



RQF LEVEL 4



CSACE401
**COMPUTER SYSTEM
AND ARCHITECTURE**

**Creation of
Electronics
Enclosure**

TRAINEE'S MANUAL

October, 2024



CREATION OF ELECTRONICS ENCLOSURE



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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 trainee's manual includes all the knowledge and skills required in Computer system and Architecture specifically for the module of "**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 trainee'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 trainee, you will start by addressing questions related to the activities, which are designed to foster critical thinking and guide you towards practical applications in the labor market. The manual also provides essential information, including learning hours, required materials, and key tasks to complete throughout the learning process.

All activities included in this training manual are designed to facilitate both individual and group work. After completing the activities, you will conduct a formative assessment, referred to as the end learning outcome assessment. Ensure that you thoroughly review the key readings 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
<ul style="list-style-type: none">● Description of electronics enclosure● Description of System requirements● Description of object modelling● Description of various modelling stages	<ul style="list-style-type: none">● Interpreting the electronic device diagrams● Designing for EMI prevention/reduction● Applying measurement of the object● Developing 3D Conceptual model● Drawing of conceptual model object	<ul style="list-style-type: none">● Being innovative● Being organizer● Having flexibility● Being problem Solver● Having team work split● Being hard worker



Duration: 15 hrs



Learning outcome 1 objectives:

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

1. Introduce correctly electronic enclosure 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 circuit according to circuit board diagrams specifications.
4. Identify properly object-modelling stage according to the form factor of the electronic components.
5. Design properly EMI prevention according to their types
6. Perform correctly dimension of the object according to electronic circuit
7. Develop correctly 3D conceptual design of the object according to circuit board diagrams specifications



Resources

Equipment	Tools	Materials
<ul style="list-style-type: none"> ● Computer ● Projector ● Drawing board ● Drawing table 	<ul style="list-style-type: none"> ● Drawing set 	<ul style="list-style-type: none"> ● Internet ● Electricity ● Pen and Paper



Indicative content 1.1: Identification of Enclosure Modelling Requirements



Duration: 4hrs



Theoretical Activity 1.1.1: Description of enclosure modelling requirements



Tasks:

1. 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.
2. Write the answers on papers/flipcharts.
3. Present your findings to the whole class.
4. Pay attention on trainer’s clarifications and ask questions if any.
5. For more information, read the key readings 1.1.1 in your manual.



Key readings 1.1.1.: Description of enclosure modelling requirements

- The electronics enclosure

An electronic enclosure is a protective casing designed to house and safeguard electronic components and systems. It serves to shield these components from environmental factors such as dust, moisture, and physical damage, while also preventing electromagnetic interference. Enclosures can be made from various materials, including metal, plastic, or composite materials, and they come in different shapes and sizes depending on the application.



- Purpose of electronic enclosure

The purpose of an electronic enclosure includes:

Protection: Shields electronic components from environmental hazards like dust, moisture, and physical impact.

Safety: Prevents accidental contact with live electrical parts, reducing the risk of electric shock.

Electromagnetic Interference (EMI) Shielding: Minimizes interference from external sources and prevents emissions from the enclosure.

Thermal Management: Helps dissipate heat generated by electronic components, maintaining optimal operating temperatures.

Aesthetics: Provides a finished look for devices, often enhancing their marketability.

Regulatory Compliance: Ensures that products meet safety and environmental regulations.

- Functional system requirement

Enclosure should be constructed of materials capable of withstanding the mechanical, electrical, thermal and environmental stresses to be encountered in service conditions. Enclosure should be constructed of materials with strong resistance, remain undamaged.

Plastic Enclosure



- Non-functional system requirement

Non-functional requirements are “how well” the system should perform in one or more areas.

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

Examples: Compatibility, portability, capacity and reliability.



Practical Activity 1.1.2. Interpreting of electronic device diagram



Task:

1. you are requested 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.
2. Follow the instructions given in key readings 1.1.2 and perform the given task
3. Present your work to the whole class
4. Pay attention on trainer's demonstration and ask questions if any.
4. Pay attention on trainer's clarification



Key readings 1.1.2: Interpreting of electronic device diagram

- Interpreting electronic device diagrams involves understanding the symbols and conventions used in schematic diagrams, circuit diagrams, or block diagrams. These diagrams are visual representations of electronic circuits or systems, and they use standardized symbols to represent various components and connections. Here are some common elements you might encounter: components, connection lines, power supply and ground, wires and junctions, control elements, antenna and transducer

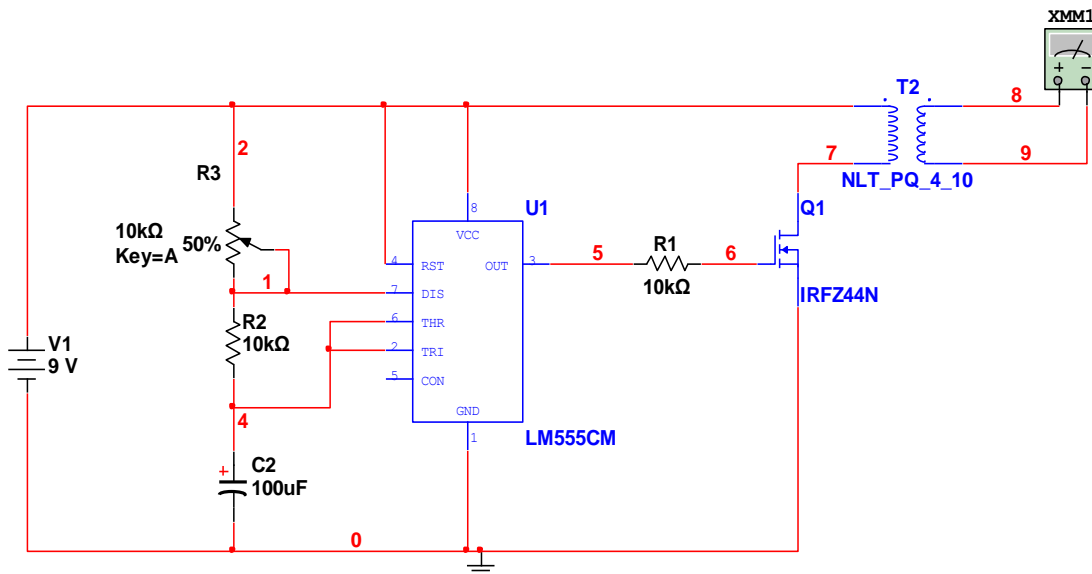


Figure: Circuit diagram of an inverter

- Consideration should be taken when creating an electronic device diagram

Clear labeling of components for easy identification.

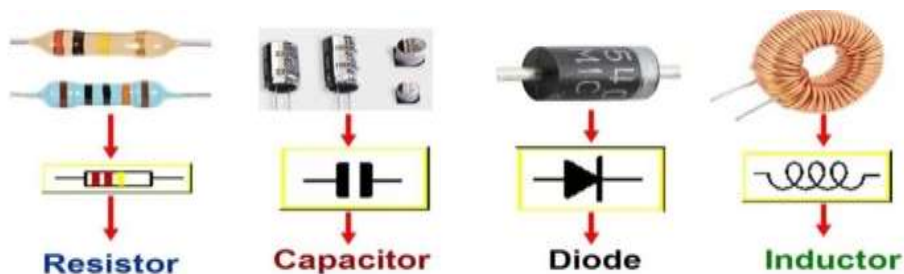
Logical layout that minimizes signal interference and facilitates airflow.

Inclusion of dimensions and mounting points for proper installation.

Compliance with safety regulations and standards for enclosures.

Interpreting an electronic device diagram involves several key steps. Here's a straightforward guide to be followed while interpreting electronic device diagram:

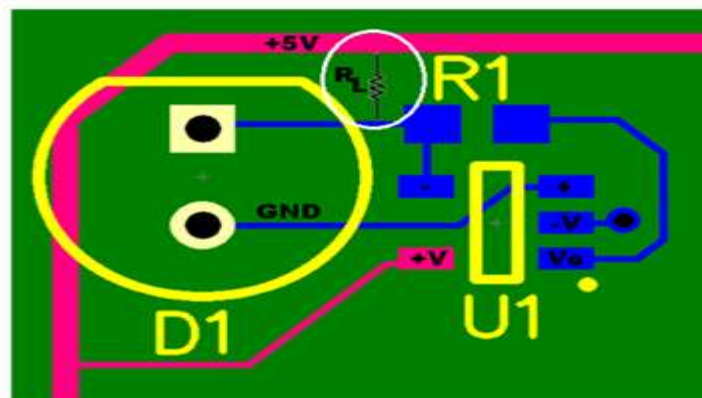
Familiarize Yourself with Symbols: Get to know common circuit symbols (such as resistors, capacitors, diodes, and transistors) and their roles.



Identify the Power Source: Find the power supply in the diagram, typically shown as a battery symbol or power supply icon.



Trace the Circuit Path: Follow the lines in the diagram to understand how components are connected, noting series and parallel configurations.



Check Component Values: Pay attention to the values of resistors, capacitors, and other components, usually listed next to their symbols.

Understand Ground Connections: Locate the ground symbol, which indicates a common reference point in the circuit.

Analyse Signal Flow: Determine the direction of current flow, particularly in active components like transistors and op-amps.

Look for Feedback Loops: In circuits such as amplifiers, identify any feedback paths that may influence circuit behaviour.

Review Labels and Notes: Check for labels, notes, or annotations that offer additional information about the circuit.

Simulate if Possible: Utilize simulation software to visualize how the circuit operates, which can deepen your understanding.

Practice with Examples: Work with different circuit diagrams to become more familiar with various configurations and components.



Points to Remember

- **Electronic Enclosure Definition:** A protective casing that shields electronic components from environmental threats and electromagnetic interference.
- **Purpose and Functions:** Ensures component protection, safety, EMI reduction, heat management, aesthetic enhancement, and regulatory compliance.
- **Requirements:** Functional requirements involve material durability against various stresses; non-functional requirements cover performance aspects like compatibility and reliability.
- **Material Selection:** Must be durable and resilient to mechanical, electrical, thermal, and environmental stresses.
- **Diagram Interpretation:** Involves understanding symbols, tracing circuit paths, and analyzing signal flow to comprehend circuit behavior.
- **Practical Application:** Simulation tools and practicing with circuit diagrams improve diagram interpretation skills.



Application of learning 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.



Indicative content 1.2: Identification of Object Modelling Stages



Duration: 7 hrs



Theoretical Activity 1.2.1: Identification of object modelling stages



Tasks:

1. You are requested to answer 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
2. Provide the answer for the asked questions and write them on flipchart/paper.
3. Present the findings to the whole
4. For more clarification, read the key readings 1.2.1.



Key readings 1.2.1 Identification of object modeling stages

- Object modeling stages for electronic enclosures involve representing the structure and behavior of the system using a systematic and standardized approach. The Unified Modeling Language (UML) is commonly used for object modeling.
- Key factors to consider:

Compatibility

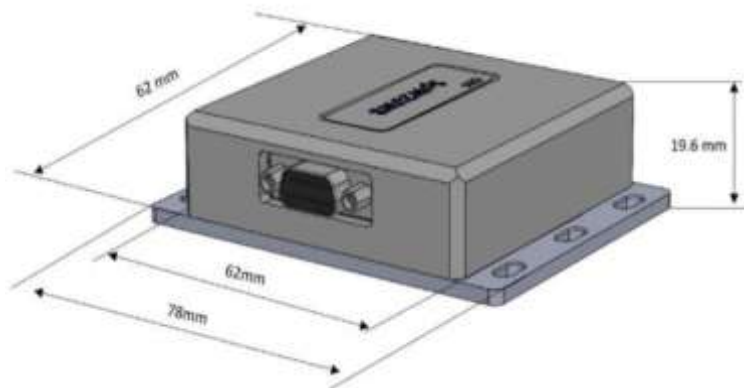
Compatibility in the context of electronic enclosures generally refers to the ability of the enclosure to work effectively with the electronic components it houses, as well as its ability to interface with external systems or components.

Computer Enclosure



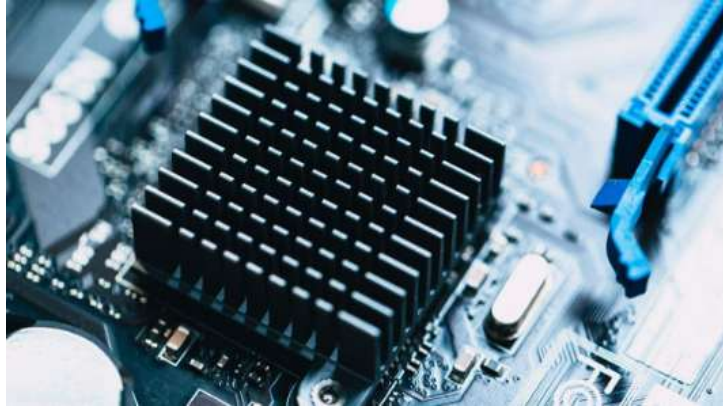
Dimensional Fit

Dimensional fit in the context of an enclosure refers to the accurate and precise alignment of the enclosure's physical dimensions with the components it is designed to house. This includes ensuring that the internal and external dimensions of the enclosure are suitable for the **electronic** components, PCBs (Printed Circuit Boards), and other elements that will be installed within it. The goal is to achieve a secure, well-fitting, and functional arrangement.



Thermal Management

Thermal management is the monitoring and control of temperature produced by devices in electrical enclosures. Efficient thermal management is crucial for preventing overheating, maintaining optimal operating conditions, and ensuring the reliability and longevity of electronic devices.



Environmental protection

Meticulously engineered enclosure boxes can protect these critical systems against high temperatures, moisture, humidity and other harsh environmental conditions that may otherwise compromise these electrical systems.

Environmental protection in electronic enclosures refers to the measures and design considerations taken to shield electronic components from various external environmental factors that could potentially impact their performance, reliability, and longevity.



User Ergonomics

User ergonomics in electronic enclosures is crucial to ensure that the end-users can interact with the device comfortably and efficiently.

There are five aspects of ergonomics: safety, comfort, ease of use, productivity/performance, and aesthetics. Ergonomics is a science concerned with the 'fit' between people and their work.



Aesthetics and Branding

Aesthetics is a core design principle that defines a design's pleasing qualities. In visual terms, aesthetics includes factors such as balance, color, movement, pattern, scale, shape and visual weight. Designers use aesthetics to complement their designs' usability, and so enhance functionality with attractive layouts.



Branding

Electronic enclosures are *box-like structures* that are designed to protect, contain, and enclose electronic components such as switches, relays, printed circuit.

The term "brand" refers to the unique identity, image, and reputation associated with a specific manufacturer or company that produces the enclosures. A brand goes beyond just a name; it encompasses the overall perception that customers have about the company and its products.

Modularity and customization

Modularity allows the combination of independent units (different modules) through

well-defined interfaces to form products.

In the context of electronics enclosures, modularity refers to a design approach where the overall enclosure is composed of distinct and independent modules or components that can be assembled, disassembled, replaced or upgraded easily.

Custom (or bespoke) electronic enclosures are designed from new each time whereas customized enclosures are standard housings that have been modified to your specific requirements.

In the context of electronics enclosures, customization refers to the ability to modify or tailor the design, features, and specifications of an enclosure to meet specific requirements or preferences of a customer or end-user.

Description of various modeling stages

The modeling stages in the design of electronics enclosures typically involve a step-by-step process that encompasses various aspects of the enclosure's development.

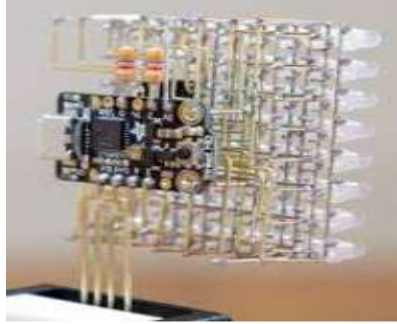
Skelton/Thumbnail

An electronic enclosure is a protective case for electronic components, and adding a skeleton or thumbnail design can enhance its aesthetics or functionality.



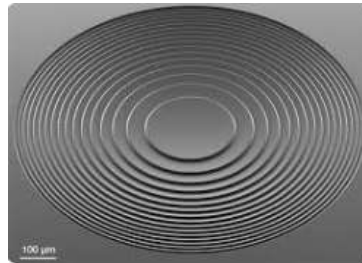
Sculpting

The term "sculpting" suggests a more artistic or creative approach to the design, where the form of the enclosure is carefully crafted to meet not only functional requirements but also to create a pleasing and harmonious design.



Texturing

"Texturing" usually refers to the application of a specific surface finish or texture to the external or internal surfaces of the enclosure. This process serves both functional and aesthetic purposes.



Rigging

"Rigging" refers to the process of creating a digital skeleton or framework for characters or objects. This framework allows animators to manipulate and control the movement of the characters or objects.

"Rigging" could refer to the process of assembling and configuring various components or devices to work together. For example, setting up a system of interconnected sensors, actuators, or other electronic components.

Animation

In the 3D modeling stage, you could create animated prototypes or simulations of the enclosure. This allows you to visualize how different components fit together, how the enclosure opens or closes, and how users might interact with it.



Practical Activity 1.2.2: Designing EMI Prevention/Reduction



Task:

1. You are asked to perform the following activities:

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.
2. Read the key readings 1.2.2 in trainee manual
 3. Pay attention on trainer's demonstration and ask questions if any.
 4. Interpret the electronic circuit diagram by respecting the trainer's instructions.
 5. Present your work to the whole class
 6. Pay attention on trainer's clarification



Key readings 1.2.2.: Designing EMI Prevention/Reduction

Design for EMI prevention/reduction

EMI refers to the unwanted electromagnetic emissions or susceptibility that can interfere with the operation of electronic devices.

EMI Shielding Design

EMI Shielding in electronic devices and equipment is the use of manufacturing techniques and materials to protect signals from being disrupted by external electromagnetic signals as well as preventing generated signals from interfering with surrounding components.

Electromagnetic Interference (EMI) shielding design is crucial in electronic systems to prevent unwanted electromagnetic emissions and to protect sensitive components from external interference. Effective EMI shielding helps ensure the proper functioning of electronic devices and compliance with electromagnetic compatibility (EMC) standards.

Grounding Schemes

Grounding schemes refer to the systematic design and implementation of connections to the ground reference to ensure proper functioning, safety, and compliance with electromagnetic compatibility (EMC) standards.

Also it is the process of directing excess electricity to the ground via a wire.

EMI filters

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.

EMI (Electromagnetic Interference) filters in electronics enclosures are components or devices designed to reduce or eliminate electromagnetic interference that can affect the performance of electronic equipment. EMI filters are commonly used to suppress conducted electromagnetic interference, which refers to unwanted high-frequency electrical noise that can be transmitted through power lines and signal cables.

Minimization of PCB layout

Refers to the practice of optimizing and reducing the size and complexity of the PCB design to meet specific goals or constraints. This could involve minimizing the footprint of the PCB, reducing the number of layers, or simplifying the layout while maintaining functionality and performance.

Basically, we want to minimize the existence of these inductance loops on a PCB, which means minimizing the distance a trace travels, and how “circular” that trace is. We minimize the loops by placing and orienting components intelligently on a PCB



Points to Remember

- Object Modeling Stages: Systematically represent the structure and behavior of electronic enclosures using UML techniques.
- Key Considerations: Focus on compatibility, thermal management, ergonomics, aesthetics, and branding in design.
- Modularity and Customization: Implement modular designs for easy assembly and tailored user requirements.
- Modeling Phases: Progress from skeleton designs to sculpting, texturing, rigging, and animation for thorough visualization.
- Environmental and Thermal Concerns: Prioritize protection against harsh conditions and effective heat management for reliability.
- User-Centric Design: Emphasize ergonomics and aesthetics to enhance functionality and market appeal.
- EMI Definition: Identify unwanted electromagnetic emissions that can disrupt device operations.
- EMI Shielding: Utilize materials and techniques to protect signals from external interference.
- Grounding Schemes: Establish systematic ground connections for safety and electromagnetic compatibility.
- PCB Layout Minimization: Optimize PCB design to reduce size, complexity, and inductance loops, minimizing 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.



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

Tasks:

1. Perform the following activities:

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.

2. Read the key readings 1.3.1 in trainee manual
3. Pay attention on trainer's demonstration and ask questions if any.
4. Interpret the electronic circuit diagram by respecting the trainer's instructions.
5. Present your work to the whole class
6. Pay attention on trainer's clarification



Key readings 1.3.1: Sketching the conceptual design of the object

- Interpret electronic circuit board diagrams
Interpreting electronic circuit board diagrams, also known as schematics, is a fundamental skill for electronics engineers and enthusiasts. A circuit diagram is a graphical representation of an electrical circuit that uses standardized symbols to depict components and their connections.
- Types of electronic circuit board diagrams
 - ✓ Schematic diagram, also called electrical schematic diagram.
Schematics directly reflect the structure and working principles of electronic

circuits and are generally used for circuit design and analysis. When analysing a circuit, you can learn how the circuit actually works by identifying the symbols of the various circuit elements drawn in the diagram and the connections between them. A schematic diagram is a tool that reflects the working of an electronic circuit.

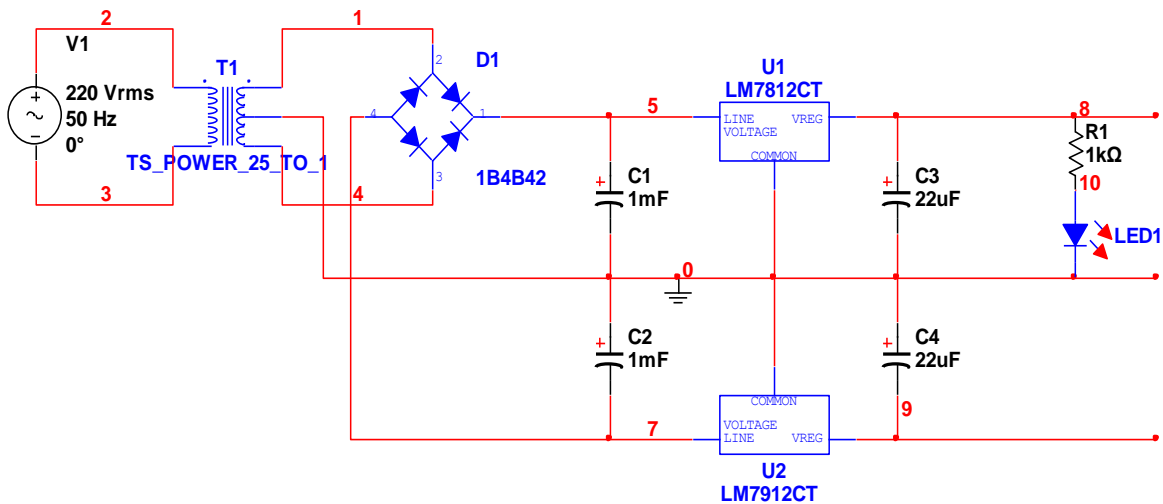


Figure: Circuit diagram of a Dual Power Supply (Positive and Negative Supply)

✓ Block diagram.

A block diagram is a circuit diagram that uses block and connections to represent the working principle and composition of a circuit. Basically, this is also a schematic diagram, but in this diagram there are almost no symbols except boxes and wires. The main difference between the above schematic and a schematic diagram is that all components of the circuit and how to connect them are drawn in great detail. A schematic simply divides the circuit into functional parts, describes each part as a box, gives the box a simple description, and uses connecting lines (sometimes arrows) between modules. Relationships between boxes. Therefore, the block diagram can only reflect the general working principle of the circuit

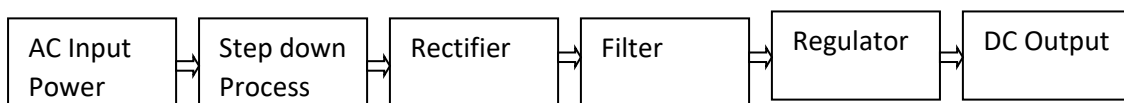


Figure: block diagram of AC to DC converter

✓ Assembly drawing

This is the circuit assembly diagram. The symbols on the diagrams are usually physical outlines of circuit components. We just need to follow the drawings and connect some circuit components to assemble the circuit. This circuit diagram is usually used by beginners. The assembly drawings vary depending on the assembly template.

The main purpose of electronic products is the printed circuit board (PCB) introduced below, so the printed circuit board is the main form of assembly drawing. When we first started learning electronic knowledge, in order to get in touch with electronic technology earlier, we chose a threaded plate as the basic installation template, so the installation diagram became another model.

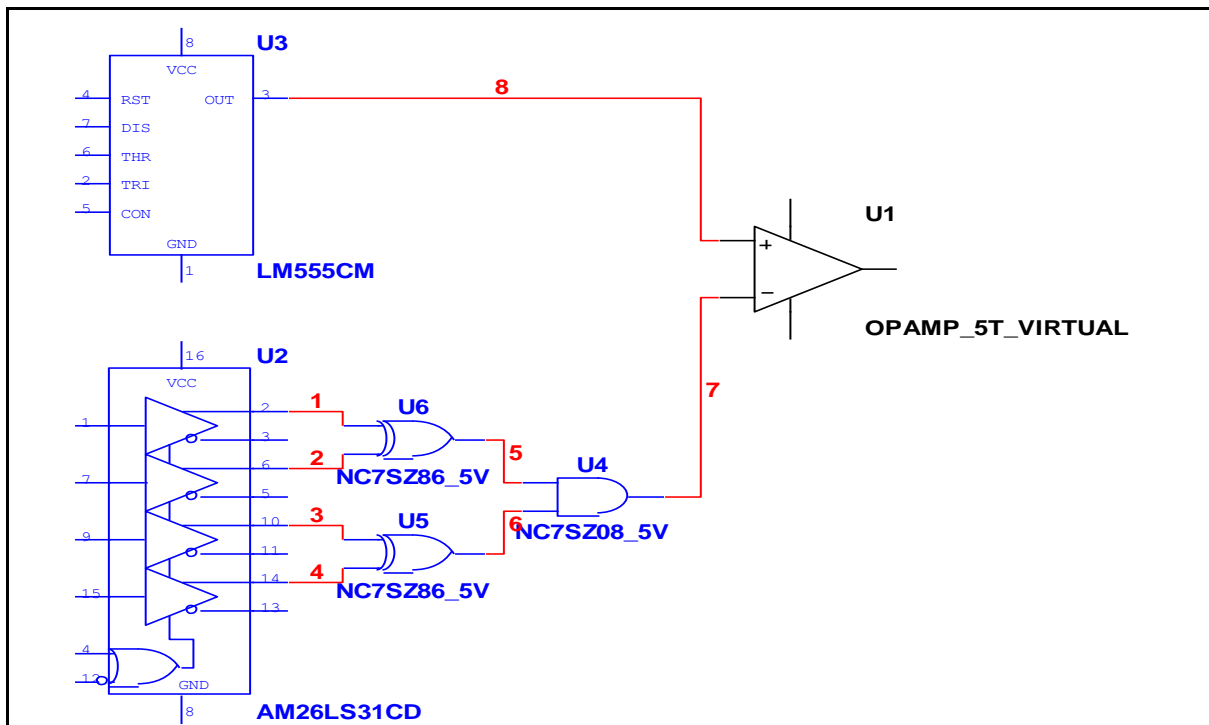


Figure: Assembly design diagram

- Apply Dimensioning of the object

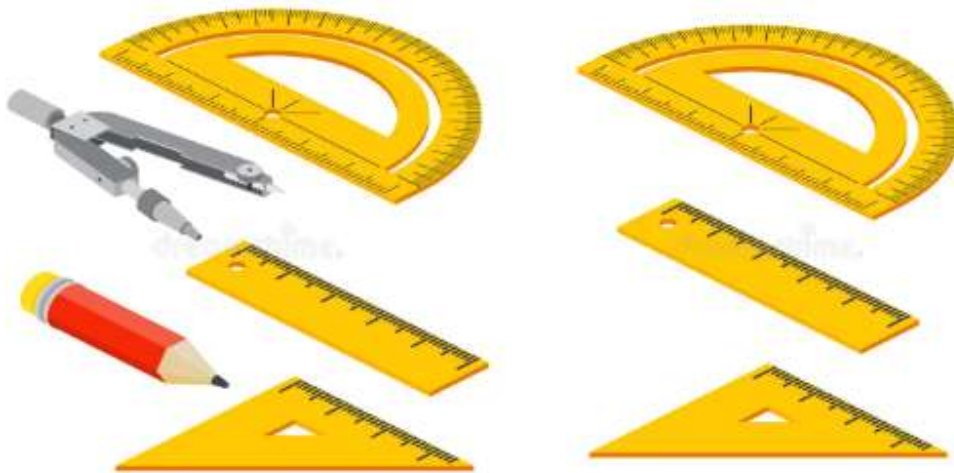
What is dimension

The dimension of an object typically refers to its physical extent or size in space, specifically in terms of length, width, and height.

Click to select the line, and then click to place the dimension. The command remains active so that you can dimension another object. You see a preview of an angular dimension aligned with that line. Click to select the line, and then click to place the dimension.

Selection of tools used in measuring dimensions

AutoCAD's MEASUREGEOM command offers various measurement tools to analyze different aspects of a drawing, including area, distance, and angle. The Distance tool can provide a straight line measurement between any two points in a drawing.



Draw

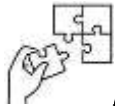
Creating a conceptual model or ideation sketch for an electronic enclosure involves visually representing the basic design concept and layout of the enclosure. Here's a simple and generic ideation sketch for an electronic enclosure. Note that this is a conceptual representation, and the details would depend on the specific requirements of your project.



Points to Remember

- Understanding Schematics: Schematic diagrams are crucial for visualizing and analyzing electronic circuits, using standardized symbols for components and their connections.
- Block Diagrams: These diagrams represent the general working principles of a circuit, using simple boxes and connecting lines to show relationships between functional parts, without detailed symbols.
- Assembly Drawings: Focused on the physical layout of components, assembly drawings guide beginners in constructing circuits by outlining how to connect parts, often featuring a printed circuit board (PCB).

- **Circuit Board Diagrams:** These diagrams illustrate the physical and electrical layout of a circuit, integrating various types of information for assembly and troubleshooting.
- **Dimensioning:** The dimensions of an object refer to its physical size, typically described in terms of length, width, and height, essential for accurate design and fitting.
- **Using AutoCAD Tools:** Tools like AutoCAD's MEASUREGEOM command provide precise measurements for aspects such as area, distance, and angles, facilitating accurate design work.
- **Creating Conceptual Models:** Sketching a conceptual model for an electronic enclosure helps visualize the design layout, ensuring that functional and aesthetic requirements 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:

- a) Interpret a circuit diagram and apply dimensioning to an object in design software
- b) Design electronic circuit board diagrams.
- c) Perform a conceptual model or ideation sketch



Learning outcome 1 end assessment

Written 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

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

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

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

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

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.
- 2. Non-functional requirements are “how well” the system should perform in one or more areas.
- 3. User ergonomics is the monitoring and control of temperature produced by devices in electrical enclosures.
- 4. In the 3D modelling stage, you could create animated prototypes or simulations of the enclosure.
- 5. Brand is the unique identity, image, and reputation associated with a specific manufacturer or company that produces the enclosures.

III. Match Indicators with corresponding functions

Answer	Indicators	Functions
1.....	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	2.Safety	b. Is a protective case for electronic components, and adding a skeleton or thumbnail design can enhance its aesthetics or functionality.
3	3. EMI Filters	c. Is to prevents accidental contact with live electrical parts, reducing the risk of electric shock
		d. 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. You are asked to analyse devices and circuit diagrams, design to minimize electromagnetic interference (EMI), and ensuring accurate dimensions to produce a more efficient electronic enclosure.



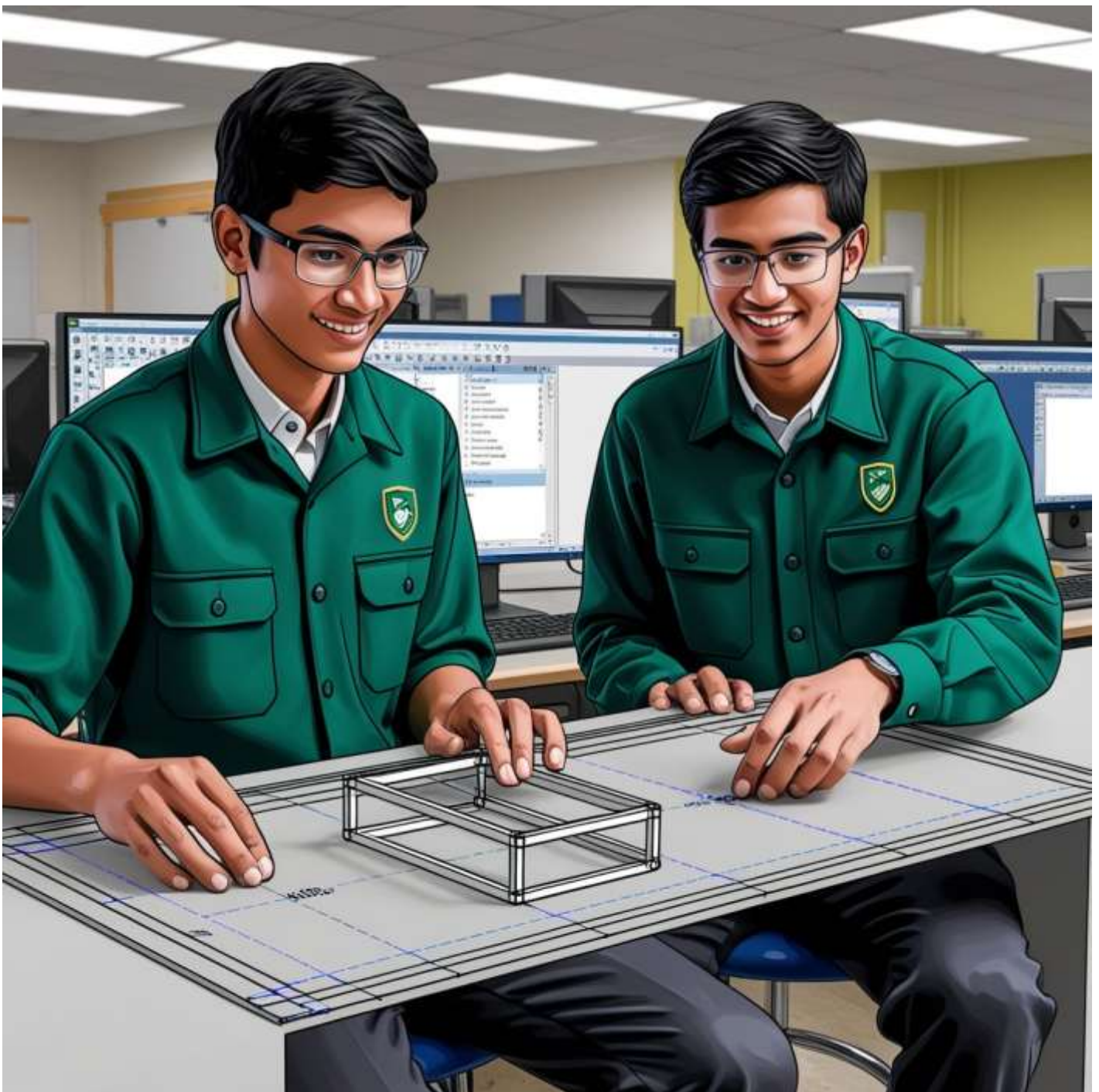
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Learning Outcome 2: Design 3D Model of Electronics Enclosure with CAD



Indicative contents

2.1 Selection of tools, materials and equipment of 3D model

2.2 Installation of CAD software

2.3 Apply a 3D model design

2.4 Perform a 3D animation

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

Knowledge	Skills	Attitudes
<ul style="list-style-type: none">● Description of 3D model● Description of hardware specification● Explanation software tools (Solid works)● Description of common elements in 3D software design interface● Explanation of 3D file types● Description of 3D enclosure modelling considerations	<ul style="list-style-type: none">● Installing CAD software● Selecting tools, materials and equipment● Applying a 3D model design● Performing 3D animation	<ul style="list-style-type: none">● Being innovative● Being organization● Being safety First● Being flexibility● Being problem Solving● Being team work● Being hard worker



Duration: 35 hrs



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
<ul style="list-style-type: none"> ● Computer ● Projector 	<ul style="list-style-type: none"> ● CAD software (SolidWorks, Autodesk Maya, AutoCAD) 	<ul style="list-style-type: none"> ● Electricity ● Internet



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



Duration: 3hrs



Theoretical Activity 2.1.1: Description of Selection tools, material and equipment



Tasks:

1. Introduce the activity and ask trainees to do 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.
2. Provide the answer for the asked questions and write them on papers.
3. Present the findings/answers to the whole class
4. For more clarification, read the key readings 2.1.1



Key readings 2.1.1. Selecting tools, materials and equipment of 3D model

Description of 3D model

Three-dimensional (3D) models represent a physical body using a collection of points in 3D space, connected by various geometric entities such as triangles, lines, curved surfaces, etc.

Definition

The term “3D modeling” refers to the process of creating a three-dimensional representation of an object using specialized software.

Characteristics

Three-dimensional (3D) models represent a physical body using a collection of points in 3D space, connected by various geometric entities such as triangles, lines, curved

surfaces

Key characteristics include:

Geometry: The model's shape and structure.

Textures: Surface details that enhance realism.

Materials: Properties that affect light interaction, like color and reflectivity.

Scalability: The ability to resize without losing detail.

Interactivity: Potential for user engagement in applications like games.

These main 3D shape properties include:

Faces: A face is a flat or curved surface on a 3D shape. For example, a cube has six faces, a cylinder has three and a sphere has just one.

Edges: An edge is where two faces meet. ...

Vertices: A vertex is a corner where edges meet.

Types of angle views

The two orthogonal projection methods used internationally are first angle projection and third angle projection. Third angle projection is used mainly in The United States and Canada whilst first angle projection is used mainly throughout Europe and the rest of the world.

The types of angle views include:

Orthographic Views: 2D representations from multiple angles without perspective distortion.

Isometric Views: A 3D representation where the three axes appear equally foreshortened.

Perspective Views: Realistic views where objects appear smaller with distance, mimicking human vision.

Required computer hardware specifications

Recommended component and specifications for new personal computer purchases

- i. Memory (RAM): 8-16 GB of RAM
- ii. Storage: 256 GB solid state drive, or larger.
- iii. Video/Graphics: Integrated or discrete graphics processor capable of 1440 X 900 resolution, or better (1920 X 1080 or 1200 ideal).
- iv. Processor: Multi-core CPU (e.g., Intel i5/i7 or AMD Ryzen).

A programming tool or software development tool is a computer program that

software developers use to create, debug, maintain, or otherwise support other programs and applications.

Solid Works

Solid Works (stylized as SOLIDWORKS) is a brand within Dassault Systems that develops and markets solid modeling computer-aided design, computer-aided engineering, 3D CAD design and collaboration, analysis, and product data management software.

AutoCAD

AutoCAD is a computer-aided design software developed by the company Autodesk (hence the name AutoCAD). It allows you to draw and edit digital 2D and 3D designs more quickly and easily than you could by hand.



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

Task:

1. Answer the following questions:

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.

2. Read the key readings 2.1.1 in the manual
3. Pay attention on trainer's demonstration and ask questions if any.
4. Select tools, materials and equipments to install 3D model design software respecting the trainer's instructions.
5. Present your work to the whole class
6. Pay attention on trainer's clarification



Key readings 2.1.2: Selecting tools, materials and equipment for 3D model

When designing and 3D printing an electronics enclosure, selecting the right tools, materials, and equipment is crucial for ensuring that the final product meets both functional and aesthetic requirements. An electronics enclosure needs to be durable, protect the internal components, and potentially provide space for heat dissipation, ease of assembly, and other specific features.

Below, I'll provide detailed guidance on selecting tools, materials, and equipment for creating a 3D model and printing a custom electronics enclosure.

Tools for Designing the Electronics Enclosure

Before you even begin 3D printing, the design process is key. Here are the tools that can help with designing a 3D model of an electronics enclosure:

CAD (Computer-Aided Design) Software

CAD software is essential for creating precise and detailed models of your electronics enclosure. It helps you design everything from the external shape to the internal compartments where electronic components will be housed.

Fusion 360: A popular choice for 3D design, Fusion 360 offers robust parametric design tools that are ideal for creating enclosures. It also provides features for thermal simulation and stress analysis, which can help in optimizing the design for mechanical stability and heat dissipation.

SolidWorks: Known for its advanced mechanical design tools, SolidWorks is perfect for designing precise, manufacturable electronic enclosures. It is widely used in engineering and can simulate physical stress, heat distribution, and airflow.

Tinkercad: A more beginner-friendly tool, Tinkercad is web-based and suitable for simpler enclosures, especially for smaller projects or rapid prototyping.

FreeCAD: An open-source CAD software that can be used for more complex designs and is flexible for creating 3D models of enclosures.

Slicing Software: After the CAD model is created, you will need to slice it into layers for the 3D printer. Slicing software converts the 3D model into a set of instructions (G-code) that the 3D printer follows.

Cura: A highly popular slicing software for FDM printers. It is free and has an intuitive interface, with customizable settings for layer height, infill density, print speed, and support structures.

PrusaSlicer: Especially useful for Prusa printers but also works for many other machines. It offers advanced settings for print optimization and supports multiple filament types.

Simplify3D: A paid slicing software that is known for offering more control over print settings, which can be helpful for complex electronics enclosures.

Materials for 3D Printing Electronics Enclosures

Selecting the right material is one of the most critical steps when 3D printing an electronics enclosure. The material needs to meet the functional requirements of the enclosure while being compatible with the 3D printer. Key factors to consider when choosing materials include strength, thermal stability, electrical properties, and easy of printing.

Common Materials for Electronics Enclosures

ABS (Acrylonitrile Butadiene Styrene)

- **Strength:** Strong and impact-resistant, making it ideal for housing electronics.
- **Thermal Resistance:** High heat resistance, which can help in protecting internal components from heat.
- **Electrically Insulative:** ABS is a good choice for non-conductive enclosures.
- **Challenges:** Prone to warping and requires a heated bed for proper adhesion.

PLA (Polylactic Acid)

- **Ease of Use:** PLA is easy to print, making it a good choice for beginners.
- **Strength:** While it's less durable than ABS, it's fine for low-heat applications.
- **Environmental Consideration:** PLA is biodegradable and considered more environmentally friendly than ABS.
- **Limitations:** Not as heat-resistant as ABS, so it's unsuitable for enclosures that will experience high temperatures (e.g., near power components).

PETG (Polyethylene Terephthalate Glycol)

- **Strength and Flexibility:** PETG is a strong and flexible material with excellent impact resistance.
- **Heat Resistance:** It has a higher heat resistance than PLA and is more durable under moderate temperatures.
- **Ease of Use:** It's easy to print with a minimal risk of warping, making it ideal for custom electronics enclosures.
- **Electrical Insulation:** PETG is non-conductive, making it a good choice for electrical housings.

Nylon

- **Durability:** Very strong and durable, and resistant to wear, making it great for applications where the enclosure will be subjected to physical stress.
- **Flexibility:** Offers excellent flexibility and impact resistance.
- **Moisture Absorption:** Nylon tends to absorb moisture, so post-processing may be required to dry it before printing.
- **Use Case:** Ideal for enclosures that need to withstand mechanical forces.

Polycarbonate (PC)

- **Strength and Durability:** One of the strongest 3D printing materials, offering high resistance to impact and heat.
- **Heat Resistance:** Excellent heat resistance, suitable for enclosures near high-power electronics.
- **Electrical Insulation:** Polycarbonate is electrically insulative.
- **Challenges:** Requires high printing temperatures and a heated bed, making it trickier to print with.

Conductive Materials (e.g., Conductive PLA or PETG)

Use Case: These materials can be useful if you need to create enclosures with controlled electrostatic properties. However, they should be used carefully, as they

will not offer the same level of protection as standard non-conductive materials.

Choosing Based on Application:

- For general purpose enclosures: ABS or PETG.
- For high-temperature electronics: Polycarbonate or Nylon.
- For beginner-friendly and low-cost applications: PLA.
- For structurally demanding applications: Nylon or Carbon Fiber Composite.

Equipment for 3D Printing Electronics Enclosures

The equipment you use can vary based on the complexity of the enclosure and the material selected.

3D Printers

FDM Printers (Fused Deposition Modeling): These are most commonly used for creating plastic enclosures. They work with a variety of materials like PLA, ABS, and PETG. Some popular FDM 3D printers for electronics enclosures include:

- Creality Ender 3 (affordable, reliable)
- Prusa i3 MK3 (high precision, user-friendly)
- Ultimaker S5 (high-end, professional quality)

SLA Printers (Stereolithography): If you need extremely detailed, high-quality enclosures, an SLA printer like the Anycubic Photon or Formlabs Form 3 could be a better choice, although SLA is typically more suited for small, intricate parts than large enclosures.

SLS Printers (Selective Laser Sintering): For more industrial-grade and durable enclosures, SLS printers like the EOS Formiga can work with high-performance materials such as nylon powders.

Post-Processing Equipment

- Sandpaper or Files: After printing, rough edges or imperfections can be smoothed out using sandpaper or files. This is particularly important if you need tight tolerances or if you want a clean surface for painting.
- UV Curing Station: For SLA prints, you'll need a UV curing station to fully cure the

resin and achieve maximum strength and finish.

- **Heat Bed:** Ensure your printer has a heated bed (if using ABS or similar materials) to prevent warping, especially for larger enclosures.
- **Power Tools (for Post-Processing):** Depending on the complexity of the design, tools like rotary tools (Dremel) may be useful for adding custom slots, cutouts, or for post-processing.
- **Spray Paint or Coating:** After printing, you can add a paint finish for aesthetics or protective coatings to improve the durability of the enclosure. Epoxy coatings can help improve the enclosure's strength.

Assembly Tools

- If your enclosure design is split into multiple parts, you might need to assemble it. In this case, consider the following tools:
 - **Screws and Screwdrivers:** For mechanical assembly of multiple parts.
 - **Adhesives:** If you prefer bonding parts together, you may want to use epoxy or strong plastic adhesives.
 - **Heat Staking Tools:** For adding inserts to your enclosure to secure components like screws or connectors.

Other Considerations

Ventilation and Cooling

For enclosures containing electronics that generate heat, you may need to design ventilation holes or heat sinks within your enclosure. Some materials, like Nylon, naturally dissipate heat better than others, and fan mounts or openings for airflow can be added to the design.

Modular Design: Designing your enclosure to be modular can make it easier to swap out parts or upgrade components. Consider creating a snap-fit design or using



Points to Remember

- **3D Modeling design:** this include all the steps in drawing and creating 3D representations using specialized software to represent physical objects in space.
- **Key factors to consider:** include strength, thermal stability, electrical properties, and ease of printing, Common Materials for Electronics
- **Key Characteristics:** Essential features include geometry, textures for realism, material properties affecting light, scalability for resizing, and interactivity for user engagement.
- **Geometric Properties:** Important elements are faces (surfaces), edges (intersections of faces), and vertices (corners where edges meet).
- **Angle Views:** Two main projection methods are first angle (common in Europe) and third angle (used in the US/Canada), each offering unique perspectives like orthographic, isometric, and perspective views.
- **Hardware Specifications:** Recommended specs for 3D modeling include 8-16 GB RAM, SSD storage of at least 256 GB, and a graphics processor with high resolution capabilities.
- **Software Tools:** Essential software for 3D modeling includes tools for development, debugging, and collaboration, which support the creation and maintenance of applications.
- **SolidWorks:** This software focuses on solid modeling and CAD, offering robust tools for design, engineering, and product management.



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



Indicative content 2.2: Installation of CAD Software



Duration: 10 hrs



Theoretical Activity 2.2.1: Install CAD software

Tasks:

1. You are asked 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.
2. Provide the answer for the asked questions and write them on papers.
3. Present the findings to the whole class.
4. Pay attention on trainer's clarification and ask questions if any.
5. Read the key readings 2.2.1 for more information.



Key readings 2.2.1.: Install CAD software

- Selection criteria

When evaluating CAD software, find out how efficiently each package creates the types of products your company makes. For example, if your company makes sheet metal parts, pay attention to the special tools for creating them and automatically generating flat patterns.

Computer hardware compatibility

Compatibility in CAD (Computer-Aided Design) software refers to the ability of different CAD programs or versions to work together seamlessly, allowing the

exchange and use of design data between them.

Software features

Software features in CAD (Computer-Aided Design) refer to the specific functionalities and capabilities that a CAD program provides to users. These features are designed to facilitate the creation, modification, and analysis of digital models and drawings.

3D file types

Stereo lithography (. STL)

A universal file format is the STL format. It is a format that 3D software specifically developed for storing 3D data. Using STL 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.

- Wave front OBJ(.OBJ)

The OBJ file format allows the definition of polygon-based objects, as well as of free-form curves and Surfaces.

It enables users to represent complex or irregularly shaped objects by dividing their surface into small, triangular "tiles." This tessellation process makes it easier to manipulate and render the design since you can modify each tile separately from the rest.

Some features of an obj;

OBJ supports high-resolution data compared to similar file formats like STL files.

They can store textures and multiple colors in the same object, unlike STL files, which only support one color per object.

- 3D Manufacturing File(.3MF)

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. 3MF files can be viewed with an online application called a 3MF

The .3MF file format is specifically designed to streamline the workflow in 3D printing and additive manufacturing. It aims to provide a more comprehensive and extensible format compared to STL

- Description of 3D enclosure modelling considerations

Designing a 3D enclosure involves several considerations to ensure that the final model meets the requirements of the intended application. Whether it's for electronic devices, machinery, or any other purpose,

- **Shape and Size**

The shape defines the overall appearance, dimensions, and contours of the enclosure.

"size" refers to the physical dimensions of the enclosure in three-dimensional space. These dimensions include length, width, and height, and they play a crucial role in determining the overall form and volume of the enclosure. The size of an enclosure is a fundamental aspect of the design process and is influenced by various factors such as the internal components, functionality, user requirements, and aesthetics.

- **Wall Thickness and Material**

In 3D printing, wall thickness refers to the distance between one surface of your model and the opposite sheer surface. Wall thickness can either provide you with a strong solid surface, or with a flexible and expandable surface.



Material: In 3D enclosure modelling, "material" refers to the substance or substances from which the enclosure is constructed. The choice of material has significant implications for the functionality, aesthetics, durability, and manufacturability of the enclosure. Enclosure materials can vary widely, and the selection is influenced by factors such as the intended use, environmental conditions, manufacturing processes, and cost considerations.



- EMI Shielding Design

Involves creating a housing or structure that effectively mitigates the impact of electromagnetic interference on the electronic components within the enclosure and prevents the emission of electromagnetic radiation from the enclosure itself. EMI shielding is crucial in electronic devices to ensure proper functionality, prevent signal interference, and comply with regulatory standards.

- Aesthetics and Branding

"aesthetics" refers to the visual and design elements that contribute to the overall appearance, style, and attractiveness of the enclosure. Aesthetic considerations are crucial in product design, influencing how users perceive and interact with the enclosure.



- Branding

It involves creating a cohesive and recognizable visual representation of a brand through the design, color scheme, logos, and other branding elements of the enclosure.



Practical Activity 2.2.2: Installing CAD Software



Task:

1. You are asked to perform the task below:

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.

2. Read the key readings 2.2.2 in trainee manual
3. Pay attention on trainer's demonstration and ask questions if any.
4. Install CAD software by respecting the trainer's instructions.
5. Present your work to the whole class
6. Pay attention on trainer's clarification



Key readings 2.2.2.: Installing CAD Software

- Selection criteria

When evaluating CAD software, find out how efficiently each package creates the types of products your company makes. For example, if your company makes sheet metal parts, pay attention to the special tools for creating them and automatically generating flat patterns.

Computer hardware compatibility

Compatibility in CAD (Computer-Aided Design) software refers to the ability of different CAD programs or versions to work together seamlessly, allowing the exchange and use of design data between them.



Software features

Software features in CAD (Computer-Aided Design) refer to the specific functionalities and capabilities that a CAD program provides to users. These features are designed to facilitate the creation, modification, and analysis of digital models and drawings.

- Download CAD software

To "download CAD software" refers to the process of obtaining a computer-aided design (CAD) application from the internet and saving it to your local computer or device.

- Installation manufacturer's guide

CAD drawings can be used in projects of varying complexity.

The blog at archicgi discusses the enduring effectiveness of CAD software for a variety of project requirements. CAD software includes tools that serve different building departments and design needs. CAD software allows for accurate drafting, simulation, modeling, evaluation of cost, and documentation.

✓ **Traditional 2D CAD is often preferred for smaller projects.**

For small teams and simple projects, 2D CAD is easy to use, widely understood, and more accessible for all team members. It requires no extra expertise and avoids the steep learning curve of 3D programs.

✓ **Printed 2D drawings are portable and can be brought to a building site.**

2D drawings allow for a visual reference while on site, and easy modifications can

be made to shop drawings while at a building site. Moreover, 2D CAD drawings are relied on by contractors during construction.

✓ **Contractually, 2D drawings continue to form the basis for project contracts.**

This means 2D drawings continue to be a necessary part of the project as discussed by Allplan Blog. Design teams face balancing the efficiency of and capability of BIM and intelligent 3D modeling, while fulfilling the contractual obligations that require 2D drawings.

✓ **CAD drawings communicate important project information.**

Architectural 2D drawings include information such as the layout of building supply services such as electricity and ventilation, as well as dimensional information.

✓ **Minimal information is needed to create 2D CAD.**

Accurate 2D CAD can be created even when the only information available is the dimensions.

✓ **CAD drawings can often be produced in less time than 3D models.**

Some of the more time consuming parts of the BIM process are not required for 2D CAD models, such as rendering. Experienced CAD technicians are skilled with using software productivity tools to create drawings in less time.

✓ **AutoCAD software from Autodesk continues to improve and update.**

Autodesk frequently releases new toolsets and updates to improve drawing and documentation.

✓ **CAD environment installation process**

The CAD (Computer-Aided Design) environment installation process involves setting up the necessary software and tools on your computer to begin working with CAD applications. The specific steps can vary depending on the CAD software you are installing, but here is a general guide

✓ **System Requirements Check:**

Before you start, check the system requirements for the CAD software you plan to install. Ensure that your computer meets or exceeds the specified hardware and software requirements.

Download Software:

Visit the official website of the CAD software provider. Locate the download section, choose the appropriate version (trial, free, or licensed), and initiate the download.

✓ **Create User Account (if required):**

Some CAD software may require you to create a user account on the provider's website. This account may be used for licensing, accessing updates, or managing subscriptions.

✓ **Save Installer Locally:**

Once the download is complete, save the installer file to a location on your local device.

✓ **Run Installer:**

Locate the downloaded installer file and run it. This may involve double-clicking the file or executing it from the command line.

✓ **Accept License Agreement:**

Read and accept the license agreement presented during the installation process. This agreement outlines the terms and conditions for using the software.

✓ **Choose Installation Options:**

During the installation, you may be prompted to choose installation options. These can include selecting the components to install, specifying the installation directory, and configuring additional settings.

✓ **Enter License Information (if applicable):**

If you have a license key or serial number, enter it when prompted. This step is crucial for activating a licensed version of the CAD software.

✓ **Follow On-Screen Instructions:**

Follow the on-screen instructions provided by the installer. These may include confirming installation settings, choosing a destination folder, or configuring advanced options.

✓ **Install Additional Components (if necessary):**

Some CAD software may require the installation of additional components, plugins,

or libraries. Install these components as needed.

✓ **Finalize Installation:**

1. Allow the installer to complete the installation process. This may involve copying files, configuring settings, and creating program shortcuts.

2. Rules of thumb.

Rules of thumb in CAD software are general guidelines that improve efficiency and design quality, based on common experiences and industry standards. For example, server disk capacity should match the total capacity of all connected CAD workstations, and RAID systems protect engineering data through redundancy.

✓ **Layer Organization:**

Rule: Organize your drawing elements using layers.

Reasoning: Layers help you manage different components of your design, control visibility, and simplify editing.

✓ **Consistent Units:**

Rule: Set and use consistent units throughout your project.

Reasoning: Consistent units ensure accuracy in measurements and dimensions, preventing errors in design.

✓ **Regular Saving:**

Rule: Save your work frequently.

Reasoning: Regular saving prevents data loss in case of unexpected software crashes or issues.

✓ **Named Views:**

Rule: Utilize named views for different perspectives or sections.

Reasoning: Named views make it easier to navigate complex designs and enhance presentation capabilities.

✓ **Grid and Snapping:**

Rule: Use grids and snapping tools for precision.

Reasoning: Grids and snapping aid in aligning elements accurately, maintaining

✓ **Clean Geometry:**

Rule: Keep your geometry clean and avoid unnecessary entities.

Reasoning: Clean geometry reduces errors, enhances performance, and improves the overall clarity of your design.

✓ **Grouping and Blocks:**

Rule: Group related objects and use blocks for repeated elements.

Reasoning: Grouping and blocks streamline editing, especially in complex designs or assemblies.

✓ **Consistent Naming Conventions:**

Rule: Establish and follow consistent naming conventions.

Reasoning: Consistent naming makes it easier to identify and manage different components in your design.

✓ **Document and Annotate:**

Rule: Add dimensions, annotations, and documentation to your design.

Reasoning: Proper documentation improves communication and helps others understand your design intent.

✓ **Parametric Design:**

Rule: Use parametric features whenever possible.

Reasoning: Parametric design allows for easy modifications by updating related elements automatically.

✓ **Learning Shortcuts:**

Rule: Learn and use keyboard shortcuts.

Reasoning: Keyboard shortcuts enhance efficiency and speed up your workflow.

✓ **Regular Backups:**

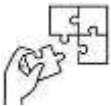
Rule: Maintain regular backups of your CAD files.

Reasoning: Backups provide a safety net in case of file corruption or unintended changes.



Points to Remember

- Select CAD software based on its efficiency for specific products, like sheet metal parts, while ensuring compatibility with existing hardware.
- Evaluate key features that facilitate the creation, modification, and analysis of digital models for streamlined design workflows.
- Understand 3D file types: STL is geometry-focused, OBJ supports textures and complex shapes, and 3MF enhances 3D printing processes.
- Consider critical factors in 3D enclosure design, including shape, size, wall thickness, and material selection for optimal performance and aesthetics.
- Incorporate EMI shielding to protect electronic components while ensuring the design aligns with branding goals for a cohesive identity.
- Download CAD software from reputable sources and follow the manufacturer's installation guide for proper setup.
- Traditional 2D CAD remains popular for smaller projects due to its simplicity and contract relevance.
- Adhere to best practices, like layer organization and regular backups, to improve workflow efficiency 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.



Indicative content 2.3: Apply a 3D Model Design



Duration: 20hrs



Practical Activity 2.3.1: Applying a 3D model design

Tasks:

1. You are requested 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.
2. Read the key readings 2.3.1 in trainee manual
3. Pay attention on trainer's demonstration and ask questions if any.
4. Design 3D model according to instructions.
5. Present your work to the whole class
6. Pay attention on trainer's clarification



Key readings 2.3.1.: Applying a 3D model design

- Interpreting a conceptual model in 3D model design involves understanding and extracting meaningful information from the abstract representation of a design concept. A conceptual model in 3D design serves as a high-level, simplified representation of the design idea, conveying the essential elements without getting into detailed specifics

The conceptual model consists of a set of components: the objectives, inputs, outputs, content, assumptions and simplifications of the model. The modelling objectives describe the purpose of the model and simulation project.

This is the initial step where you analyze the conceptual design or idea behind the model. It involves understanding the purpose, function, and aesthetic of the model.

Key elements include:

Research: Gather information about the subject.

Sketching: Create rough drawings to visualize concepts.

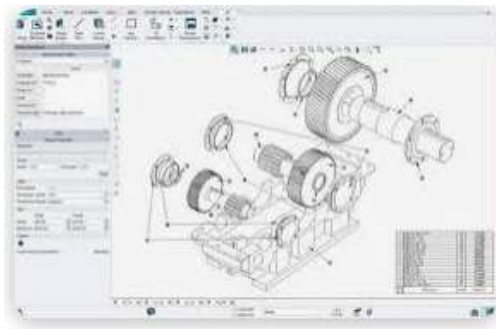
Feedback: Collaborate with stakeholders to refine ideas.

- Design

3D design is the process of using software to create a mathematical representation of a 3-dimensional object or shape. The created object is called a 3D model and these 3-dimensional models are used for computer-generated (CG) design.

3D Mode

3D modelling is the process of creating three-dimensional representations of an object or a surface. 3D models are made within computer-based 3D modelling software, which we'll explore a little later. During the 3D modelling process, you can determine an object's size, shape, and texture.



Once the conceptual model is understood, the next step is creating a detailed 3D representation. This involves:

Modeling Software: Using tools like Blender, Maya, or 3ds Max to build the model.

Geometry Creation: Crafting the structure by defining shapes, surfaces, and textures.

Detailing: Adding finer elements like textures, colors, and materials to enhance realism.

- Perform Rigging

3D rigging is the process of creating a skeleton for a 3D model so it can move. Most commonly, characters are rigged before they are animated because if a character model doesn't have a rig, they can't be deformed and moved around.



Rigging is the process of creating a skeleton for the 3D model, allowing it to move.

Key aspects include:

Skeleton Creation: Setting up bones and joints within the model.

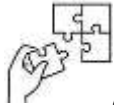
Skinning: Attaching the model's surface to the rig so it deforms properly during movement.

Animation Controls: Setting up controls for animators to manipulate the rig easily



Points to Remember

- In 3D model design, interpret conceptual models by extracting key information and understanding the design's purpose and aesthetics.
- Initial steps include researching the subject, sketching concepts, and collaborating with stakeholders for feedback.
- 3D modeling software is used to create mathematical representations, focusing on an object's size, shape, and texture.
- After understanding the conceptual model, use tools like Blender or Maya to create detailed 3D representations with defined geometry.
- 3D rigging involves creating a skeleton for models, enabling movement through the setup of bones and joints.
- Skinning and animation controls ensure the model deforms correctly and can be easily manipulated for animation.



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.



Indicative content 2.4: Perform a 3D animation



Duration: 2hrs



Practical Activity 2.4.1: Performing a 3D Animation



Task:

1. You are asked to perform the following activity:

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.

2. Read the key readings 2.4.1 in trainee manual
3. Pay attention on trainer's demonstration and ask questions if any.
4. Design 3D model according to instructions.
5. Present your work to the whole class
6. Pay attention on trainer's clarification



Key readings 2.4.1.:Performing a 3D animation

Keyframing

Keyframing is the simplest form of animating an object. Based on the notion that an object has a beginning state or condition and will be changing over time, in position, form, color, luminosity, or any other property, to some different final form.

Keyframing is the process of defining specific points in time where an object's attributes (like position, rotation, and scale) change. By setting keyframes at certain intervals, the animation software interpolates the frames in between, creating smooth motion

Pose blocking

Blocking is an animation technique in which key poses are created to establish timing and placement of characters and props in a given scene or shot. This technique is most commonly used in 3D computer animation, where it is sometimes referred to as Stepped animation.



Timing and spacing

A key frame is a frame that defines the start or the end of a movement or pose in your animation. A timing chart shows you how many frames are between each key frame, and how fast or slow the movement is in that interval.

Timing is crucial because it dictates how fast or slow an animation plays out, affecting the overall perception of movement

Spacing

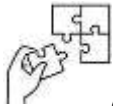
Spacing is the distance between each frame or keyframe of your animation, which determines the speed and acceleration of your motion.



Points to Remember

- Key framing is the fundamental animation technique that defines an object's initial and final states, changing over time in properties like position and color.
- Pose blocking involves creating key poses to establish the timing and placement of characters and props within a scene, often referred to as Stepped animation in 3D.
- Each keyframe marks the start or end of a movement or pose, serving as crucial reference points in the animation process.

- A timing chart indicates the number of frames between keyframes, helping to control the speed of the movement.
- Spacing refers to the distance between keyframes, directly influencing the speed and acceleration of the animation.
- Understanding key framing, pose blocking, timing, and spacing is essential for creating smooth and effective animations.
-



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.



Learning outcome 2 end assessment

Written 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
2. What are the types of view angles for 3D models
 - a) First angle projection and third angle projection
 - b) Orthographic Views and Isometric Views
 - c) Storage
3. What are the minimum computer hardware specifications for 3D modelling
 - a) RAM Memory: 8GB
 - b) SSD Memory: 256GB or HDD Memory: 500GB
 - c) Isometric Views
 - d) 3D file
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

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
- b. 3D design is the process of using software to create a geometrical representation of a 3-dimensional object or shape
- c. Key framing is the simplest form of animating an object based on the notion that an object has a beginning state

III. Match the indicators with corresponding Description

Complete the following table:

Answer	Indicators	Description
1...	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...	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...	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

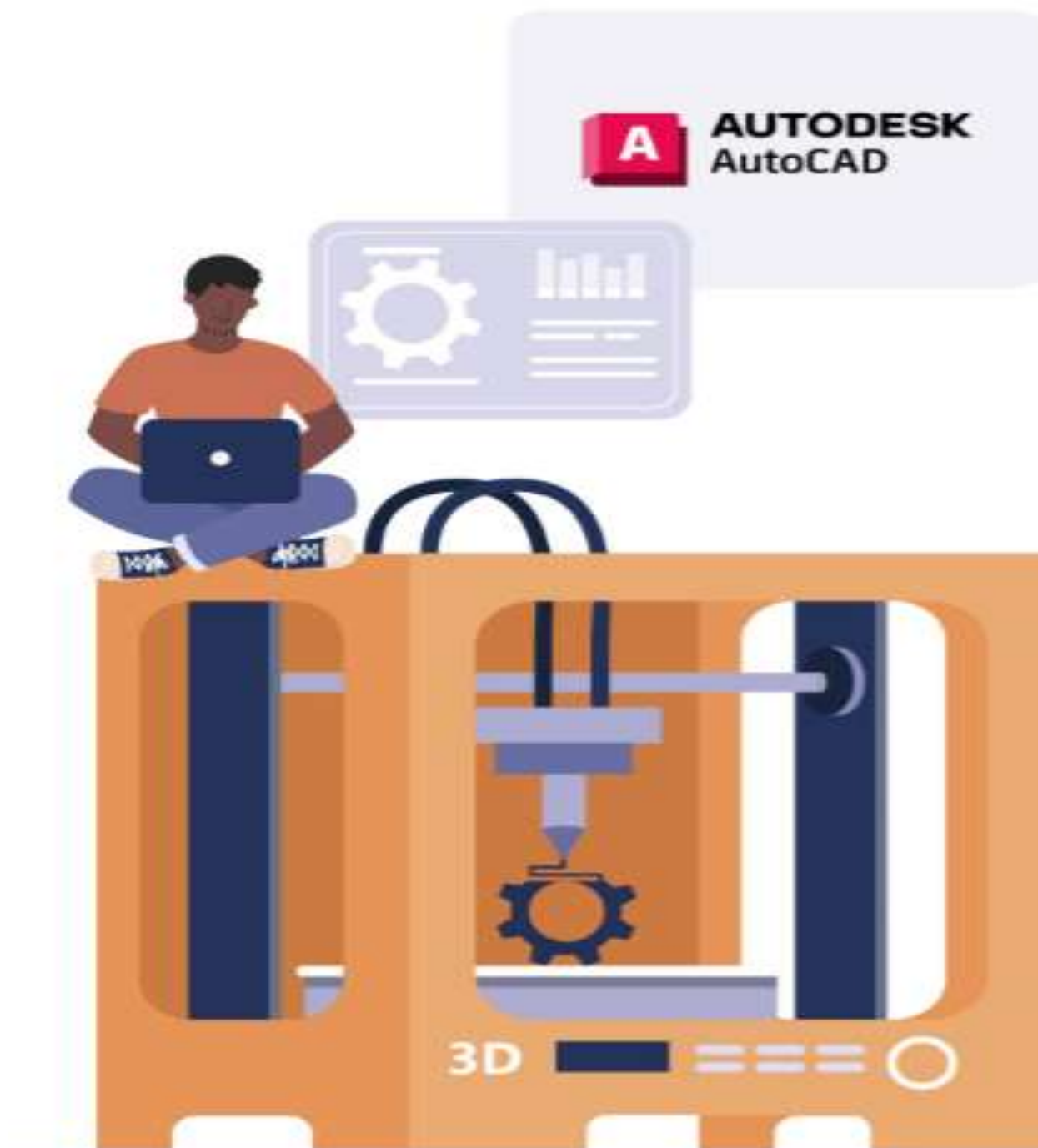
XYZ Company intends to design 3D model of electronic enclosures, and you have been selected to lead this activity. As the lead designer for this activity, your duties include installing the latest version of the CAD software, creating a 3D model, and implementing a 3D animation of the object. Provide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



References

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Learning Outcome 3: Print Electronics Enclosure



Indicative contents

3.1 Selection of 3D Printer

3.2 Identification of printing materials

3.3 Slicing 3D model

3.4 Set up 3D printer for printing

3.5 Perform 3D printing post-processing

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

Knowledge	Skills	Attitudes
<ul style="list-style-type: none">● Identification of print materials● Description of EMI shield● Description of thermoplastics● Description of printing properties● Description Slicing 3D model● Identification of 3D printing requirements● Description of slicing software● Identification of 3D printer	<ul style="list-style-type: none">● Selecting of 3D Printer● Selecting of 3D Print Technologies● Performing conditions of 3D printed enclosure● Installing slicer software● Converting the 3D model into a series of 2D layers● Performing 3D printing	<ul style="list-style-type: none">● Being innovative● Being organization● Being safety First● Being flexibility● Being problem Solving● Being team work● 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
<ul style="list-style-type: none"> ● Computer ● 3D printer ● Safety equipment (safety glasses, gloves, overall, shoes, helmet) 	<ul style="list-style-type: none"> ● CAD software (SolidWorks, Autodesk Maya, AutoCAD) ● Slicer software 	<ul style="list-style-type: none"> ● 3D printing Filaments (ABS and polycarbonate) ● Adhesives ● Internet ● Electricity ● sanding blocks, paint sprayers, or heat guns)



Indicative content 3.1: Selection of 3D Printer



Duration:2hr



Theoretical Activity 3.1.1: Description of Critical conditions of 3D printed



Tasks:

1. Answer 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.
2. Write the answers on papers/flipcharts.
3. Present your findings to the whole class.
4. Pay attention on trainer's clarifications and ask questions if any.
5. For more information, read the key readings 3.1.1 in your manual.



Key readings 3.1.1.:Addressing Critical conditions of 3D printed enclosure

Rapid prototyping (prototyping plastics)

Rapid prototyping is the use of digital technologies to design and fabricate prototypes faster and easier. Rapid prototyping typically relies on 3D printing technologies to fabricate the prototypes quickly, as it circumvents the need to use tool or die sets.

Rapid prototyping is a manufacturing process that creates physical models from a digital 3D design. It allows for quick iteration and testing of products without the need for traditional manufacturing methods.

Prototyping plastics are materials specifically used in rapid prototyping, often offering a balance of strength, durability, and ease of processing.

High temperature refers to materials or processes that can withstand or operate at elevated temperatures. This is often crucial in applications like aerospace, automotive, and industrial machinery.

High quality surface finish refers to a smooth and even surface on a manufactured product. This is important for aesthetics, functionality, and performance in many applications.

In technology, the surface finish describes the roughness of a surface. The higher the surface quality, the smoother and higher the quality of the surface of a work piece.



High accuracy means that a product or process is very precise and has minimal error. This is essential in fields like engineering, manufacturing, and scientific research.

High accuracy, the precision and consistency with which a 3D printer can produce objects, ensuring that the printed model closely matches the intended design specifications.



Transparent materials allow light to pass through them without significant obstruction. This property is useful in applications like optics, displays, and packaging.

Transparent is to the ability of a material to allow light to pass through, making objects or surfaces visible on the other side.



Fixed material refers to a material that is not intended to be changed or modified after it is produced. This is often the case with finished products or components that are not designed for customization

Fixed material is to the use of a specific, predetermined material for manufacturing the enclosure.



Points to Remember

- **Rapid prototyping** transforms digital 3D designs into physical models, enabling fast product iteration and testing without traditional manufacturing constraints.
- **Prototyping plastics** balance strength, durability, and processing ease, making them ideal for quick development.
- **High temperature** materials are essential for applications in aerospace, automotive, and industrial sectors, ensuring performance under elevated conditions.
- **High-quality** surface finishes enhance aesthetics, functionality, and performance, critical for many manufactured products.
- **High accuracy** is vital in engineering and scientific fields, ensuring precision and minimal errors in production processes.
- **Transparent materials** facilitate light transmission, benefiting optics, displays, and packaging applications, while fixed materials remain unchanged post-production.



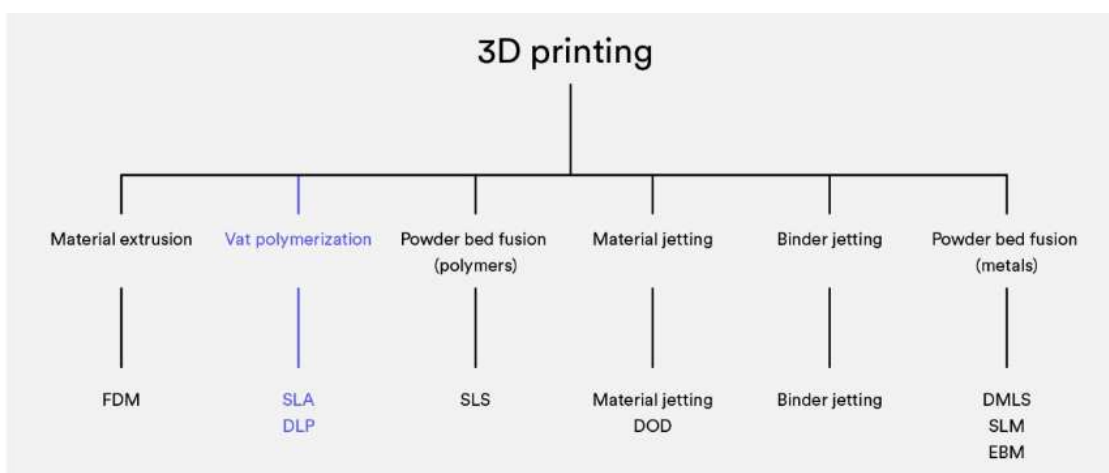
Theoretical Activity 3.1.2: Description of 3D printing Technology

Tasks:

1. Answer 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
2. Write the answers on papers/flipcharts.
3. Present your findings to the whole class.
4. Pay attention on trainer's clarifications and ask questions if any.
5. For more information, read the key readings 3.1.2 in your manual.



Key readings 3.1.2.: Description of 3D Printing Technologies



- FDM(FFF)
Fused filament fabrication:FDM and FFF are common prototyping methods that

melt and deposit a polymer filament via a heated nozzle in order to build a 3D object. Stratasys Inc. owns the trademark rights to the term Fused Deposition Modelling (FDM). The wider market refers to this basic process as fused filament fabrication or FFF.

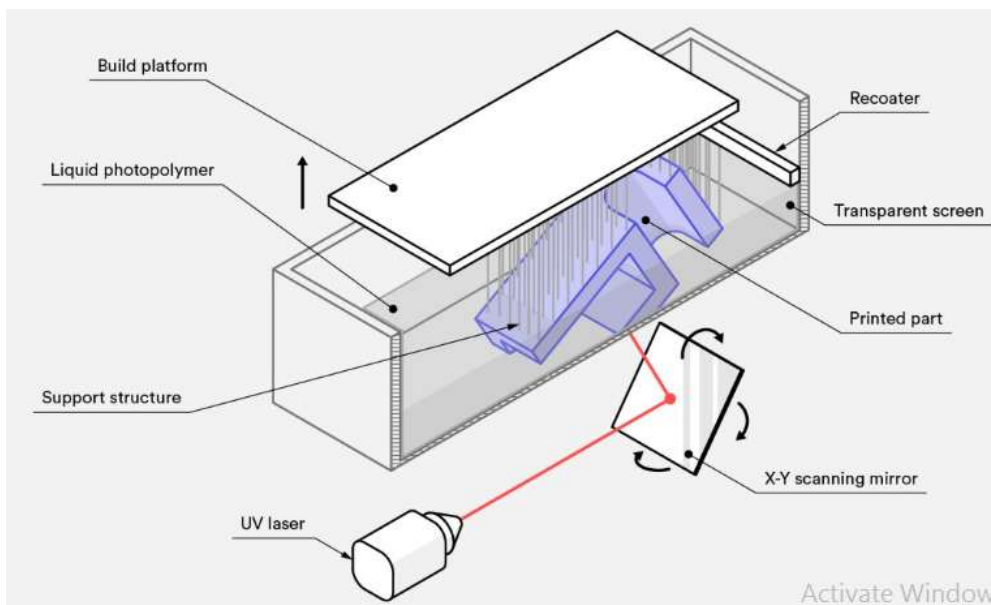


- SLA and SLA flexible resin

Stereo lithography (SLA) is an additive manufacturing process that belongs to the vat photo polymerization family. Also known as resin 3D printing, there are three main 3D printing technologies associated with vat polymerization: SLA, DLP and LCD.

DLP (digital light processing) is a 3D printing technology that makes use of a projector and a DMD (digital mirror device) to selectively cure a photopolymer one layer at a time. The DMD is an array of tiny mirrors that direct UV light at the build plate in the pattern of each slice of the 3D model.

The photopolymerization process is irreversible and there is no way to convert the SLA parts back to their liquid form. Heating these SLA parts will cause them to burn instead of melt. This is because the materials that are produced with SLA are made of thermoset polymers, as opposed to the thermoplastics that fused deposition modeling (FDM) uses.

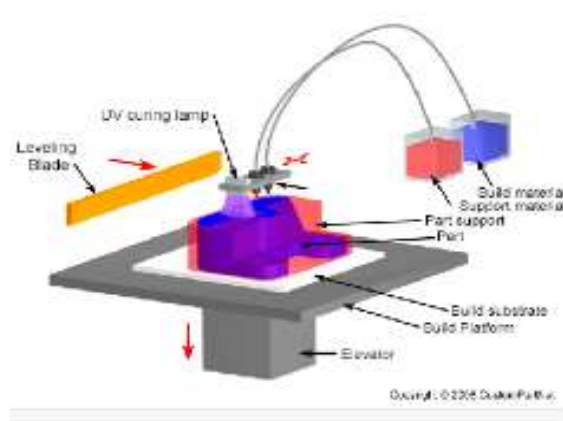


- **Selective Laser Sintering (SLS)**

Selective Laser Sintering (SLS) 3D Printing Work? SLS 3D printer uses a laser to melt polymer powder and fuse it into a solid 3D printed part. SLS is part of the Laser Powder Bed Fusion (LPBF), one of the most advanced and reliable technologies in 3D printing.

- **Material jetting**

Material Jetting builds objects in a similar method to a two dimensional ink jet printer. Multiple materials can be used in one process and the material can be changed during the build stage. Material is jetted onto the build platform surface in droplets, which are formed using an oscillating nozzle.



- **Rubber-like plastics**

Thermoplastic Polyurethane (TPU) has emerged as a go-to material for individuals

and industries looking to 3D print flexible objects. Its properties provide a close resemblance to rubber while also being adaptable to the 3D printing process.



Points to Remember

- **Exploration of Technologies:** Trainees 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:** Trainees 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 trainees to think outside the box.
- **Future Potential:** Ms. Carter emphasizes the vast opportunities in the 3D printing field, inspiring continued exploration.



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.



Indicative content 3.2: Identification of printing materials



Duration: 1 hrs



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

Tasks:

1. Answer 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.
2. Write the answers on papers/flipcharts.
3. Present your findings to the whole class.
4. Pay attention on trainer's clarifications and ask questions if any.
5. For more information, read the key readings **3.2.1** in your manual.



Key readings 3.2.1.: Description of EMI shielding, Thermoplastic, printing property

- Conductive filament is a specialized 3D printing material designed to conduct electricity. It typically consists of a base polymer mixed with conductive additives, such as carbon black, graphene, or metal particles like copper and nickel.

Conductive filaments allow the application of an electric current to generate Joule heating, thus changing the stiffness of the conductive material itself and of surrounding materials.

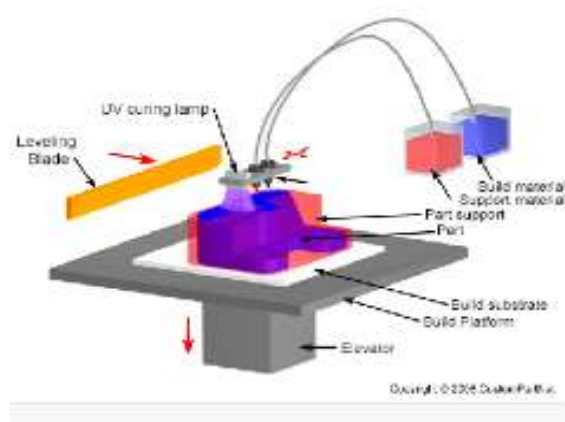


Materials Conductive filaments are typically made by combining a base polymer with conductive additives, such as carbon fibers, graphene, or metal particles (e.g., copper or nickel).

- **Carbon-based materials:**
 - ✓ **Graphene:** Offers excellent electrical conductivity and strength.
 - ✓ **Carbon black:** Inexpensive and provides good conductivity when mixed with polymers.
 - ✓ **Carbon nanotubes:** Highly conductive and lightweight, enhancing the mechanical properties of the filament.
- **Metallic particles:**
 - ✓ **Silver:** Known for its high conductivity, often used in small amounts due to cost.
 - ✓ **Copper:** Provides good conductivity and is less expensive than silver.
 - ✓ **Nickel:** Often used for its magnetic properties as well as conductivity.
- **Conductive polymers:**
 - ✓ **Polyaniline:** A conductive polymer that can enhance the conductivity of the composite.
 - ✓ **Polypyrrole:** Another conductive polymer that can be incorporated for improved conductivity.
- **Ionic conductors:**
 - ✓ **Salts or ionic liquids:** Sometimes added to enhance ion conduction in certain applications, particularly for electrochemical devices.
- **Material jetting**

Material Jetting builds objects in a similar method to a two dimensional ink jet printer. Multiple materials can be used in one process and the material can be

changed during the build stage. Material is jetted onto the build platform surface in droplets, which are formed using an oscillating nozzle.



- Coatings are protective or decorative layers applied to the surface of 3D printed parts to enhance their properties. These can include paints, varnishes, or specialized materials like epoxy or ceramic
- Coating technologies provide corrosion resistance, adhesion qualities, surface protection, and visual and aesthetic properties. However, coating 3D printed parts is not always as easy as coating conventional parts. These complex designs tend to have intricate internal channels that anodization can't reach.

The 3D Ceramic Coating is a high-quality protective product that will chemically bond to the vehicles factory paint to leave behind an extremely durable layer.



- Applying coatings to 3D printed parts comes with several challenges, including:

Surface Preparation: Properly preparing the surface of the printed part is crucial for adhesion. This may involve cleaning, sanding, or priming, which can be time-consuming and may alter the part's dimensions.

Adhesion Issues: Some coatings may not bond well to certain 3D printed materials, leading to peeling or flaking over time. Ensuring compatibility between the coating and the substrate is essential.

Material Shrinkage: Some coatings may shrink as they dry or cure, potentially causing warping or distortion in the printed part.

Thickness Control: Achieving a uniform coating thickness can be challenging, especially for intricate geometries. Uneven coatings can affect appearance and functionality.

Print Layer Lines: The layer lines typical in 3D printed parts may become more pronounced after coating, affecting the aesthetic quality of the final product.

Temperature Sensitivity: Some coatings require specific curing temperatures that may be too high for certain 3D printed materials, leading to deformation or damage.

Chemical Resistance: The coating must be chemically compatible with the environment in which the part will be used; otherwise, it may degrade or fail prematurely.

Cost and Time: The application of coatings can increase production costs and lead times, especially if multiple layers or special techniques are required.

Testing and Quality Control: Ensuring that the coating performs as expected in terms of durability and functionality often requires additional testing and quality assurance measures.

Thermoplastics

Thermoplastics are plastic materials, or polymers, that become pliable when heated to a specific temperature and solidify upon cooling.

Thermoplastic materials are a type of plastic polymer material that becomes mouldable at certain high temperatures and then becomes solid after cooling.



- **Printing properties**

When it comes to determining the suitability of a 3D printing material for a project, you need to know how hard, how strong and how flexible that material is. These things are referred to as the 'mechanical properties' of a material. The phrase “good mechanical properties” is widely used in the 3D printing industry.

- **Print Quality**

Print resolution is the measure of how detailed and smooth your 3D printed object will be. It is usually expressed in microns, which are one thousandth of a millimeter, or in layer height, which is the thickness of each layer of material that is deposited by the printer.

Print quality is the clarity of printed documents or images, achieved using high-quality equipment and maintenance based on resolution, color accuracy, and contrast.

- **Print speed**

Print speed refers to the rate at which the 3D printer extrusion system moves when extruding filament. Print speed is measured in millimeters per second (mm/s), and most FFF 3D printers have the capacity to print at speeds in the range of 40 mm/s to 150 mm/s.

- **Print Volume**

EOS 3D printers are high-tech laser-sintering machines from a German company of the same name. These printers, of course, are big, bulky things, not suited for hobbyists or smaller offices; but as far as serious 3D printers go, EOS machines are fairly user-friendly and easy to use.

The 3D printing volume of a printer gives the maximum size that one object can have in order to be printed. EOS 3D printer. The size of the printing volume

depends on the chosen material which in turns determinates the type of printer used.



Points to Remember

- **Conductive filaments** combine base polymers with additives like carbon or metal particles to enable electrical conductivity, allowing for applications like Joule heating that alters material stiffness.
- **Carbon-based materials** such as graphene and carbon nanotubes enhance electrical conductivity and mechanical properties, while metallic particles like copper and silver provide efficient conductivity.
- **Material jetting technology** enables multi-material 3D printing by jetting droplets onto a build surface, offering versatility during the manufacturing process.
- Coatings enhance the properties of 3D printed parts, providing protection and aesthetics, but pose challenges like adhesion issues and surface preparation complexities.
- Thermoplastics become moldable when heated and solidify upon cooling, making them suitable for various applications in 3D printing.
- Key printing properties include mechanical strength, print quality, speed, and volume, all crucial for determining the effectiveness and suitability of materials in 3D printing projects.



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. As a trainee you are asked to choose the best material using in 3D printer.



Indicative content 3.3: Slicing 3D model



Duration: 10 hrs



Theoretical Activity 3.3.1: Description of slicing software



Tasks:

1. You are asked to answer the following questions:
 - i. What is 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?
2. Present your findings to the whole class.
3. Pay attention on trainer's clarifications and ask questions if any.
4. For more information, read the key readings 3.3.1 in your manual.



Key readings 3.3.1.:Description of slicing software

Definition

Slicing a 3D drawing translates the 3D drawing into a language that a 3D printer can understand and print. If you want a slightly more technical explanation, slicing turns digital 3D models into G-codes (a generic name for a control language) that a 3D printer can understand.

A slicer is a piece of 3D printing software that acts as a link between the digital model (generated on a computer) and the actual model (constructed by the 3D printer itself).

Slicer

A slicer is a piece of 3D printing software that acts as a link between the digital model (generated on a computer) and the actual model (constructed by the 3D printer itself). The 3D printing slicer software transforms the digital model into printing instructions, called G-code.

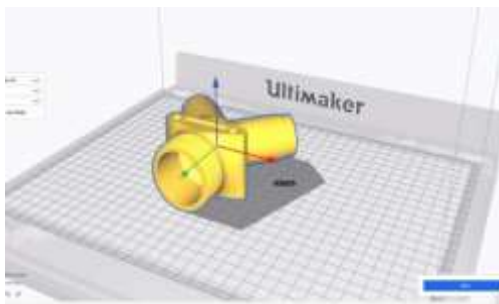
What does Cura do?

Cura slices 3D models. In other words, it translates your 3D printing file (containing a 3D model you drew in CAD software) into G-code. G-code is the language your 3D printer understands, with the sliced file containing print instructions for your 3D printer.

What features does Cura have?

Cura is a feature-packed slicer with several advantages over other tools:

- ✓ Backups – work anytime, anywhere. Keep your settings in the cloud
- ✓ Remote printing – print anytime, anywhere. Send files to print anywhere with an internet connection
- ✓ Marketplace – access material profiles and plugin integrations easily, with reviews and tips baked in
- ✓ Pre-configured print profiles
- ✓ Advanced settings (over 400)
- ✓ Manage multiple printers.
- ✓ Remote printing and queue management

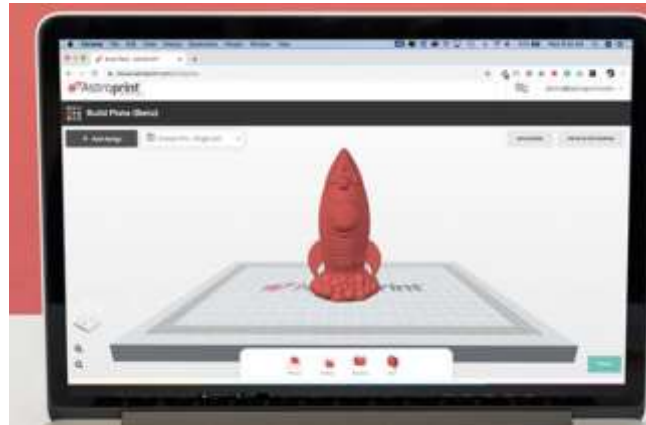


Astroprint

Astroprint is another 3D slicing software that was developed similar to that of OctoPrint. It works on a web browser with Raspberry Pi and pcDuino systems. You

can easily monitor your 3D printer remotely from any device connected to the internet.

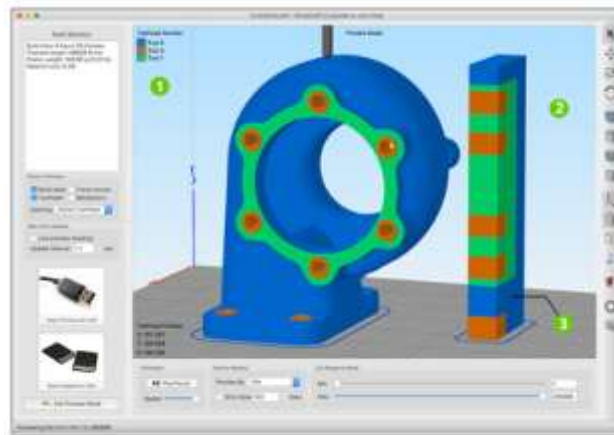
Astroprint has two modes, viz advanced and straightforward modes. In simple terms, you will get the tools to choose the desired section and quality before sending it to the 3D printer. You can manipulate the tools set in advanced modes to get excellent results.



Simplify 3D slicing software

Simplify3D is a powerful 3D slicing program with user-friendly, sophisticated capabilities. The software is appropriate for experienced users who require a 3D slicer for high-quality printing. The slicer is compatible with Windows, macOS, and Linux and works with practically all 3D printers. You can prepare, import, and edit STL files using Simplify3D. Additionally, you may import OBJ, and 3MF files easily.

Simplify 3D provides you with a preprint option to analyze and test your readied print easily. If you don't identify problems manually, it can automatically find design mistakes minutely and solve them.



Pros:

It has a wide variety and overwhelming tool options.

Harmonize with any 3D printer.

User-friendly interface.

Cons:

It is not available in the free version.

key factors to consider slicer software for your 3D printing need

- ✓ **Printer Compatibility:** Ensure the slicer supports your specific 3D printer model. Some slicers are designed for certain brands or types.
- ✓ **User Interface:** Look for software that is intuitive and user-friendly, especially if you're a beginner. A clean layout with helpful tutorials can be beneficial.
- ✓ **Features:** Assess the features you need, such as:
 - ✚ Customizable print settings (layer height, infill density, etc.)
 - ✚ Support for different materials
 - ✚ Advanced options (e.g., variable layer height, adaptive infill)
- ✓ **Community and Support:** A strong user community can provide valuable resources, tips, and troubleshooting assistance. Check forums, tutorials, and documentation.
- ✓ **Updates and Development:** Regular updates can indicate active development and improvements. Look for software that is consistently updated to fix bugs and add features.

- ✓ **Cost:** Determine if you need a free version or if you're willing to pay for a premium slicer with advanced features.
- ✓ **Compatibility with File Formats:** Ensure the slicer supports the file formats you plan to use (like STL, OBJ, etc.).
- ✓ **Performance and Speed:** Consider the slicing speed and how it handles complex models. Some slicers are faster than others, especially with larger files.
- ✓ **Integration with Other Tools:** If you use CAD software or other tools, see if the slicer integrates well with them.
- ✓ **Specific Needs:** Consider any specific needs you may have, like multi-material printing or specific slicing algorithms.



Practical Activity 3.3.2: Installing Slicing Software



Task:

1. Answer the following questions:

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.

2. Read the key readings 3.3.2 in trainee manual
3. Pay attention on trainer's demonstration and ask questions if any.
4. Install slicing software by respecting the trainer's instructions.
5. Present your work to the whole class
6. Pay attention on trainer's clarification



Key readings 3.3.2.: Install Slicing Software

- **Key Features of Slicing Software:**
 - ✓ **Usability:** Intuitive UI for ease of use.
 - ✓ **Error Notification:** Ability to detect and notify users of errors in files.
 - ✓ **Support Structures:** Options to add supports for overhanging parts.
 - ✓ **Orientation & Layer Height:** Critical for print quality and resolution.
 - ✓ **Infill Density & Patterns:** Affects strength and flexibility of prints; recommended patterns vary based on print type.
 - ✓ **Print Speed & Temperature:** Settings must be adjusted for optimal results based on model geometry and material type.
- **Considerations for Choosing a Slicer:**
 - ✓ **Cost:** Weigh the advantages of paid software against free alternatives.
 - ✓ **File Import Speed:** Efficient handling of large or complex STL files.
 - ✓ **Preview Functionality:** Accurate estimates for printing time and material usage.
- **Installation Process for Slicer Software:**
 - ✓ Go to the page Slicer on Autodesk App Store
 - ✓ Select your operating system
 - ✓ Click the **Download** button on the right side of the site
 - ✓ Run the installer (click YES when it asks to extract to a certain directory).
 - ✓ Once the installation is finished, restart Fusion 360
 - ✓ In the Model workspace, select **Make -> Slicer for Fusion 360**



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



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



Task:

1. Answer the following questions:

You are requested to go in the 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.

2. Read the key readings 3.3.2 in trainee manual
3. Pay attention on trainer's demonstration and ask questions if any.
4. Install slicing software by respecting the trainer's instructions.
5. Present your work to the whole class
6. Pay attention on trainer's clarification



Key readings 3.3.3. Converting the 3D Model into a Series of 2D Layers

- **Converting the 3D Model into a Series of 2D Layers**

The act of converting a 3D model into a set of instructions for the 3D printers is called Slicing. Quite literally, it 'slices' the 3D model into thin layers, and further determine how each layer should be printed (the tool path) to get minimum time, best strength, etc.

- **Identify slicing software**

A good slicing software should be able to handle high-poly models, multiple objects, and advanced settings without compromising on speed and stability. You should also look for a software that can preview your sliced model in real time, so you can check for any errors or adjustments before printing.

- **Import the 3d model**

The Import 3D model function allows for importing 3D models into the workspace / workdesk environment from the following file formats: Format. Version. Extension.

- ✓ Import 3D models to a project
- ✓ Select File > Import > File or use the Import option in the Project panel.
- ✓ Select GLB or GLTF file formats from the device to import and select Open. A new folder with the model's name is created in the project for the 3D model file
- ✓ Configure print settings

Identify What Kit You Own:

Start by identifying what type of 3D printing kit you own. There are generally three styles of 3D printer kits to consider: pre-assembled, partially assembled, and DIY printer kits. Pre-assembled kits are the easiest to get started with as they come ready to use straight out of the box. Partially assembled kits offer a middle-ground option. These kits are usually divided into components to save space during shipping. DIY kits represent the most hands-on approach. These kits require substantial assembly, and you'll likely spend more time constructing the printer from the ground up.

Read and Follow the Assembly Instructions

After you've identified the 3D printer kit you own, it's important to carefully read the assembly instructions. Whether you're dealing with a pre-assembled, partially assembled, or DIY kit, taking the time to understand the setup process up front is very important. Reading instructions carefully, organizing components, and executing assembly steps accurately not only reduces the need for later adjustments but also ensures safe and reliable performance

Check To See if Everything Is Level and Square

If your printer came pre-assembled you'll only need to plug in a few extensions and pieces of equipment. After you've assembled the printer, you'll want to check that everything is level and square. This is important for precise filament deposition and successful object construction. This leveling process can vary between machines, with options for both manual and automatic adjustments.

Assume Your Printer Is Not Calibrated

Assuming that your printer is calibrated could lead to a costly exercise as it will result in a lot of filament being wasted. Calibrating your 3D printer is the key to consistently producing high-quality prints. Your instruction manual typically includes a section dedicated to calibration instructions.

Lubricate Everything Well

Proper lubrication is crucial for the numerous moving components to keep your 3D printer running smoothly. If a part interacts with another surface, it likely requires lubrication, but the specific lubricant depends on the component's function.

For instance, components like the threaded rod and nut along the Z-axis, responsible for adjusting the printer nozzle's height, demand lubrication. The X- and Y-axis guide rails, guiding the printhead and bed, also benefit from proper lubrication. This not only ensures a trouble-free printing process but also prolongs the life of the printer's parts.

- Set the Preferred Print Speed

- ✓ Print speed dictates how rapidly the 3D printer's extruder moves while depositing material. It is typically measured in millimeters per second (mm/s) or millimeters per minute (mm/min). The choice of print speed involves a trade-off between print quality and efficiency. Slower print speeds tend to yield higher-quality prints, allowing for precise material deposition and better adhesion between layers. Conversely, higher speeds may compromise print quality, especially for intricate details.

Filament Should Be Fed Into the Extruder

- ✓ Before initiating the printing process, it's essential to prepare the extruder for filament extrusion. This procedure commences with heating the hot end to the specific melting temperature of the filament, which typically exceeds 175 °C. This can vary, however, depending on the filament type. Subsequently, you'll introduce the filament into the heated extruder.

Pick a Design

- ✓ Your 3D printer often comes with a USB stick containing a test model to get you started. Once you're ready to explore further, you'll want to learn where to source and possibly even create your own 3D models. For beginners, the most suitable option is to download models from various websites and 3D model archives, such as: Thingiverse®, MyMiniFactory, TurboSquid, GrabCAD®, and Cults3D. These models are typically available in STL file format, although OBJ and 3MF formats are also occasionally used. Additionally, you can even import

.jpg and .png files into software like Cura to generate Lithophane models.

Setup and Print

- ✓ After creating a 3D model in design software, use specialized software that translates the model into the machine instructions script. This crucial task is accomplished through slicing software, commonly referred to as a slicer. Once you've imported your 3D model into the slicer, you have the flexibility to fine-tune various settings to align with your specific requirements. Among these settings are critical parameters like: printing speed, temperature, wall thickness, infill percentage, layer height, and many others.

Orientation and placement

- ✓ In 3D printing, orientation is defined as the alignment of an object within the space of the build volume. It impacts stability, surface finish, and printability.

Support generation

- ✓ Support structure generation is another foundational operation of 3D printing. It affects printing quality and material consumption. If the necessary support structures are missed, then 3D printing will fail. In addition, unnecessary support structures mean more required materials and more printing time.
- ✓ Support is extra material that is added to your model to help print parts that won't print well normally. This might include parts in midair, parts with large overhangs, or long bridges in air.

Export g-code

- ✓ G-code (also known as RS-274) is the name of the most prevalent programming language for computer numerical control (CNC) in computer-aided design and manufacturing (CAD/CAM). G-code provides metric-based numeric control of CAM-controlled equipment such as CNC milling machines.
- ✓ G-code is a language that humans use to tell a machine how to do something. With 3D printing, G-code contains commands to move parts within the printer.
- ✓ G-code (geometric code) is the most common CNC (computer numerical control) programming language used to drive computer-controlled manufacturing machines.

G-Code Blocks

The G-code standard was published back in the days when machines had small amounts of memory. Because of this memory limitation, G-code is an extremely compact and concise language that might almost seem archaic at first glance. Take, for example, this line of code:

```
G01 X1 Y1 F20 T01 M03 S500
```

In this single line, we're giving the machine a series of instructions:

G01 – Perform a linear feed move

X1/Y1 – Move to these X and Y coordinates

F20 – Move at a feed rate of 20

T01 – Use Tool 1 to get the job done

M03 – Turn the spindle on

S500 – Set a spindle speed of 500

Multiple lines of G-code like these combine to form a complete CNC program. Your CNC machine will then read the code one line at a time from left to right and top to bottom, like reading a book. Each set of instructions is on a separate line or a block.

G-Code Programs

The goal of every G-code program is to produce parts in the safest and most efficient way possible. To achieve this, you'll typically find G-code blocks arranged in a particular order like this:

Start the CNC program.

Load the required tool.

Turn the spindle on.

Turn the coolant on.

Move to a position above a part.

Start the machining process.

Turn the coolant off.

Turn the spindle off.

Move away from the part to a safe location.

End the CNC program.

- This flow is a simple program using only one tool for one operation. In practice, you will typically rinse and repeat steps 2 through 9. For example, the G-code program

below encompasses all of the code blocks above with repeating sections where needed:

- Transfer the g-code file to your 3d printer to print
 - ✓ Navigate to Print from SD.
 - ✓ You should see the PRINT FILES folder, open it.
 - ✓ You should see the test. gcode file.
 - ✓ If you click it, the Printer should begin printing it as usual.



Points to Remember

- Usability: Choose slicing software with an intuitive interface to enhance the user experience.
- Error Notification: Opt for software that alerts users to 3D model errors for better print outcomes.
- Support Structures: Learn about support options for complex designs with overhangs.
- Layer Height & Orientation: Understand how these settings influence print quality and resolution.
- Infill Patterns: Balance infill density and patterns to ensure strength and flexibility.
- Key Considerations: Evaluate slicers for compatibility, interface, community support, and features.
- Slicing Process: Recognize slicing as the conversion of 3D models into 2D layers for efficient printing.
- G-code Export: Generate G-code to guide the printer through each print job step.



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.



Indicative content 3.4: Set up 3D Printer for Printing



Duration: 2 hrs



Practical Activity 3.4.1: Set up 3D Printer for Printing



Task:

1. Answer the following questions:

You are requested to go in 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.

2. Read the key readings 3.4.1 in trainee manual
3. Pay attention on trainer's demonstration and ask questions if any.
4. Converting the 3D model into a series of 2D Layers by respecting the trainer's instructions.
5. Present your work to the whole class
6. Pay attention on trainer's clarification



Key readings 3.4.1: Set up 3D Printer for Printing

- **Identification of 3D Printer Settings**
 - ✓ **Layer Height:** Determines the height of each layer, influencing print time, detail, and surface finish.
 - ✓ **Shell Thickness:** Affects the number of outer wall layers, impacting the strength and appearance of the part.
 - ✓ **Retraction:** Controls the retraction of filament to minimize oozing and stringing during printing.
 - ✓ **Infill Density:** Regulates the amount of internal material, influencing print

time, strength, and weight.

- **Calibration of 3D Printer Settings Using the User Manual**

When a 3D printer is assembled or newly acquired, it requires a calibration process to ensure consistent and precise 3D prints. This initial setup is crucial for achieving accurate results and is often referred to as 3D printer calibration. During this process, you'll need to manually adjust and test several key parameters to ensure optimal printing quality.

To effectively calibrate a 3D printer, focus on the following main aspects:

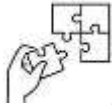
- **Bed Level Adjustment:** Ensure the print bed is perfectly leveled and at the correct distance from the nozzle for flat prints.
- **Accurate Extruder Settings:** Verify that the correct amount of filament is extruded for precise layering and dimensional accuracy.
- **Stepper Motor Calibration:** Ensure the stepper motors operate at consistent distances along the X, Y, and Z axes.
- **Temperature Settings:** Set the appropriate temperature according to the material being used to guarantee proper adhesion.
- **Print Speed Customization:** Test and adjust the print speed to prevent over-extrusion or under-extrusion, ensuring high-quality, consistent prints.



Points to Remember

- **Slicing and Software:** Slicing transforms a 3D model into 2D layers, generating instructions for optimized printing; choose software that handles complex models and provides error-checking previews.
- **Model Import and Settings:** Import models in formats like GLB/GLTF, then configure print settings, identifying the printer type, and calibrating it correctly.
- **Supports and Orientation:** Add supports for overhangs and adjust model orientation to enhance print stability and quality.

- **Exporting G-code:** Export the G-code and transfer it to the printer to start the printing process.
- **Printer Calibration:** Regularly calibrate, including bed leveling and extruder adjustments, for consistent results.
- **Print Settings Optimization:** Adjust layer height, shell thickness, retraction, infill density, and stepper motor calibration for a balanced print.



Application of learning 3.4

ABC company 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.



Indicative content 3.5: Perform 3D Printing Post Processing



Duration: 5 hrs



Practical Activity 3.5.1: Performing 3D Printing Post-Processing



Task:

1. Answer the following questions:

After completing the 3D printing 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.

2. Read the key readings 3.5.1 in trainee manual
3. Pay attention on trainer's demonstration and ask questions if any.
4. Converting the 3D model into a series of 2D Layers by respecting the trainer's instructions.
5. Present your work to the whole class
6. Pay attention on trainer's clarification



Key readings 3.5.1.: Performing 3D printing post-processing

3D printing post processing is used to enhance the surface properties of prints in many aspects to deliver improved mechanical performance and aesthetic appearance.

- **Finishing the enclosure**

Finishing a 3D printed part often involves a combination of the following processes: smoother application, sanding, polishing, cleaning and painting. The process is unique to the material type. A smooth finish with 3D printing is achievable but, post-processing will greatly improve the smoothness of parts.

- **Test quality assurance of the enclosure**

Quality assurance for the enclosure of 3D printing post-processing means involves ensuring that the enclosure meets certain standards and criteria to guarantee safety,

functionality, and efficiency.

Autodesk Maya, commonly shortened to just Maya, is a 3D computer graphics application that runs on Windows, macOS and Linux, originally developed by Alias and currently owned and developed by Autodesk.



Points to Remember

- **Purpose of Post-Processing:** Enhances surface properties for better mechanical performance and aesthetic appeal.
- **Finishing Techniques:** Involves sanding, polishing, cleaning, and painting to achieve a smooth finish.
- **Material-Specific Processes:** Post-processing methods vary based on the material type used in the print.
- **Achieving Smoothness:** While 3D printing can create smooth surfaces, post-processing significantly improves quality.
- **Quality Assurance Importance:** Ensures that the enclosure meets safety, functionality, and efficiency standards.
- **Inspection Criteria:** Quality checks involve measuring dimensions and inspecting for defects.
- **Role of Software:** Tools like Autodesk Maya can aid in designing and refining 3D models before printing.
- **Final Review:** Post-processing is essential for delivering high-quality, reliable 3D printed parts.



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.



Learning outcome 3 end assessment

Theoretical 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
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
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
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.
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.

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.
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.
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.

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.
2. A slicer is only used for viewing 3D models, not for printing.
3. Cura is a slicer that allows remote printing and has over 400 advanced settings.
4. Astroprint can only be used on Windows operating systems.
5. Simplify3D is suitable for beginners due to its simple interface and lack of complex features.
6. Regular updates for slicing software indicate active development and improvements.
7. The only important factor when choosing slicer software is the cost.
8. Simplify3D supports multiple file formats including STL, OBJ, and 3MF.
9. User community support is not important when selecting slicer software.
10. Astroprint has only one mode of operation for slicing.

III. Match the following terms with their correct descriptions:

Answer	Indicators	Description
1.....	1.Slicing	A. A programming language used by 3D printers to understand print instructions.
2.....	2. Cura	B. Software that allows monitoring and controlling a 3D printer from any internet-connected device.
3.....	3.Astroprint	C. A slicer known for its extensive features, including cloud backups and remote management.
4.....	4. Simplify3D	D. Materials designed for quick prototype creation, balancing strength and ease of processing.
5.....	5. G-code	E. A powerful slicer compatible with multiple operating systems, offering tools for experienced users.
6.....	6. Prototyping Plastics	F. The visual layout and design of software that affects usability, especially for beginners.
7.....	7. User Interface	G. The process of converting a 3D model into instructions for a 3D printer.
8.....	8. Remote Printing	H. The ability to send print jobs to a 3D printer from any location via the internet.

Practical assessment

Smart Home Solutions is a burgeoning start-up 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, Smart Home Solutions is looking to hire

you as a solution provider to help overcome these enclosure design challenges for their smart doorbell.



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