.OBJ) | c) It is a file format that design applications can use to store information about a full-fidelity 3D model that is relevant to the 3D printing process. |
| | | d) Physical dimensions of the enclosure in three-dimensional space. |

**Practical assessment**

XYZ Company intends to design 3D model of electronic enclosures, and you have been selected to lead this activity. As the lead designer for this activity, your duties include installing the latest version of the CAD software, creating a 3D model, and implementing a 3D animation of the object. Provide a report for the documenting product.

**Checklist**

| SN | Criteria | Indicators | Score | |
|---|---|---|---|---|
| | | | Yes | No |
| 1 | Software tool and hardware devices are well identified | 1.1. Software tool with current version is well selected | | |
| | | 1.2. Hardware deviceare well selected | | |
| 2 | CAD software is installed properly | 2.1. Installation steps are followed | | |
| | | 2.2. CAD software is well functioning | | |
| 3 | 3D model well created | 3.1. Interpretation of an object is correct | | |
| | | 3Dobject of electronic enclosure is well drawn | | |
| | | 3D object animation is running properly | | |
| 4 | Report is well created | Documenting product generated | | |

## Further information to the trainer

HubSpot. (n.d.). *Enclosure design for 3D printing: A step-by-step guide*. HubSpot. https://www.hubs.com/knowledge-base/enclosure-design-3d-printing-step-step-guide/

All About Circuits. (2021, June 29). *Six steps for designing a custom 3D printed electronics enclosure*.https://www.allaboutcircuits.com/industry-articles/six-steps-for-designing-a-custom-3d-printed-electronics-enclosure/

GrabCAD. (n.d.). *Enclosures*. https://grabcad.com/library?tags=enclosure


AUTODESK
AutoCAD
3D

| Indicative contents |
|---|
| **3.1 Selection of 3D Printer**<br>**3.2 Identification of printing materials**<br>**3.3 Slicing 3D model**<br>**3.4 Set up 3D printer for printing**<br>**3.5 Perform 3D printing post-processing** |

## Key Competencies for Learning Outcome 3 : Selection of 3D Printer

| Knowledge | Skills | Attitudes |
|---|---|---|
| • Identification of print materials<br>• Description of EMI shield<br>• Description of thermoplastics<br>• Description of printing properties<br>• Description Slicing 3D model<br>• Identification of 3D printing requirements<br>• Description of slicing software<br>• Identification of 3D printer | • Selecting of 3D Printer<br>• Selecting of 3D Print Technologies<br>• Performing conditions of 3D printed enclosure<br>• Installing slicer software<br>• Converting the 3D model into a series of 2D layers<br>• Performing 3D printing | • Being innovative<br>• Being organization<br>• Being safety First<br>• Being flexibility<br>• Being problem Solving<br>• Being team work<br>• Being hard worker |

**Duration: 20 hrs**

**Learning outcome 3 objectives**:

By the end of the learning outcome, the trainees will be able to:

1. Identify properly printing materials based on the electronics enclosure
2. Describe clearly EMI shield according to print materials
3. Describe clearly thermoplastics according to print materials
4. Introduce correctly Slicing 3D model according to electronic enclosure
5. Describe clearly slicing based on the type of software
6. Identify properly printing properties according to the Quality, Speed and Volume
7. Identify properly 3D printer according to the electronic enclosure
8. Select properly 3D Printer according to the electronic enclosure
9. Perform correctly printing conditions of 3D printed according to enclosure technologies
10. Install properly slicer software according to electronic enclosure
11. Perform correctly 3D model into a series of 2D layers according to slice process
12. Perform 3D print according to post-process

**Resources**

| Equipment | Tools | Materials |
|---|---|---|
| • Computer<br>• 3D printer<br>• Safety equipment (safety glasses, gloves, overall, shoes, helmet) | • CAD software (SolidWorks, Autodesk Maya, AutoCAD)<br>• Slicer software | • 3D printing Filaments (ABS and polycarbonate)<br>• Adhesives<br>• Internet<br>• Electricity |

| | | |
|---|---|---|
| | | • sanding blocks, paint sprayers, or heat guns) |

**Advance Preparation:**

Before delivering this learning outcome, you are recommended to:

- Have Ultimate cura, Clarity slicer, Simplify3D, Slic3r / PrusaSlicer, Matter Control, Craft Ware software to experiment with 3D printer configurations
- Have a computer with installed CAD software like solid works

## Indicative content 3.1: Selection of 3D Printer

**Duration: 2hrs**

**Theoretical Activity 3.1.1: Addressing Critical conditions of 3D printed enclosure**

**Notes to the trainer:**

- Trainer may use small group or brainstorming method
- Avail visual aids can help students grasp the concepts more effectively.
- Prepare handouts or reference materials to provide to participants for further reading and future references.

**Key steps:**

**While delivering this activity, pass through the following steps:**

**Step1:**Introduce the activity and ask trainees to do the following questions:

i. What is rapid prototyping, and how does it relate to prototyping plastics?

ii. Outline the key characteristics and benefits of high quality surface finish in 3D printing.

iii. Distinguish between fixed material and flexible material in the context of manufacturing applications.

**Step 2:** Asks trainees to write provided answers on flipchart/paper.

**Step4.** Asks Trainees to discuss the provided answer and choose correct answers.

**Step5.** Provide expert view and clarify ideas by using didactic materials.

**Step6.** Address any questions or concerns.

**Step7.** Ask trainees to read the key reading **3.1.1**in the trainee manual.

**Points to Remember**

- **Rapid prototyping** quickly transforms digital designs into physical models, enabling fast testing and iteration.
- **Prototyping plastics** offer an ideal mix of strength, durability, and processing ease for development.
- **High temperature** materials are crucial for aerospace and automotive applications, ensuring reliability under stress.
- **High-quality** surface finishes improve aesthetics and performance, while high accuracy ensures precision in manufacturing.
- **Transparentmaterials** enhance light transmission for optics and displays, whereas fixed materials remain unchanged after production.

**Theoretical Activity 3.1.2: Description of 3D printing Technology**

**Notes to the trainer:**

- Trainer may use small group or brainstorming method
- Avail visual aids can help students grasp the concepts more effectively.
- Prepare handouts or reference materials to provide to participants for further reading and future reference.

**Key steps:**

**While delivering this activity, pass through the following steps:**

**Step1:**Introduce the activity and ask trainees to do the following questions:

i. What are the main differences between Fused Deposition Modeling (FDM) and Stereo Lithography (SLA) in 3D printing?
ii. Outline the key processes and applications of Selective Laser Sintering (SLS) and Material Jetting in additive manufacturing.
iii. Distinguish between thermoplastic materials, like those used in FDM, and thermoset polymers used in SLA printing

**Step 2:** Asks trainees to write provided answers on flipchart/paper.

**Step4.** Asks Trainees to discuss the provided answer and choose correct answers.

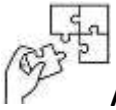
**Step5.** Provide expert view and clarify ideas by using didactic materials.

**Step6.** Address any questions or concerns.

**Step7.** Ask trainees to read the key reading **3.1.2**in the trainee manual.

**Points to Remember**

- **Exploration of Technologies:** Students engage with various 3D printing methods, including FDM, SLA, SLS, and Material Jetting.
- **Hands-on Experience:** Each group focuses on practical applications, creating functional and intricate prototypes.
- **Team Collaboration:** Students work together to brainstorm and execute their designs effectively.
- **Learning Outcomes:** They gain insights into the strengths and limitations of each printing technology.
- **Creativity and Innovation:** The workshop fosters creativity, encouraging students to think outside the box.
-



**Application of learning 3.1**

An ABC company needs to purchase a 3D printer suitable for printing electronic enclosures. According to knowledge and skills of designing electronic enclosure you are tasked to guide the manager to choose the best 3D printer for optimal electronic enclosure.

**Checklist**

| **Indicators** | **Score** | |
|---|---|---|
| | **Yes** | **No** |
| Printer type and technology is identified | | |
| Build volumeis identified | | |
| Material compatibilityis identified | | |
| Speedis identified | | |
| Reliability is checked | | |
| Durabilityis checked | | |
| Cost is checked | | |

## Indicative content 3.2: Identification of Printing Materials

**Duration: 1hrs**

**Theoretical Activity 3.2.1: Description of EMI shielding, Thermoplastic, printing**

**Notes to the trainer:**

- Trainer may use small group for describing
- Avail visual aids can help trainees grasp the concepts more effectively.
- Prepare handouts or reference materials to provide to participants for further reading and future reference.

**Key steps:**

**While delivering this activity, pass through the following steps:**

**Step1**: Introduce the activity and ask trainees to do the following questions:

i. Explain the concept of conductive filaments and their importance in 3D printing applications.
ii. Outline the materials typically combined with polymers to create conductive filaments and discuss their roles.
iii. Distinguish between the key printing properties of thermoplastics used for electronic enclosures and how these properties affect print quality and speed.

**Step 2:** Asks trainees to write provided answers on flipchart/paper.

**Step4.** Asks Trainees to discuss the provided answer and choose correct answers.

**Step5.** Provides expert view and clarifies ideas by using didactic materials.

**Step6.** Address any questions or concerns.

**Step7.** Ask trainees to read the key reading **3.2.1**in the trainee manual.

**Points to Remember**

- **Conductive filaments** enable electrical conductivity by combining polymers with additives like carbon or metals, allowing for applications like Joule heating.
- **Material jetting** allows for multi-material 3D printing by depositing droplets, enhancing versatility in design.
- **Coatings** improve protection and aesthetics of printed parts but present challenges in adhesion and surface preparation.
- **Thermoplastics** are moldable when heated and solidify upon cooling, making them ideal for various applications.
- **Key printing properties** include mechanical strength, print quality, speed, and volume, crucial for effective material selection in 3D printing.

**Application of learning 3.2**

XYZ develops a 3D-printed electronic device using conductive filaments for electrical functionality. They utilize material jetting for multi-material versatility and apply coatings for protection. You are asked to choose the best material used in 3D printing process.

**Checklist**

| **Indicators** | **Score** | |
|---|---|---|
| | **Yes** | **No** |
| Conductive properties are identified | | |
| Mechanical strength is verified | | |
| Material are selected based on printing technology | | |
| Material are selected based on environmental impact | | |

## Indicative content 3.3: Slicing 3D model

**Duration: 10hrs**

### Theoretical Activity 3.3.1: Description of slicing software

**Notes to the trainer:**

- Trainer may use small group for describing Slicing software
- Avail visual aids can help trainees grasp the concepts more effectively.
- Prepare handouts or reference materials to provide to participants for further readings.

**Key steps:**

**While delivering this activity, pass through the following steps:**

**Step 1:** Introduce the activity by asking trainees to answer the following questions:

i. Whatis the primary function of a slicer in 3D printing, and how does it interact with digital models and 3D printers?
ii. Outline the key features of Cura, and explain how these features enhance the user experience compared to other slicing software.
iii. Distinguish between Cura, Astroprint, and Simplify3D specific functionalities. What makes each one unique?

**Step 2:** Ask trainees to present their findings to the whole class.
**Step 3:** Provide an expert view and relate it to what they presented.
**Step 4:** Address any questions or concerns.
**Step 5:** Ask them to read the Key readings 3.3.1 in their manuals

**Points to Remember**

- **Slicing Definition**: Slicing converts 3D models into G-code, enabling 3D printers to execute print instructions.
- **Cura Features**: Cura provides cloud backups, remote printing, and extensive settings for efficient slicing.

- **Astroprint**: This web-based software allows remote monitoring and offers both advanced and simple modes for user flexibility.
- **Simplify3D Advantages**: It features a user-friendly interface, supports multiple file formats, and can automatically detect design errors.
- **Key Considerations**: Choose slicers based on printer compatibility, usability, community support, and essential features for optimal results.

**Practical Activity 3.3.2: install Slicing Software**

**Notes to the trainer**

- The computer lab must be accessible
- Trainer may use small group in order to perform a practical activity
- Trainer may use image, video

**Key steps:**

**While delivering this activity, pass through the following steps:**

**Step 1:** Introduce the topic and ask trainees to do the following task:

You are requested to go in computer lab that has a room equipped with 20 desktop computers. Your task is to install slicer software into these computers to facilitate the design of the electronic enclosure.

**Step2:**Explain the task and provide clear work instruction (Task, PPE, Time allocated)

**Step3:** Facilitate learners in selection of tools, materials and equipment used for IP Configurations.

**Step 4:** Provide more explanations where necessary.

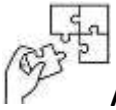
**Step 5:** Verify whether tools and equipment used for configuration.

**Step 6:** Ask trainees to read key reading 3.3.2.

**Points to Remember**

- **Usability**: Select slicing software with an intuitive interface for easier navigation and learning.
- **Error Notifications**: Effective software should alert users to any issues in 3D models before printing.

- **Support Structures**: Learn how to add supports for overhanging parts to ensure print stability.
- **Layer Height & Infill**: Adjust these settings to optimize print quality and balance strength with flexibility.
- **Cost vs. Features**: Weigh the advantages of paid software against free options, ensuring efficient handling of STL files.



**Application of learning 3.3.2**

XYZ Company has a room equipped with 40 desktop computers and wish to hire a competent technician to install slicer software to improve the production of electronic enclosures. The company's owner chooses you to install this slicer software on these computers to streamline the design process for the electronic enclosure product

| Criteria | Indicators | Observation | |
|---|---|---|---|
| | | Yes | No |
| Tools and material are well selected | Computers and slicer software are selected | | |
| | Computer requirement are checked | | |
| Slicer software is Installed properly | Installation process are followed | | |
| | Slicer software is running properly | | |

**Practical Activity 3.3.3: Converting the 3D Model into a Series of 2D Layers**

**Notes to the trainer**

- Trainer may use small group or brainstorming method.
- Avail visual aids can help students grasp the concepts more effectively.
- Prepare handouts or reference materials to provide to participants for further readings.

**Key steps:**

**While delivering this activity, pass through the following steps:**

**Step 1:** Introduce the activity by asking trainees to answer the following questions:

You are requested to go inthe computer lab, which is equipped with 15 desktop computers. Your task is to import a 3D model designed from CAD software into a slicer to generate the G-code needed for 3D printing. Configure the print settings and transfer the G-code file to your 3D printer.

**Step2**. Provide the answer for the asked questions.

**Step3.**Present the findings/answers to the whole class

**Steps 4.** In addition, ask questions where necessary.

**Step5**. For more clarification, read the key 3.3.3

**Points to Remember**

- **Slicing** converts, a 3D model into 2D layers, creating instructions for efficient printing.
- **Select slicing software** that manages complex models and offers real-time previews for accuracy.
- **Import models** in formats like GLB or GLTF using the software's import function.
- **Configure printer settings** by leveling, calibrating, and generating necessary supports for the model.
- **Export G-code** to transfer to the printer and initiate the printing process.

**Application of learning 3.3.3**

XYZ Company is seeking a designer to carry out the report of 3D model into a series of 2D layers. Your responsibility will be to import a 3D model created in CAD software into a slicing program to generate the necessary G-code for 3D printing. After generating the G-code, you will need to configure the print settings and transfer the file to the 3D printer to begin the printing.

‘

| **Criteria** | **Indicators** | **Observation** | |
|---|---|---|---|
| | | **Yes** | **No** |
| 3D model is imported | 3D model is correctly oriented and placed | | |
| | G-code is well generated | | |
| Printer settings are configured | Print settings are correctlyConfigured | | |
| Transfer the G-code file to 3Dprinter are successful | 3D printer is performing well | | |

## Indicative content 3.4: Set up 3D Printer for Printing

**Duration: 2hrs**

### Practical Activity 3.4.1: Set up 3D Printer for Printing

**Notes to the trainer**

- Trainer may use small group method.

**Key steps:**

**While delivering this activity, pass through the following steps:**

**Step1**. Introduce the activity by asking trainees to answer the following questions:

You are requested to goin workshop to design the electronic enclosure. As the designer, identify the necessary settings such as high temperature, high accuracy, and rapid prototyping, then calibrate the printer following the user manual. After calibration, ensure that the settings align with the project requirements.

**Step3**. Provide the answer for the asked questions.

**Step4.** Present the findings/answers to the whole class

**Steps 5.** In addition, ask questions where necessary.

**Step6**. For more clarification, read the key **3.4.1**

**Points to Remember**

- **Set Up the 3D Printer:** Start with a thorough setup to ensure optimal performance.
- **Layer Height and Shell Thickness:** Choose layer height for detail and adjust shell thickness for strength and appearance.
- **Retraction and Infill Density:** Configure retraction to minimize stringing and set infill density for balance between strength and weight.
- **Slicing** converts, a 3D model into 2D layers, creating instructions for efficient printing.

- **Select slicing software** that manages complex models and offers real-time previews for accuracy.
- **Import models** in formats like GLB or GLTF using the software's import function.
- **Configure printer settings** by leveling, calibrating, and generating necessary supports for the model.
- **Export G-code** to transfer to the printer and initiate the printing process.

**Application of learning 3.4**

ABCcompany needs to ensure that the 3D printer is set up properly for a new project. As the designer, identify the specific printer settings, such as Rapid prototyping, temperatures, and calibrate the printer using the user manual for accuracy. Once calibrated, verify that all settings are correctly configured.

**Checklist:**

| **Criteria** | **Indicators** | **Observation** | |
|---|---|---|---|
| | | **Yes** | **No** |
| 3D printer settings is well identified | 1. 3D printer is connected correctly powered | | |
| | 2. 3D printer Calibrationis well done | | |
| | 3. Settings are properly adjusted | | |

## Indicative content 3.5: Perform 3D Printing Post Processing

**Duration: 5hrs**

### Practical Activity 3.5.1: Performing 3D Printing Post-Processing

**Notes to the trainer**

- Trainer may use small group or brainstorming method.

**Key steps:**

**While delivering this activity, pass through the following steps:**

**Step1.**Introduce the activity by asking trainees to answer the following questions:

After completing the 3Dprinting of an electronic enclosure, you are requested to concentrate on post-processing for optimal quality by painting, sealing and applying protective coatings. Once the finishing touches are complete, conduct quality assurance tests to ensure it meets all specifications.

**Step3**. Provide the answer for the asked questions.

**Step4.**Present the findings/answers to the whole class

**Step 5.** In addition, ask questions where necessary.

**Step6**. For more clarification, read the key **3.5.1**

**Points to Remember**

- **Post-processing** enhances surface properties for improved mechanical performance and aesthetics.
- **Techniques** include sanding, polishing, cleaning, and painting, tailored to the material type.
- **While 3D printing** achieves a decent finish, post-processing significantly enhances smoothness.

- **Quality assurance** ensures enclosures meet safety and functionality standards through careful inspection.
- **Tools** like Autodesk Maya can help refine designs before printing, ensuring high-quality results.

**Application of learning 3.5.**

KAMARI 3D Printing Company is seeking someone to improve the surface quality of printed enclosures. As the selected candidate, your task will be to conduct quality assurance tests on the electronic enclosures to ensure they meet high standards.

**Checklist**

| SN | Criteria | Indicators | Observation | |
|---|---|---|---|---|
| | | | Yes | No |
| 1 | Quality standards are assured | 1.1. Electronic enclosure fits properly with the intended use | | |
| | | 1.2. Electronic enclosure provide protection correctly | | |
| | | 1.3. Electronic enclosure is properly reliable to the intended application | | |
| | | 1.4. Electronic enclosure aesthetic is well performed | | |
| 2 | Surface Inspection is verified | electronic enclosure smoothness is done properly | | |

## Learning outcome 3 end assessment

**Written assessment**

**I. Multiple Choice Questions**

1. What is rapid prototyping primarily used for?

A) Traditional manufacturing methods

B) Fast and easy prototype creation from digital designs

C) Long-term production of final products

D) High-volume mass production

**Correct Answer: B**

2. Which property is essential for a high-quality surface finish in 3D printing?

A) Roughness

B) Aesthetic appeal

C) Low strength

D) High cost

**Correct Answer: B**

3. What is a key characteristic of prototyping plastics?

A) They are solely for final products

B) They offer a balance of strength, durability, and ease of processing

C) They cannot be used in rapid prototyping

D) They are always transparent

**Correct Answer: B**

4. Which of the following describes conductive filaments?

A) They are only used for insulation.

B) They can conduct electricity and may include additives like carbon or metal.

C) They are made solely from thermoplastics.

D) They are non-conductive materials.

**Correct Answer: B**

5. What is a major challenge in applying coatings to 3D printed parts?

A) Coatings are always unnecessary.

B) Adhesion issues and surface preparation are critical for successful application.

C) Coatings improve print speed significantly.

D) Coatings eliminate the need for calibration.

**Correct Answer: B**

6. What defines thermoplastics?

A) They cannot be molded.

B) They remain rigid regardless of temperature.

C) They become pliable when heated and solidify upon cooling.

D) They are exclusively used for electronics.

**Correct Answer: C**

7. Why is calibration important for a 3D printer?

A) It allows for faster printing speeds.

B) It ensures consistent and precise printing results.

C) It reduces the need for materials.

D) It improves aesthetic quality alone.

**Correct Answer: B**

8. What does print speed refer to in 3D printing?

A) The quality of the print resolution.

B) The rate at which the extruder moves while printing.

C) The size of the printer.

D) The type of material used.

**Correct Answer: B**

**II. Read the following statements, and Answer by TRUE if the statement is right or FALSE if it is wrong**.

**1.** Slicing translates a 3D drawing into G-code for 3D printers.

**Answer: True**

**2.** A slicer is only used for viewing 3D models, not for printing.

**Answer: False**

3. Cura is a slicer that allows remote printing and has over 400 advanced settings.

**Answer: True**

4. Astroprint can only be used on Windows operating systems.

**Answer: False**

5. Simplify3D is suitable for beginners due to its simple interface and lack of complex features.

**Answer: False**

6. Regular updates for slicing software indicate active development and improvements.

**Answer: True**

7. The only important factor when choosing slicer software is the cost.

**Answer: False**

8. Simplify3D supports multiple file formats including STL, OBJ, and 3MF.

**Answer: True**

9. User community support is not important when selecting slicer software.

**Answer: False**

10. Astroprint has only one mode of operation for slicing.

**Answer: False**

**I. Match the following terms with their correct descriptions:**

| **Answer** | **Indicators** | **Description** |
|---|---|---|
| **1 - G..** | 1.Slicing | A. A programming language used by 3D printers to understand print instructions. |
| **2 - C..** | 2. Cura | B. Software that allows monitoring and controlling a 3D printer from any internet-connected device. |
| **3 … B..** | 3. Astroprint | C. A slicer known for its extensive features, including cloud backups and remote management. |

| | | |
|---|---|---|
| **4 …E…** | 4. Simplify3D | D. Materials designed for quick prototype creation, balancing strength and ease of processing. |
| **5 …A…** | 5. G-code | E. A powerful slicer compatible with multiple operating systems, offering tools for experienced users. |
| **6 …D…** | 6. Prototyping Plastics | F. The visual layout and design of software that affects usability, especially for beginners. |
| **7 ..F…** | 7. User Interface | G. The process of converting a 3D model into instructions for a 3D printer. |
| **8 .. H…** | 8. Remote Printing | H. The ability to send print jobs to a 3D printer from any location via the internet. |

**Practical assessment**

SmartHome Solutions is a burgeoning startup dedicated to creating innovative smart home devices that enhance security and convenience. They are in the final stages of developing a state-of-the-art smart doorbell that features video recording, motion detection, and two-way audio, all controlled via a mobile app. However, the team is struggling with designing an enclosure that effectively protects the internal electronics from outdoor elements like rain and dust while maintaining an attractive appearance. Additionally, the enclosure needs to be easy to install on various door types. As a result, SmartHome Solutions is looking to hire you as a solution provider to help overcome these enclosure design challenges for their smart doorbell.

**Checklist:**

| SN | Criteria | Indicators | Observation | |
|---|---|---|---|---|
| | | | Yes | No |
| 1 | Electronic device enclosure requirements are well identified | 1.1. Electronic circuit diagram is interpreted | | |
| | | 1.2. Appropriate measurement tools are selected | | |
| | | 1.3. Accurate Dimensions are measured | | |
| 2 | 3D conceptual design is well drawn | 2.1. Appropriate drawing tools are selected | | |
| | | 2.2. 3D conceptual object is drawn | | |
| 3 | 3D Object is well designed | 3.1.3D model is designed | | |
| | | 3.2. 3D animation is performed | | |
| 4 | Slicer is well manipulated | 4.1. The 3D model is imported | | |
| | | 4.2. The 3D model is well oriented and placed | | |
| | | 4.3. Components heat is managed | | |

| | | | | |
|---|---|---|---|---|
| 5 | 3D printer is well selected | 5.1. 3D Printer is selected | | |
| | | 5.2. Printing materials are selected | | |
| | | 5.3. The designed object is printed | | |

## Further information to the trainer


Budi, Y. E. (2023). *Effectiveness of CAD-CAM application for the development, design, and implementation of maintenance tools*. ResearchGate.

Enkhuizen, L. v. (2024). *The top 10 CAD/CAM software suites for sheet metal fabrication (2024)*. Sheet Metal Connect.

KRAMER. (2024). *ELECTRONICA*. JLCPDFM.

Mathur, N. (2007). *Google Scholar*. Retrieved from Durham University.

Schlick, J. (2024). *What is rapid prototyping: Process, stages, types and tools*.TechniWaterjet.

Wright, G. (n.d.). *Electromagnetic interference (EMI)*. TechTarget.

RTB | RWANDA TVET BOARD

October, 2024