Laboratory 7: Digital Piano - Introduction to Model CAD

Introduction and Objective: In this laboratory, you will learn the principles, processes, and tips for designing a model using Computer Aided Design (CAD). A case will be designed to handle the printed circuit board (PCB) of the digital piano draw in the last laboratory. Such a case will be fabricated in the next laboratory using laser cutting. You should acquire the basic skills of 3D CAD by practicing.

1 Introduction

In this laboratory, we will explore the fundamentals of 3D CAD and learn how to bring your design ideas to life. This laboratory will provide you with the tools and knowledge to excel in the field of digital design. In the end, you will be able to create a 3D model of mechanical assembly professionally for further fabrication, such as laser cutting and 3D printing.

2 What is CAD?

CAD is the use of computer software to create, modify, analyze, and optimize designs for a wide range of applications. CAD has revolutionized the way we design and manufacture products, enabling engineers and designers to create complex, detailed, and precise models that can be easily shared, modified, and tested. From mechanical parts and architectural structures to consumer products and electronics, CAD is an essential tool in modern engineering and design. 3D CAD allows you to create three-dimensional models that provide a realistic representation of your design. Unlike 2D drawings, 3D models offer a more intuitive and comprehensive view of how a product will look and function in the real world. With 3D CAD, you can visualize your designs from any angle, simulate real-world conditions, such as stress, motion, and thermal effects, generate technical drawings and documentation for manufacturing, and rapidly prototype and iterate on your designs.

3 Parametric Feature-Based CAD

Parametric Feature-Based CAD uses parameters and features to create and modify 3D models. The CAD relies on parametric design, where parameters drive the model by defining dimensions, shapes, and relationships, such as lengths, angles, parallelism, or tangency. Adjusting parameters automatically updates the model, ensuring consistency and minimizing manual rework. Feature-based modeling means that it uses features as the building blocks of a 3D model, representing geometric shapes or operations such as extrusions, holes, and fillets. Created sequentially, they form a ”feature tree” that logs modeling steps, allowing designers to modify previous stages easily. Features are often parametric, allowing their dimensions and properties to be adjusted.

In parametric CAD, the workflow starts with creating dimensioned 2D sketches with constraints, which are then transformed into 3D features via extrusion, revolution, or loft operations. Designers set parameters and relationships for precise geometry control. The model can be refined by adjusting these parameters or features. The system generates 2D drawings, BOMs, or simulations from the 3D model, simplifying documentation.

Figure 1: An example of the certification.

Parametric feature-based CAD captures the design intent by embedding relationships and constraints, ensuring the logical propagation of changes. This associativity automatically updates related components, like drawings or assemblies, when modifications occur, enhancing flexibility. Parametric models are also reusable and easily adaptable for similar projects by modifying parameters, saving time and effort. In summary, Parametric CAD is a versatile approach to 3D design, merging flexibility of parametric modeling with structure of feature-based design. It is essential in modern engineering, allowing for sophisticated, adaptable, and precise models for today's industries.

4 CAD Software

In the laboratory, we will use Onshape for modeling. Onshape is a parametric feature-based CAD, which is a modern cloud-based CAD platform that allows one to create and manage 3D models entirely in your web browser or mobile device. Unlike traditional CAD software, Onshape does not require installation or powerful hardware, as all computations are performed in the cloud. This makes it an ideal tool for collaboration, as multiple users can work on the same design simultaneously, regardless of their location or device. In Onshape, you can easily track changes and revert to previous versions of your design. It is parametric modeling; you can create models that can be easily modified by changing parameters. There are integrated tools in Onshape, and you can access built-in tools for simulation, rendering, and data management. List 2 more CAD software and the advantages in the answer sheet.

4.1 Table for CAD software and the advantages.

5 CAD basic and Onshape Learning

Open the official website of Onshape (https://www.onshape.com/). Sign up for a new account using your MUST email and your name. After creating your account, go to the "CAD Basics" learning pathway (https://learn.onshape.com/learning-paths/introduction-to-cad). Finish the first three courses/training stated as follows:

1. Introduction to Parametric Feature-Based CAD
2. Introduction to Part Studios

3. Introduction to Assembly Design

After the course/training, you should learn how to build a part using a sketch and assemble the parts. By finishing each course/training, you should gain a digital certification as shown in Fig. 1. Post all three certifications on the answer sheet.

5.1 The three certifications of the Onshape course/training.

6 Modeling a Case for the Digital Piano

Now we should design the case for the PCB circuit of the digital piano fabricated in the last laboratory. A demo is shown in Fig.2. You might refer to the web video https://youtu.be/dPR1oUVL8Y4 for case modeling. First, import the 3D model of the PCB to Onshape from Moodle. By sketching the bottom of the case referring to the size of the PCB, you should extrude the bottom with a thickness of 2 mm. Two M2 holes (with diameter of 2.2 mm) and two M3 holes (with diameter of 3.3 mm) should be drifted in the bottom to fix the PCB (with screws) and the case (with standoffs), see inset in Fig. 2. Copy the bottom to be the draft sketch of the top, and remove the part of the top that might block the electrical components (i.e. ESP32C6, buttons, LED and Buzzer) on the PCB. The back and sides of the case (with thickness of 2 mm) should be designed to ensure that the space between the top and bottom is 6 mm, for the M3 standoff installation. Screenshot the plane views of the parts and post it to the answer sheet.

6.1 Screenshot of the parts.

Assemble the parts to be a case and insert the 3D model of the digital piano (including the PCB and the electrical components) into the case. Screenshot the assembly and post it to the answer sheet.

6.2 Screenshot of the assembly.

For laser cutting, you should export the top, bottom, back, and sides of the case to the drawing. The region of the parts in the drawing should be restricted to 200×100 mm, which is the size of the acrylic sheet provided. Post the drawing to the answer sheet.

6.3 Screenshot of the drawing for laser cutting.

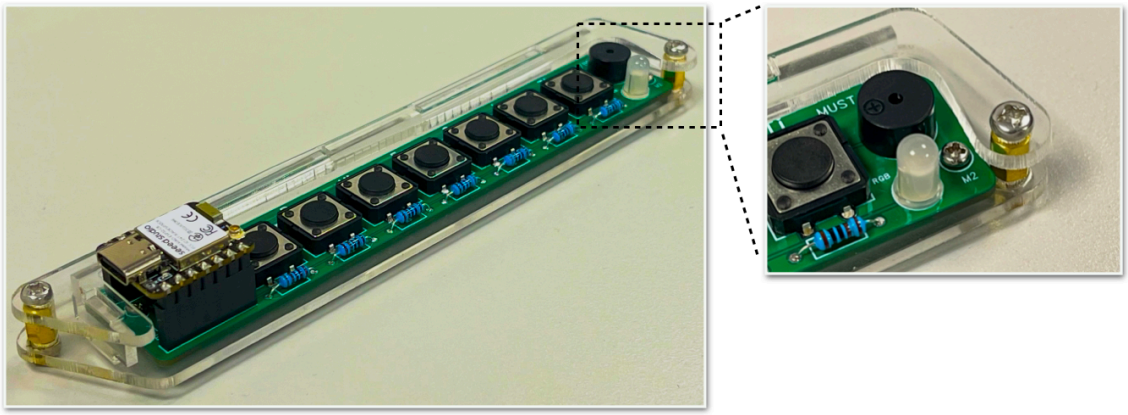

Figure 2: A demo of the digital piano case.

7 Conclusion

In this laboratory, you gained hands-on experience in CAD modeling by sketching, extruding, and assembling the case of the digital piano using Onshape. Your understanding of CAD should also be improved by taking web courses and training. The digital piano case modeling provides a solid foundation for future object design. We will fabricate the case in the next laboratory.