



CHAPTER 7

3D Modelling

Learning Outcomes

- Introduction to Frames & Reference Frame
- Applications of Frame
- Comparison

3D modelling is a way of creating and designing objects on a computer before making them in real life. It allows us to shape, move, resize, and rotate objects in a virtual space, using three directions—left and right (X-axis), up and down (Y-axis), and forward and backward (Z-axis). This makes it useful for designing buildings, machines, toys, and many other things.

One of the easiest tools for learning 3D modeling is **Tinkercad**. It is free, web-based software that helps beginners create 3D designs using simple shapes. With Tinkercad, you can drag and drop different shapes, join them together, and modify them to build various structures. You can even prepare your designs for 3D printing!

In this chapter, you will learn the basics of **3D modelling** and how to use Tinkercad to design different objects.

What is 3D Modelling?

3D Modelling is the process of creating a three-dimensional representation of an object or a scene using specialized computer software. These models are used in various fields such as robotics, animation, gaming, architecture, manufacturing, and medical imaging. The models can be rendered into 2D images, used for simulations, or printed using 3D printing technology.

Types of 3D Modelling

1. Solid Modelling

- Represents objects as solid volumes.
- Includes details like mass, weight, and density.

- Used in engineering and manufacturing (e.g., CAD software like SolidWorks, AutoCAD).

2. Surface Modelling

- Focuses on the external shape of an object without defining its volume.
- Used for creating aesthetically appealing designs (e.g., automotive and product design).

3. Wireframe Modelling

- Represents objects using lines and curves.
- Appears like a skeletal framework of the model.
- Used for conceptual design before applying solid or surface modelling.

Steps in 3D Modelling

1. Concept Development

- Create a rough sketch or idea of the object to be modelled.
- Define dimensions and features required.

2. Choosing the Right Software

- Examples: Tinkercad, Blender, Fusion 360, AutoCAD, SolidWorks, Maya.

3. Creating Basic Geometry

- Use primitive shapes like cubes, cylinders, spheres, and cones as building blocks.

4. Refining the Model

- Modify shapes using scaling, rotation, extrusion, and Boolean operations.

5. Adding Details

- Apply textures, materials, and colours.
- Use sculpting tools for intricate designs.

6. Rendering & Exporting

- Add lighting and camera effects for realistic views.
- Convert into a format compatible with 3D printing, animation, or simulation (e.g., STL, OBJ, FBX).

Applications of 3D Modelling

Robotics

- Designing robot components such as arms, grippers, and wheels.
- Simulating robotic movement and testing before real-world implementation.

3D Printing

- Creating prototypes and manufacturing parts efficiently.
- Used in industries like healthcare (prosthetics), automotive, and aerospace.

Animation & Gaming

- Developing characters, environments, and assets for movies and games.

Architecture & Interior Design

- Visualizing building structures before construction.

Medical & Scientific Research

- 3D models of human organs for study, surgery planning, and prosthetic development.

Advantages of 3D Modelling

- **Precision & Accuracy** – Helps in designing intricate details with high accuracy.
- **Cost-Effective Prototyping** – Reduces material wastage in manufacturing.
- **Faster Product Development** – Allows quick iterations and modifications.
- **Enhanced Visualization** – Provides a better understanding of the design before production.

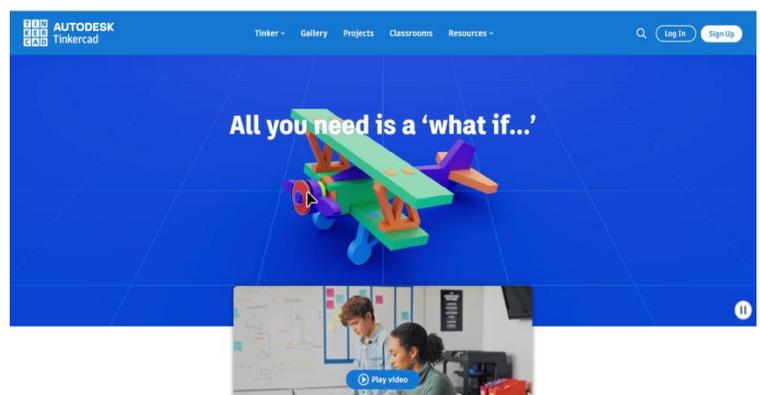
3D modelling is the process of creating and designing objects on a computer, allowing us to change their shape, size, and position. It uses basic shapes like cubes, spheres, and cylinders, which can be combined to make more complex structures. In 3D modelling, we can move objects in different directions along three axes: **X-axis** (left and right), **Y-axis** (up and down), and **Z-axis** (forward and backward). We can also **resize (scale)** objects to make them bigger or smaller and **rotate** them to change their angle or direction. These basic actions help in designing buildings, machines, vehicles, and even characters for movies and video games. 3D modelling is widely used in fields like **architecture, engineering, animation, and 3D printing**. It allows designers to experiment with different ideas, improve their designs, and create objects that can later be built in the real world. As technology advances, 3D modelling has become an important skill for both professionals and beginners, making it easier to bring creative ideas to life.

Tinkercad: An Easy-to-Use 3D Modelling Tool

Tinkercad is a free, online tool that makes **3D modelling** simple and fun, especially for beginners. It allows users to create 3D designs by using basic shapes like cubes, spheres, and cylinders. The tool is easy to use because it has a simple **drag-and-drop** interface, meaning you can just click and move shapes to build your design.

One of the best things about **Tinkercad** is that it works in a **web browser**, so there is no need to download or install anything. You can **move, resize, and rotate** objects in all directions to create different structures. It also lets you **combine shapes**, create holes, and align objects perfectly.

Tinkercad is useful for **3D printing, robotics, and electronics**. You can design objects and print them using a **3D printer**, or even create simple electronic circuits with components like **LEDs and sensors**. It is a great tool for students, hobbyists, and anyone who wants to learn **3D design** without needing advanced skills.



With **step-by-step tutorials** and ready-made shapes, Tinkercad makes learning **3D modelling** easy and fun. Whether you want to design toys, mechanical parts, or buildings, **Tinkercad is a great place to start!**

Tinkercad is a simple and user-friendly **3D modelling tool** that runs online in a web browser. It's easy-to-use interface makes it a perfect choice for beginners. To get started, visit www.tinkercad.com and create an account by clicking the **"Start Tinkering"** button. You will need to provide an **email address and password** to set up your account. Once registered, you can begin designing right away!

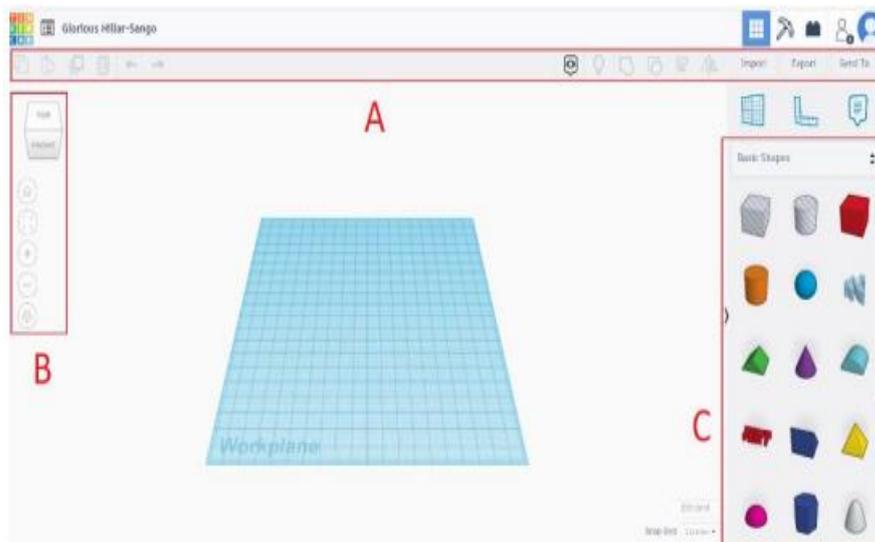
After completing the registration process, the user reaches the **main panel** of Tinkercad. Here, they can either follow an **online tutorial** or start designing right away. For now, close the tutorial and go to the **home page**, then click on **"Create new design"** to begin.



To understand the basics of Tinkercad, this guide will walk through designing a **simple wrench**. A **wrench** is a common tool used for **tightening nuts and bolts**. It has a basic shape, making it an easy model to create and later **3D print**.

1. Setting up the Project

Figure shows the **main interface** of a Tinkercad project. At the center is the **Work plane**, where all models are created and modified. The interface includes the following key components:



A. Top Toolbar – This contains general tools like **Copy, Paste, and Delete** on the left, while the right side has design functions like **Group and Align** to organize objects.

B. Navigation Tools – These allow users to **zoom in and out** for better viewing. You can also use the **mouse wheel** to navigate the workspace easily.

C. Shape Panel – This section provides all the **building blocks** needed for designing, including **basic shapes** like cubes, spheres, and text. Many of these shapes have **customizable options**, making the design process more creative and fun!

2. Breaking the Model into Parts

In **3D modelling**, breaking a design into smaller parts is an important technique. Instead of creating a complex shape all at once, we **divide it into simpler shapes** and work on each piece separately. Later, these pieces are **combined** to form the final model.

For our **wrench design**, we will divide it into **three main parts**:

- **The Ring** – The circular end of the wrench.
- **The Handle** – The long section used for gripping.
- **The Jaw** – The open end used to tighten or loosen nuts and bolts.



By designing each part individually, we can make the modelling process **easier and more precise**.

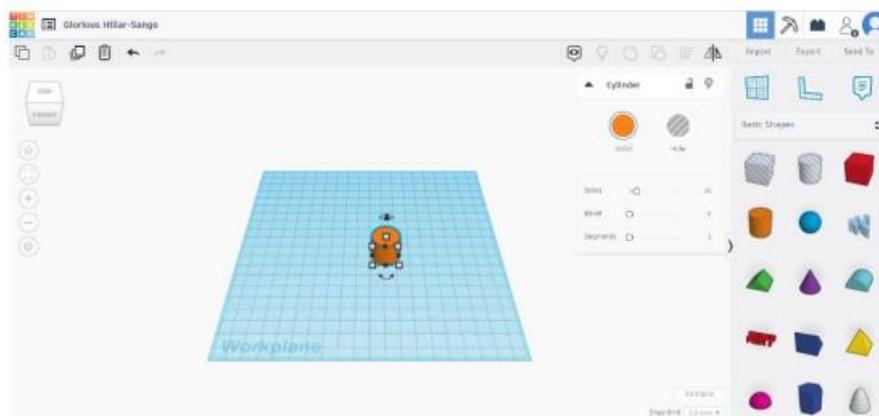
These parts will be created in the next three steps, and then they will be **combined** to complete the wrench model. In the **final step**, we will also add **text** to the wrench to display its size for easy identification.

3. Designing the Ring

The **ring** of the wrench looks like a **thick washer**, with a solid outer disk and a **hollow circular** area in the middle. To create this shape:

1. **Drag a cylinder** from the **Basic Shapes** panel onto the **Work plane**.
2. Click on the cylinder to open its **Shape Options**.
3. When selected, you will see five **white handles**—four around the **base** of the shape and one on **top** of the cylinder. These handles allow you to resize and modify the shape as needed.

This forms the **base structure** for the wrench's ring, which will later be refined by adjusting its dimensions and adding a hollow center.



3.1 Adjusting Dimensions

The **bottom four handles** of the cylinder are used to adjust its **length and width**. For our wrench's ring, we need a **diameter of 25 mm**.

- Click on a **white square handle**, and a small box will display the current dimensions.
- Either **drag the handle** until the length and width are **25 mm**, or **enter the values manually** by clicking the dimension box and pressing **Enter**.
- Tinkercad automatically snaps to values like **1 mm**, making adjustments precise.

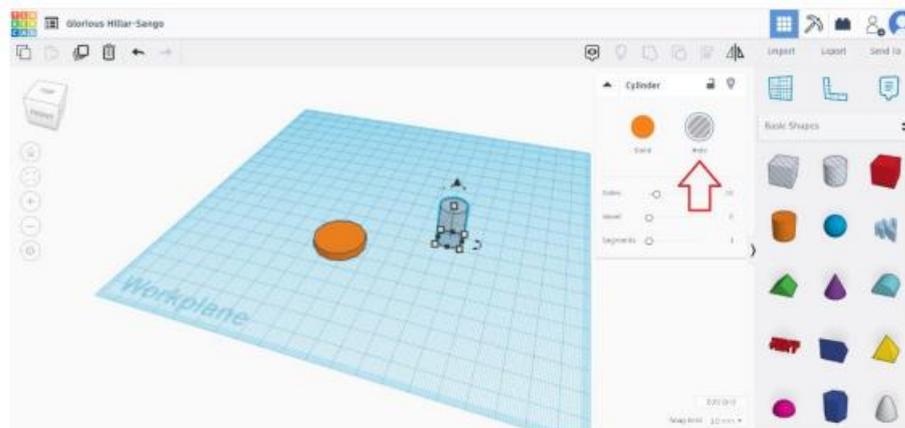
The **top handle** controls the **height** of the cylinder. Since we want the wrench's ring to be **4 mm thick**, adjust it in the same way as the length and width.

3.2 Boolean Operations and Creating a Hole

Tinkercad follows the **Boolean design principle**, allowing users to **add or subtract** shapes to create complex objects. In this step, we will use **subtraction** to make a **hole in the ring**.

1. **Drag another cylinder** from the **Basic Shapes** panel onto the **Work plane**.
2. Adjust its **length and width to 12 mm**, which will be the **diameter of the hole**.
3. With the new cylinder selected, click on "**Hole**" in the **upper-right window**. This tells Tinkercad to treat this shape as a cut-out rather than a solid object.

Once completed, this **hollowed-out cylinder** will form the **ring** of our wrench.



3.3 Aligning the Shapes

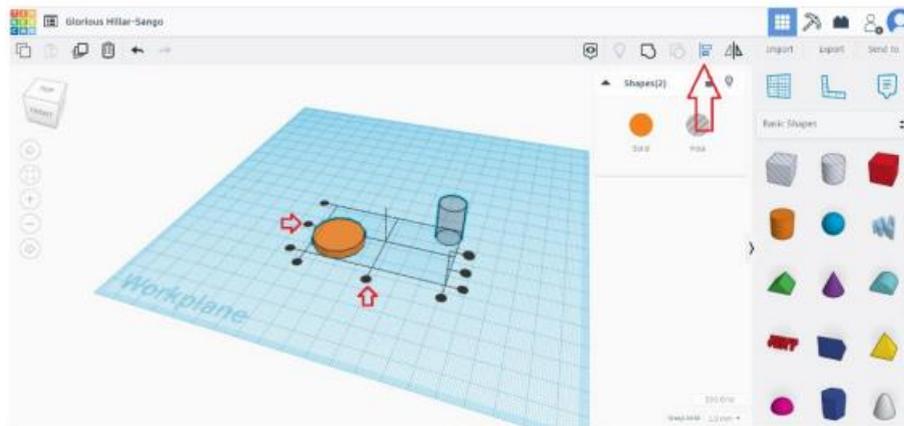
To create a perfect hole in the **center** of the solid disk, we need to **align** the two cylinders properly. We will use the **Align Tool** in the **top toolbar** to do this.

Steps to Align the Hole and the Solid Disk:

1. **Select both objects:**
 - Left-click the **solid disk** to select it.
 - While holding the **Shift key**, left-click the **cylinder hole**.
 - Both shapes should now be highlighted, indicating they are selected together.
2. **Use the Align Tool:**

- Click on the **“Align”** button in the **top toolbar**.
 - You will see **black round handles** appear on the work plane.
3. **Center the hole:**
- Click on the **bottom middle handles** to align the objects along their **X and Y axes**.
 - This ensures the **hole is perfectly centered** inside the solid disk.

Now, the hollow cylinder is correctly positioned, forming the **ring** of the wrench.



3.4 Grouping the Shapes

After aligning the two shapes, we need to **combine** them to create the final ring. This is done using the **Group Tool**, which merges shapes into a single object. However, when one of the shapes is marked as a **hole**, grouping will **subtract** it from the solid shape, creating an empty space.

Steps to Group the Shapes:

1. Select both objects (the solid disk and the hole) by holding **Shift** and clicking each one.
2. Click the **“Group”** button in the **top toolbar**.
3. If done correctly, the hole will be removed, leaving a **hollow ring**.

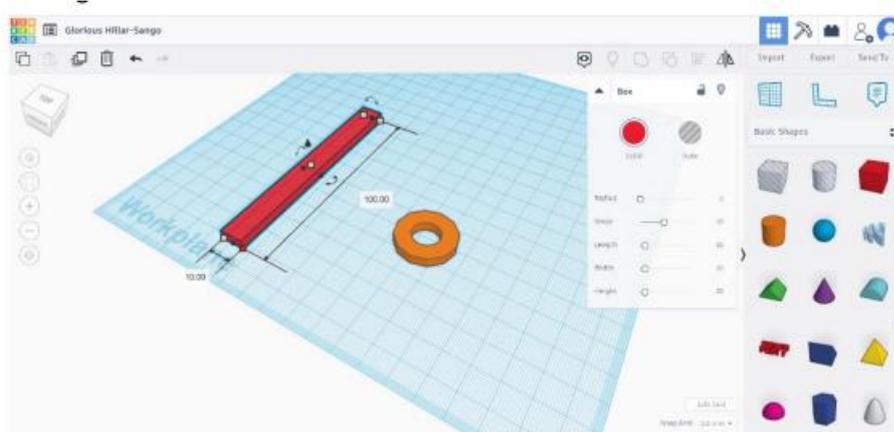
Now, the ring of the wrench is **complete** and ready for the next step!

4. Designing the Handle

The **handle** is the simplest part of the wrench. It is basically a **rectangle** with specific dimensions.

Steps to Create the Handle:

1. Drag and drop a **box** from the **Basic Shapes** panel onto the **work plane**.
2. Adjust the dimensions:
 - **Length:** 100 mm
 - **Width:** 10 mm
 - **Height:** 4 mm (to match the ring’s thickness)
3. Now, the handle is ready to be connected to the ring in the next step.



5. Designing the Jaw

The **jaw** is another circular disk, but this time it has a **hexagonal hole** cut out at an angle.

Steps to Create the Jaw:

1. Drag a **cylinder** from the **Basic Shapes** panel onto the **work plane**.
2. Set its **diameter** to **30 mm** and its **height** to **4 mm** (same as the handle and ring).

Creating the Hexagonal Hole:

1. Drag a **Polygon shape** onto the work plane. By default, it appears as a **hexagon**, which is perfect for our wrench. (You can change the number of sides if needed using the **Shape settings**.)
2. Align the **hexagon** with the circular disk:
 - Select both objects (hold **Shift** and click on both).
 - Click the **Align** button in the **top toolbar**.
 - Click the **black round handle** to center the hexagon in one direction (not both).

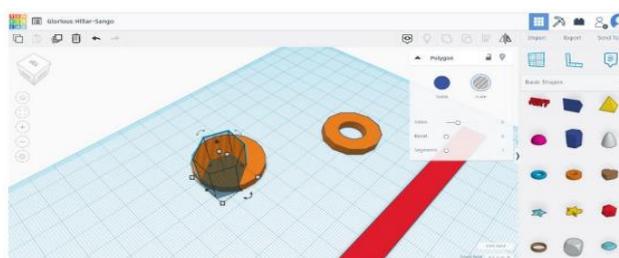
Adjusting the Hexagon Size:

- We'll create a **15 mm wrench**, but you can adjust it based on your needs.
- Values between **22-23 mm** are also suitable for standard sizes.

Cutting Out the Hole:

1. Select **both** the **hexagon** and the **circular disk**.
2. Click on the **"Group"** button in the **top menu**.
3. The hexagon shape will be **subtracted**, leaving a **hexagonal hole** in the disk.

Now, the **jaw is complete**, and we are ready to assemble the wrench!



6. Assembling the Wrench

Now that all the individual parts—the **ring**, **handle**, and **jaw**—are ready, it's time to put them together.

Aligning the Components:

1. Select the **ring** and the **handle** using **Shift + Left Click**.
2. Click the **Align** button in the **top toolbar**.
3. Align them along their **long axis** so they form a straight connection.

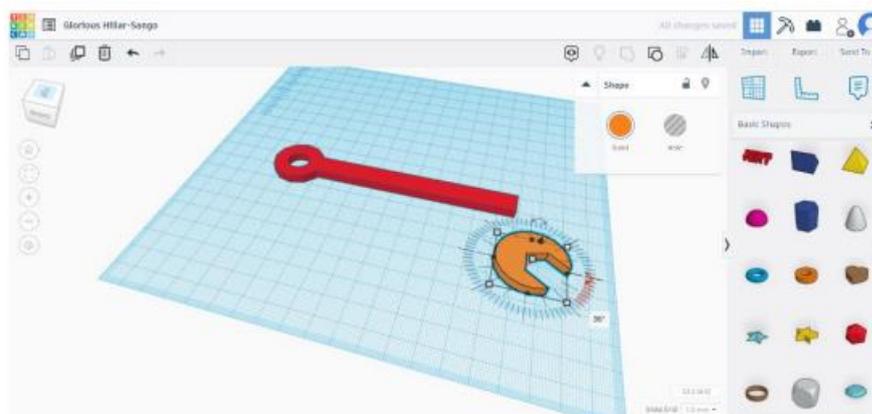
Merging the Ring and Handle:

1. Move the **ring** slightly towards the **handle** to create a small overlap (use the reference image if available).
2. Once positioned correctly, press **Group** to merge them into a **single unit**.
3. The newly combined shape will now have a **uniform colour**, indicating successful merging.

Rotating the Jaw (if needed):

1. Select the **jaw** by left-clicking on it.
2. Look for the **three curved rotation handles** with **double arrows**.
3. Hover over the one in the **XY plane** (bottom view), and an **angle value** will appear.
4. **Rotate** the jaw by either:
 - Clicking and dragging the handle.
 - Manually entering the desired angle.

Once the **jaw is correctly positioned**, the wrench model is complete and ready for **final touches or 3D printing!**



7. Final Assembly and Customization

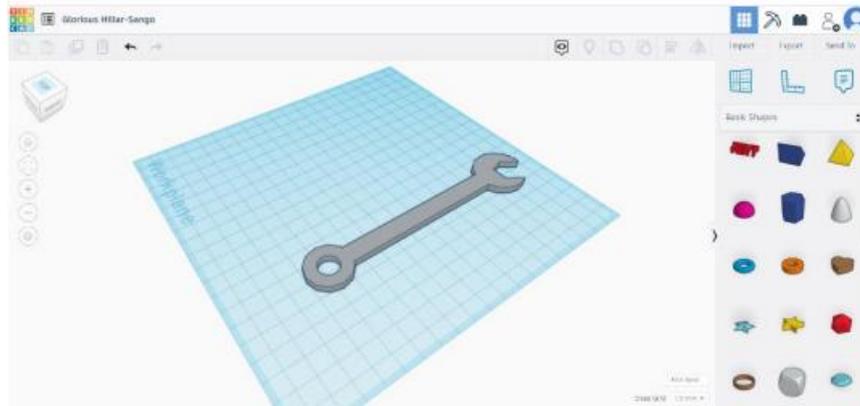
Joining the Jaw to the Wrench:

1. **Align** the **jaw** with the assembled **ring and handle** using the **Align tool**.
2. **Hold Shift** and **drag the jaw** toward the wrench, ensuring a slight overlap.
3. Once positioned correctly, press **Group** to merge all parts into a **single unit**.

Changing the Colour:

1. Select the **finalized wrench** by clicking on it.
2. In the **Shape window**, click on the **"Solid"** button.
3. A **colour palette** will appear—choose any colour you prefer for your wrench.

With this step complete, your **3D wrench model** is fully assembled and ready for **export or 3D printing!**



8. Adding Text to the Wrench

Creating the Text:

1. Locate the **"Text"** option in the **Basic Shapes** panel and **drag** it onto the work plane.
2. In the **Shape window**, find the **"Text"** field and replace the default text with **"15 mm"** to indicate the wrench size.
3. Convert the text into a **hole** so that it can be carved into the handle.

Adjusting the Size and Position:

1. Set the text's **length to 32 mm** and **width to 7 mm** for proper fit.
2. Use the **Align tool** to center the text over the handle:
 - Select both the **text and handle**, then click **"Align"** in the top toolbar.
 - Align the **top surfaces** so that the text sits flush with the wrench.
 - Use the **middle alignment handles** in the **XY plane** for proper positioning.

Finalizing the Engraving:

1. Once the text is in place, press **"Group"** to merge the shapes.
2. The text will now be **carved into the handle**, completing your **3D wrench model!**



8. 3D Printing Your Model

Now that your **TinkerCAD** wrench is complete, it's time to bring it to life with **3D printing**!

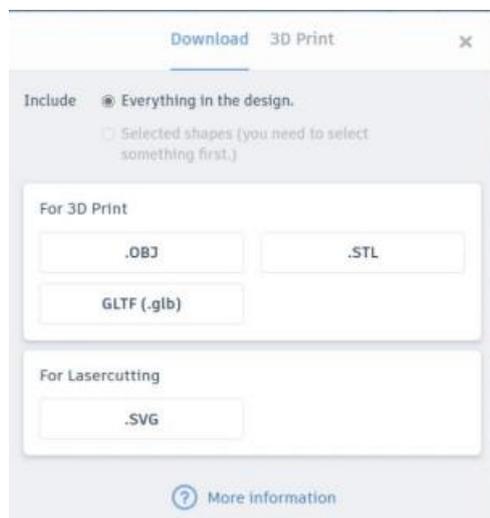
Exporting the Model:

1. Click on **"Export"** in the top menu.
2. Choose either **STL** or **OBJ** file format—both are compatible with most 3D printers.
3. A **download window** will open; save the file to your computer.

Preparing for Printing:

- If you plan to **use the wrench functionally**, select a **durable material** and set a **high infill percentage** for strength.
- If you **don't own a 3D printer**, you can upload the file to a **3D printing service**, which will print and ship the model to you.

Now, print your wrench, test it out, and impress your friends with your **maker skills**!



Chapter Highlights

- **3D Modelling** is the process of creating three-dimensional objects using computer software.
- Objects are designed using three axes: **X (left-right), Y (up-down), and Z (forward-backward)**.

Types of 3D Modelling:

- **Solid Modelling** – defines mass and volume.
- **Surface Modelling** – focuses on the outer shape.
- **Wireframe Modelling** – shows the skeleton structure.

Applications: include robotics, 3D printing, animation, architecture, and medicine.

Advantages: high precision, faster development, better visualization, and cost-effective prototyping.

➤ **Tinkercad** is a free, web-based 3D modelling tool ideal for beginners.

Exercise

Multiple Choice Questions (MCQs)

1. Which axis in 3D modelling represents movement up and down?
 - a) X-axis
 - b) Y-axis
 - c) Z-axis
 - d) None
2. What is the full form of CAD?
 - a) Computer Automated Design
 - b) Computer Aided Drawing
 - c) Computer Aided Design
 - d) Central Automated Design
3. Tinkercad is best suited for:
 - a) Professional video editing
 - b) Beginners learning 3D modelling
 - c) Spread sheet calculation
 - d) Game development
4. What is the function of the "Group" tool in Tinkercad?
 - a) Duplicate objects

- b) Align objects
 - c) Combine objects into one
 - d) Colour the objects
5. What file format is commonly used for 3D printing?
- a) .DOC
 - b) .MP3
 - c) .STL
 - d) .JPEG
6. Which of the following is NOT a basic shape in Tinkercad?
- a) Sphere
 - b) Box
 - c) Cone
 - d) Triangle
7. The "Hole" function in Tinkercad is used to:
- a) Add colour
 - b) Cut shapes out of solid objects
 - c) Save the project
 - d) Create curves
8. In 3D Modelling, the skeletal representation of an object is called:
- a) Surface modelling
 - b) Solid modelling
 - c) Wireframe modelling
 - d) Mesh modelling
9. The wrench created in this chapter was made using how many main parts?
- a) 2
 - b) 3
 - c) 4
 - d) 5
10. Which tool is used to center one object over another in Tinkercad?
- a) Hole Tool
 - b) Rotate Tool
 - c) Align Tool
 - d) Text Tool

True or False

1. Tinkercad requires you to install software on your computer.
2. The Z-axis represents left and right movement.
3. Solid modelling includes mass and volume information.
4. You can add text and convert it into a hole in Tinkercad.
5. Wireframe modelling is used mainly for rendering realistic textures.

Fill in the Blanks

1. The three axes used in 3D modelling are X, Y, and ___.
2. The basic building blocks in Tinkercad are known as ___ shapes.

3. Tinkercad runs in a ___ browser, not as installed software.
4. The ___ tool is used to combine multiple shapes into one.
5. A model can be exported in ___ format for 3D printing.

Assertion and Reason Questions

1. **Assertion (A):** Tinkercad is ideal for beginners in 3D design.
Reason (R): It has a simple drag-and-drop interface and runs in a web browser.
 - a) Both A and R are true, and R is the correct explanation of A.
 - b) Both A and R are true, but R is not the correct explanation of A.
 - c) A is true, but R is false.
 - d) A is false, but R is true.
2. **Assertion (A):** Wireframe modelling is used to apply realistic textures to 3D models.
Reason (R): Wireframe models display the skeleton of an object using lines and curves.
 - a) Both A and R are true, and R is the correct explanation of A.
 - b) Both A and R are true, but R is not the correct explanation of A.
 - c) A is true, but R is false.
 - d) A is false, but R is true.
3. **Assertion (A):** Boolean operations in Tinkercad allow combining and cutting shapes.
Reason (R): The "Group" and "Hole" functions are examples of Boolean operations.
 - a) Both A and R are true, and R is the correct explanation of A.
 - b) Both A and R are true, but R is not the correct explanation of A.
 - c) A is true, but R is false.
 - d) A is false, but R is true.
4. **Assertion (A):** Solid modelling only focuses on the outer surface of an object.
Reason (R): Solid models do not include information like mass or volume.
 - a) Both A and R are true, and R is the correct explanation of A.
 - b) Both A and R are true, but R is not the correct explanation of A.
 - c) A is true, but R is false.
 - d) A is false, but R is true.
5. **Assertion (A):** The Align tool helps place objects exactly in the center.
Reason (R): It uses black handles to align objects along the X and Y axes.
 - a) Both A and R are true, and R is the correct explanation of A.
 - b) Both A and R are true, but R is not the correct explanation of A.
 - c) A is true, but R is false.
 - d) A is false, but R is true.

Short Answer Questions

1. What is 3D modelling?
2. Name any two applications of 3D modelling.
3. What is the use of the Align tool in Tinkercad?
4. What are the three main parts of the wrench designed in the chapter?
5. Define Boolean operation in the context of Tinkercad.

Long Answer Questions

1. Explain the difference between solid, surface, and wireframe modelling.
2. Describe the steps involved in designing the ring part of the wrench in Tinkercad.
3. What are the benefits of using 3D modelling in real-world applications?
4. Write a step-by-step process to add text to a Tinkercad model and convert it into an engraving.
5. Explain how to export a model from Tinkercad for 3D printing and what precautions should be taken before printing.