



Beihang University

# An Introduction to 3D Printing

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# Contents

**I. Overview of 3D Printers**

**II. Bambu Lab FDM**

**III. Consumables**

**IV. Slicing Software**

**V. 3D Printing Operation**



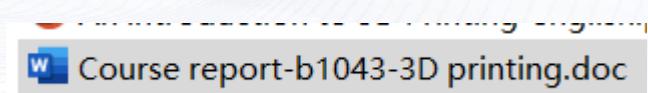
# Overview of 3D Printers

## Contents

- ◆ Understand 3D printing technology and its applications;
- ◆ Basic 3D modeling and operation processes.

## Notes

- ◆ Work in groups, each will be assigned one computer for operation.
- ◆ The group **leader** is responsible for recording the division of labor, keeping operation notes, and taking photos during the process.
- ◆ Since the 3D printing process takes a long time, please arrange time to pick up the finished prints later.
- ◆ **Materials to Submit:** Photos of the task object and the **course report**.





# Course Content & Notes

## Assessment

- ◆ Design of Assigned 3D Models (Full Score: 4 Points)
- ◆ 3D Printer Operation (Full Score: 4 Points)
- ◆ Course report (Full Score: 2 Points)
- ◆ Troubleshooting and Improvement (2 Points): Bonus



# Overview of 3D Printers

- **3D printing**, aka. **additive manufacturing**, is the process of constructing 3D objects based on computer-aided design (CAD) models or digital 3D models. It can be realized through a variety of processes, in which materials are deposited, joined, or solidified under computer control, and are usually added together **layer-by-layer**.
- In the early days, 3D printing techniques were considered suitable only for the production of functional prototypes--**rapid prototyping**.
- At present, the precision, repeatability, and material range of 3D printing have increased to the point that some 3D printing processes are considered viable as an **industrial-production technology**.

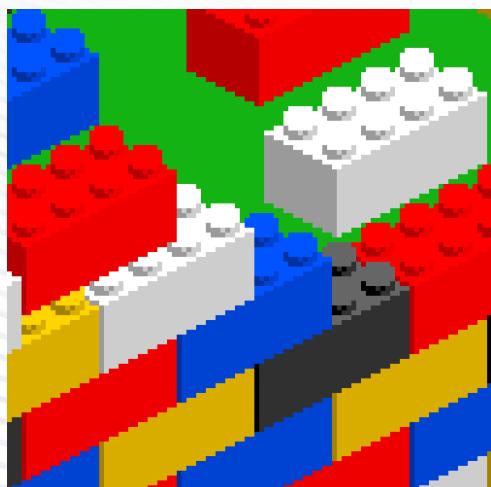


# Overview of 3D Printers

- Types of 3D Printers

## Additive Manufacturing

In a broad sense, bricklaying is also a form of additive manufacturing—which is 3D-printed house.



Lego & Minecraft

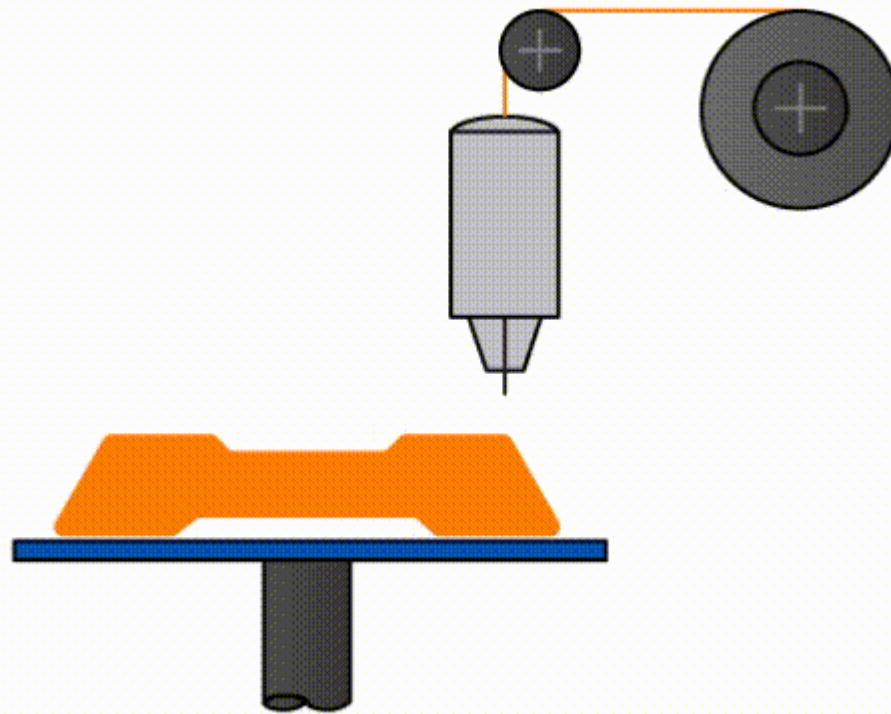




# Overview of 3D Printers

## • Types of 3D Printers

### Additive Manufacturing



### Subtractive Manufacturing



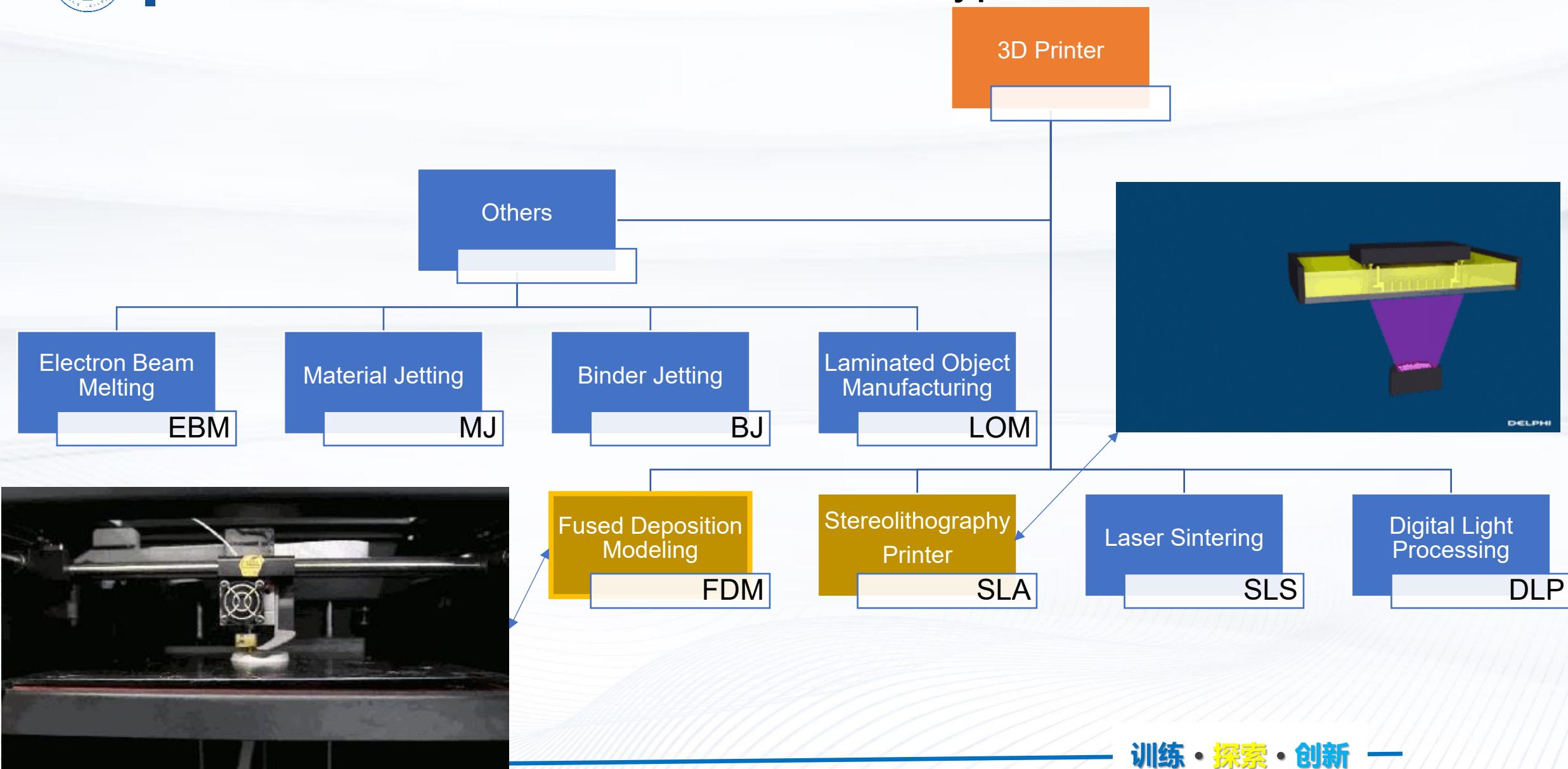
**Advantages:** Enables personalized design and the manufacturing of highly complex shapes or geometric structures, including hollow components or parts with internal truss structures. This not only reduces weight but also minimizes material waste.

**Disadvantages:** Inferior performance in terms of material consistency, strength, and other related properties.



# Overview of 3D Printers

## • Types of 3D Printers



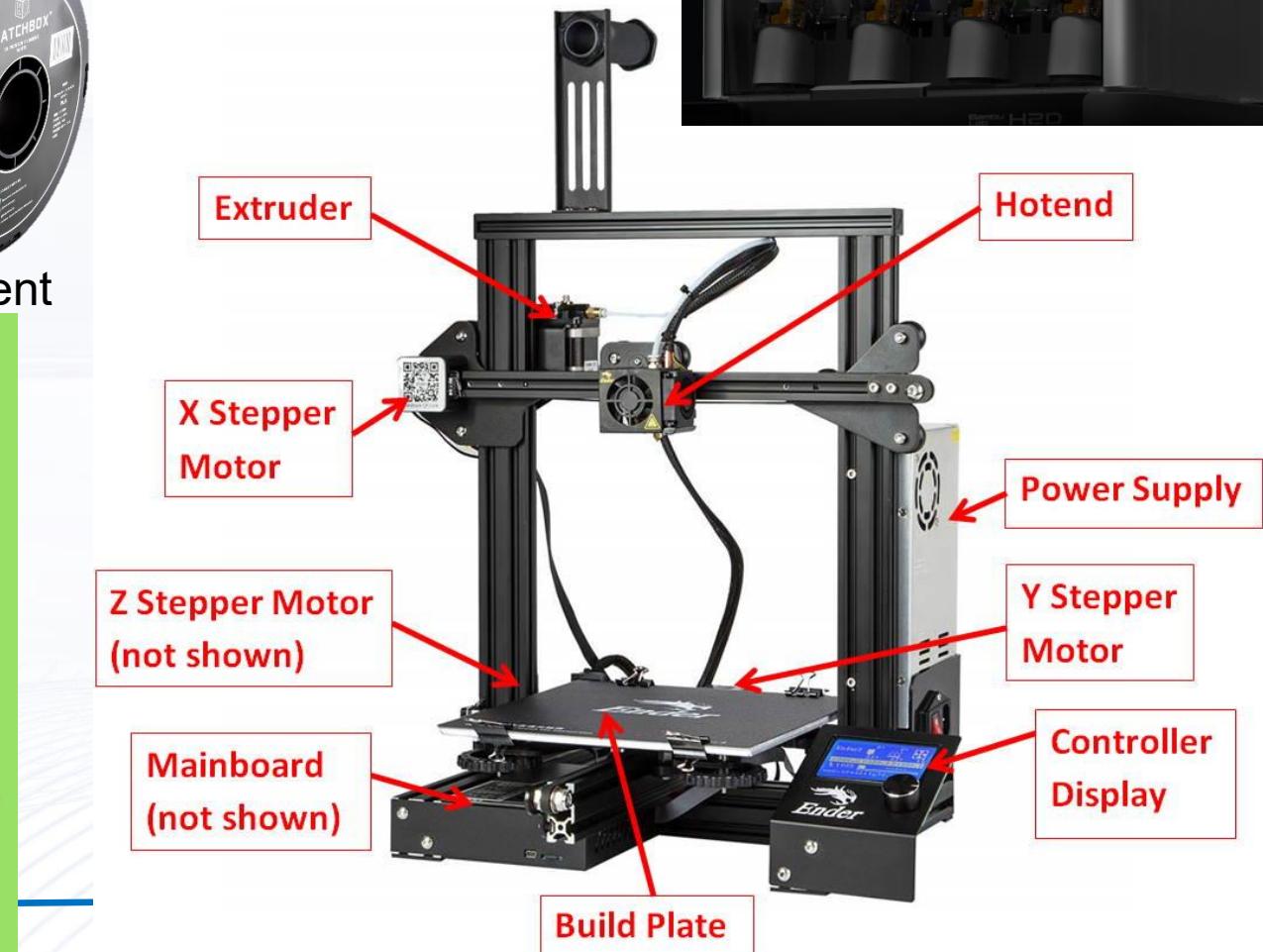
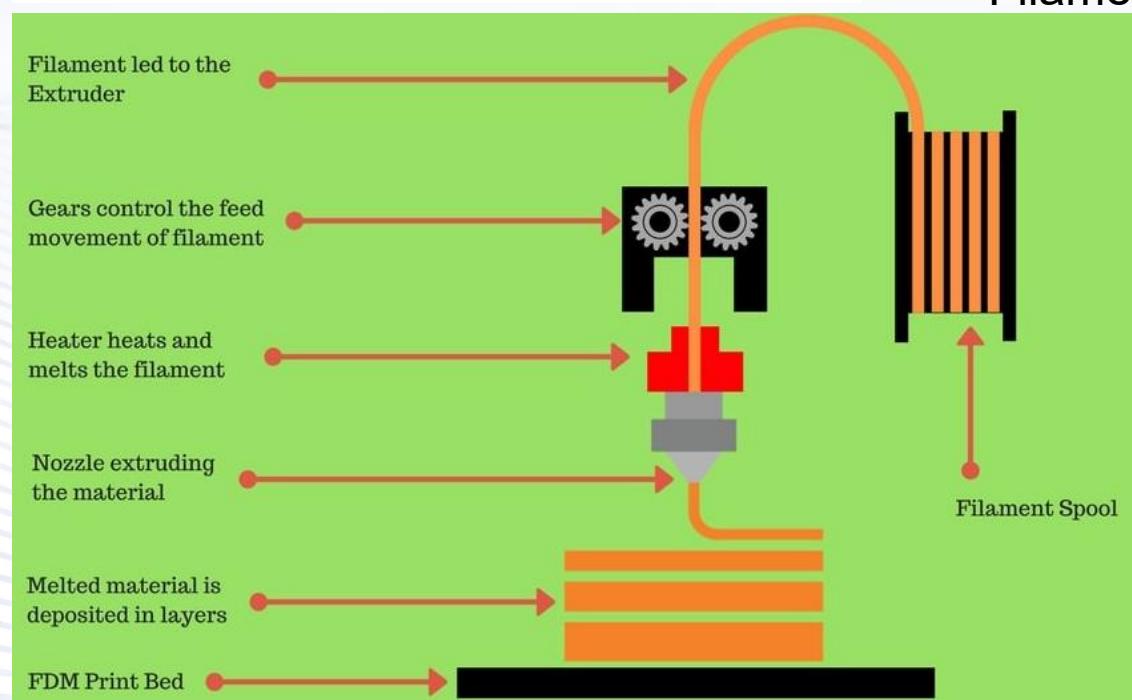
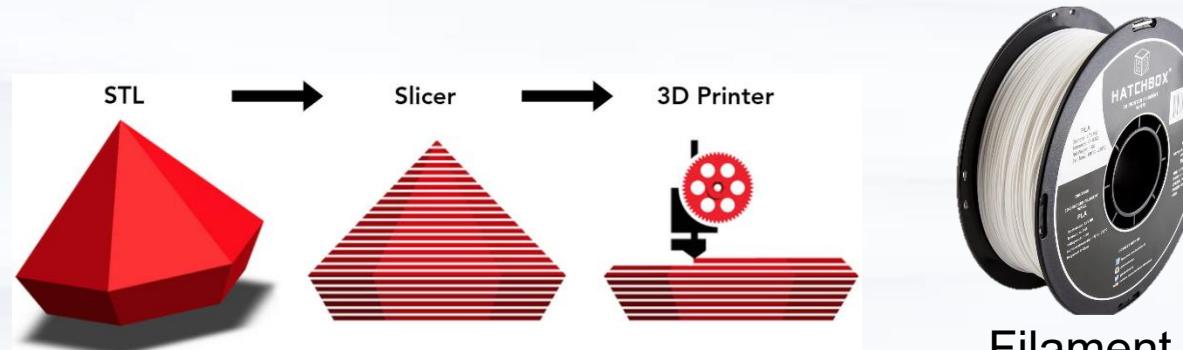


# Overview of 3D Printers

## • Types of 3D Printers

FDM

- Lead screw motors to achieve 3-axis movement.
- Extruder + hot end control system to melt the filament.
- Automatic Material System.



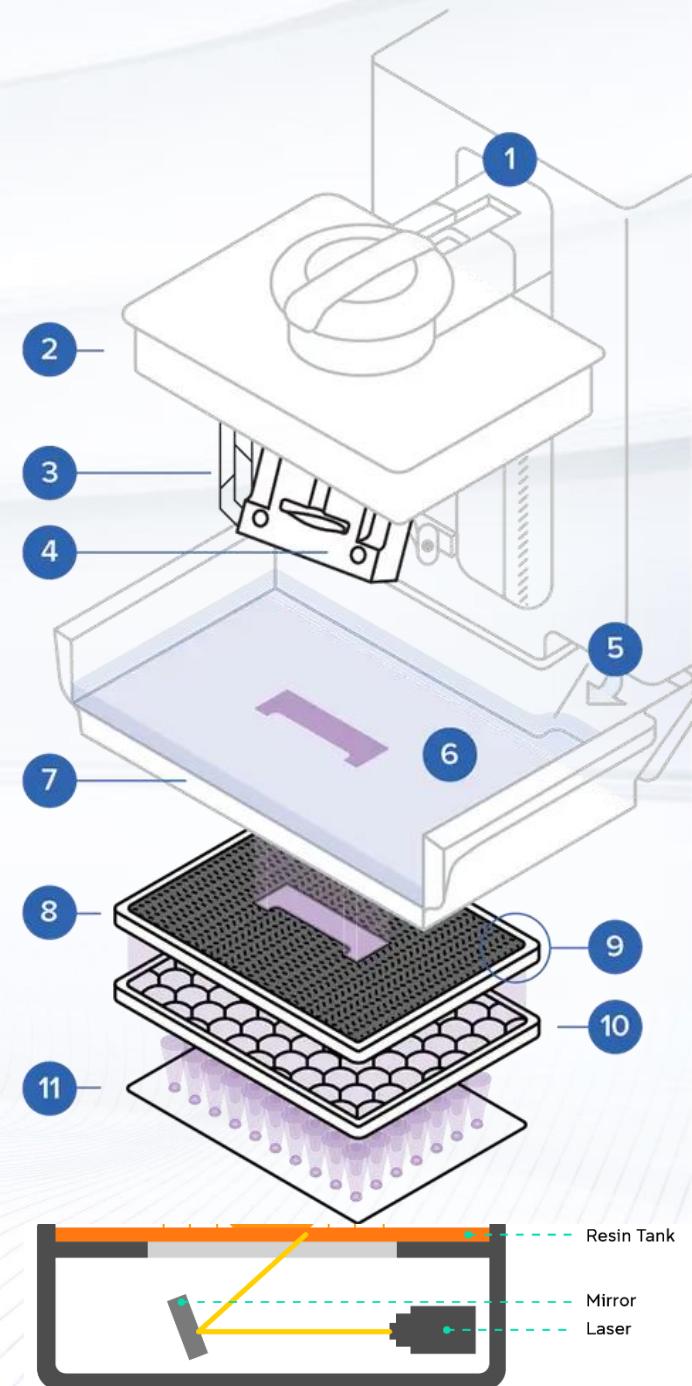


# Overview of 3D Printers

## Stereolithography



- 1 Six Control Systems
- 2 Build Platform
- 3 Supports
- 4 Printed Part
- 5 High-Speed Automatic Resin Handling
- 6 Resin
- 7 Flexible Film Resin Tank
- 8 Light Processing Unit 4
- 9 Release Texture
- 10 Collimating Lenses
- 11 LEDs



- Z-axis movement: lead screw motor
- Directional exposure curing on the X-Y plane: stereoscopic light source array
- The **storage and recycling** of resin are relatively cumbersome
- More suitable for printing small-sized, high-precision objects



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II. Bambu Lab FDM

III. Consumables

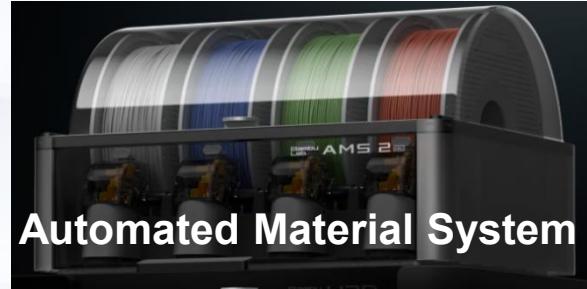
IV. Slicing Software

V. 3D Printing Operation



# 拓竹FDM

## » 打印机型号参数



Automated Material System



### Body

Build Volume: 256 x 256 x 256 mm<sup>3</sup>

Chassis: Welded Steel

### Shell:

Enclosed(Plastic & Glass)

### Speed

Max Speed of Toolhead: 500 mm/s

Max Acceleration of Toolhead: 20 m/s<sup>2</sup>

### Toolhead

Hot End: All-Metal

Nozzle: Stainless Steel

Max Hot End Temperature: 300°C

### Toolhead Cable:

Enhanced toolhead cable with cable chain

### Cooling & Filtration

Control Board Fan: Closed Loop Control

Chamber Temperature Regulator Fan: Closed Loop Control

Auxiliary Part Cooling Fan: Closed Loop Control

Air Filter: Activated Carbon Filter

### Supported Filaments

PLA, PETG, TPU, PVA, PET: Ideal

ABS, ASA: Ideal

PA, PC: Capable

Drawback: smaller size

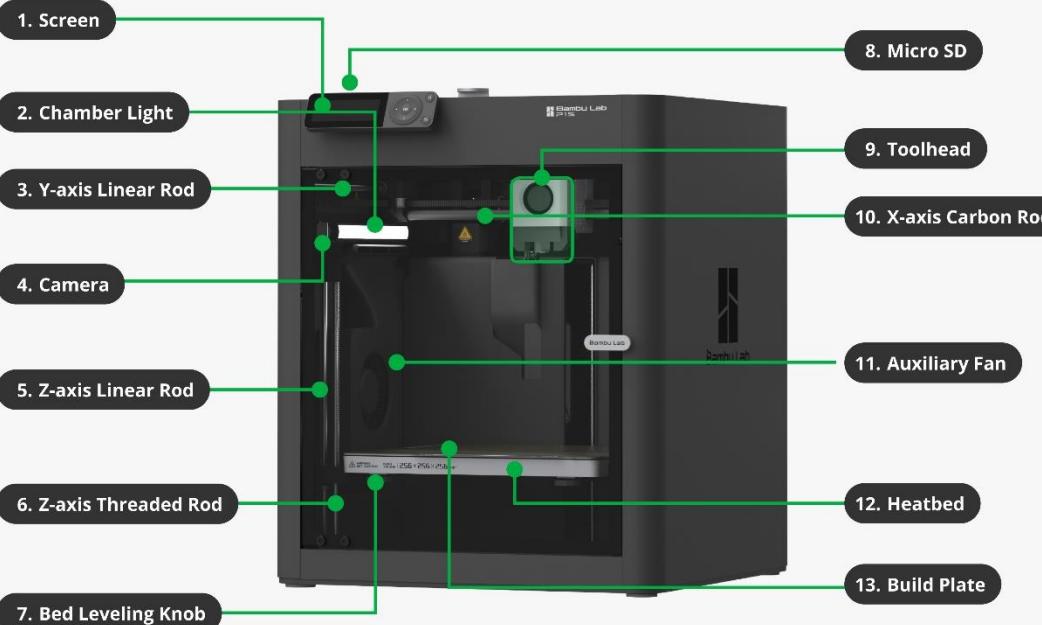
### Advantages:

1. Multi-color printing support via AMS
2. Enclosed chamber for heat preservation
3. Fast printing speed
4. Automatic bed leveling
5. Replaceable textured metal build plate
6. Support for configuring a 3D printing farm
7. Easier disassemble and maintenance
8. GitHub-enabled engineering workflow



# 拓竹FDM

## 打印机型号参数



### Home Screen Interface:

5. **Nozzle Temperature**: Displays the current temperature and target temperature of the hot end.
6. **Heat Bed Temperature**: Displays the current temperature and target temperature of the heat bed.
7. **Network Settings**: Indicates Wi-Fi connection quality, facilitating remote printing and file transfer.
8. **Camera Connection**: Displays the status of the built-in camera to confirm whether the printer's real-time monitoring function is available.
9. **Stop Button**: Stops the current print immediately. Note that once stopped, the print cannot be resumed.
10. **Resume Button**: Resumes a paused print to ensure uninterrupted printing.
11. **Progress Bar**: Displays the completion progress of the current print task as a percentage.
12. **Print Task**: Real-time display of the active print file name or HMS system alerts/errors.
13. **Print Speed**: Displays the print speed as a percentage (default: 100%), allowing mode adjustment during printing.

For Settings Interface:

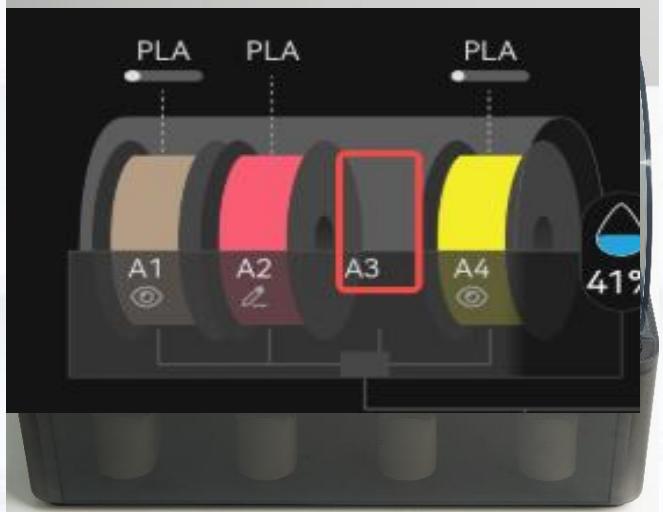
**Farm mode has been configured. Do NOT make any modifications!**



# | 拓竹FDM

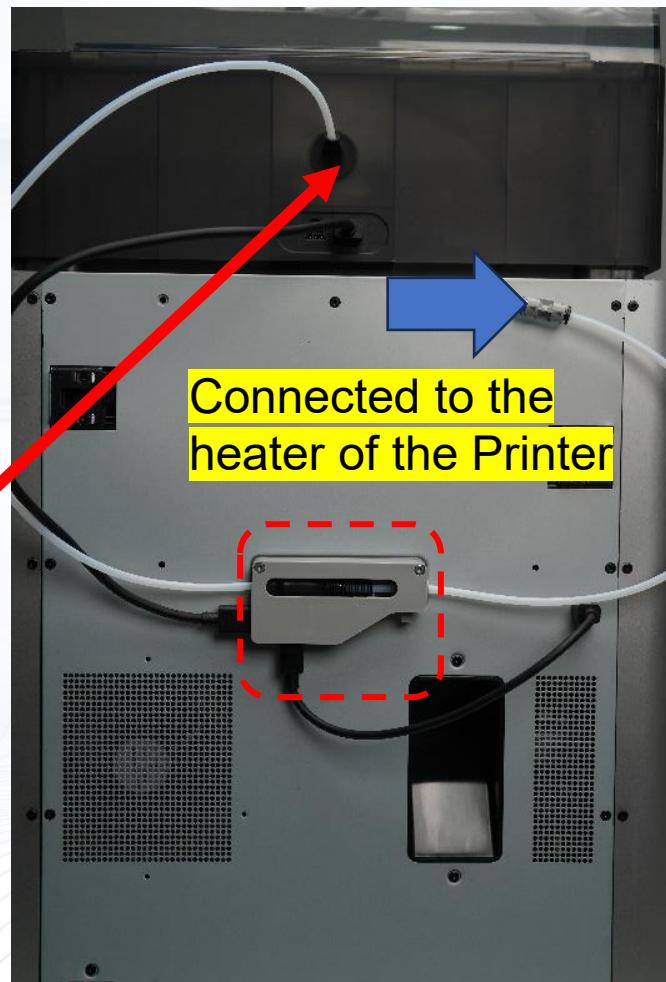
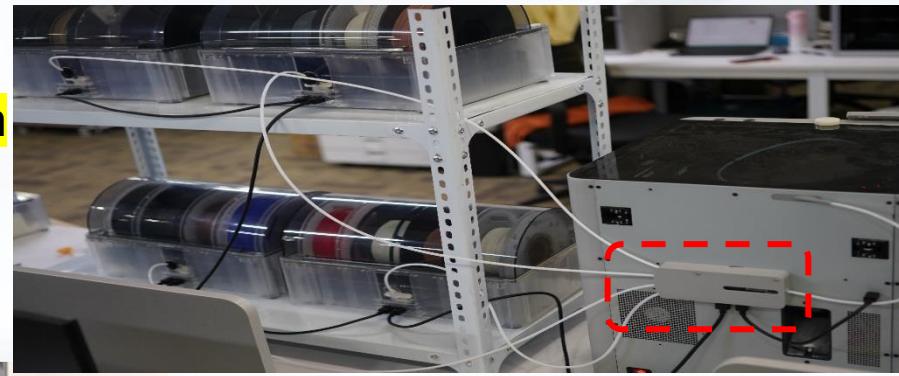
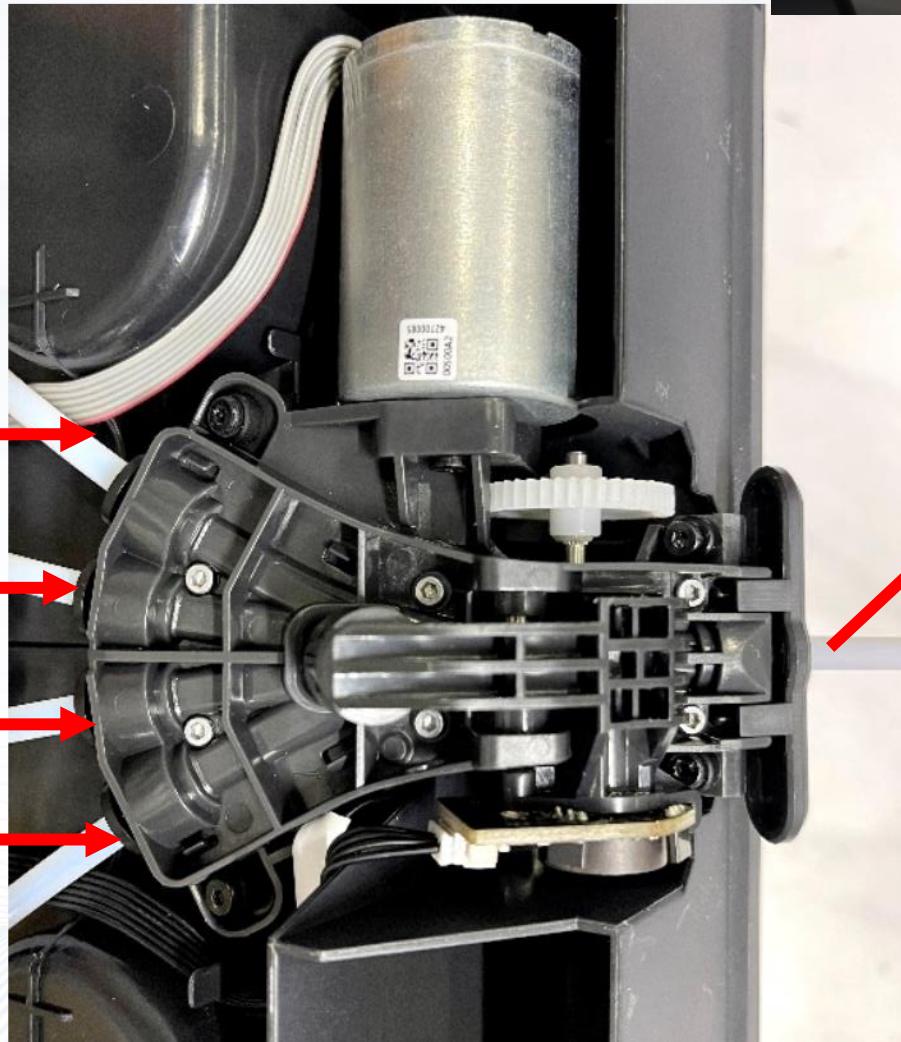
## >> The wiring of printer Filaments

AMS



16-color AMS solution

4-in-1-out



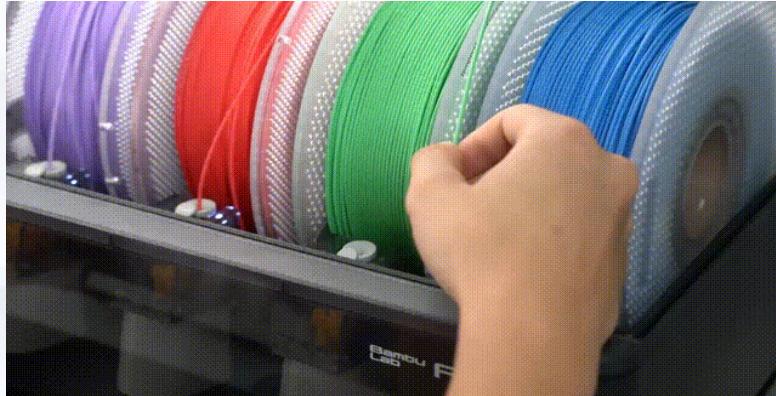
Connected to the  
heater of the Printer



# 拓竹FDM

## 打印机型号参数

### How-to use AMS



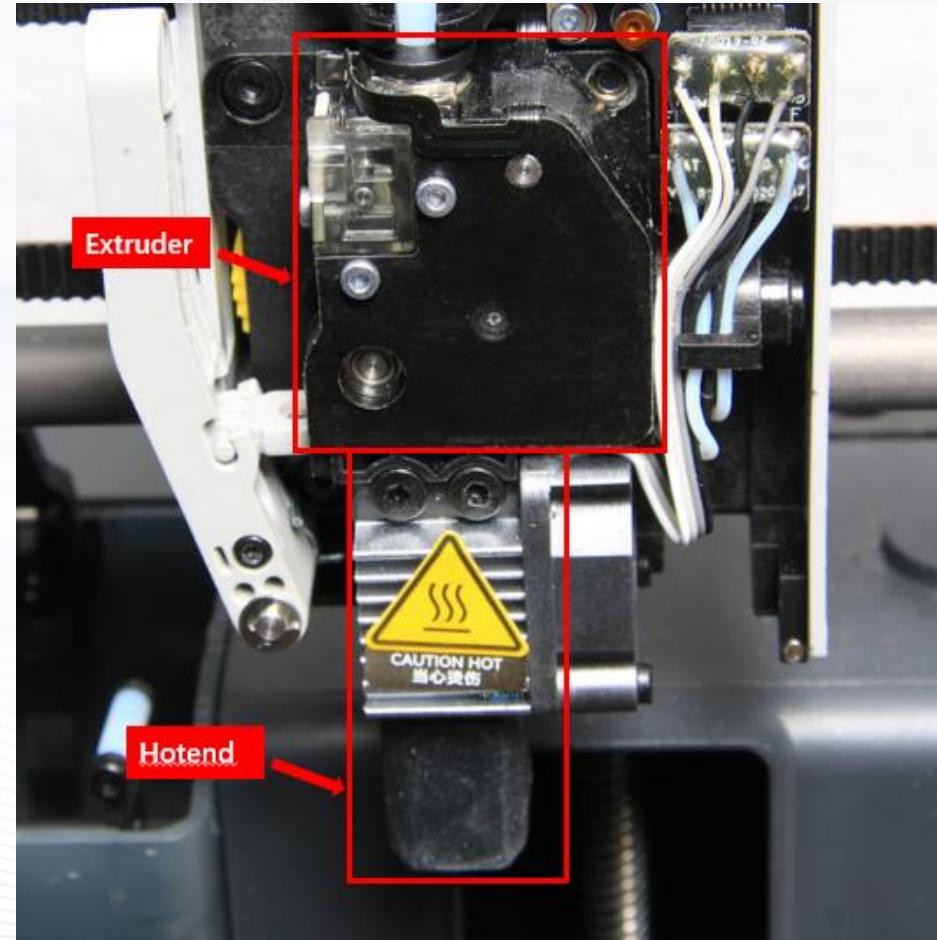
### LED State: For Troubleshooting Printer Errors

LED status	AMS status
4 white lights flash in turn	Normal status. No filament in all 4 slots
White light keeps on	Normal status. The slot has a filament inserted and is idle.
White light breathing	Normal status. The slot has filament inserted and is in a busy state (feeding, reading RFID, etc.)
Red light single flashing	Error status. It may be that the slot failed to feed the filament, and the filament is detected by the feeder but not by the filament Hub. The filament is inside the AMS
Red light double flashing	Error status. The slot failed to load or unload the filament. The filament is detected by both the feeder and the filament Hub. The filament is outside the AMS
Red light breathing	Error status. No filaments were inserted into the corresponding slots when printing start. It will return to normal after inserting the filament into the feeder
Red light keeps on	Error status. The filament is not detected by the feeder, but by the Filament Hub. It is possible that the filament is broken inside the Filament Hub
All four slots are flashing red light	Error status. AMS communication is abnormal, and AMS cannot be detected by the printer
The LED light is not on	1. When the filament is inserted into the slot, the LED lights of other empty slots without filament are not lit, which is normal; 2. When all 4 slots are empty, if the LED of one slot is always off, it means that the first stage feeder failed to power on and needs to be checked.



# 拓竹FDM

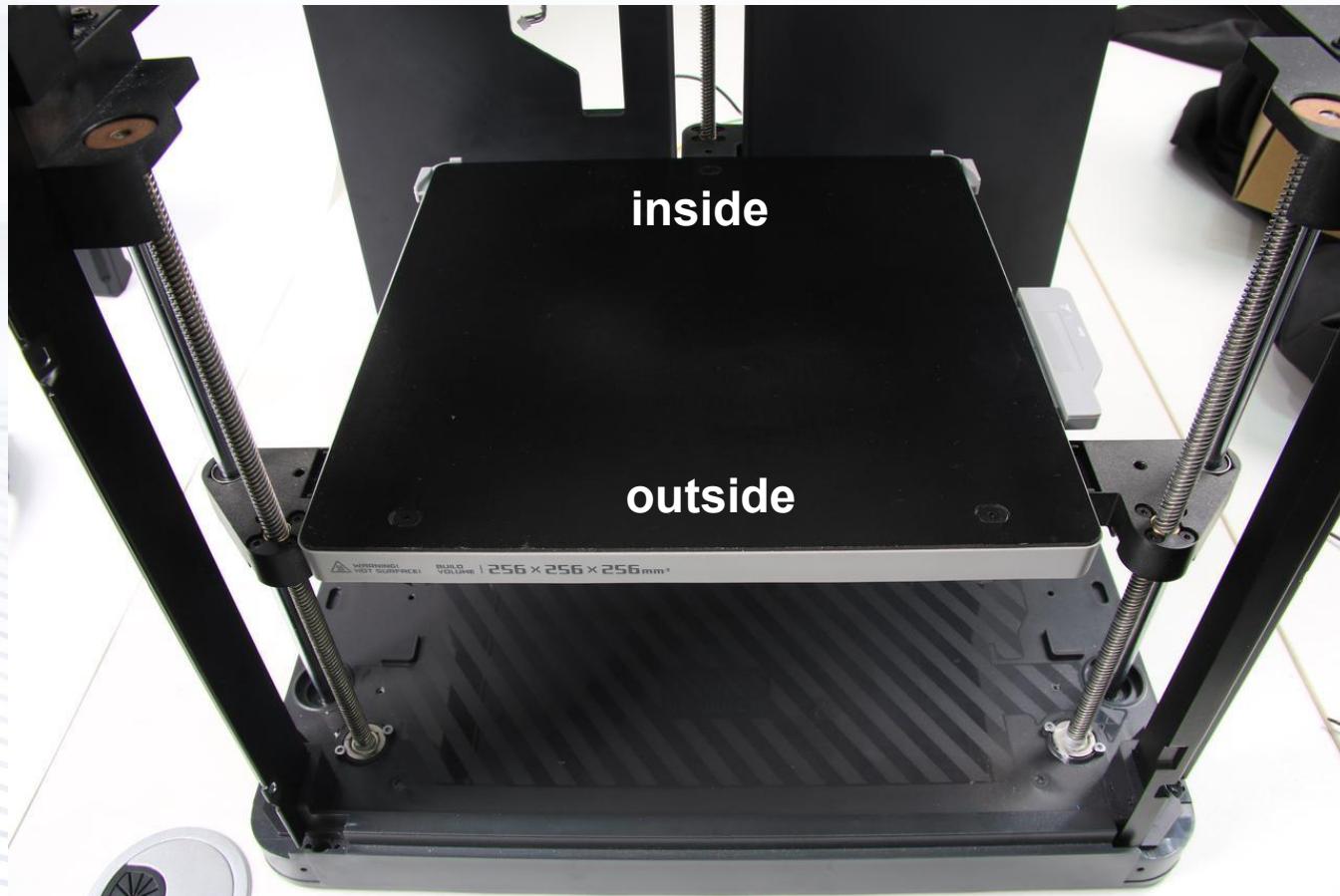
## » 打印机型号参数



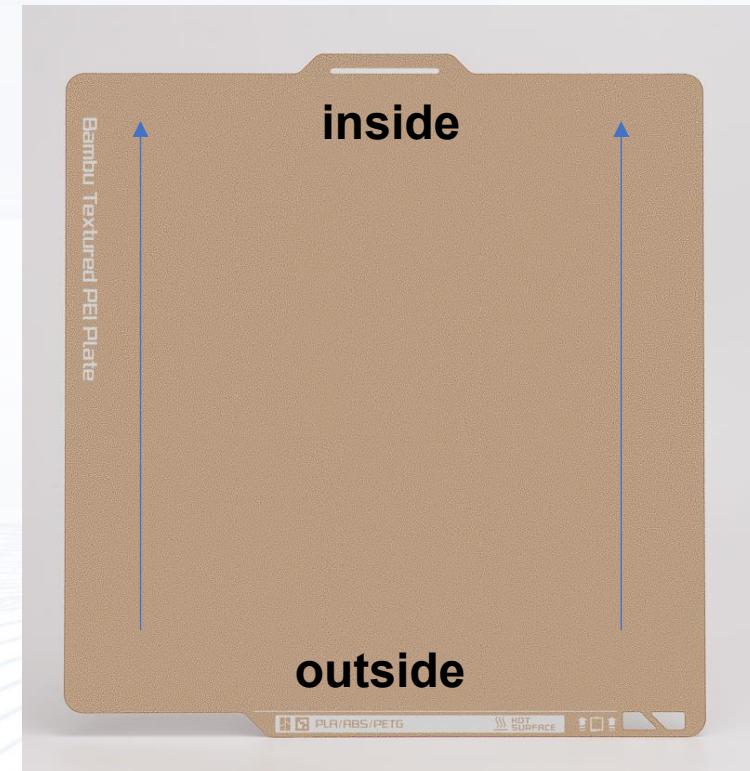
Under normal circumstances, the modules prone to **issues** are mainly the **extruder** and the **hot end**. The causes typically include material jamming, nozzle clogging, or temperature control failure.



# | 拓竹FDM



The relative assembly position of  
the build plate is as follows.  
Reversing the installation will  
cause the printer's leveling to fail.





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# Filament

Use enclosed-chamber 3D printer with a higher temperature.

Due to the time constraints of the course, we only provide one type of material—**PLA**—for everyone.

Basic	Engineering	Flexible	Support	Aesthetic	Glass/Carbon Fiber
PLA PETG	ABS、ASA、 ABS-GF\ASA- CF\PC\ASA- Aero\PCFR\PA6 -GF	TPU:85A\90A\9 5A	<b>Support Materials for</b> ABS、 PLA、 PETG、 PA\PET PVA	<b>Colored:</b> PLA 丝绸： silk/slik+ PETG半透明 PLA半透明磨砂 PLA双色渐变 PLA木质哑光 PLA夜光 PLA大理石材质 PLA金属 PLA闪耀 PLA炫彩 (只是掺杂了一些高亮颗粒) PLA-CF高强度碳纤维复合多色 PETG-CF碳纤维	PPA-CF PPS-CF PLA-CF PA6-GF PA6-CF PAHT-CF PET-CF PETG-CF ABS-GF

[Click for link: Online Filaments Guide](#)



# 耗材

## » PLA



线材\*1 & 干燥剂\*1

- Carbon Fiber Texture & Minimized Layer
- Improved Mechanical Properties
- Stabilized Printing Dimension
- Comes with Basic Reusable Spool
- Diameter: 1.75mm +/- 0.03mm

**Bambu PLA Basic**

**Silver**

Diameter : 1.75 ± 0.03 mm
Length : 330m
Printing Temp : 190 - 230 °C
Net Weight : 1kg
Made in China

**Cautions for Use**

- 0.2 mm Nozzle Not Compatible
- Stainless Steel Nozzle Not Recommended
- Dry before Use for the Highest Print Quality
- AMS & AMS lite Compatible

**Color:**

Red
Green
Black
Blue

直径 : 1.75 ± 0.03 mm

线长 : 330 m

打印温度 : 190 - 230 °C

克重 : 1 kg



first confirm the parameter information on the filament spool

**Diameter:** For mainstream desktop 3D printing filaments, the diameter is generally 1.75mm.

**Filament Length:** Refers to the length of a spool of filament.

**Printing Temperature:** The temperature set in slicing software when configuring the filament for printing.

**Weight:** The weight is generally provided in full.

### others

- If the material gets damp after being opened for a long time, it may need to be dried.



	PLA Shop now >	PETG HF Shop now >
Toughness Impact Strength - XY	26.6 kJ/m <sup>2</sup>	31.5 kJ/m <sup>2</sup>
Strength Bending Strength - XY	76 MPa	64 MPa
Stiffness Bending Modulus - XY	2750 MPa	2050 MPa
Layer Adhesion Impact Strength - Z	13.8 kJ/m <sup>2</sup>	10.6 kJ/m <sup>2</sup>
Heat Resistance HDT, 0.45 MPa	57 °C	69 °C
Saturated Water Absorption Rate 25 °C, 55% RH	0.43%	0.40%
Dry Out Before Use	Optional	Required
Drying Condition	Blast Drying Oven: 50 °C, 8 h X1 Series Heatedbed: 60 - 70 °C, 12 h	Blast Drying Oven: 65 °C, 8 h X1 Series Heatedbed: 75 - 85 °C, 12 h

Pay attention to the softening temperature of the Filaments.



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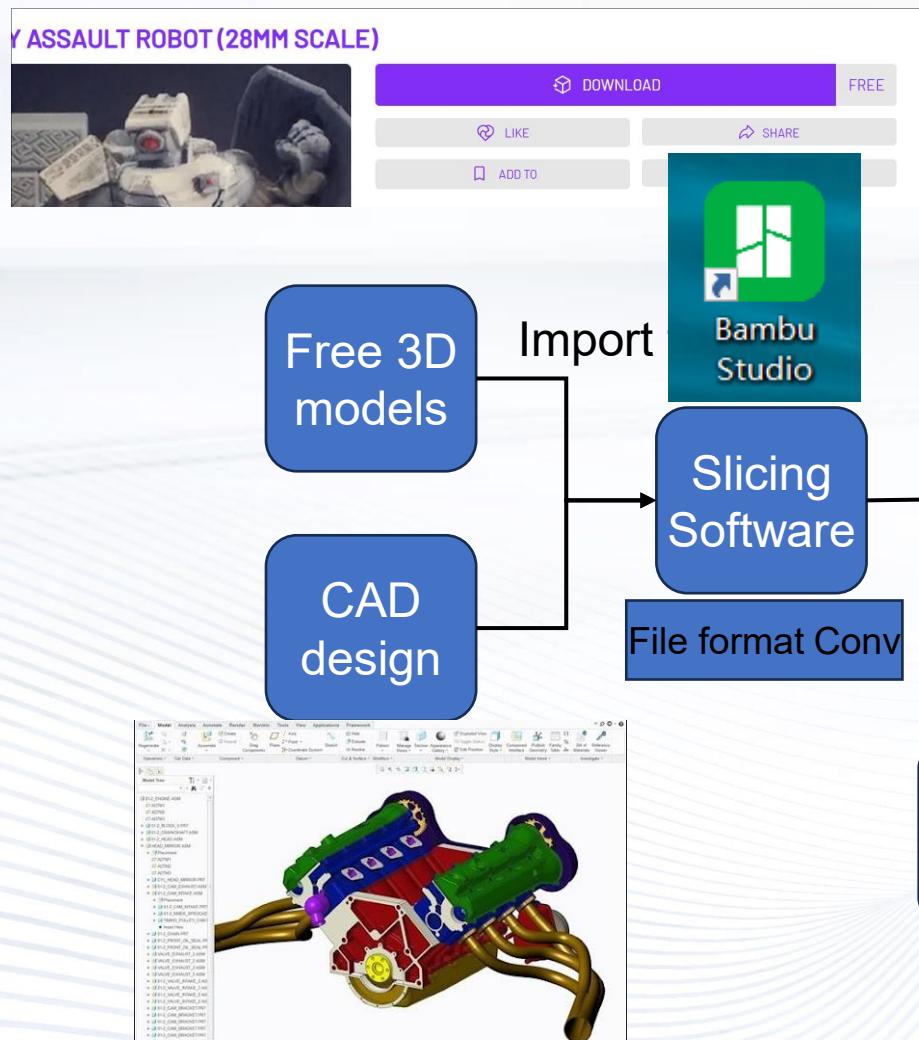
V. 3D Printing Operation



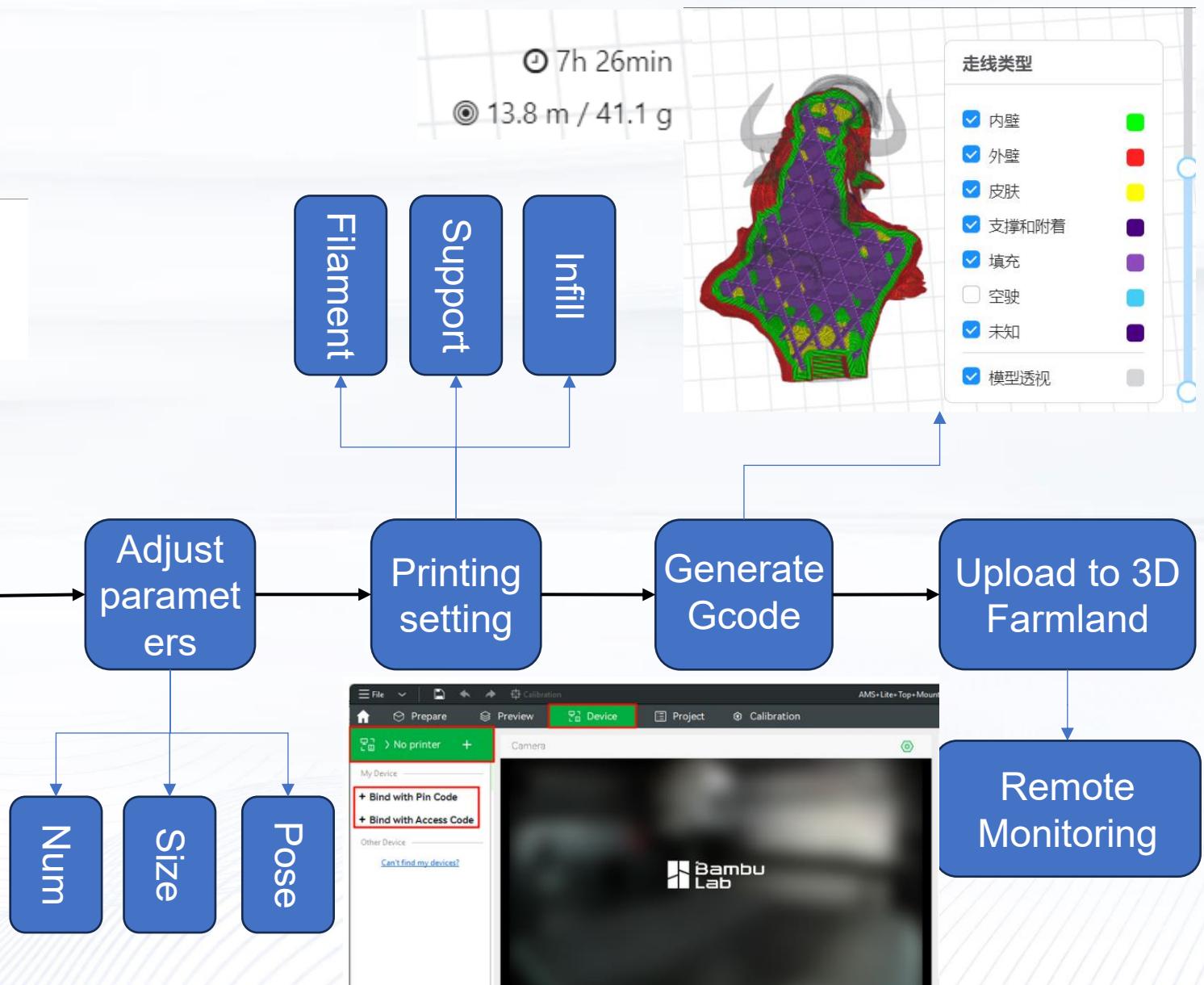
# 切片软件

» gcode

3<sup>rd</sup>-party website download



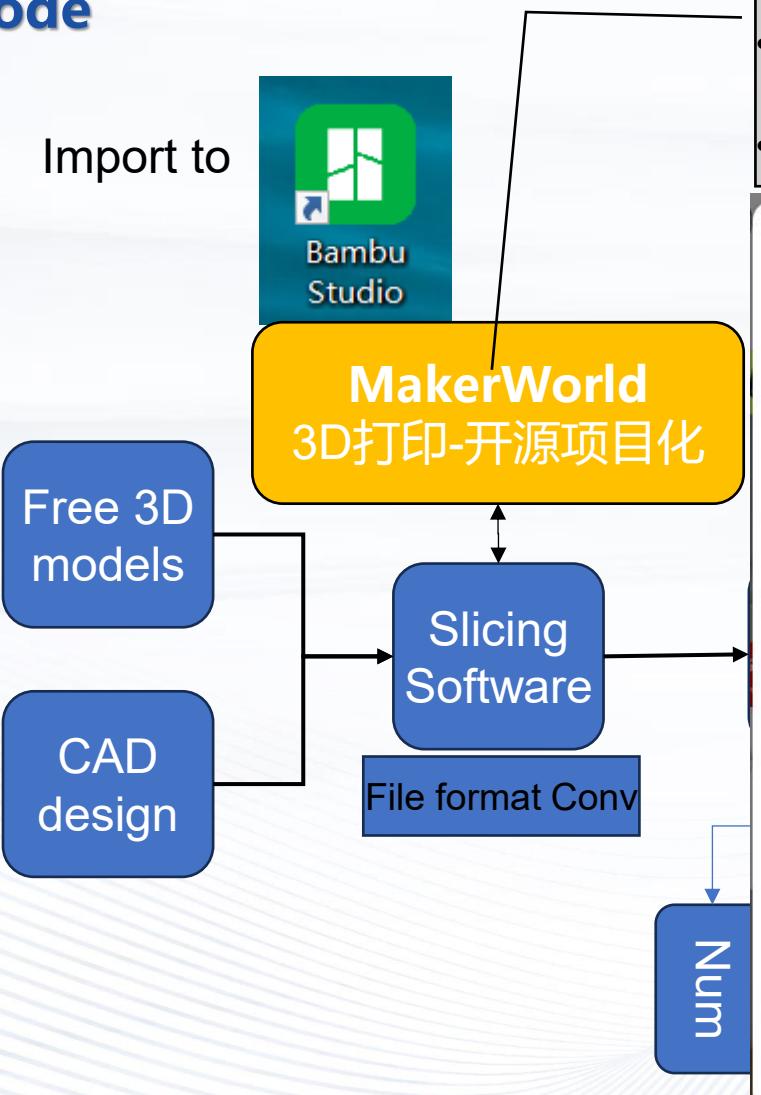
• Bambu Studio





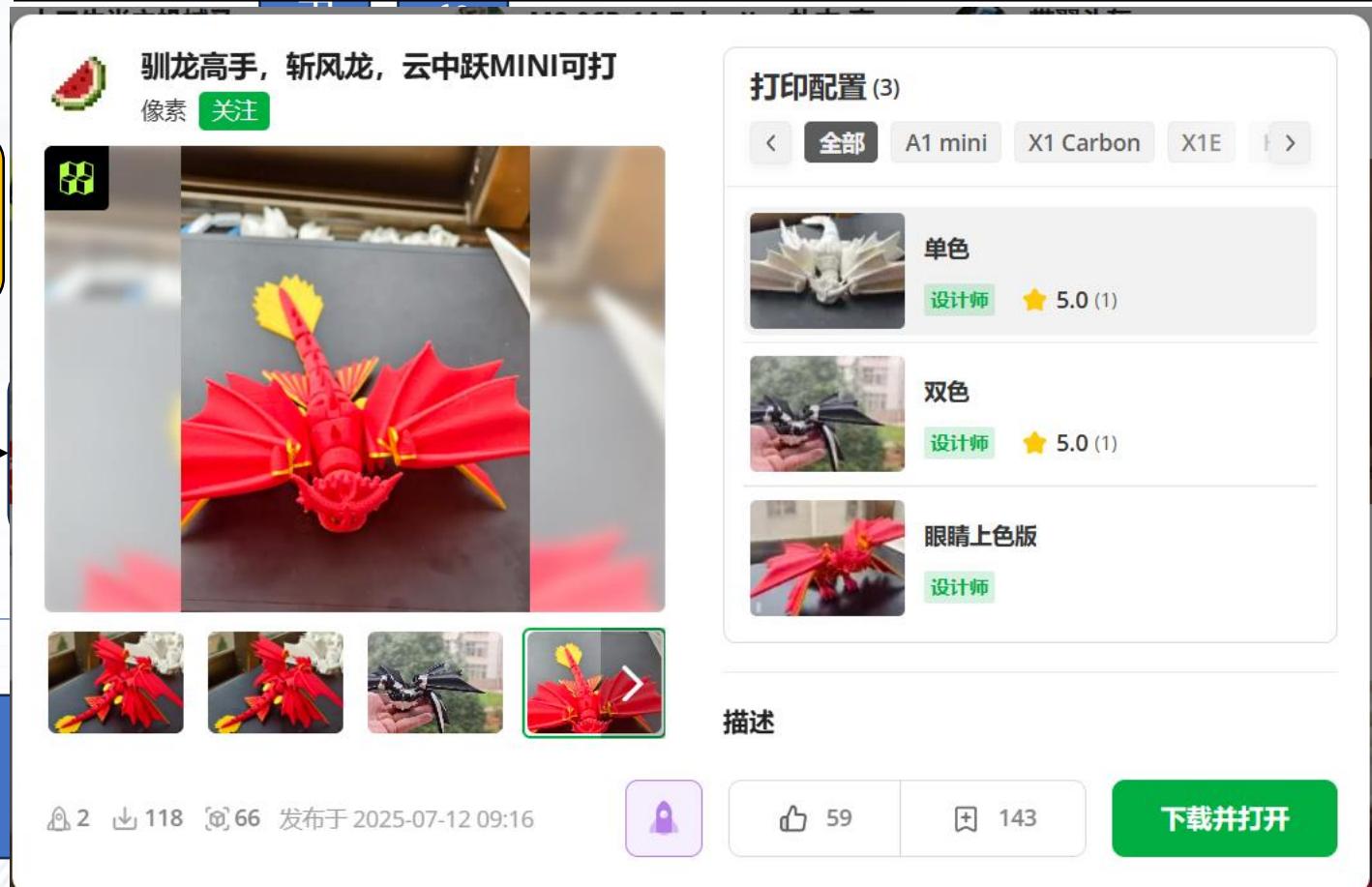
# 切片软件

» gcode



## • Bambu Studio

- **Community:** enhancing user engagement , lightweight social interactions
- **Github-style:** Open-Source Sharing, Project Iteration & Improvement, Continuous Optimization
- **Parameterization :** Printing Parameter Configurations for Multiple Machine Models, Simplify the Printing Process
- **Others:** Images, Assembly Instructions, Spare Part Information,etc





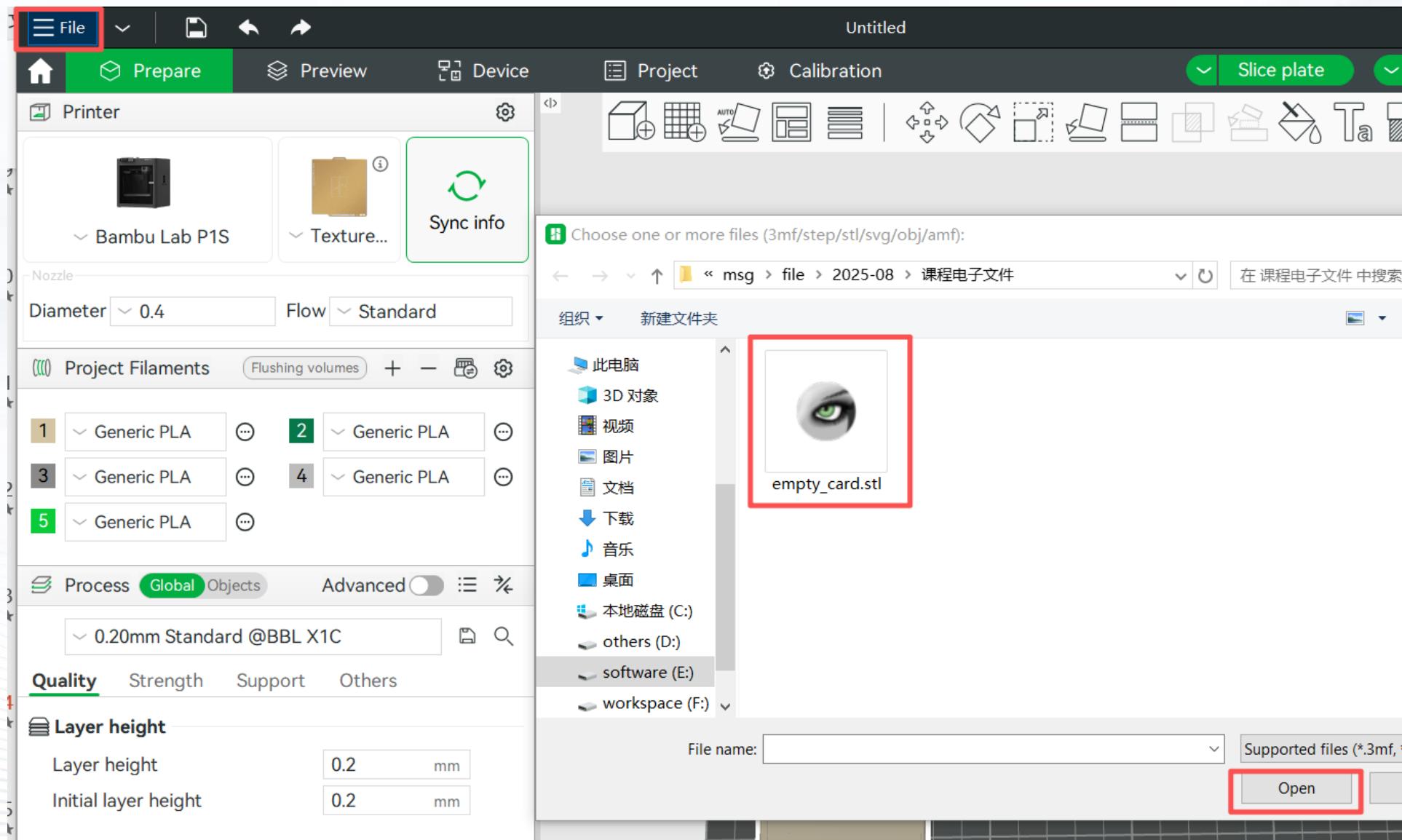
# 切片软件

## Bambu Studio

File-  
Open project  
Import/Export model file

Supported formats:  
3mf, stl, step, obj, etc.

File-Import-Import STL- choose the Target Folder -- choose the Target file--Open





# 切片软件

## Bambu Studio

Printing workflow

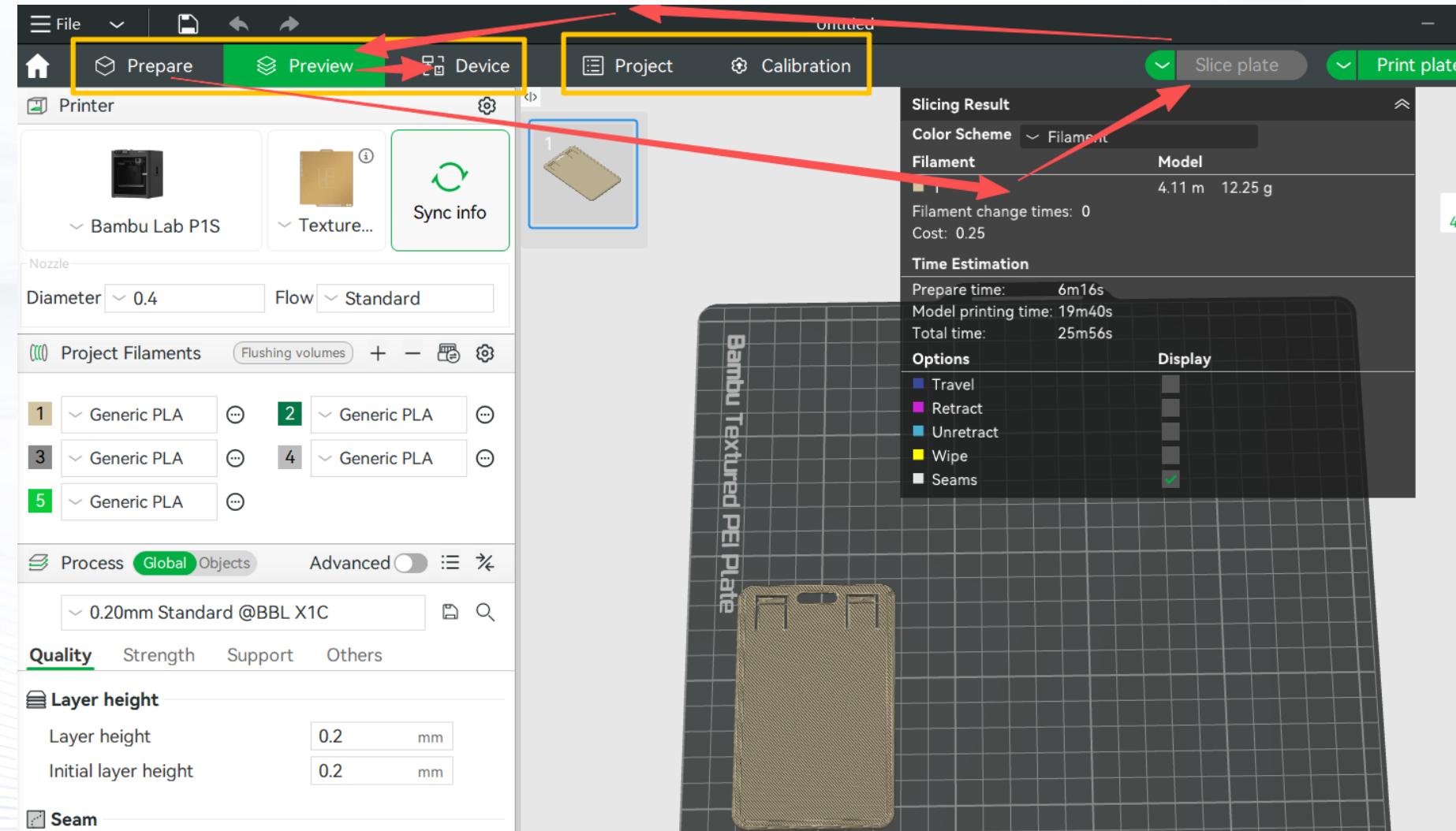
**Prepare**: setting the printer and printing parameters

**Preview**: check the gcode result.

**Device**: Target device for printing. In this course, we use Farmland mode.

**Project**: publish your project.

**Calibration**: calibrate the printer, this is often done at the very beginning or when the machine is not work.



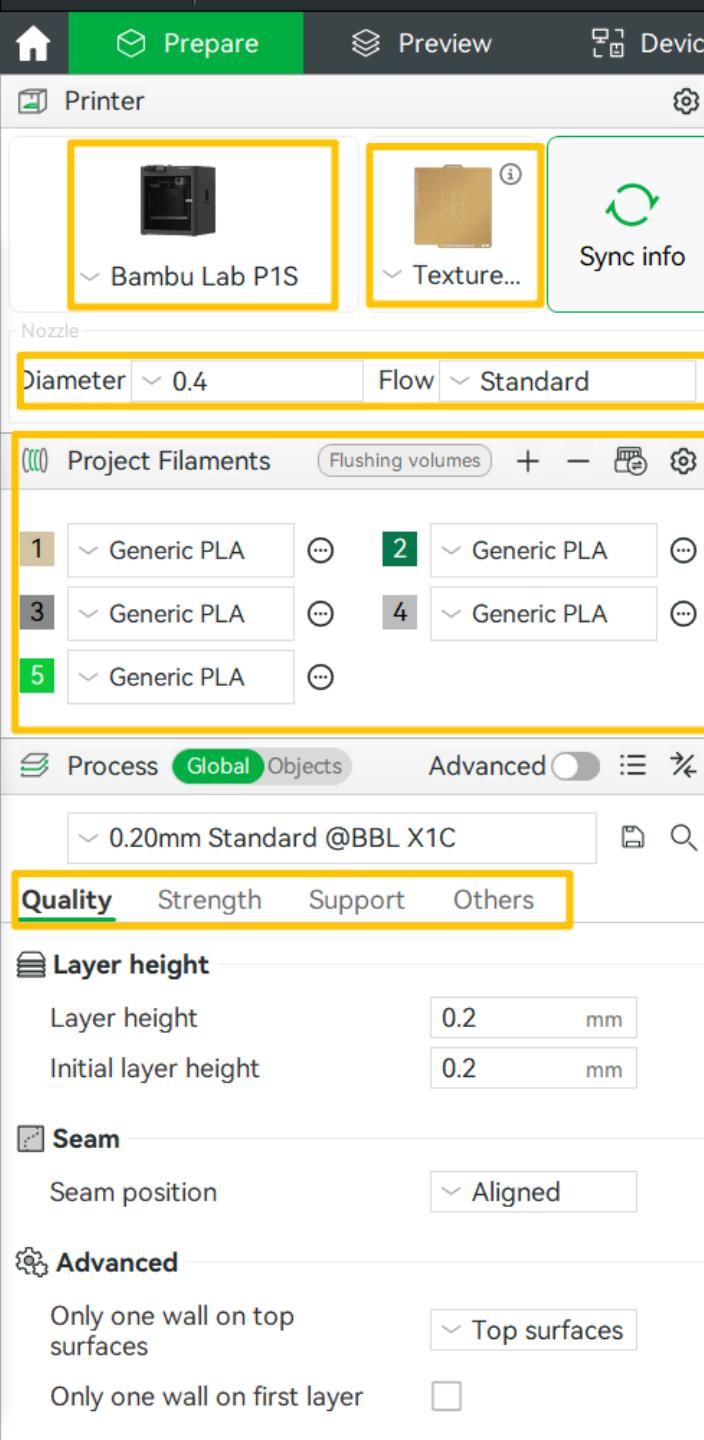


# 切片软件

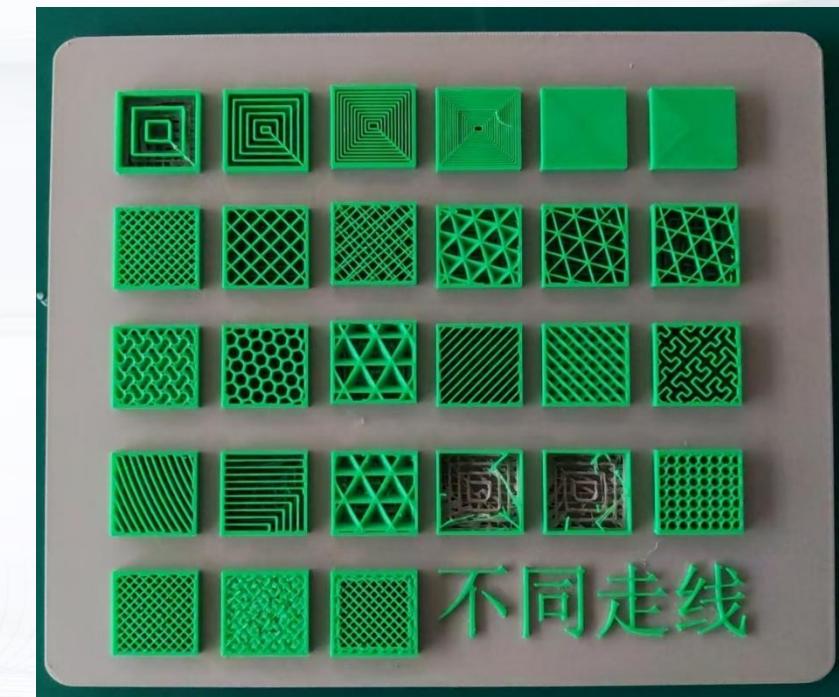
## Bambu Studio

### Printer Menu

1. Choose the Right **Printer Type** and the **Plate**.
2. Check the Diameter of Nozzle (0.4mm) and the printing speed (**standard flow**).
3. Choose the Filaments: for multi-color printing, choose the right color and Filaments (this should match the AMS).
4. Printing Params: Quality (mainly affected by layer height), Strength (mainly affected by **infill**), Support and other.



This is an example of different types of **Infill**, we shall discuss later.





# 切片软件

## Bambu Studio

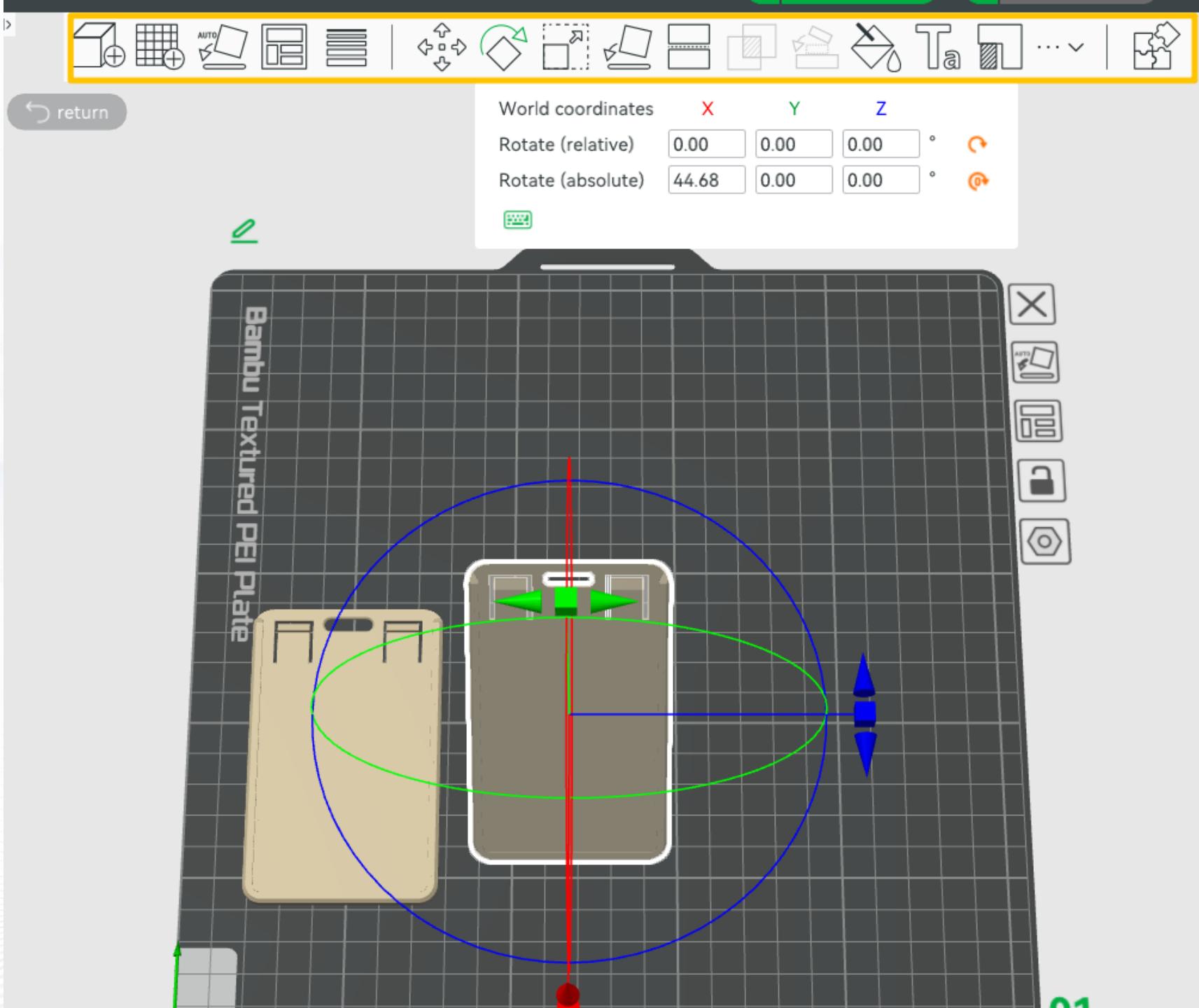
### Model Editing Menu:

1. adding basic geometric shapes and models, adding new print plate, and enabling automatic model adhesion to the bed.
2. Moving, rotating, resize model.
3. Change color, and Text.

### Model Viewing

#### Area(bottom):

The model can be viewed by rotating the field of view with the mouse.





# 切片软件

## Bambu Studio

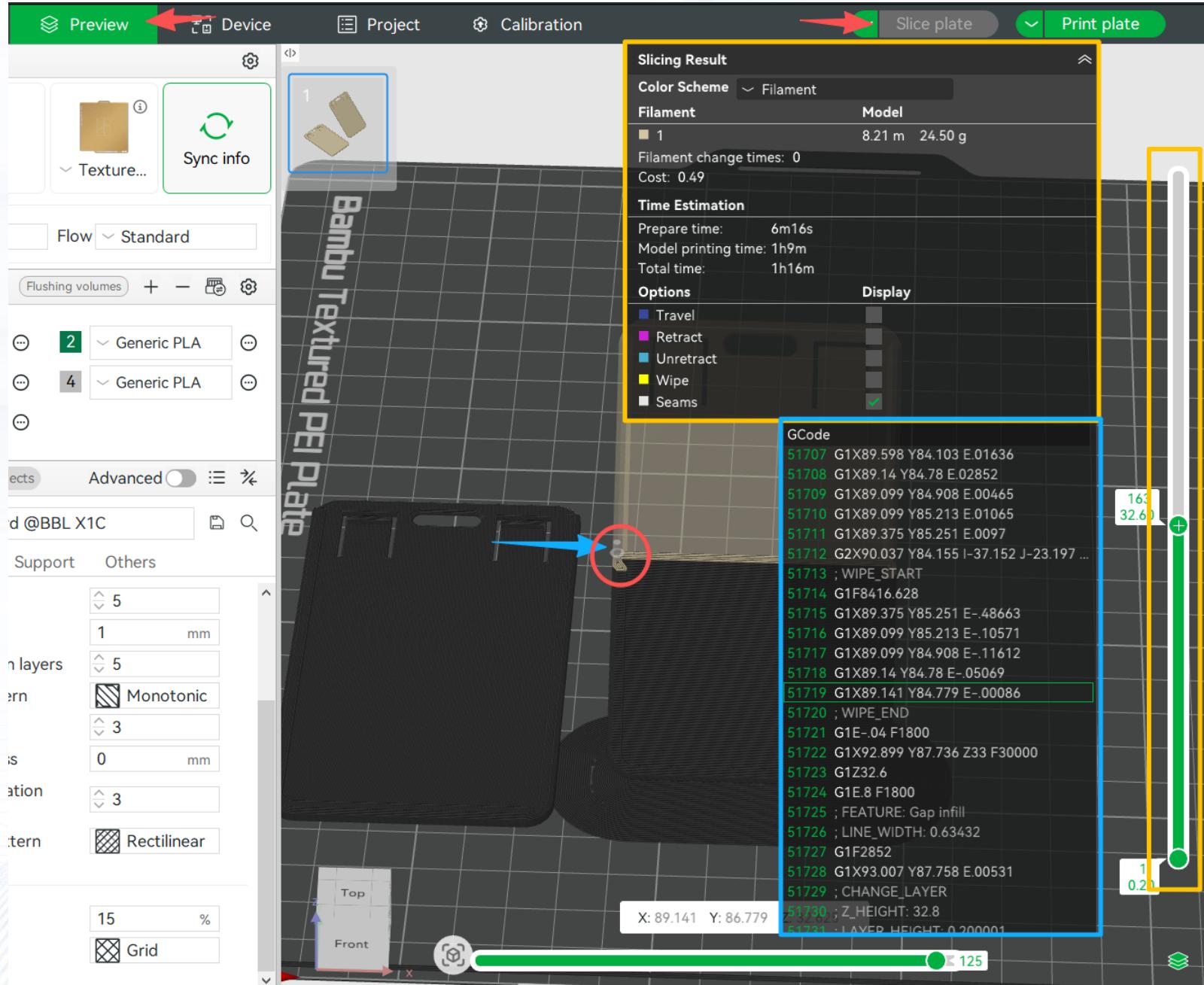
### Gcode Preview

In the View Window, the G-code toolpaths generated based on the model's printing parameters will be displayed.

Among these, the slicing result is used to show the estimated material consumption.

The progress bar on the **right** represents the current print layer divided by height; the progress bar at the **bottom** indicates the G-code progress of the current layer. Adjustments can be made to observe the movement of the printer nozzle.

After choosing the **Slice plate**, the interface jumps to **Preview**.





# 切片软件

》 Bambu Studio

Slicing Result

Color Scheme ▾ Line Type

Line Type	Time	Percent	Used filament	Display
Inner wall	16m10s	21.4%	1.74 m 5.18 g	✓
Outer wall	22m3s	29.2%	1.73 m 5.16 g	✓
Overhang wall	2s	<0.1%	0.00 m 0.00 g	✓
Internal solid infill	11m52s	15.7%	2.74 m 8.18 g	✓
Top surface	2m30s	3.3%	0.46 m 1.37 g	✓
Bottom surface	2m37s	3.5%	0.38 m 1.14 g	✓
Gap infill	7m21s	9.7%	0.91 m 2.72 g	✓
Brim	2m1s	2.7%	0.22 m 0.66 g	✓
Custom	6m2s	8.0%	0.03 m 0.09 g	✓
Travel	4m42s	6.2%		
Retract				
Unretract				
Wipe				
Seams				✓

Total Estimation

Total Filament:	8.21 m	24.50 g
Model Filament:	8.21 m	24.50 g
Cost:	0.49	
Prepare time:	6m16s	
Model printing time:	1h9m	
Total time:	1h16m	

Slicing Result

Color Scheme ▾ Summary

Total: 8.21 m / 24.50 g  
Cost: 0.49  
Total time: 1h16m

Slicing Result

Color Scheme ▾ Speed

Speed (mm/s)

- 250
- 223
- 197
- 170
- 143
- 117
- 90
- 63
- 37
- 10

Slicing Result

Color Scheme ▾ Temperature

Temperature (°C)

- 220

Options

Display

travel

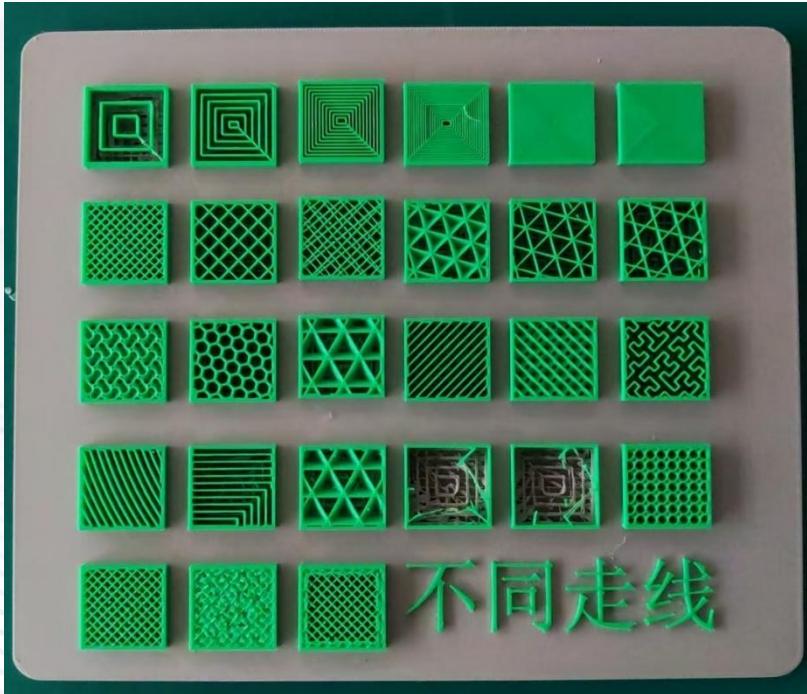
By selecting visualization content, you can perform visual analysis on different configuration parameters of the printing process.



# 切片软件

## » Bambu Studio

Infill types



Infill percentages



All-in-one Test

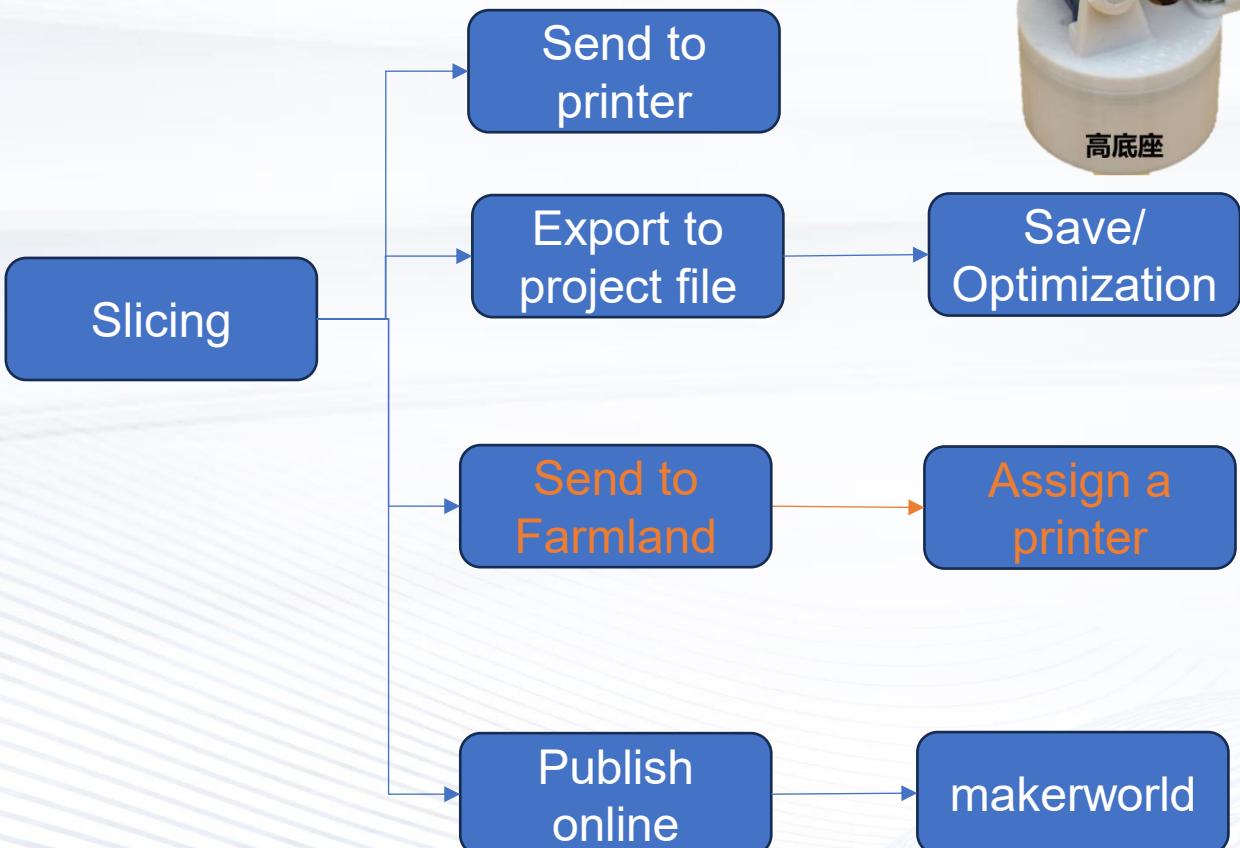


When using **new printing Filament** and being **unfamiliar with its performance** on the local printer, you can conduct a printing evaluation using the template mentioned above.



# 切片软件

» Bambu Studio



高底座



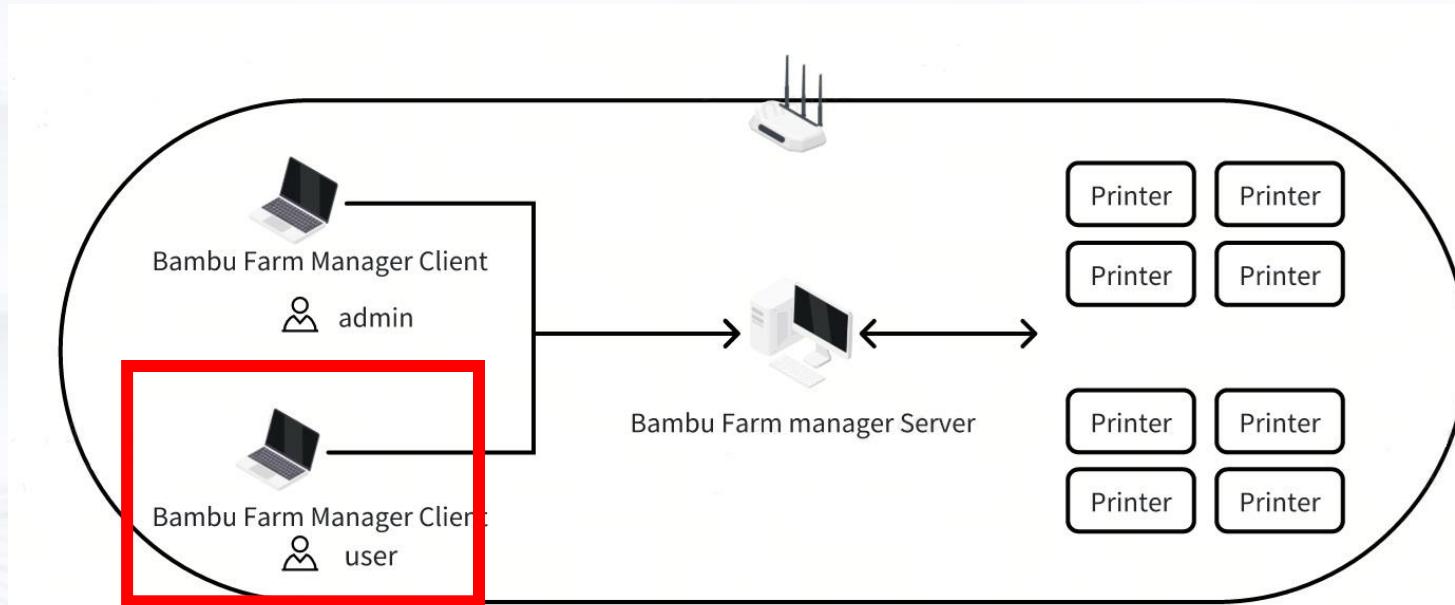
配件名称	数量/个
M2.5x10 圆柱头机牙螺丝	80
M2.5 螺母	80
M2.5x5x0.5 垫片	150
6204 深沟球轴承	2
6003 深沟球轴承	2

Currently, 3D printing is mainly used to create supports. By combining with power systems, lighting, and mechanical transmission structures, more diverse works can be designed.



# 切片软件

- 3D Farmland



The service software that handles **task distribution** and **printer connection** in the background.

Software that distributes sliced G-code files to each printer as needed.

Processing software that edits and slices online models and local models.

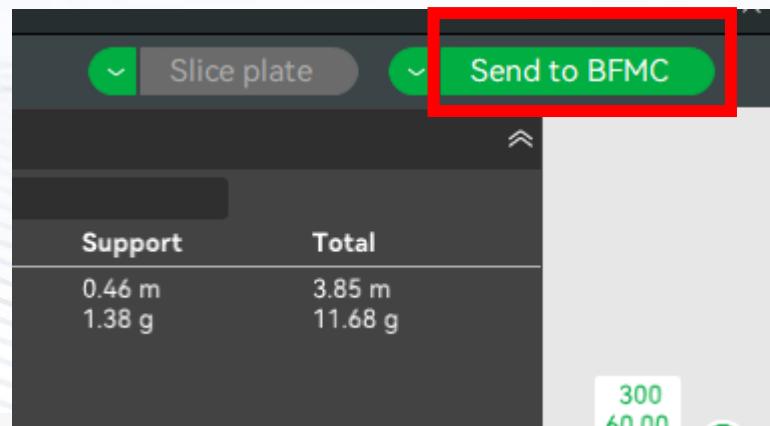


# 切片软件

- 3D printing on Farmland

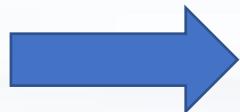


Slicing



Send to BFMC

slicing



Send to  
BFMC

Assign  
Printer



Check the estimated printing time.



Move to Farm Manager Client

操作	上传时间	耗材	打印时长	机型   喷嘴   热床	文件名称
	07/04/2025 15:26:16	101.18g PLA	3h38m	X1C   X1   P1S   X1E 0.4mm Textured PEI Plate (55°C)	apple.3mf



# 切片软件

- Assign Printer

- We currently didn't find an English version of the BMFC, so try to refer the following UI when operation.

The screenshot shows the BMFC software interface. At the top, it displays a model file: P\_Glider\_WingStar\_Basic\_V0.1\_with\_Glue\_Wings, Nose, Fin.3mf, with build parameters: Bambu Lab X1C | X1 | P1S | X1E | 0.4mm | Textured PEI Plate, and material selection: PLA PLA. Below this, the total filament usage is listed as 总耗材丝: 41g | 打印时长: 1h57m.

In the center, there are two main sections: "直接打印" (Direct Print) and "发送任务到队列" (Send Task to Queue). A red box highlights the "直接打印" button. Below it, a dropdown menu for filament position shows "外挂" (External) and "AMS" (Automatic Material Selection), with "AMS" being selected. Another red box highlights the "AMS" option. To the right of this section, a large blue double-headed arrow points to the right, labeled "Follow the Order".

To the right of the central section, there is a visual representation of four spools of filament labeled A1, A2, A3, and A4, each with a different color and a small icon indicating its status. The filament for A1 is highlighted with a red box. Below this, a circular progress bar shows 41% completion.

At the bottom left, a table lists printers: left1, left2, and right2. The row for "left1" has a checked checkbox and is highlighted with a red box. The status for "left1" is "空闲" (Idle). To the right of the table, a "耗材" (Filament) section shows four rows of filament spools. The first row has A1 PLA (highlighted with a red box) and A2 PLA-S. The second row has A1 PLA (highlighted with a red box) and A2 ?. The third row has A1 ? and A2 ?. The fourth row has A3 PLA and A4 PLA (highlighted with a red box).

At the bottom left, under "打印选项" (Print Options), a checkbox for "热床调平" (Bed leveling) is checked and highlighted with a red box. Below this, another checkbox for "延时摄影" (Delayed Photography) is shown but not checked. At the very bottom, a green "创建任务" (Create Task) button is highlighted with a red box.



# 切片软件

## • Assign Printer

- After printing starts, you can manually observe whether errors occur, stop the process promptly if any, and notify the teacher.
- You can also **monitor it** via the farm software, as shown in the figures below:

The screenshot shows a software interface for managing multiple 3D printers. On the left, there's a sidebar with printer details (right1), printer status (打印中), and material selection (AMS A1 PLA). The main area displays a table of print jobs with columns for printer, label, task, print status, progress, print speed,耗材 (material), and operations. Seven print jobs are listed, each with a red box around the progress bar. The progress bars show various completion percentages and remaining times. Below the table, a camera view shows the printer bed with several green-printed parts. At the bottom, a summary bar provides the total number of printers online (6), printing (6), and idle (0), along with detailed progress for each job.

打印机	标签	任务/文件	打印状态	进度	打印速度	耗材	操作
left1		Collapsible Ball_Arms	打印中	-1h0m 60% 18/30	标准	AMS	详情
left2		Collapsible Ball_5-Way Connectors	打印中	-9m 90% 23/36	标准	AMS	详情
left3		Collapsible Ball_3-Way Connectors	打印中	-25m 78% 21/36	标准	AMS	详情
right1		P_Glider_WingRay_Opt 1_Classic Ta...	打印中	-56m 45% 7/341	标准	AMS	详情
right2		apple	打印中	-3h21m 7% 1/72	标准	AMS	详情
right3		P_Glider_WingRay_Opt 1_Classic Ta...	打印中	-57m 44% 7/341	标准	AMS	详情

温度  
喷嘴: 220°C | 热床: 55°C

打印状态  
7/05/2025 17:35:21

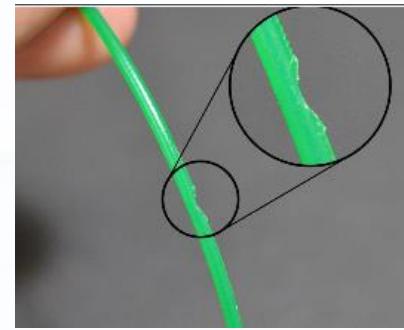
在线 6 打印中 6 空闲 0 标签过滤 所有状态 所有任务 剩余时间 详细卡片 全屏

Printer	Task	Progress
left2	Collapsible Ball_5-Way Connectors	92% -7m
left3	Collapsible Ball_3-Way Connectors	79% -23m
right1	P_Glider_WingRay_Opt 1_Classic Tail_smooth(4)(2)	46% -55m
right3	P_Glider_WingRay_Opt 1_Classic Tail_smooth(4)(2)	45% -56m
left1	Collapsible Ball_Arms	61% -59m
right2	apple	8% -3h20m



# | 切片软件

## » Common errors and solutions



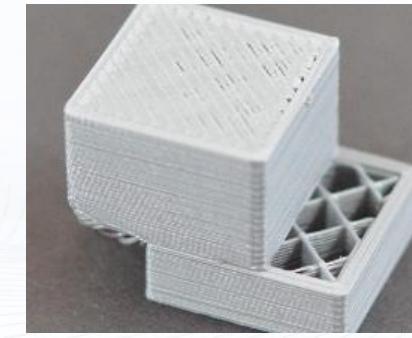
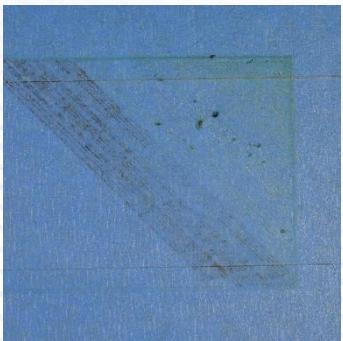
1. **Printer Error:** The printer Errors are reported in the form of error codes in LED. HMS\_1200-7000-0001-0001:

Search in this link: <https://wiki.bambulab.com/zh/home> , and solve the problem.

2. **Printing Errors:** most problems are related to the heater or Filament. Check the following Link

<https://www.simplify3d.com/resources/print-quality-troubleshooting/>

<https://all3dp.com/1/common-3d-printing-problems-troubleshooting-3d-printer-issues/>





# Contents

I. Overview of 3D Printers

II. Bambu Lab FDM

III. Consumables

IV. Slicing Software

V. 3D Printing Operation

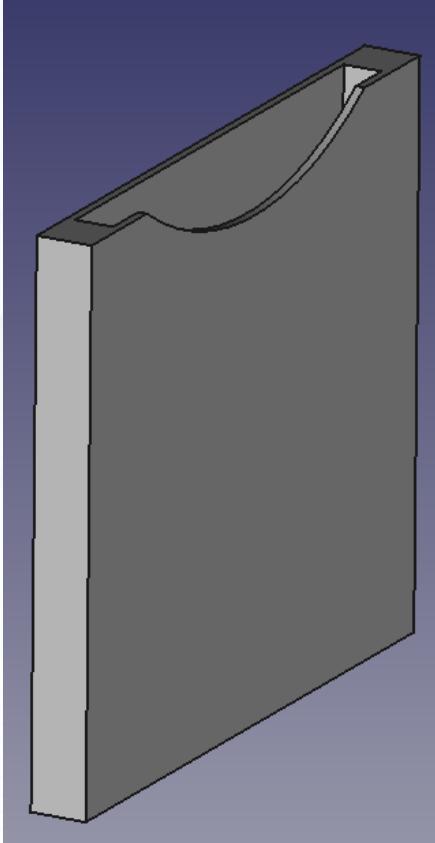


# Modeling Workflow

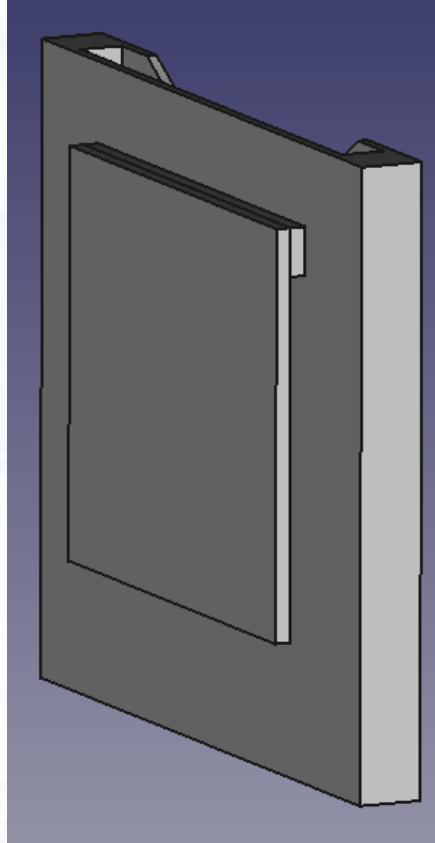
## Display of final printing effect.



IC card holder



NFC card slot



result



For international students, this is optional.



# Modeling Workflow

## » Related software

### ➤ Task1: BanbuStudio



- Bambu Studio is a feature-rich **slicing software** dedicated to Bambu Lab 3D printers.
- Bambu Studio includes a project-based workflow, a systematic slicing algorithm, and an easy-to-use graphical interface.
- Bambu Studio supports practical features such as remote printing and remote monitoring.



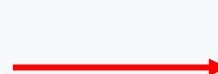
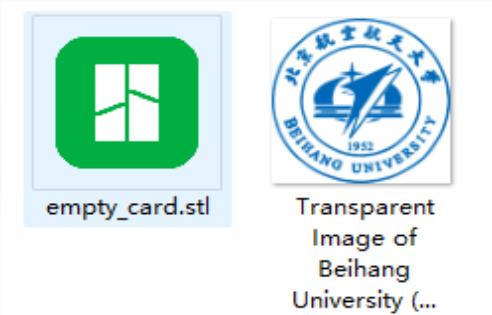
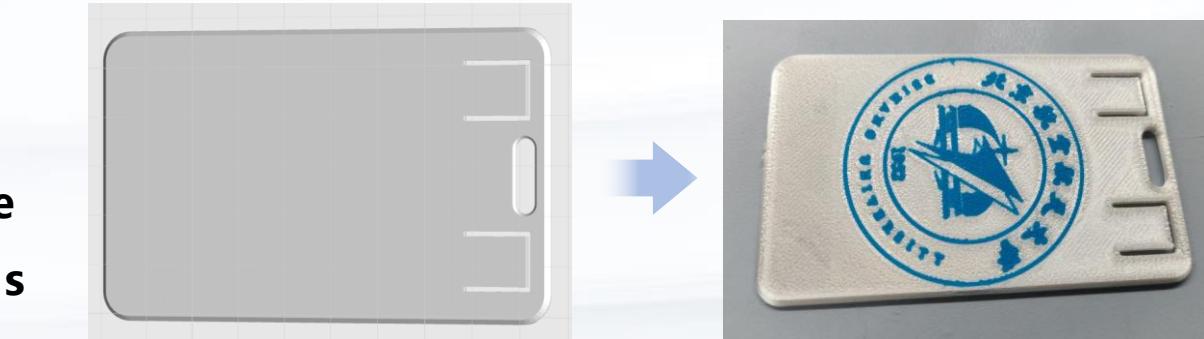
# Modeling Workflow

## » IC card holder

**Experimental Objective:** To enable free replacement of the pattern on the back of the card holder(using the BUAA school emblem as an example)

### Prepared Files (Provided in This Course)

- STL file of the card holder without a pattern
- Beihang University (BUAA) logo pattern



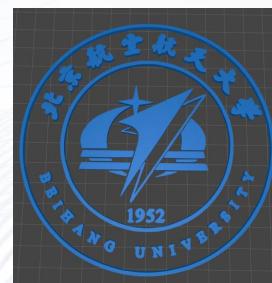
Copy the file from the shortcut to the desktop before proceeding with further operations.

## » Production Concept

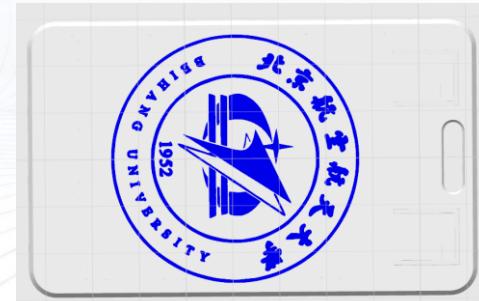
Empty Card Holder



School Emblem Model



Card with Logo



Source report about 3D printing guide  
IC Card Holder Pre-provided Files.zip

Files can be found in Folder: IC Card Holder Pre-provided Files.zip

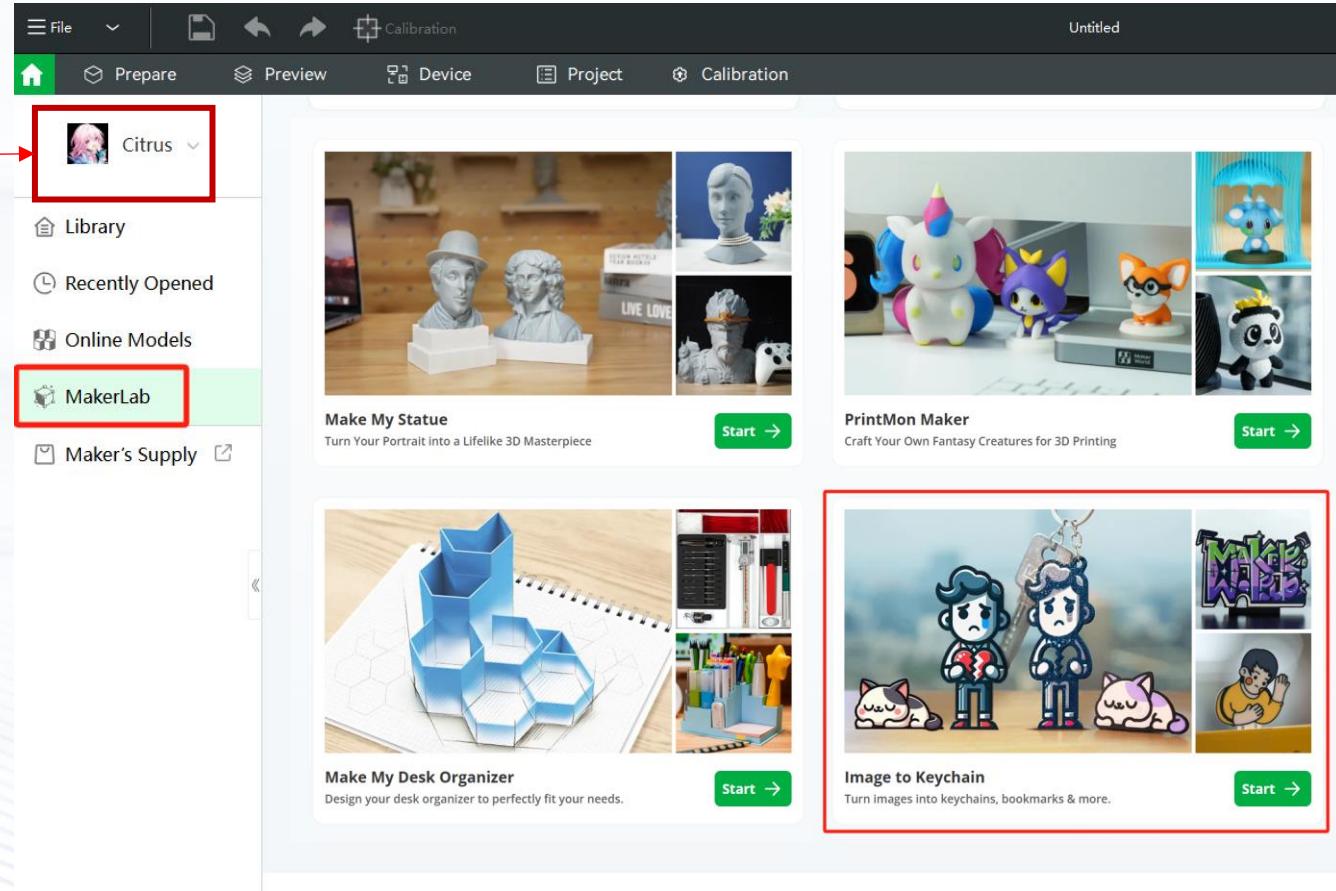


# Modeling Workflow

- Experiment 1: IC card holder

## » Step1 Create the School Emblem Model File

You need to register and log in to your own account.



- Open BambuStudio
- Click the Home Page
- Select MakerLab
- Select the Image to Keychain

- If you cannot register an account. You can directly use the "3D Model of the School Emblem.stl" located in the intermediate file directory for Bambu Studio integration.
- If you skip this step, proceed directly to Step 2.



# Modeling Workflow

- Experiment 1: IC card holder

## » Step1 Create the School Emblem Model File

**Image to Keychain**  
Turn images into keychains, bookmarks & more.

**Create from Blank**

Make your keychain by uploading an image

Drag and drop or click to upload an image  
Size: <= 20 MB

**Browse File**

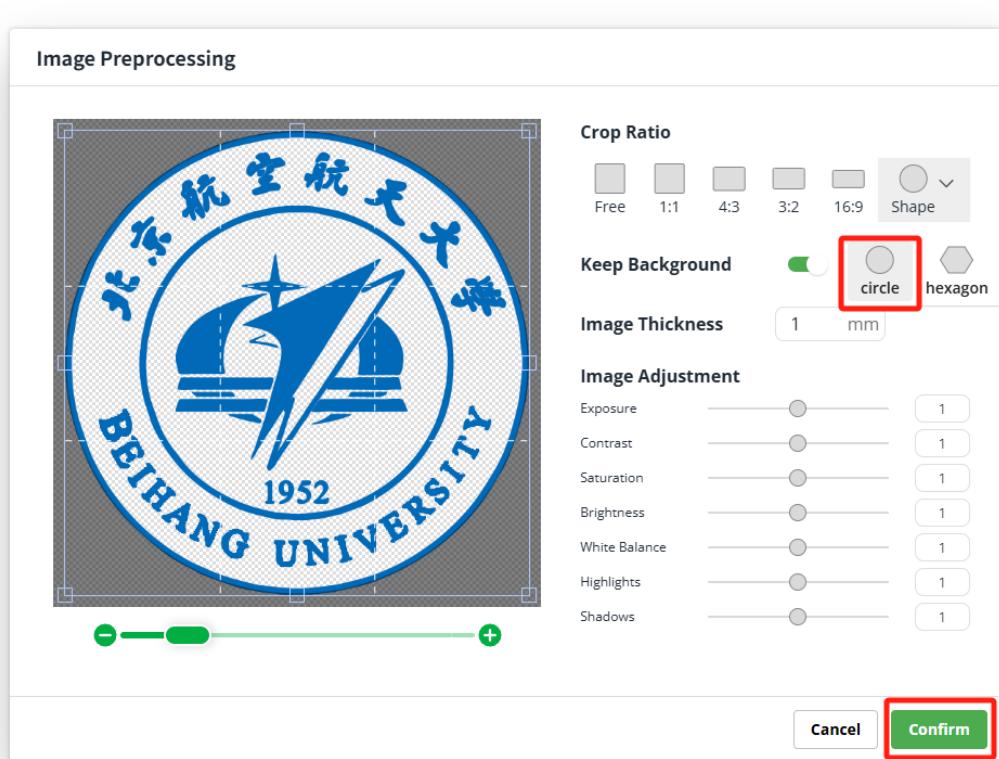
Create an empty project and upload the prepared Beihang University (BUAA) school emblem file.



# Modeling Workflow

- Experiment 1: IC card holder

## » Step1 Create the School Emblem Model File



➤ Select the circle shape, set the “image thickness” to 1mm, and click “Confirm”.

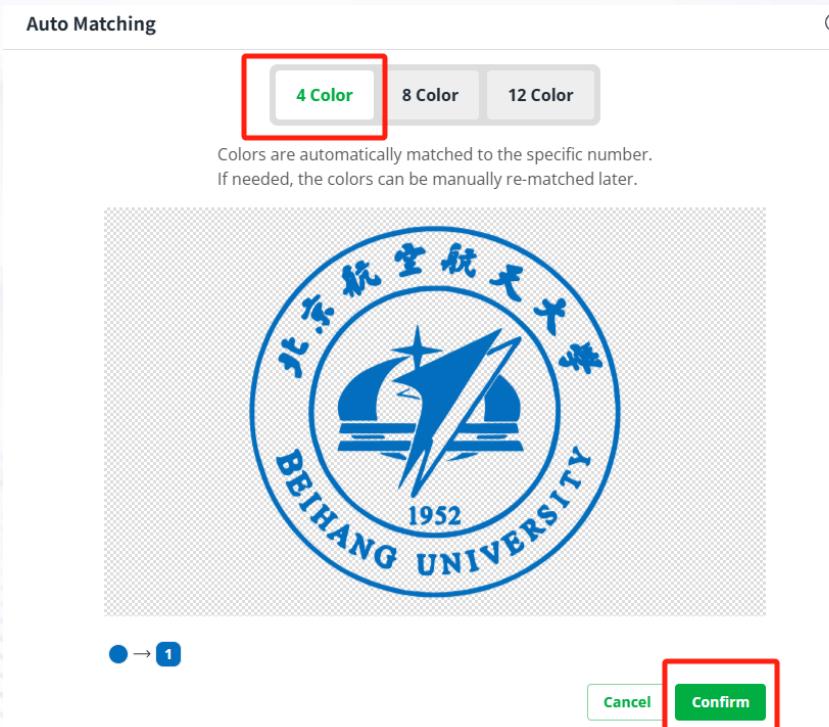
➤ Click “Confirm”.



# Modeling Workflow

- Experiment 1: IC card holder

## » Step1 Create the School Emblem Model File



➤ Select “4 colors” and click “Confirm”.



➤ Click the zoom-in button at the bottom right to preview the generated school emblem model.

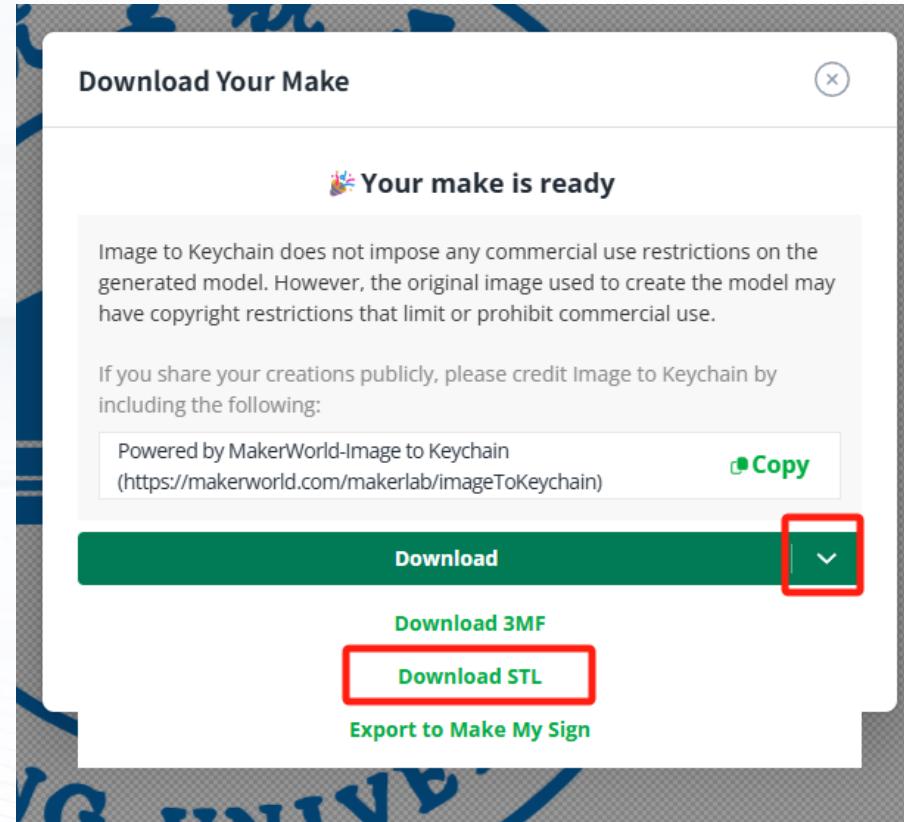
➤ Click the “download” button at the top right.



# Modeling Workflow

- Experiment 1: IC card holder

## » Step1 Create the School Emblem Model File



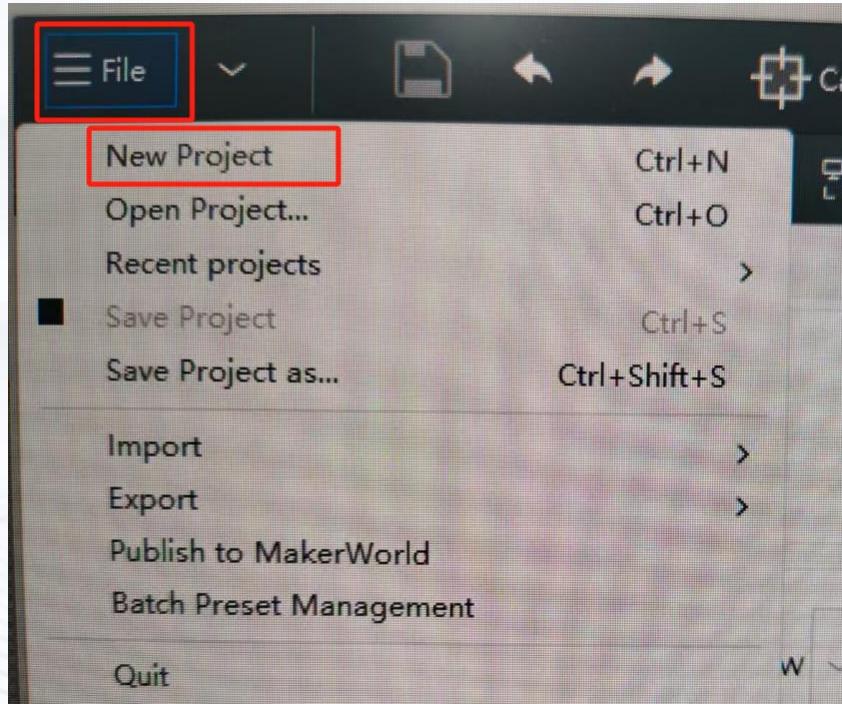
- Download the STL file, and the school emblem model file creation is complete.



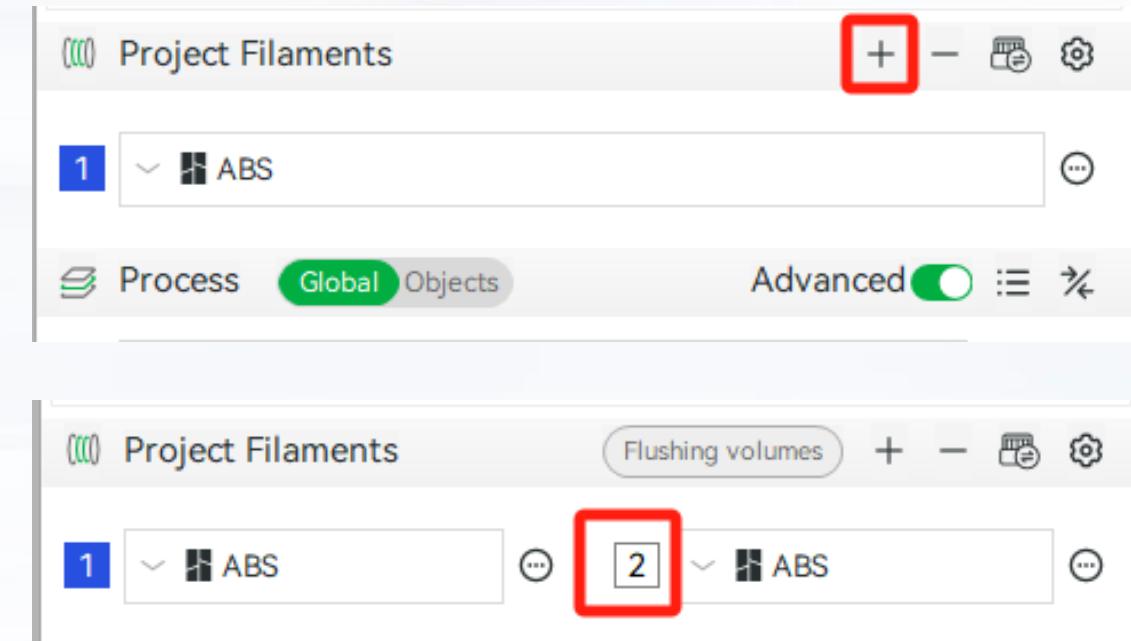
# Modeling Workflow

- Experiment 1: IC card holder

## » Step2 Make a Card Holder with a Custom Logo



➤ Click "File" and then select "New Project".



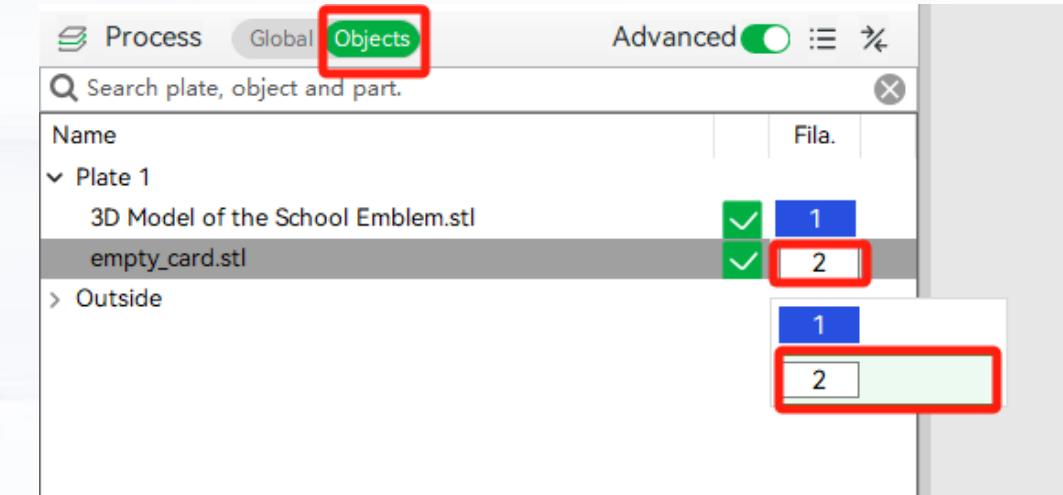
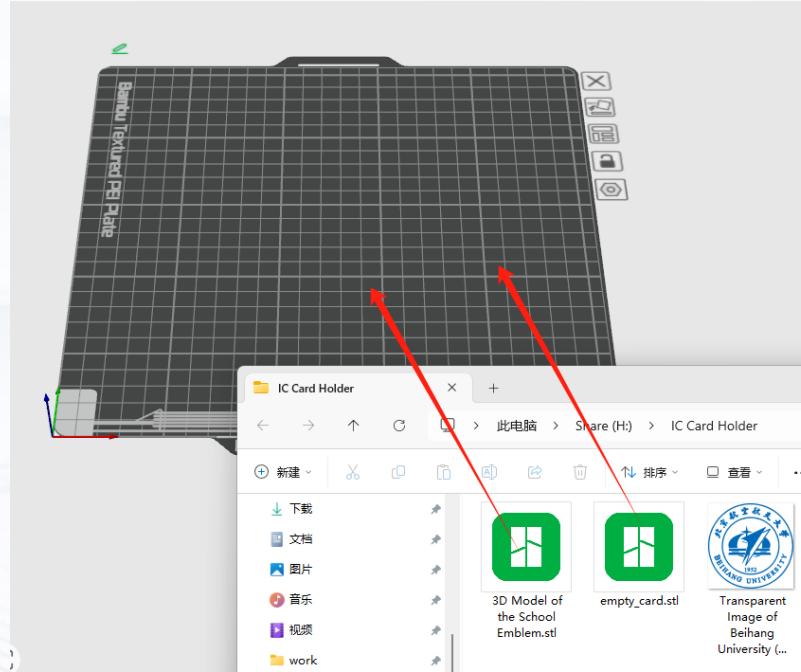
➤ Add a material color and set it to white.



# Modeling Workflow

- Experiment 1: IC card holder

## » Step2 Make a Card Holder with a Custom Logo



- Drag the empty card holder file and the school emblem model STL file downloaded just now into the project.
- If Step 1 was skipped, use the "3D Model of the School Emblem" from the intermediate file directory in this step.

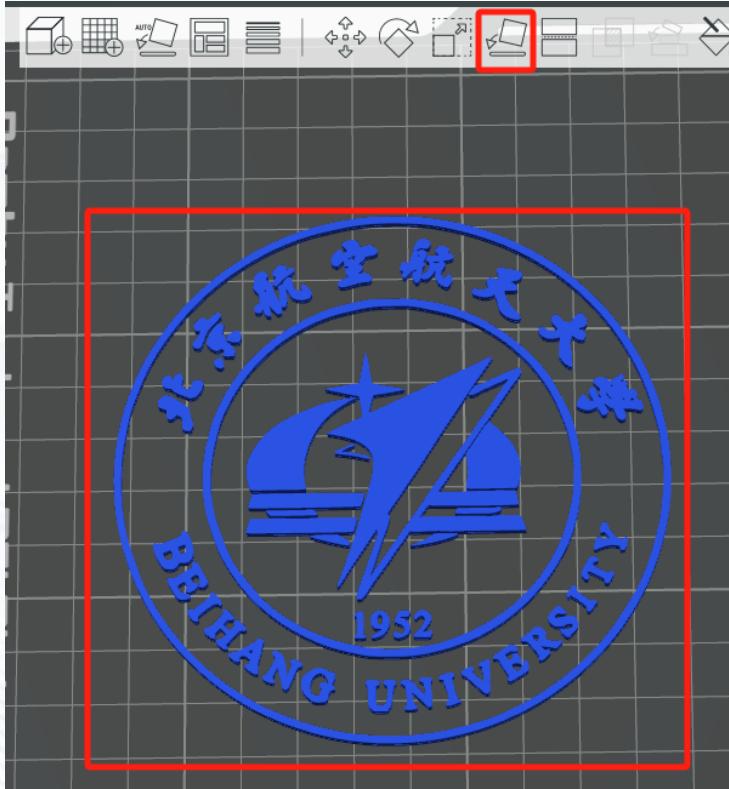
- Select the "Objects" option, click on the color of the card holder STL file, and change it to white.



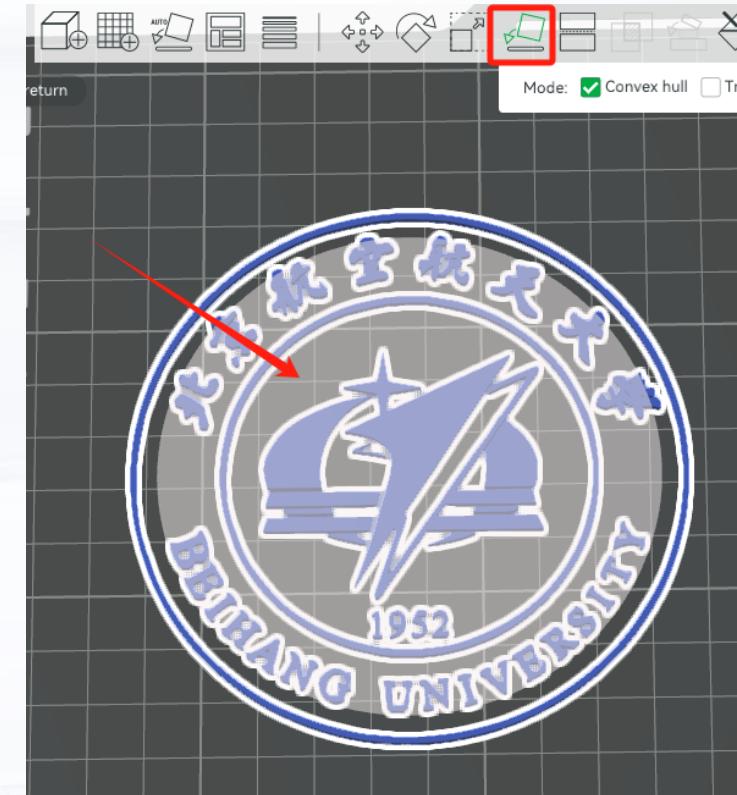
# Modeling Workflow

## » Step2 Make a Card Holder with a Custom Logo

- Experiment 1: IC card holder



- Click on the school emblem model to select it.
- Click the “Lay on Face” command.



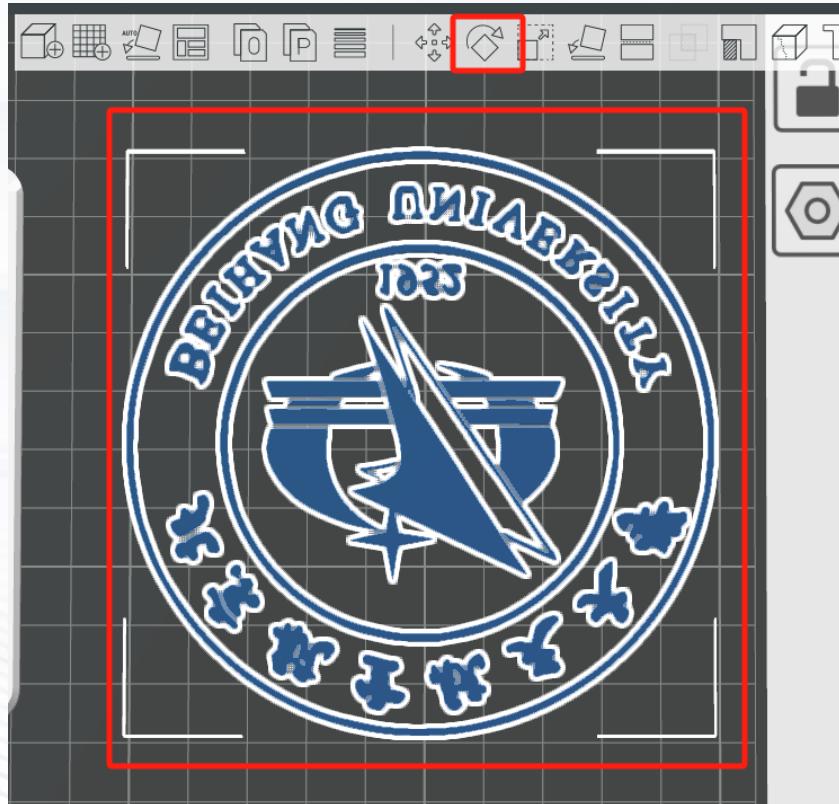
- Click the white transparent surface and set it as the bottom surface.



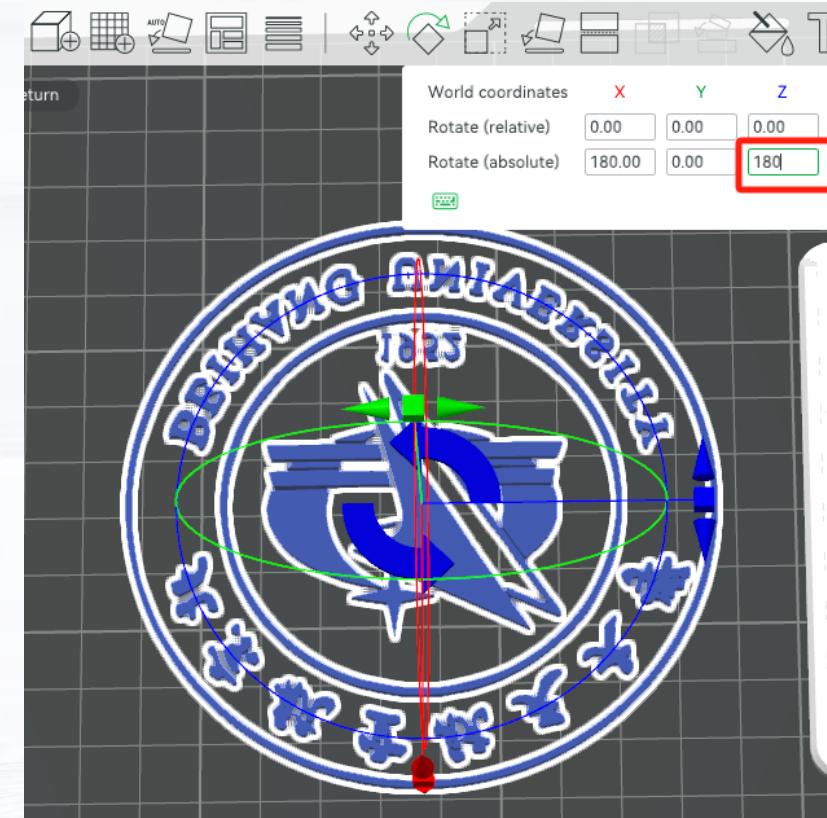
# Modeling Workflow

## » Step2 Make a Card Holder with a Custom Logo

- Experiment 1: IC card holder



- Continue to select the school emblem model.
- Click the "Rotate" command.



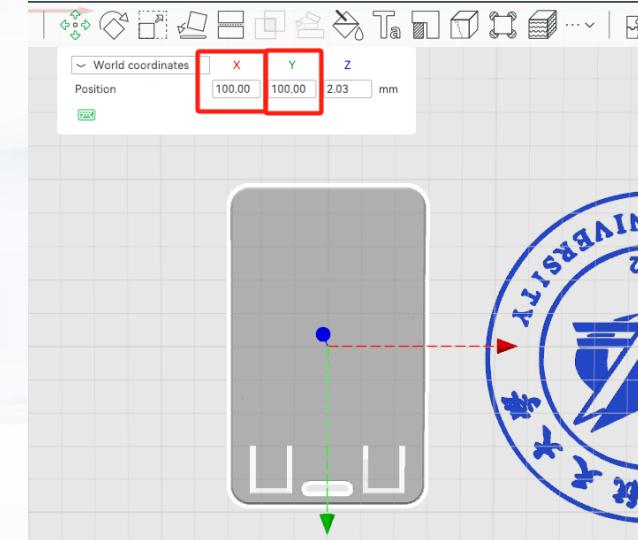
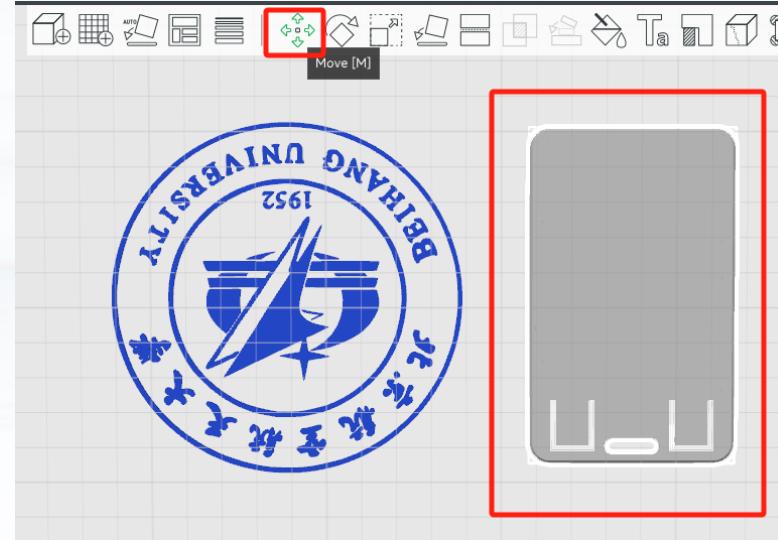
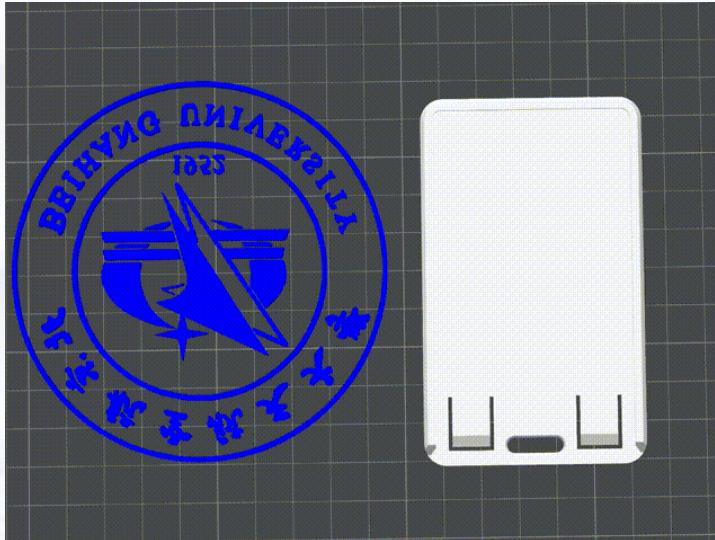
- Enter 180
- Rotate 180 degrees around the Z-axis



# Modeling Workflow

- Experiment 1: IC card holder

## » Step2 Make a Card Holder with a Custom Logo



➤ Press and hold the left mouse button, drag to adjust the view, and move it to the bottom view for easy observation (press and hold the mouse wheel to pan the view).

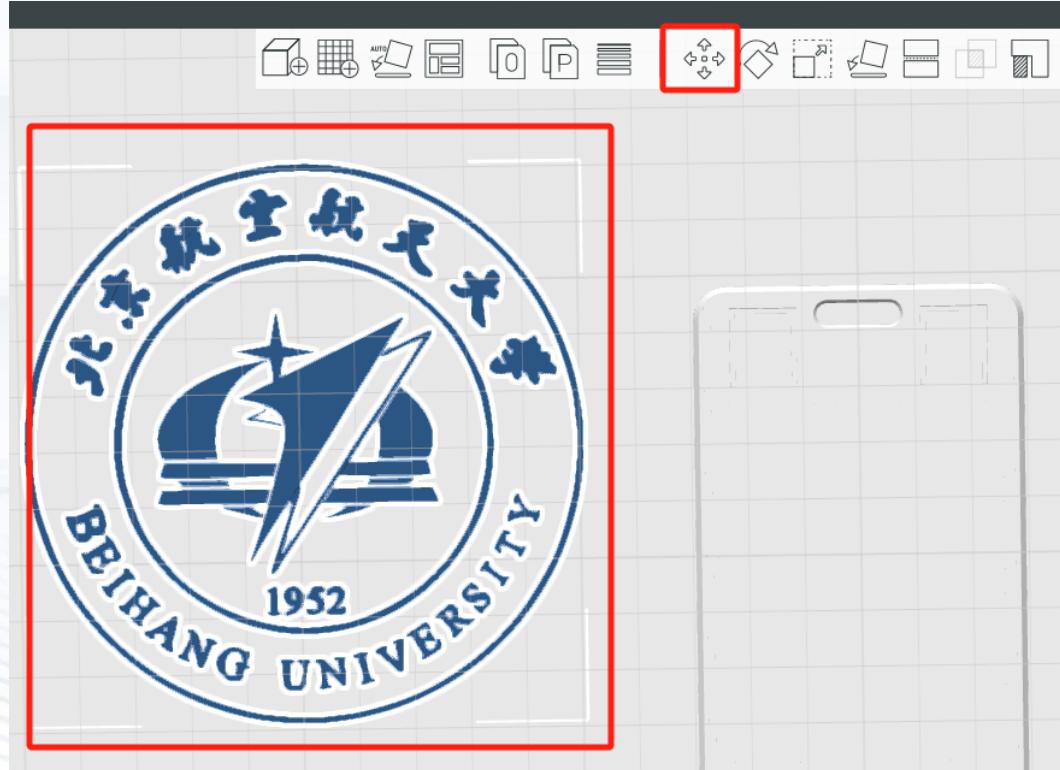
➤ Click the empty card holder to select it, then click the “Move” command.

➤ Enter  $x=100$  and  $y=100$  to position it.



# Modeling Workflow

## » Step2 Make a Card Holder with a Custom Logo



- Select the school emblem model and choose the "Move" command.

- Experiment 1: IC card holder



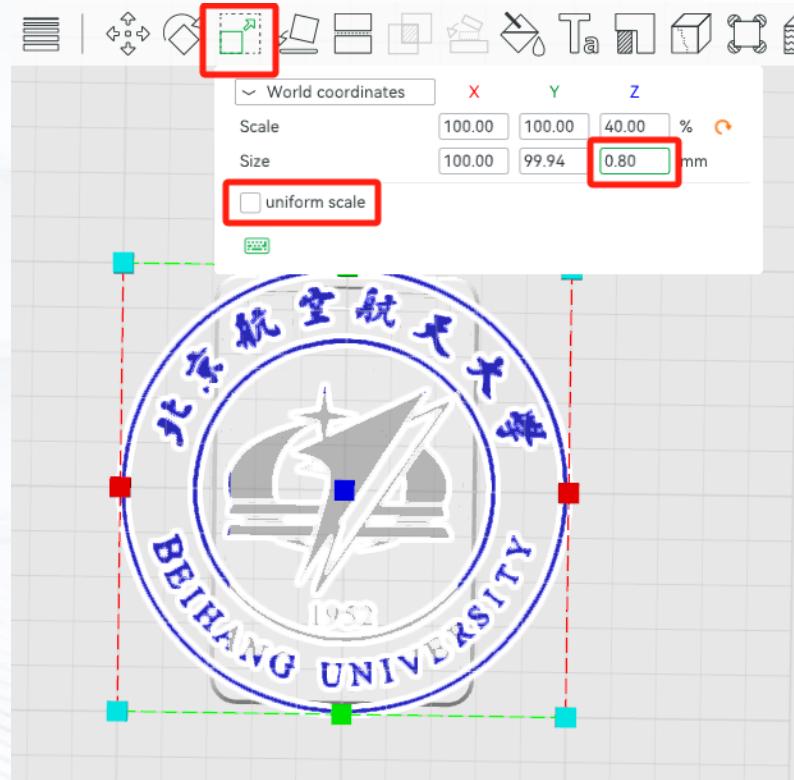
- Enter x=100 and y=100 to position it, aligning the center of the card holder with the school emblem model.



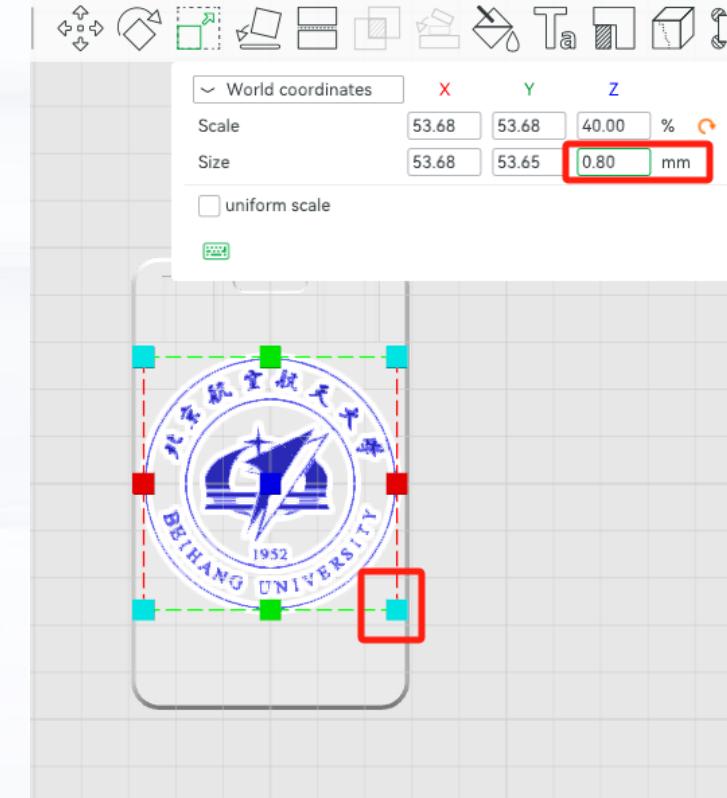
# Modeling Workflow

- Experiment 1: IC card holder

## » Step2 Make a Card Holder with a Custom Logo



- Select the school emblem model and choose the "Scale" command.
- First, uncheck “Uniform Scaling,” then enter 0.8 for the Z-dimension.

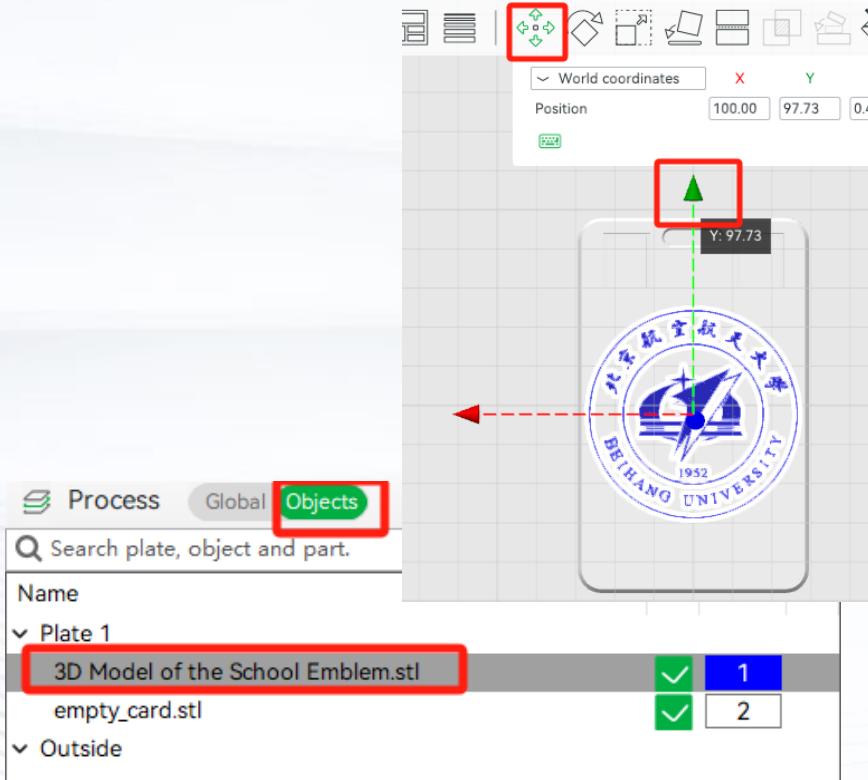


- Drag to scale the school emblem model to an appropriate size.
- Note that the Z-dimension may change after scaling. If it does, re-enter 0.8 to keep the Z-dimension at 0.8



# Modeling Workflow

## » Step2 Make a Card Holder with a Custom Logo



- Experiment 1: IC card holder



- Select the school emblem model (if it is inconvenient to select directly, click the Object Panel on the right side to select it).
- Click the “Move” command.

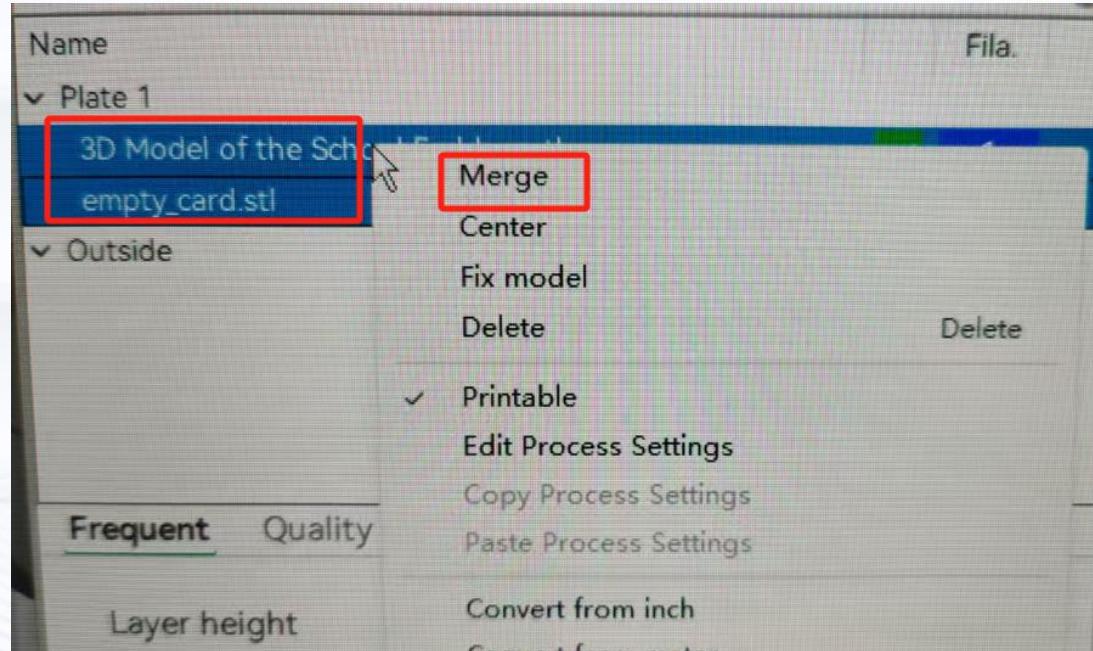
- Drag the Y-axis (green arrow) to place the school emblem model in an appropriate position.



# Modeling Workflow

## » Step2 Make a Card Holder with a Custom Logo

- Experiment 1: IC card holder



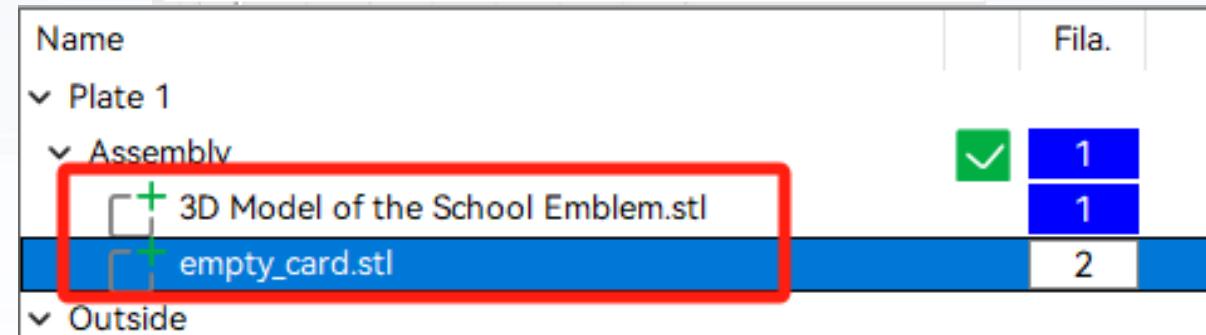
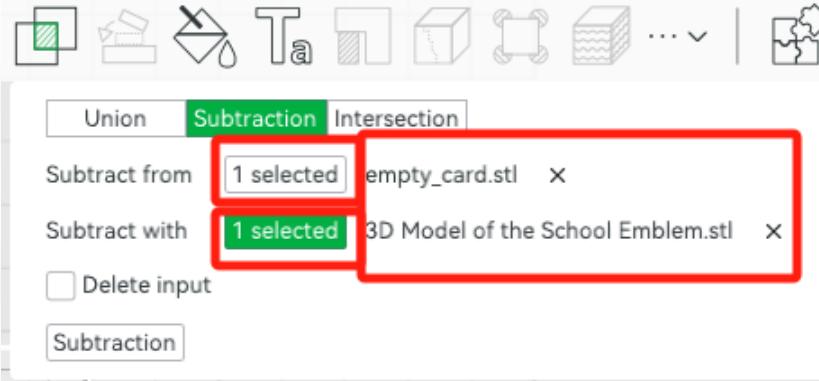
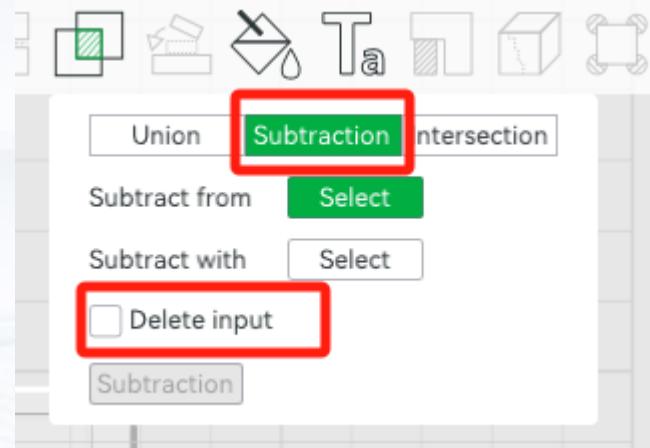
- Hold down Ctrl to select both the empty card holder and the school emblem model.
- Right-click and select "Merge".
- Click the grouped model and select the "Mesh Boolean" option.



# Modeling Workflow

- Experiment 1: IC card holder

## » Step2 Make a Card Holder with a Custom Logo



➤ Click "Subtraction" and uncheck "Delete Input".

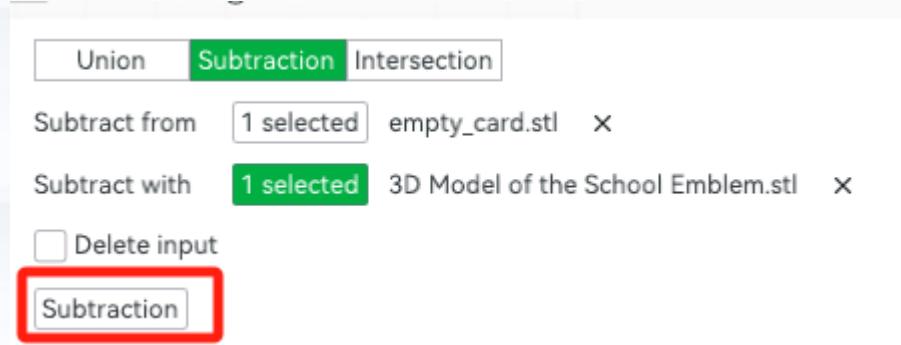
- "Subtract from" select "empty\_card"
- "Subtract with" select "3D Model of the School Emblem"
- (If it's inconvenient to select directly, select it from the object list on the left.)



# Modeling Workflow

- Experiment 1: IC card holder

## » Step2 Make a Card Holder with a Custom Logo



- After confirming everything is correct, select "Subtraction".
- (There may be lag due to **long calculation time**; please wait patiently.)
- Note: Observe the school emblem—if it becomes clear, the Difference operation has succeeded.

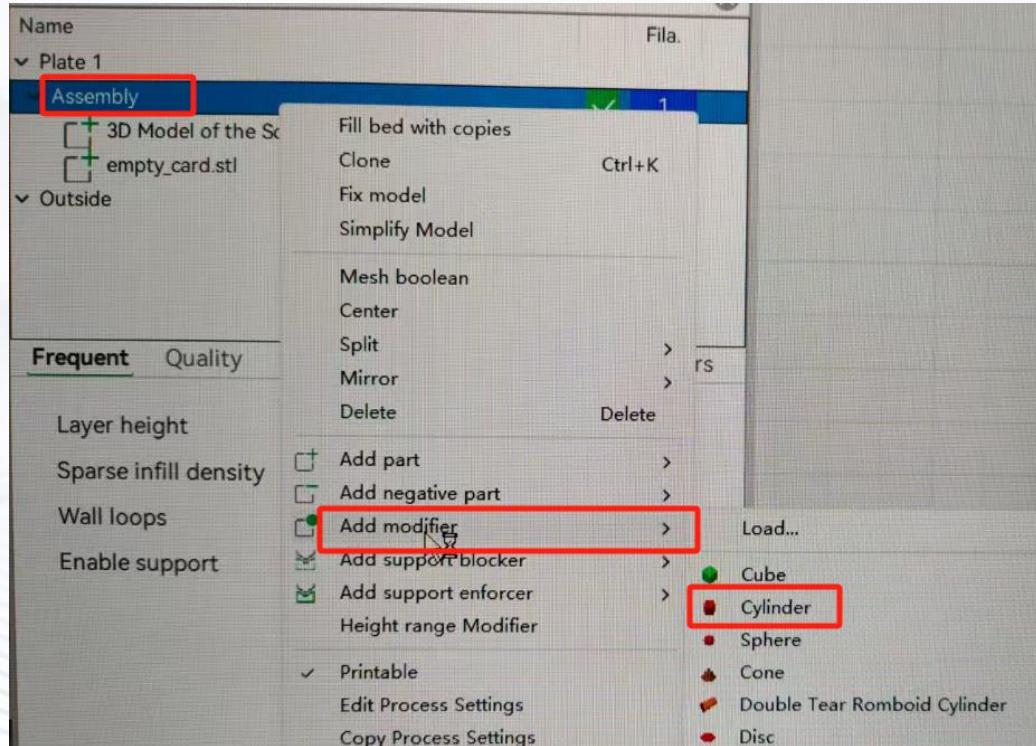
- Once successful, it will look like the image shown below, with a clear surface.



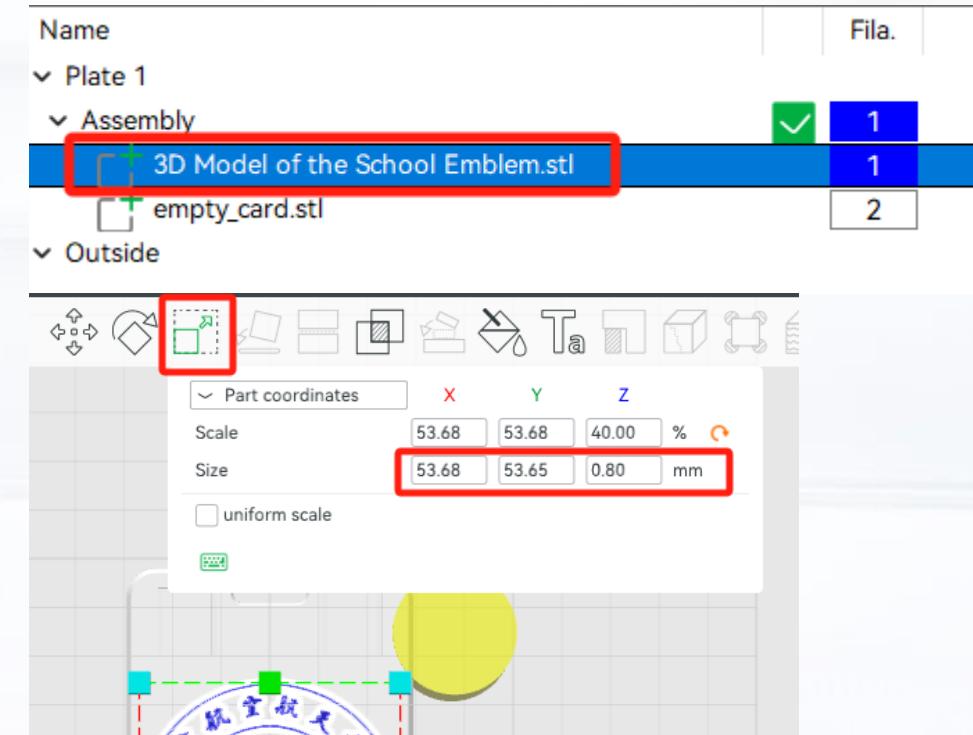
# Modeling Workflow

- Experiment 1: IC card holder

## » Step2 Make a Card Holder with a Custom Logo



➤ Right-click the “Assembly”, select “Add Modifier,” then choose “Cylinder.”



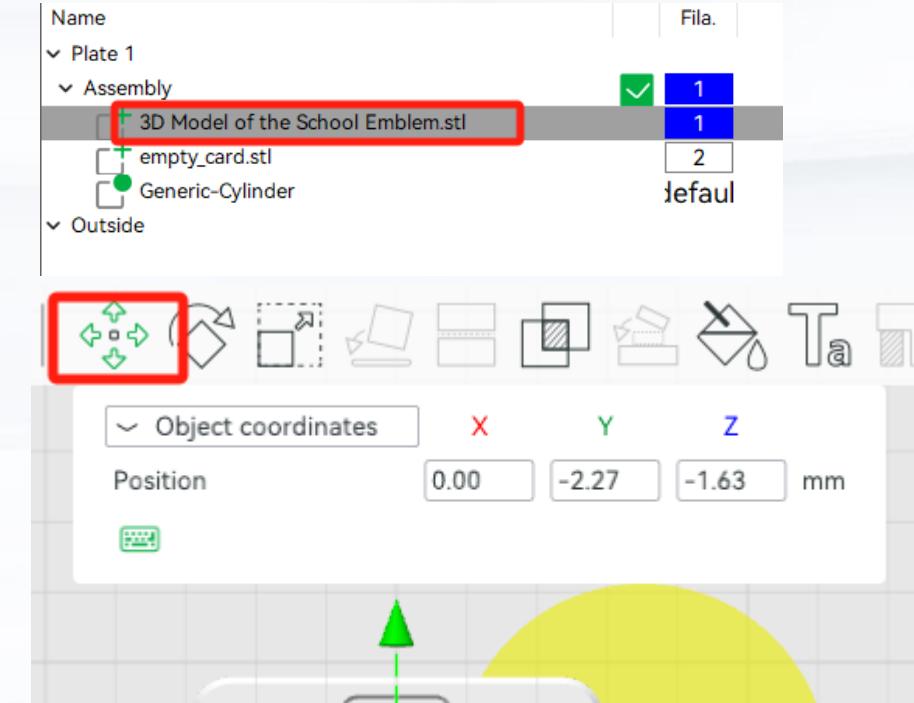
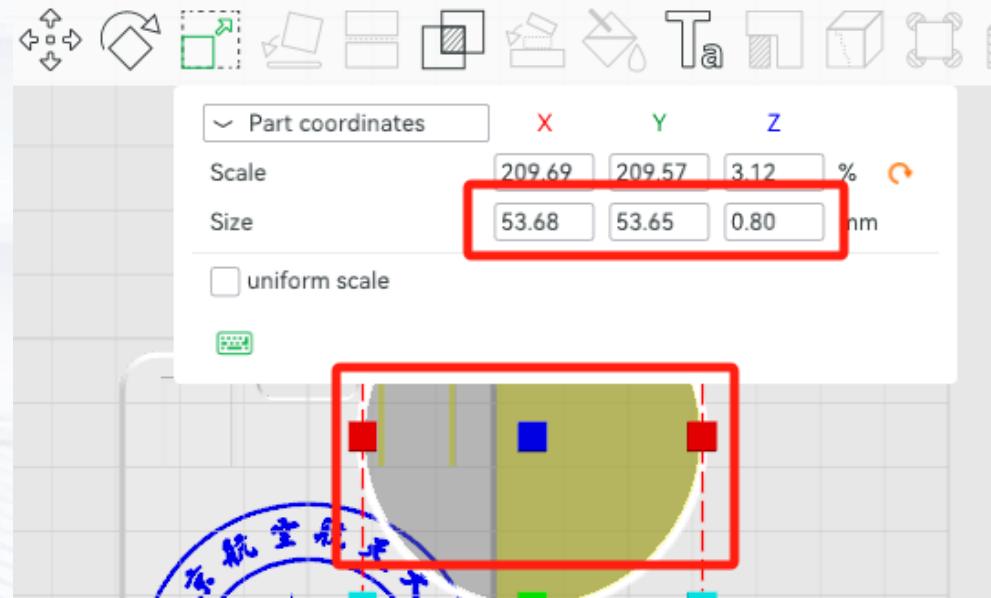
➤ Click the Beihang University emblem model, select the Scale tool, and check its size.



# Modeling Workflow

- Experiment 1: IC card holder

## » Step2 Make a Card Holder with a Custom Logo



➤ Enter the data of the school emblem model to make the modifier match the school emblem model in size.

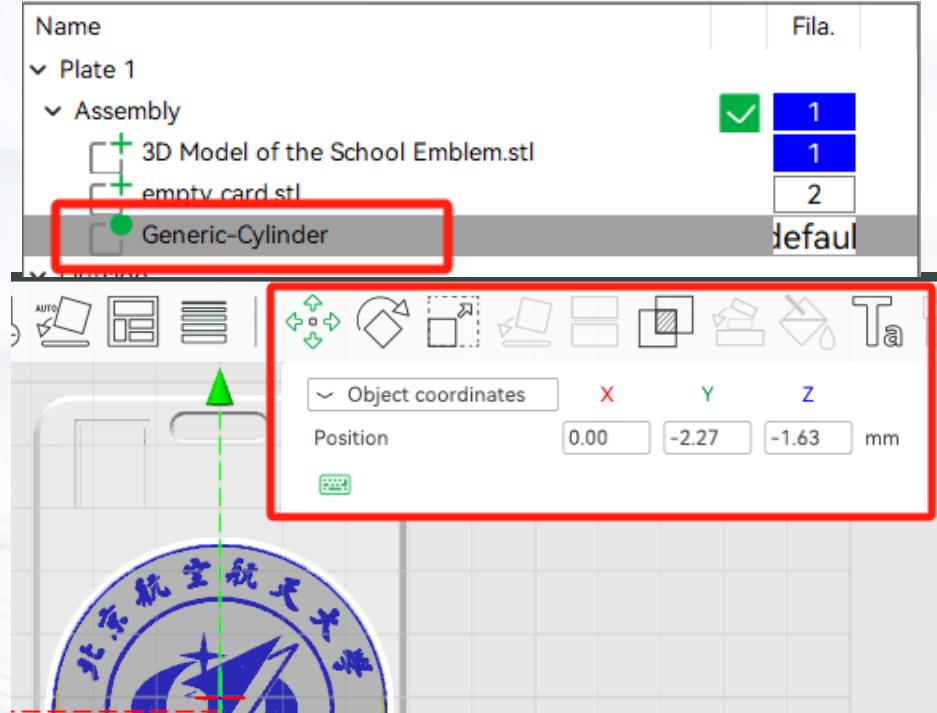
➤ Click the school emblem model, select the “Move” tool, check its position, and remember the position data.



# Modeling Workflow

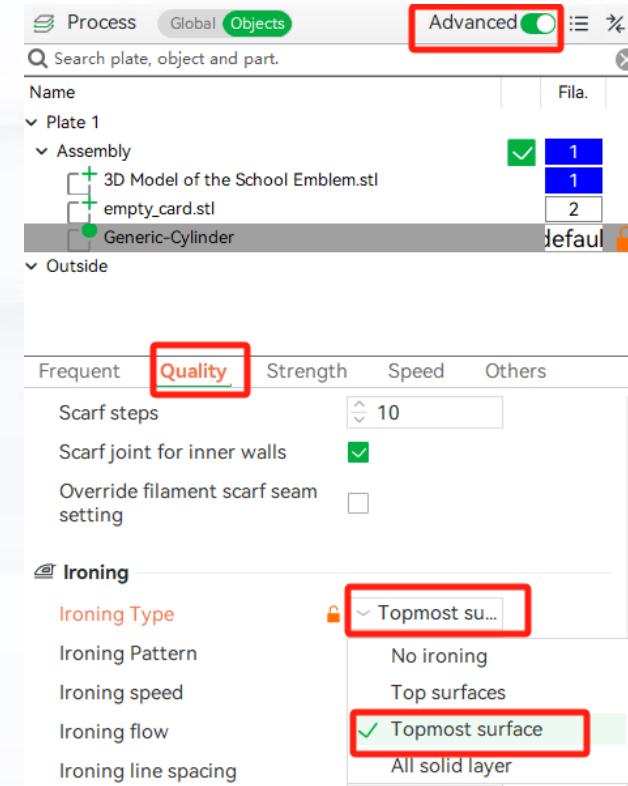
- Experiment 1: IC card holder

## » Step2 Make a Card Holder with a Custom Logo



➤ Select the “Generic-Cylinder”, then enter the position data of the school emblem model to align the modifier with the school emblem model in position.

➤ This concludes the production process.



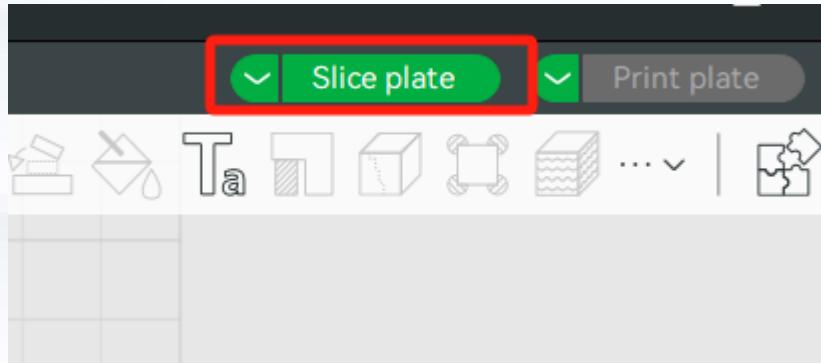
➤ Enable Advanced Mode, select the “Generic-Cylinder”, go to the “Quality” options, choose the “Ironing type” as “Topmost surface,” and keep all other parameters at their default settings.



# Modeling Workflow

## » Step3 Slice plate

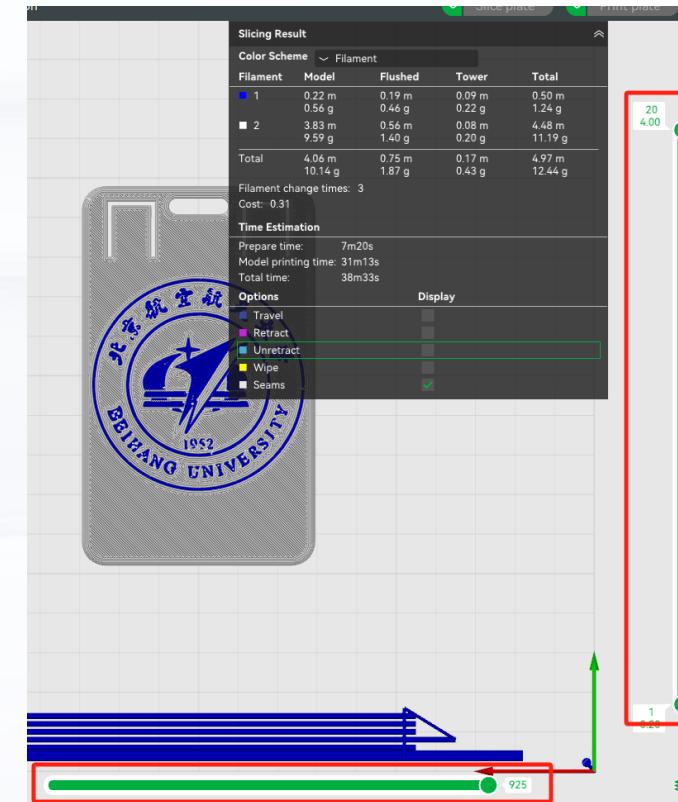
- Click “Slice plate”



If you are still unable to complete the model modification based on the above steps, you can also refer to the **operation video** we provided.

IC\_Card Holder\_6 mins.mp4

- Experiment 1: IC card holder



- Slicing completed successfully. Drag the sliders at the bottom and right side to view the toolpath of each layer.



# Modeling Workflow

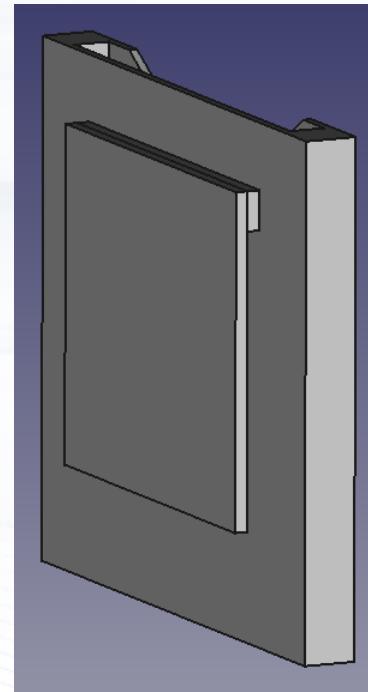
- Experiment 2: NFC Card Slot

## » Experimental Objective: Complete the Modeling of the NFC Card Slot

*Starting from this page, the remaining operations are optional for international students!!!*



➤ Original card slot



NFC card slot



➤ Result

### Functions of the Expansion Accessory:

It is compatible with both the card holder made in our class and the one provided by the school. There is **no need to remove the card holder**—you can directly insert it into the expanded induction slot to get hot water.

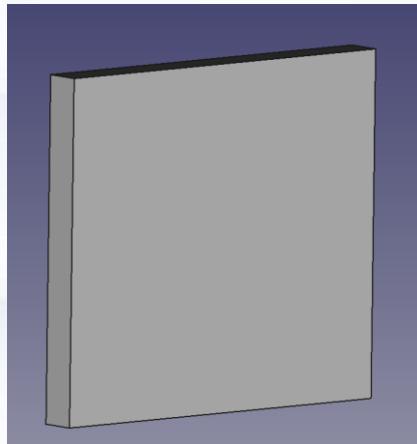
The latch on the back fits tightly into the original card slot, ensuring the card slot expansion accessory is securely installed.



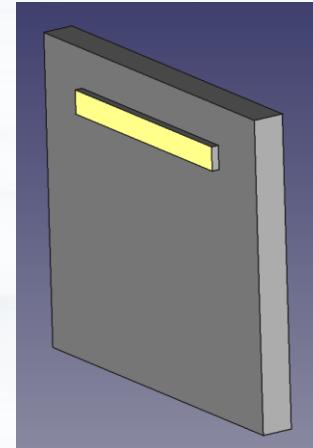
# Modeling Workflow

- Experiment 2: NFC Card Slot

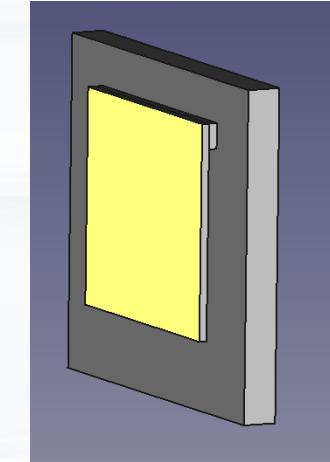
## Modeling Steps



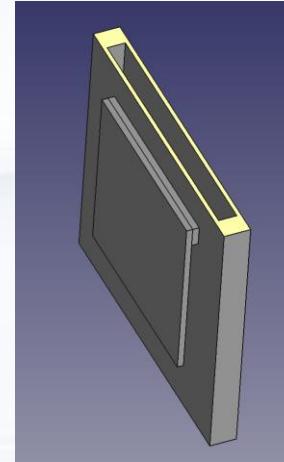
①



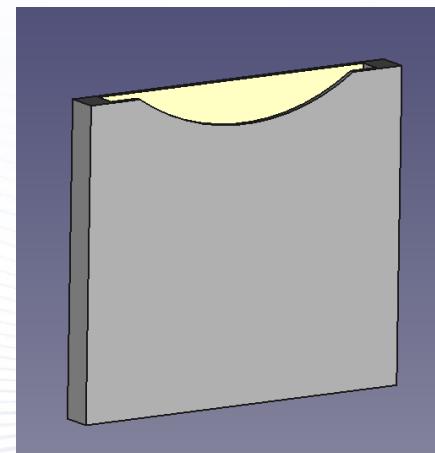
②



③



④



⑤

- Decompose the model into a **combination of simple geometric shapes**, **add features incrementally**, and complete the final modeling process.
- Once the steps are confirmed, the next steps are dimension measurement and drawing.



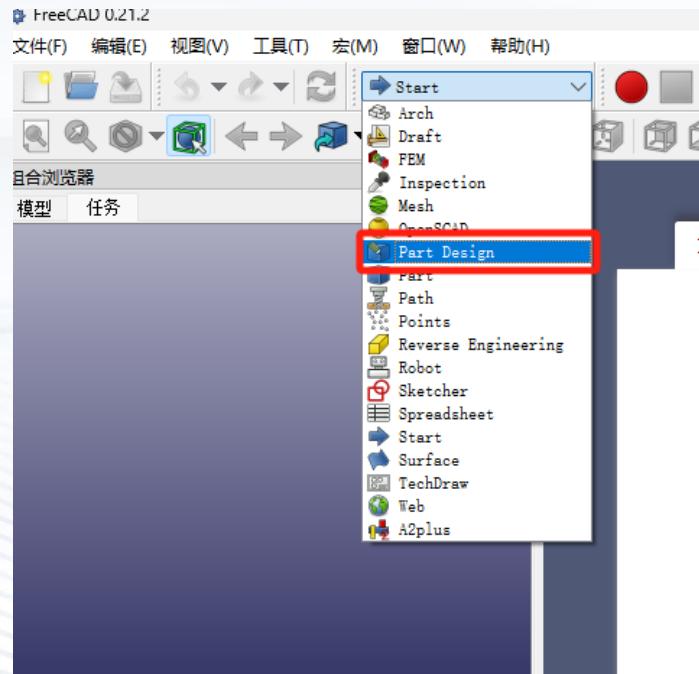
# Modeling Workflow

## • Experiment 2: NFC Card Slot

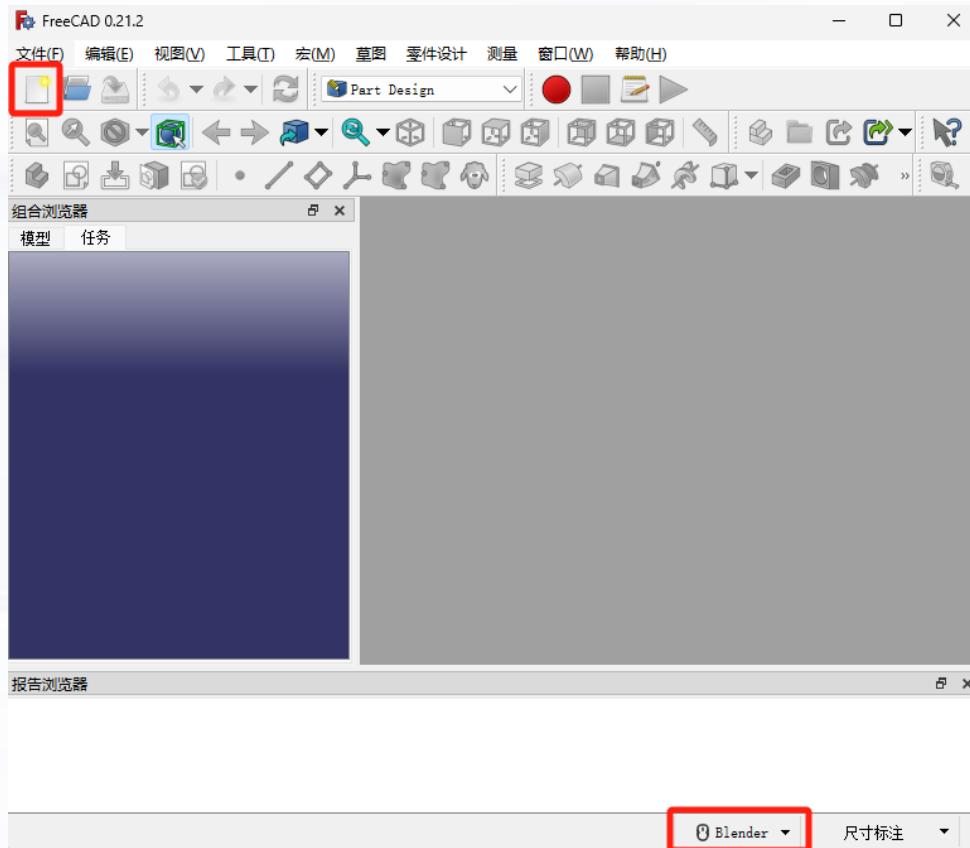
### » Create a New Part



➤ Open FreeCAD



➤ Selectg “Part Design” mode.



➤ Click "New Blank File". For the mouse control mode, you can select Blender Mode. (When drawing a part, hold down the middle mouse button and drag to rotate the model; hold down both the left and right mouse buttons and drag to pan the model; roll the mouse wheel to zoom in or out.)



# Modeling Workflow

## • Experiment 2: NFC Card Slot

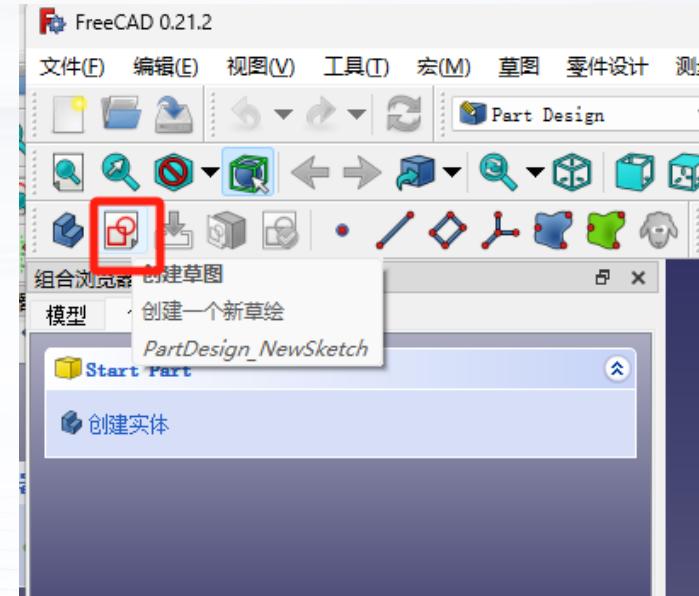
### » Step 1: Model a Cube

Measure the dimensions

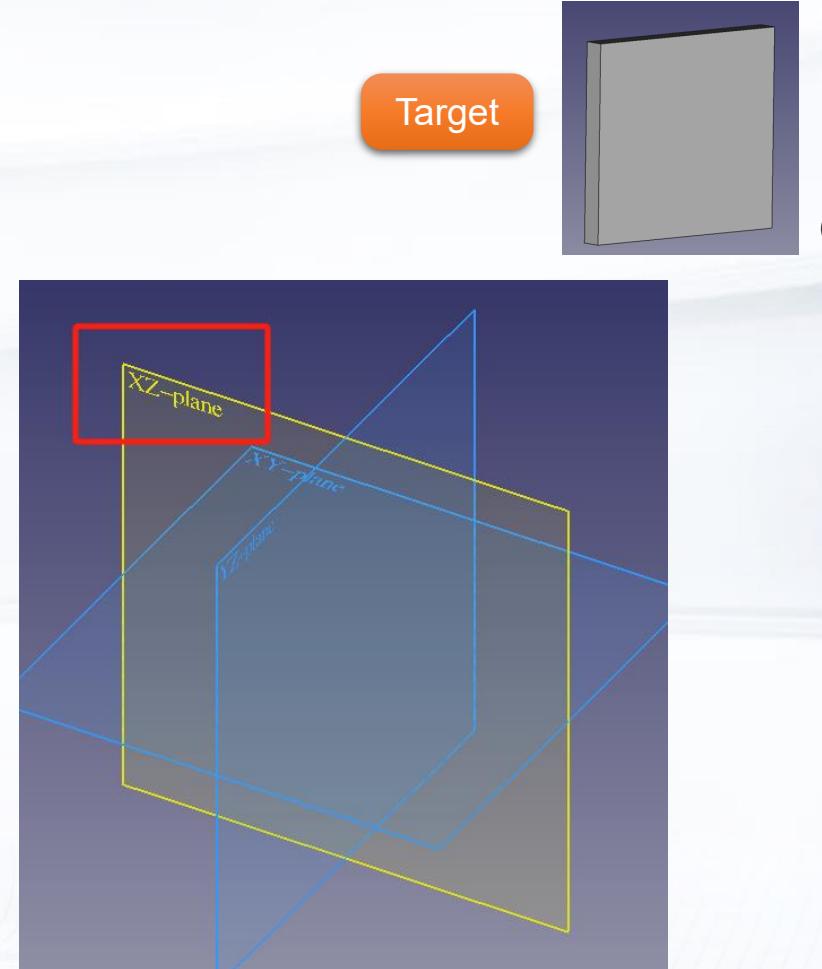


- Considering that the card holder should fit easily into the card slot, you can draw a wide cube. An estimated length of 88 (units) and width of 78 (units) will provide sufficient space to accommodate the card holder.

Draw a sketch, then extrude it—either by adding or subtracting material—to form a 3D solid.

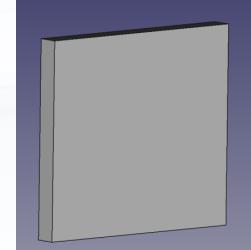


- Click "Create Sketch"



- Select the XZ plane

Target



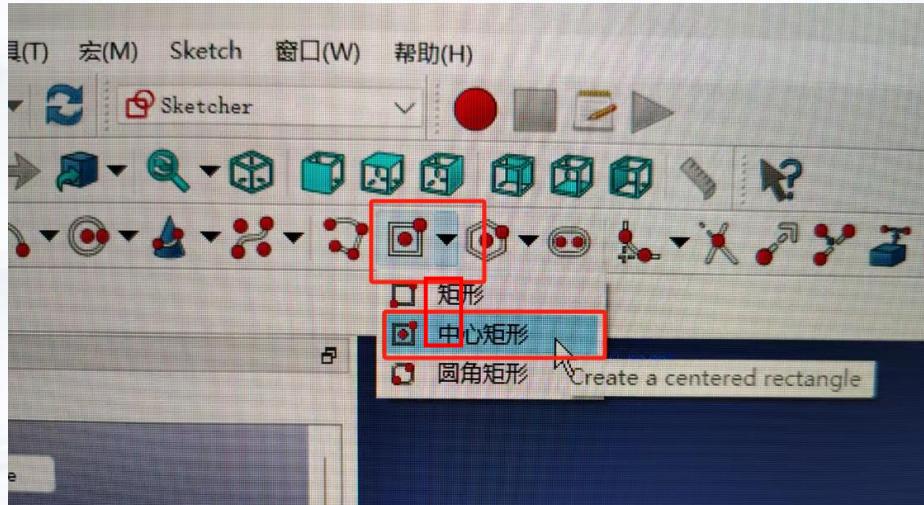
①



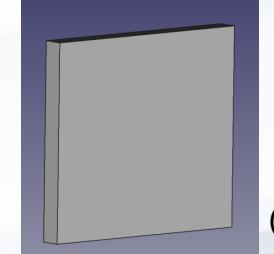
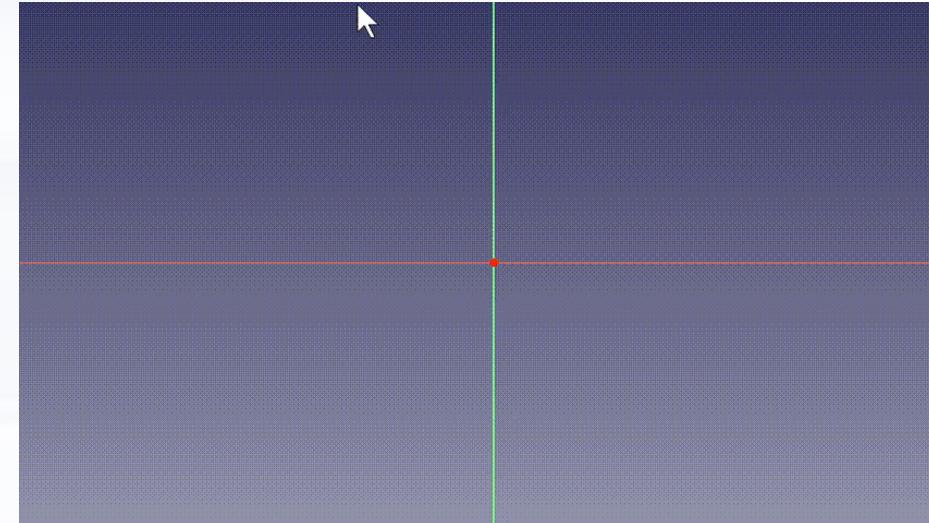
# Modeling Workflow

## • Experiment 2: NFC Card Slot

### » Step 1: Model a Cube



- Select the "Center Rectangle" command
- Tips: If you make a mistake while drawing, press Ctrl+Z to undo it.



Target

- Select the origin and click the left mouse button. Move the mouse to expand the rectangle, then click the left mouse button again at any position to draw the rectangle. Press Esc to exit the rectangle drawing mode.
- Tips: Draw using the left mouse button. After finishing the drawing, press Esc to exit the drawing (of the shape), **but do not exit the sketch drawing mode**.



# Modeling Workflow

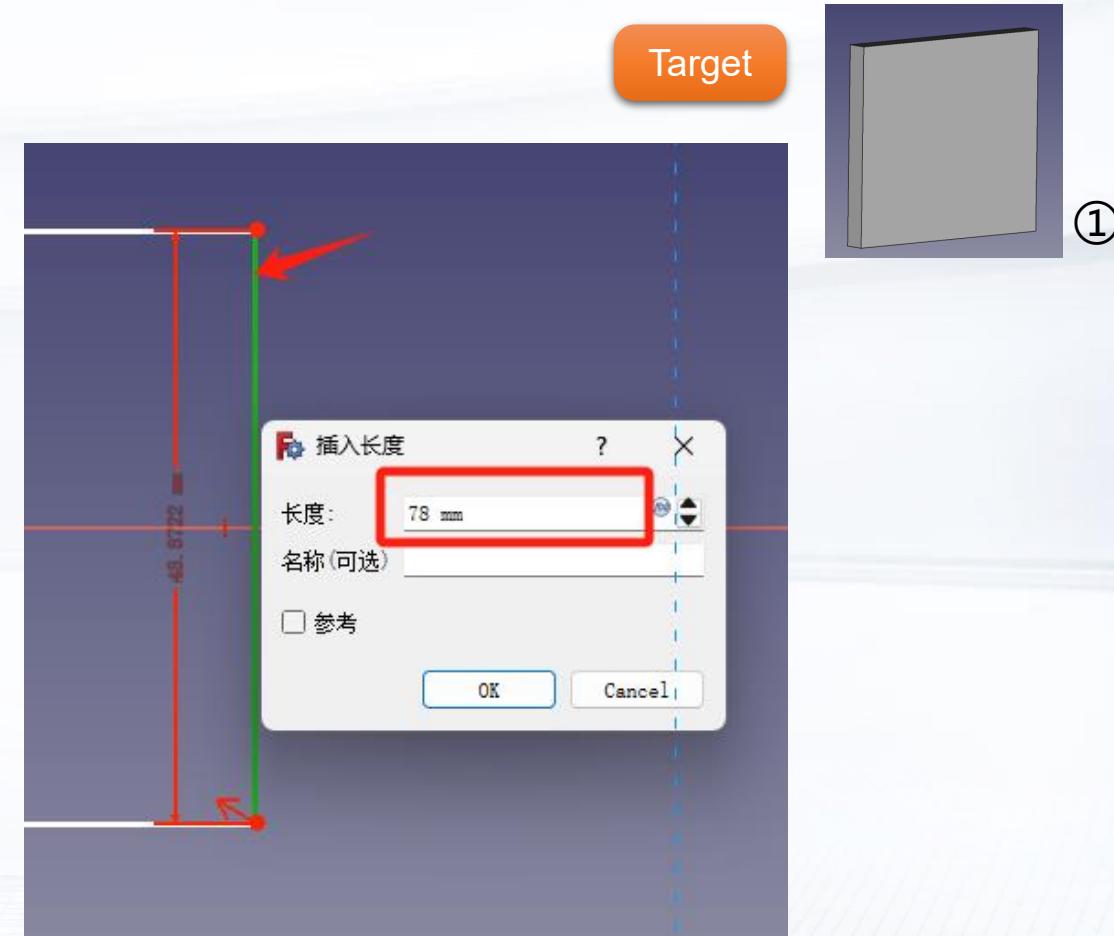
## » Step 1: Model a Cube

Constraints are restrictive conditions applied to the position and dimensions of a sketch. It is generally recommended to aim for full constraint. When fully constrained, the sketch has two degrees of freedom (this can be viewed in the solver information on the left side).



➤ Select "Limit Vertical Distance"

## • Experiment 2: NFC Card Slot

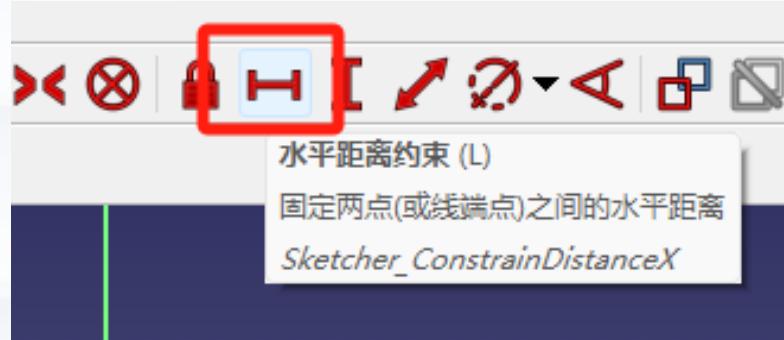


➤ Click the vertical edge of the rectangle, then enter the dimension "78".

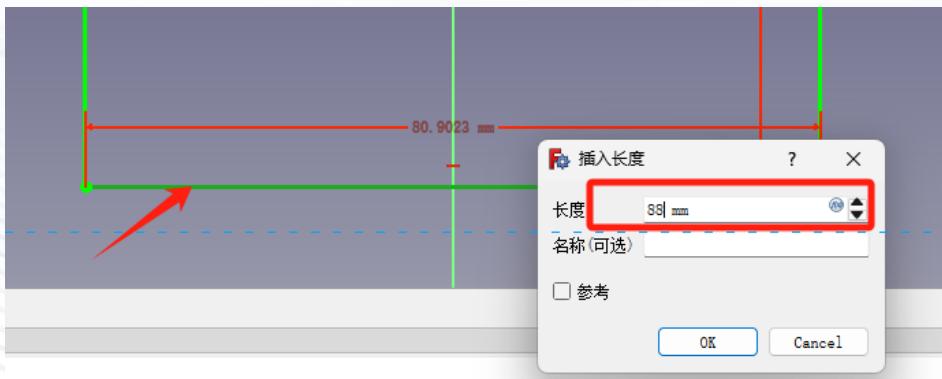


# Modeling Workflow

## » Step 1: Model a Cube

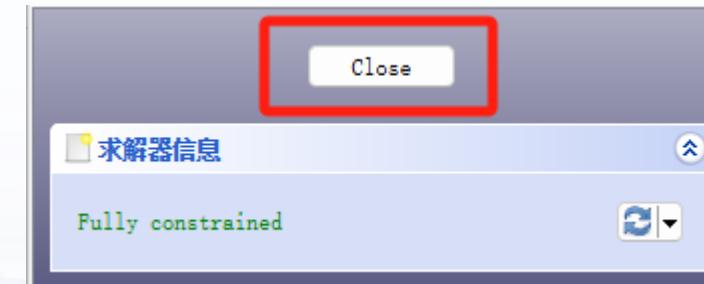
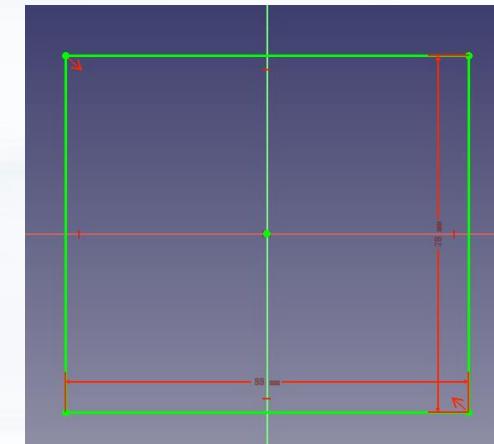
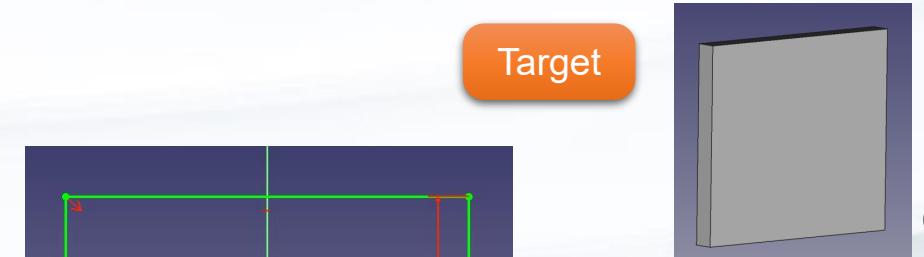


➤ Select the "Limit Horizontal Distance" constraint



➤ Enter the dimension "88"

## • Experiment 2: NFC Card Slot



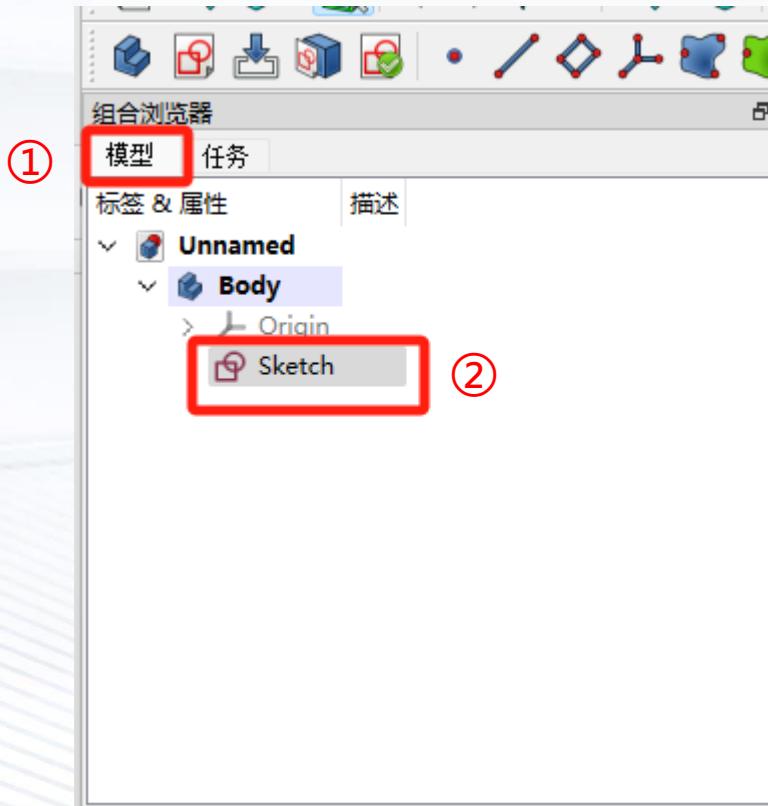
➤ The rectangle will turn green, and the solver will show "Fully Constrained". Click "Close" to finish the sketch drawing.



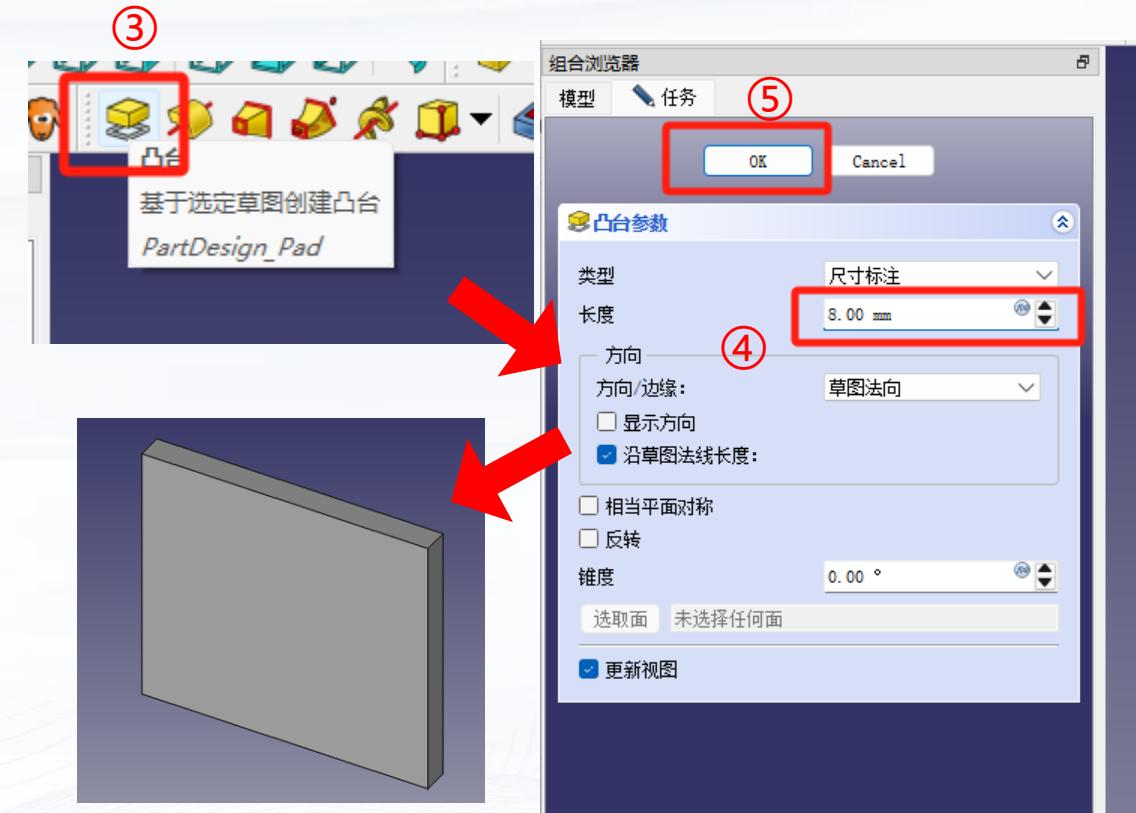
# Modeling Workflow

## • Experiment 2: NFC Card Slot

### » Step 1: Model a Cube



➤ Select the sketch you just drew



- Select the "Boss" command and enter a length of 8mm.
- The cube is now drawn.

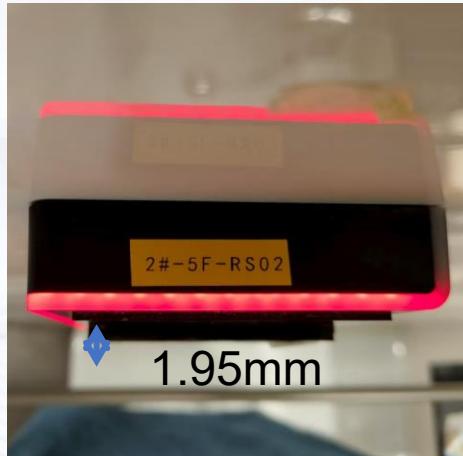


# Modeling Workflow

- Experiment 2: NFC Card Slot

## » Step2 Add a Limit Pin Support to the Cube

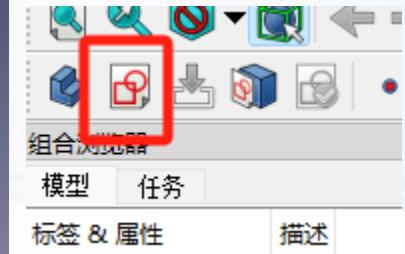
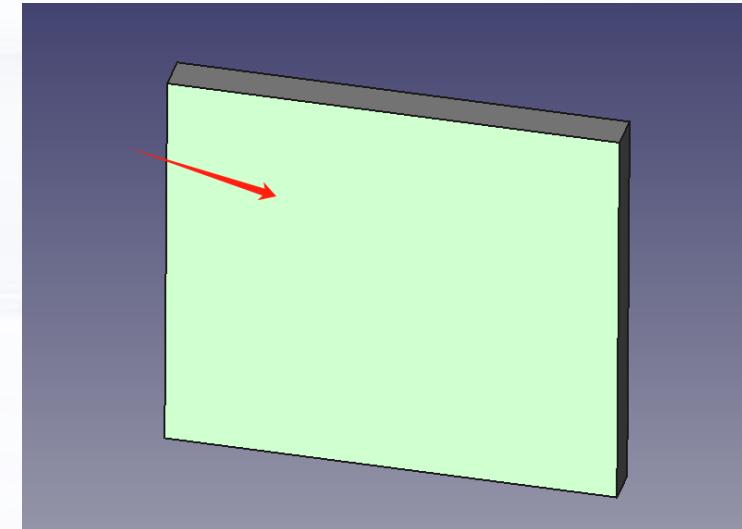
Measure the dimensions



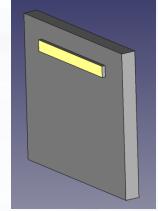
Inner width of the slot 1.84mm



- The inner slot length is 58.1 (mm). We will draw a 57 (mm) latch to insert into the card slot.
- First, draw the latch support with a thickness of 1.95 (mm).



- Select the back face, click "Sketch" (or "Start Sketching"), and draw a sketch on the back face.



Target

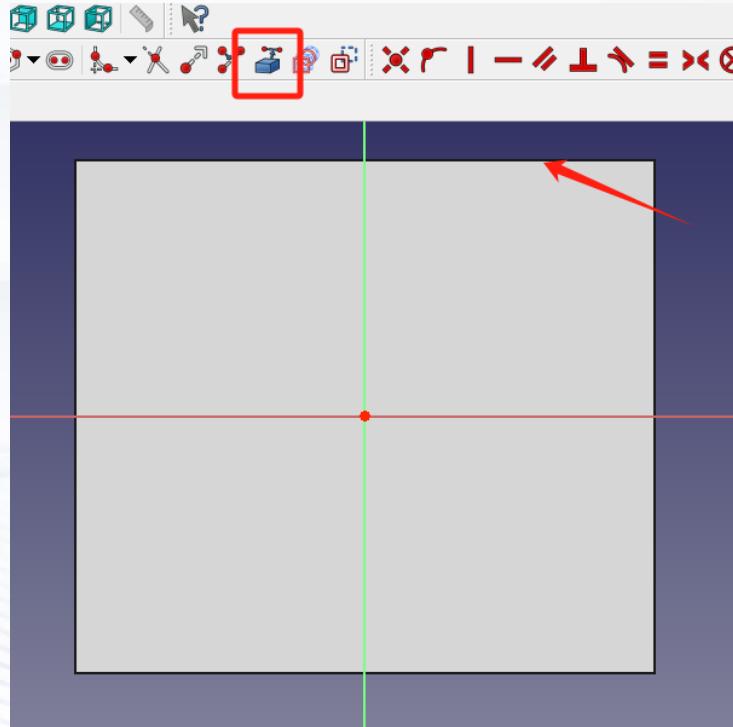
②



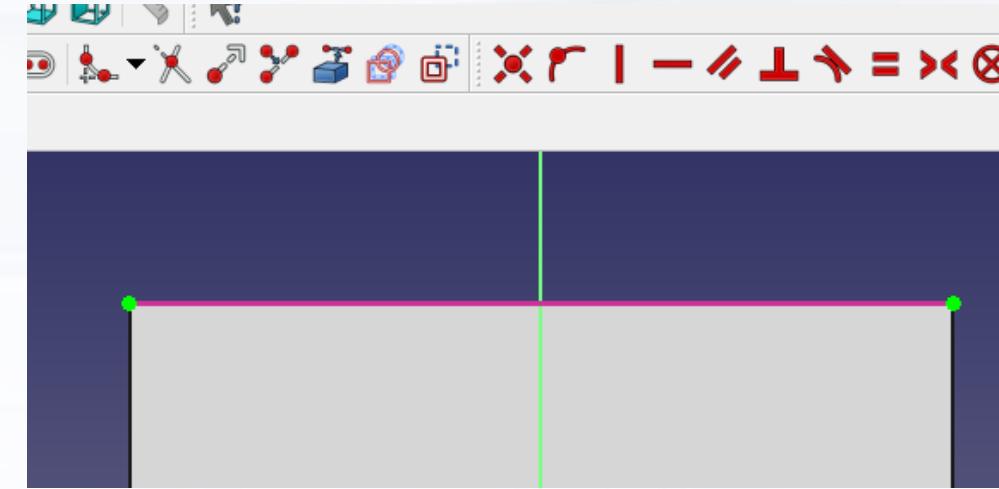
# Modeling Workflow

- Experiment 2: NFC Card Slot

## » Step2 Add a Limit Pin Support to the Cube

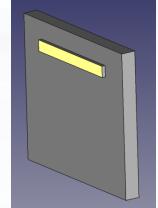


- Select the "External References" command and add reference lines.
- Select the upper edge



- Once the addition is complete, press the Esc key to exit the command. The external reference lines will appear purple.

Target



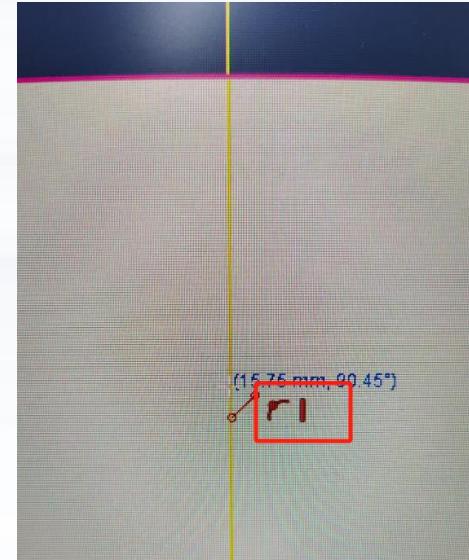
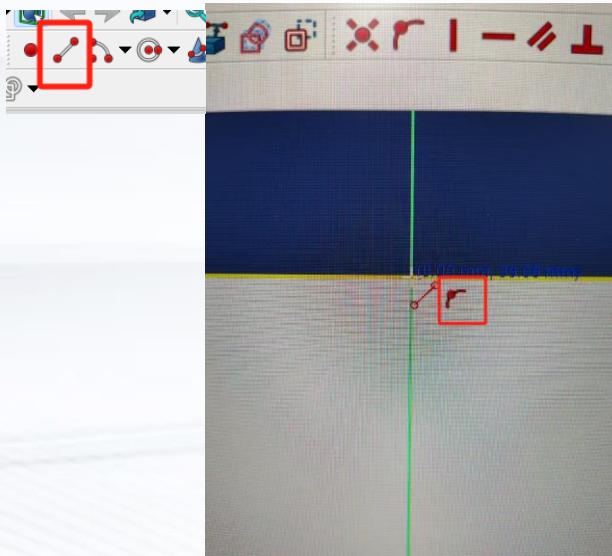
②



# Modeling Workflow

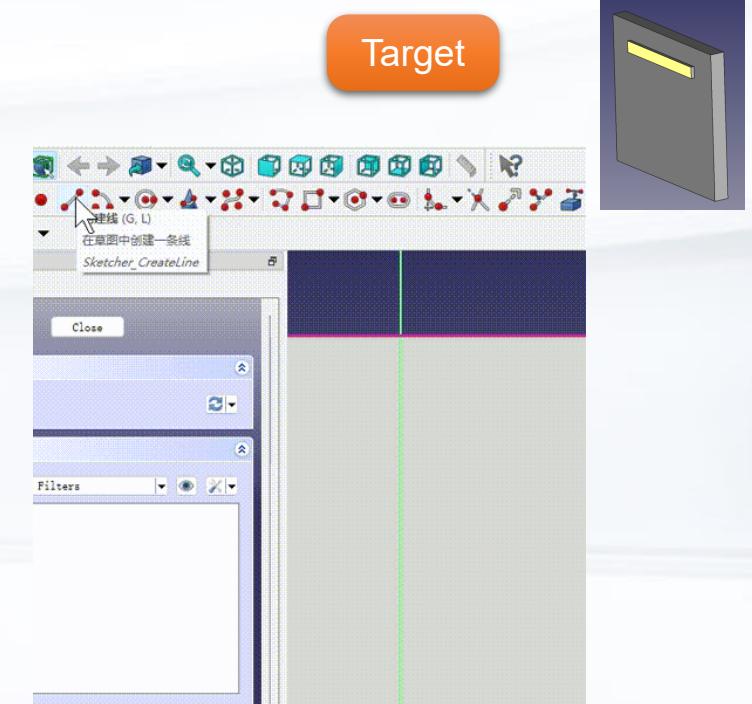
## • Experiment 2: NFC Card Slot

### » Step2 Add a Limit Pin Support to the Cube



➤ Select the Line tool. Position the mouse at the midpoint of the purple reference line and click the left mouse button (note that a "point-on-line" symbol should appear next to the cursor).

➤ Move the mouse downward, and select any position on the center line (note that both the "point-on-line" symbol and the "vertical" symbol should appear next to the cursor).



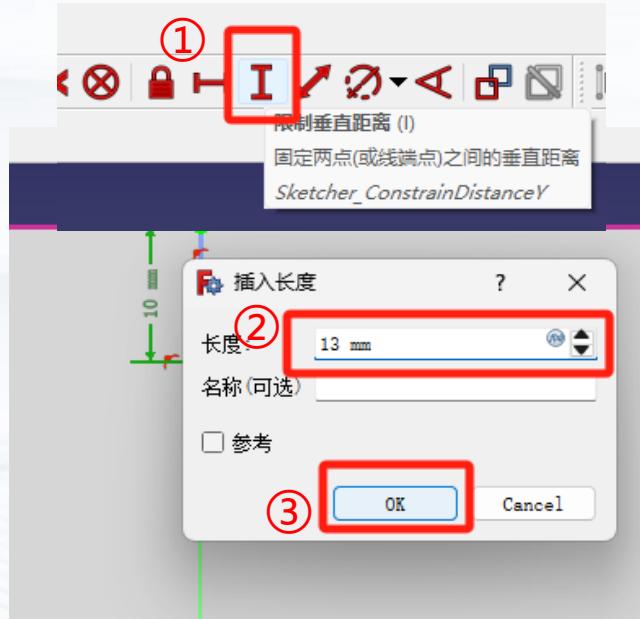
- The animation operation is as above (if two constraint symbols do not appear at the end of the line, move the mouse up and down near the center line—this will make the two symbols appear).
- Press Esc to finish drawing the line.



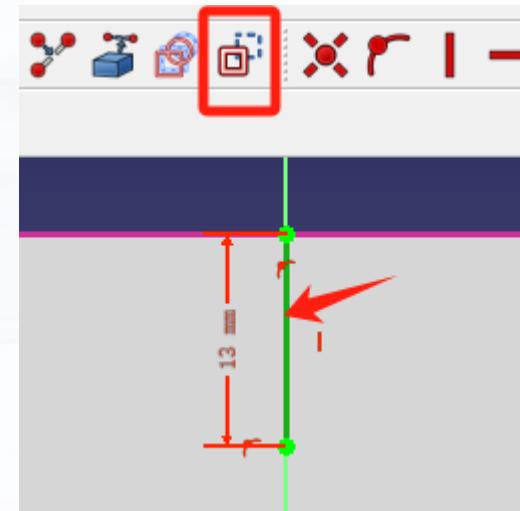
# Modeling Workflow

## • Experiment 2: NFC Card Slot

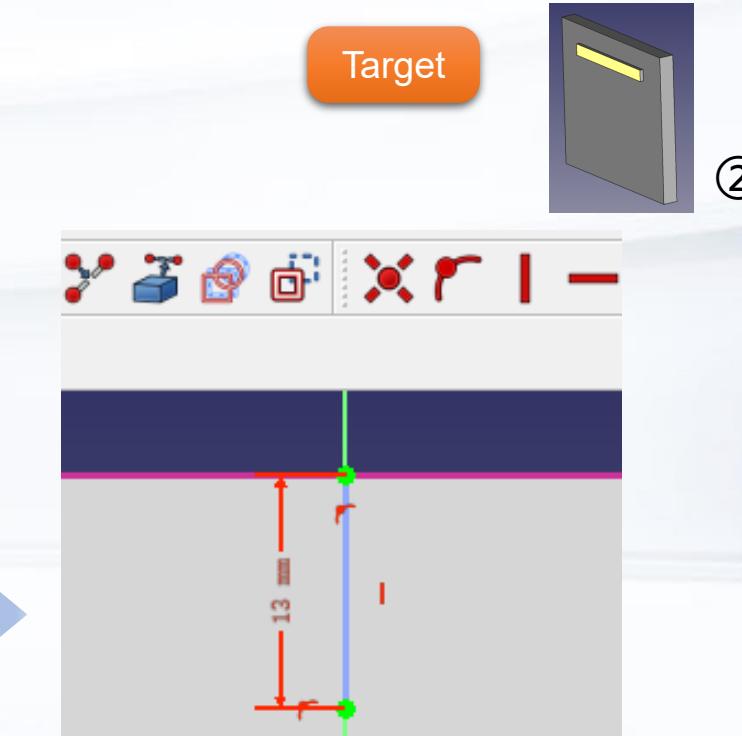
### » Step2 Add a Limit Pin Support to the Cube



- Select the "Vertical Distance" constraint, click the line you just drew, and enter 13mm.
- After clicking "OK", press Esc to exit the constraint command.



- After clicking "OK", press Esc to exit the constraint command.



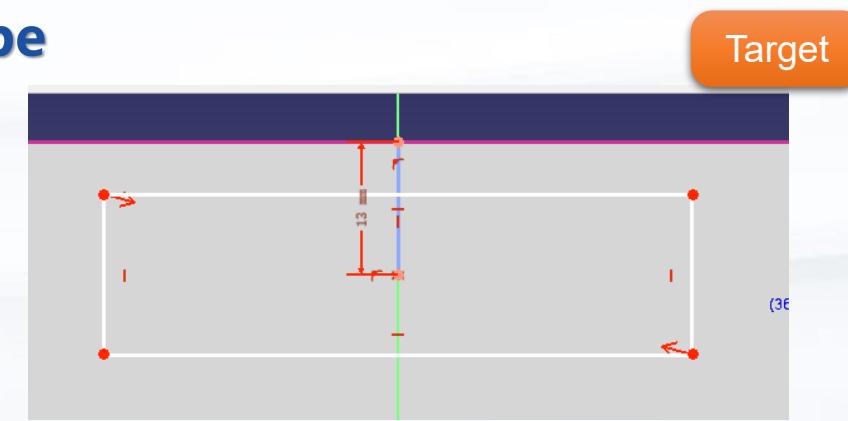
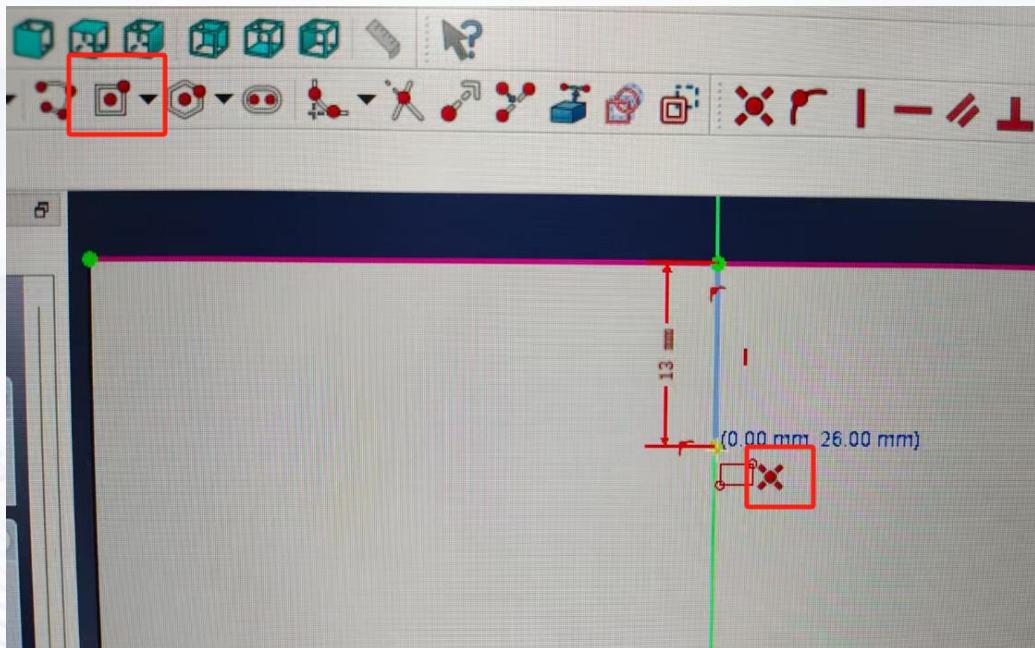
- The auxiliary lines are light blue.



# Modeling Workflow

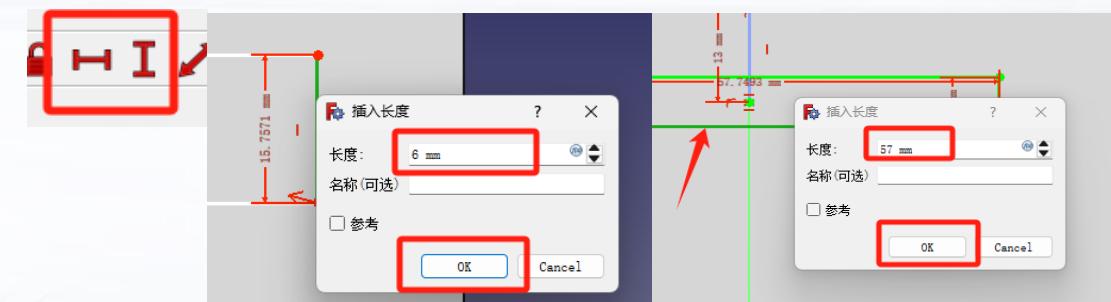
## • Experiment 2: NFC Card Slot

### » Step2 Add a Limit Pin Support to the Cube



②

➤ Draw a rectangle



➤ Select the "Center Rectangle" command, then click the endpoint of the line you just drew (a coincident constraint symbol should appear next to the cursor).

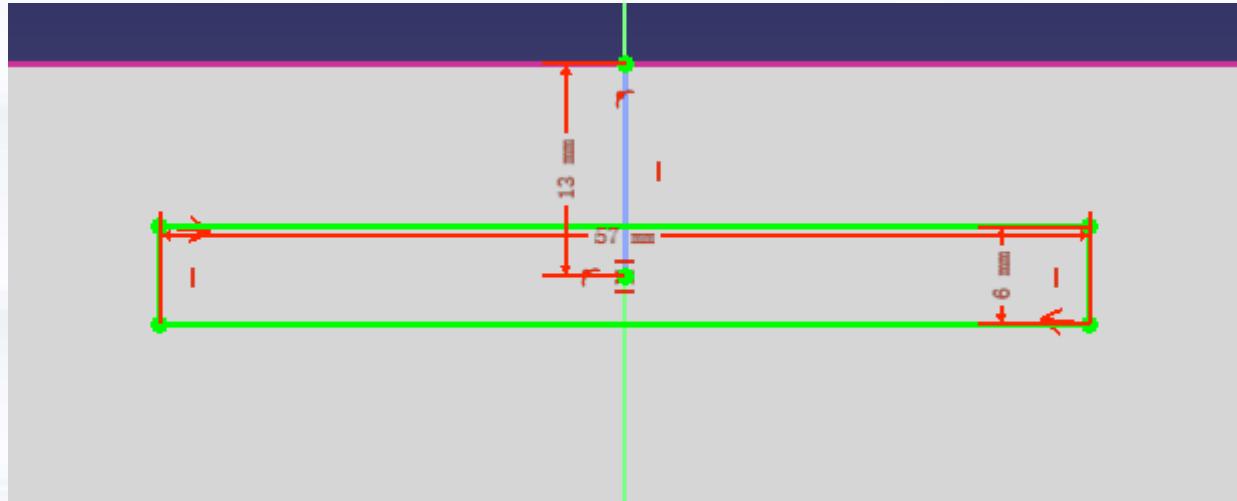
➤ Use the Distance constraint: select the two opposite sides of the rectangle respectively, enter a length of 57 (slightly smaller than the card slot) and a width of 6 (customizable; ensure it is sturdy enough for 3D printing).



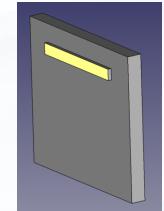
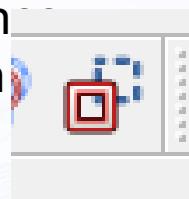
# Modeling Workflow

## • Experiment 2: NFC Card Slot

### » Step2 Add a Limit Pin Support to the Cube



- Complete the sketch as shown in the figure. The auxiliary lines are light blue, and the solid lines (which can be extruded for material addition or subtraction) are green.
- If the rectangle is light blue, select the lines and use the "Toggle Reference/Solid Line" command to switch the line type.



②

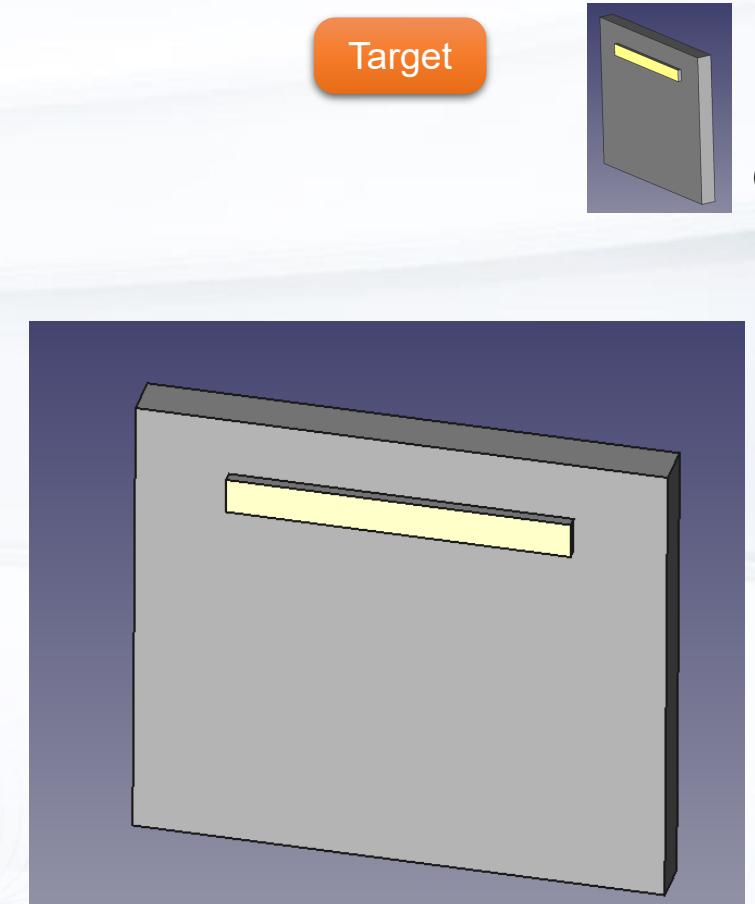
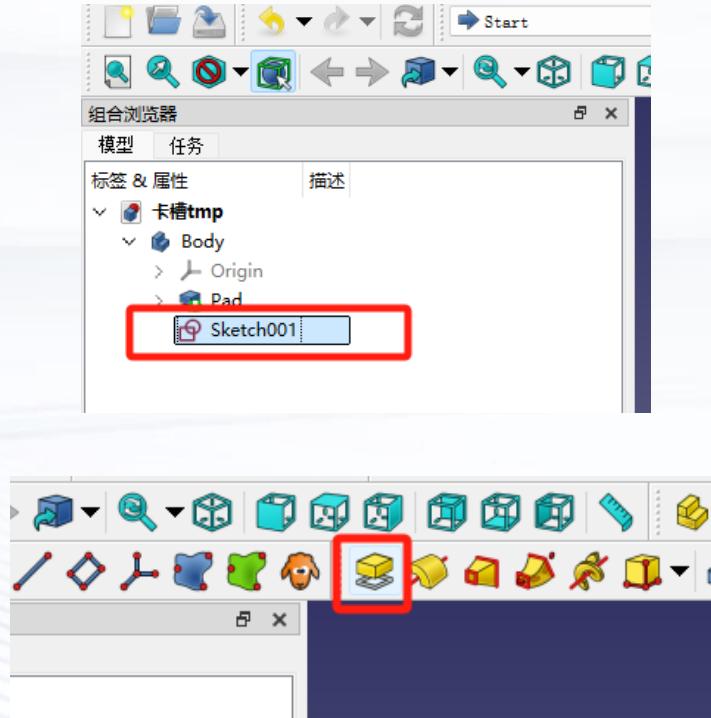
- If the solver shows "Fully Constrained," the sketch is normal.s
- Click "Close" to exit the sketch.



# Modeling Workflow

## • Experiment 2: NFC Card Slot

### » Step2 Add a Limit Pin Support to the Cube



➤ Select the sketch and click the "Boss" command.

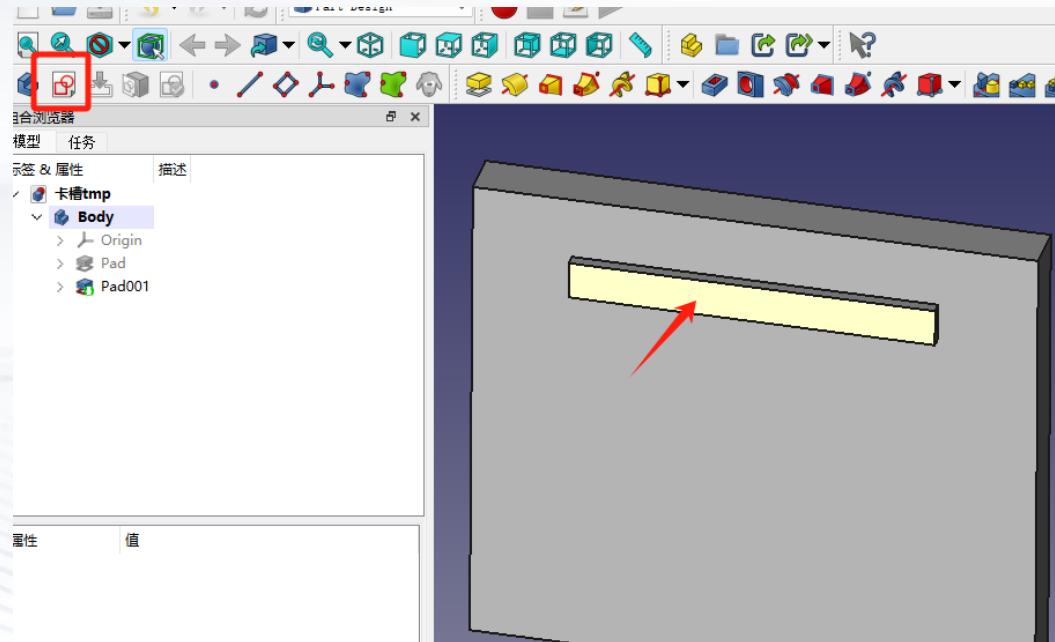
➤ Enter a dimension of 1.95 (the thickness of the card slot surface), then click "OK" to complete the boss extrusion.



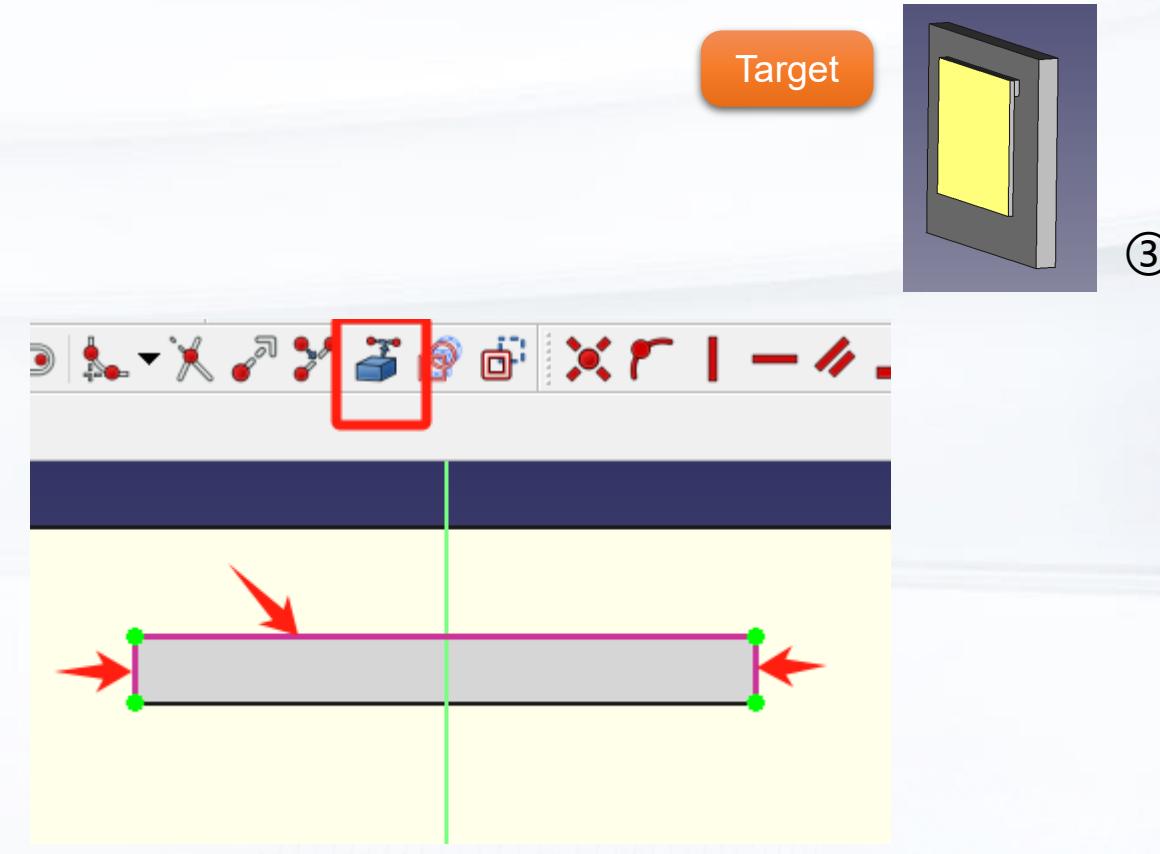
# Modeling Workflow

- Experiment 2: NFC Card Slot

## » Step3 Add a limit pin to the cube



➤ Select the latch support surface and click the "New Sketch" command.



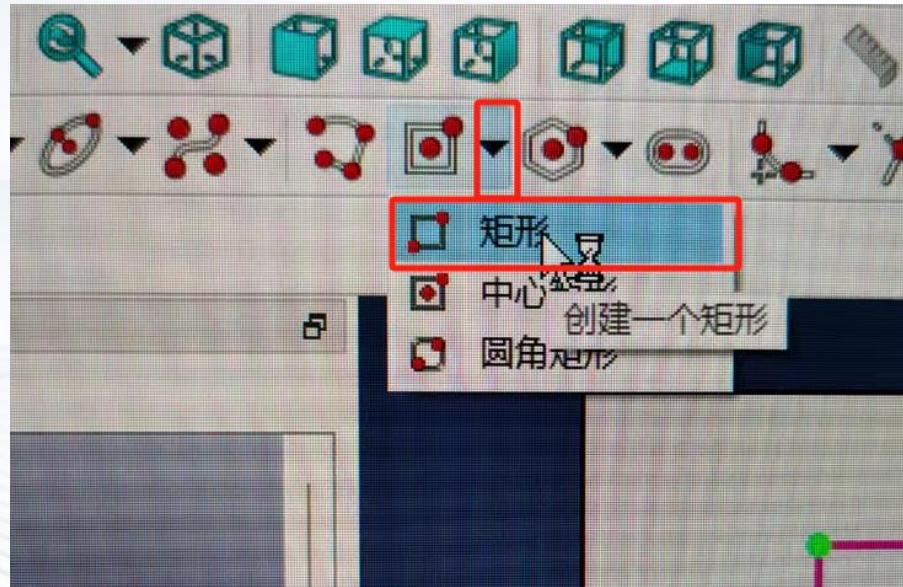
➤ Click the "External References" command, then select the three edges of the latch support.



# Modeling Workflow

## • Experiment 2: NFC Card Slot

### » Step3 Add a limit pin to the cube



- Select the "Corner Rectangle" command.



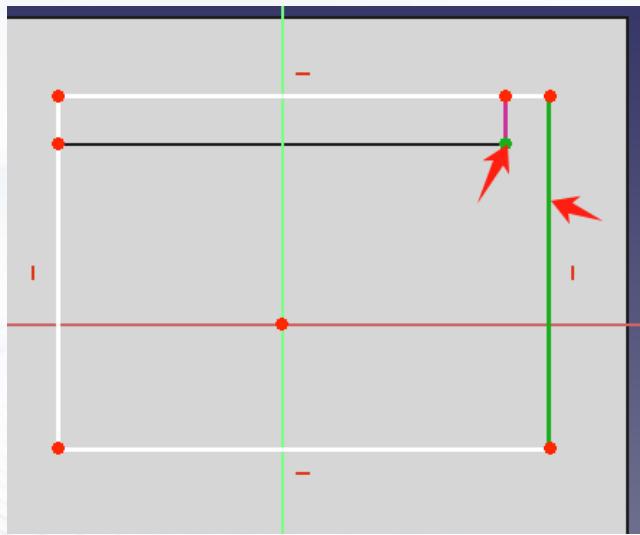
- Select the top-left vertex (note that a coincident constraint symbol should appear next to the cursor), then drag to create a rectangle—you can place the bottom-right vertex freely.



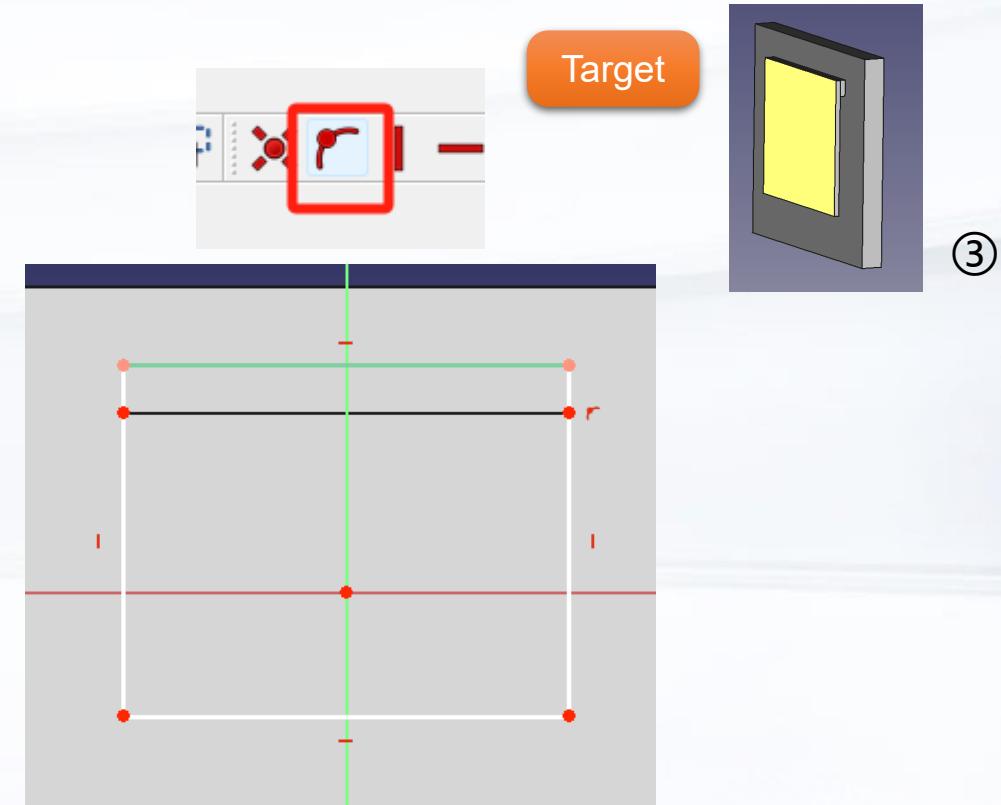
# Modeling Workflow

- Experiment 2: NFC Card Slot

## » Step3 Add a limit pin to the cube



➤ Select the right edge and the bottom-right vertex of the latch support in sequence. Once selected, they will be highlighted in dark green (no need to press the Ctrl key; just click them one after another to select).



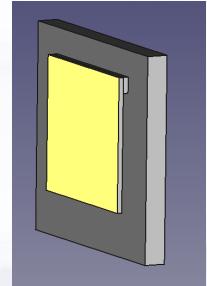
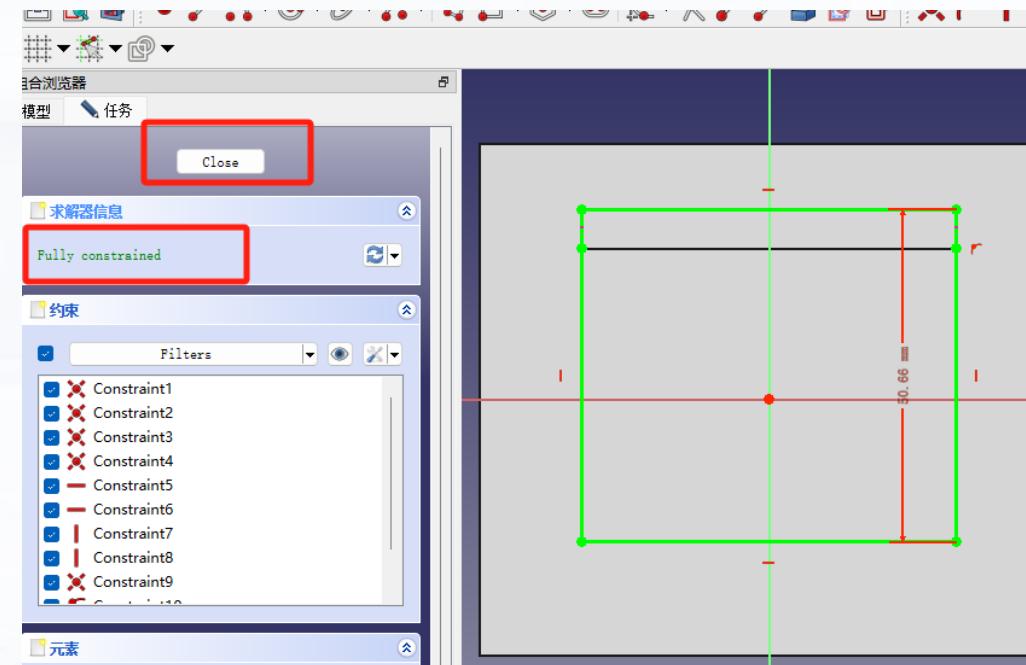
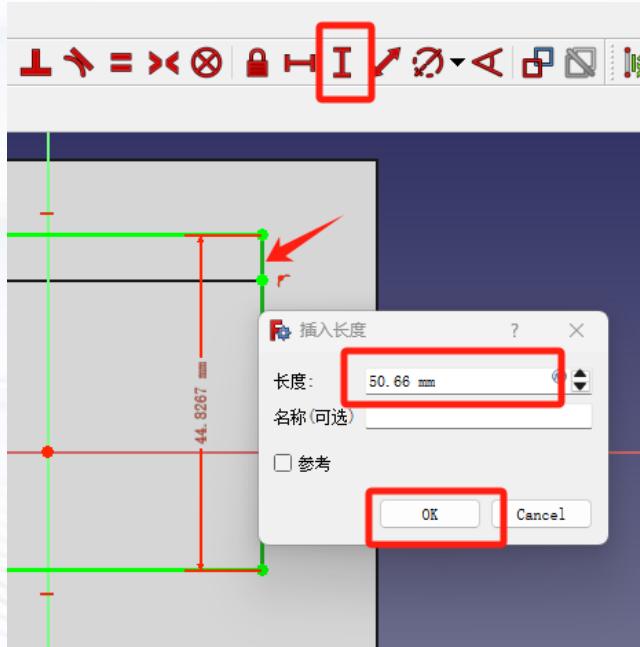
➤ With the elements still selected, click the "Constrain Point to Object" command, and you'll see the line coincide with the point.



# Modeling Workflow

- Experiment 2: NFC Card Slot

## » Step3 Add a limit pin to the cube



Target

③

- Select the "Vertical Distance" constraint, select the right edge, enter a length of 50.66 mm, then click "OK".

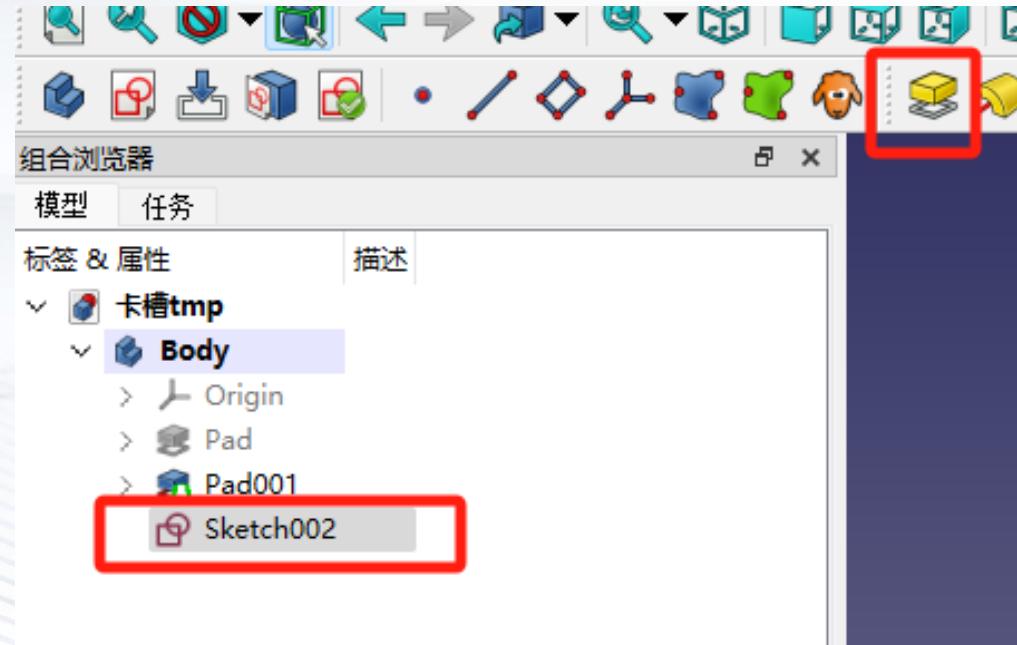
- Complete the sketch as shown in the figure. When the solver indicates "Fully Constrained," click "Close" to exit the sketch.



# Modeling Workflow

## • Experiment 2: NFC Card Slot

### » Step3 Add a limit pin to the cube



➤ Select the sketch and click the "Boss" command.

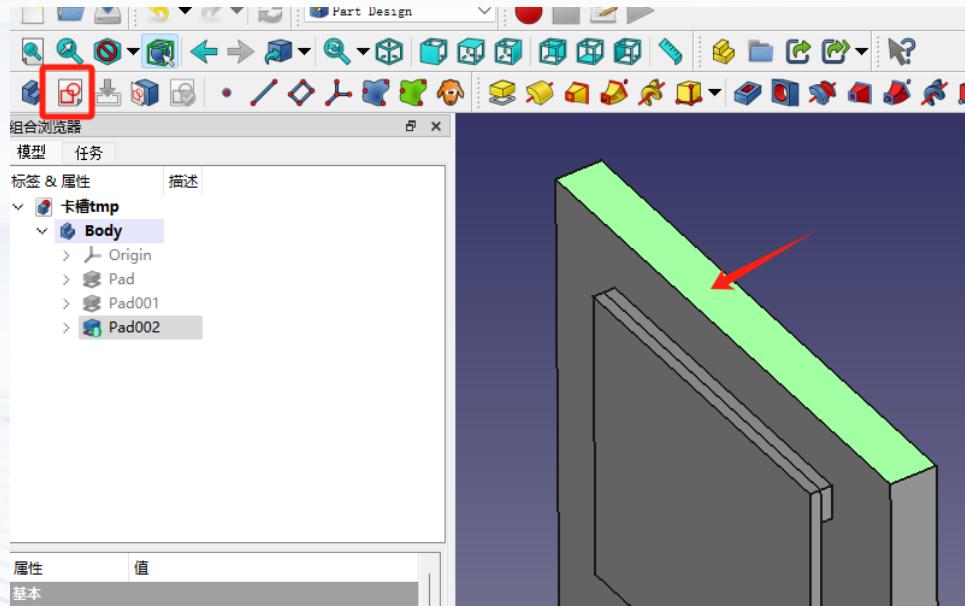
➤ Enter 1.84, click "OK," and complete the drawing of the limit latch.



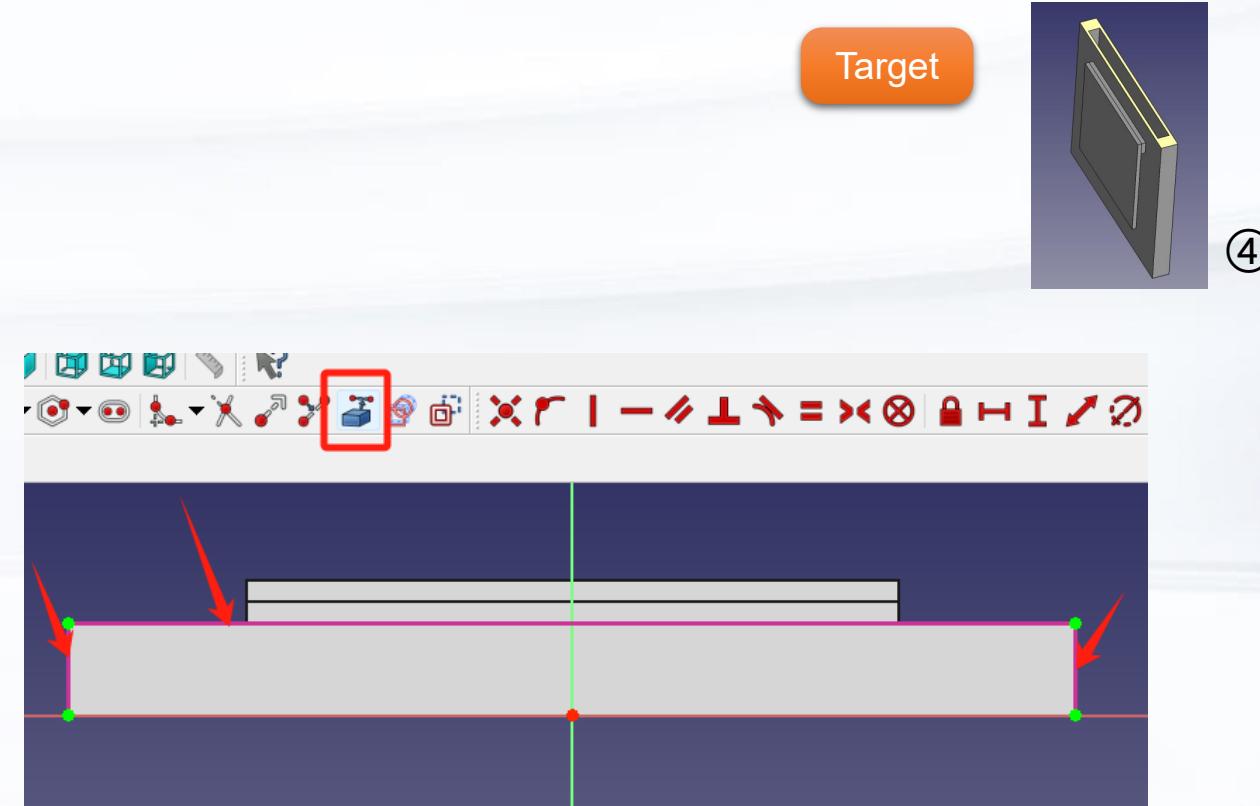
# Modeling Workflow

## • Experiment 2: NFC Card Slot

### » Step4 model a New Slot



➤ Click the top surface and select the "Sketch" command.



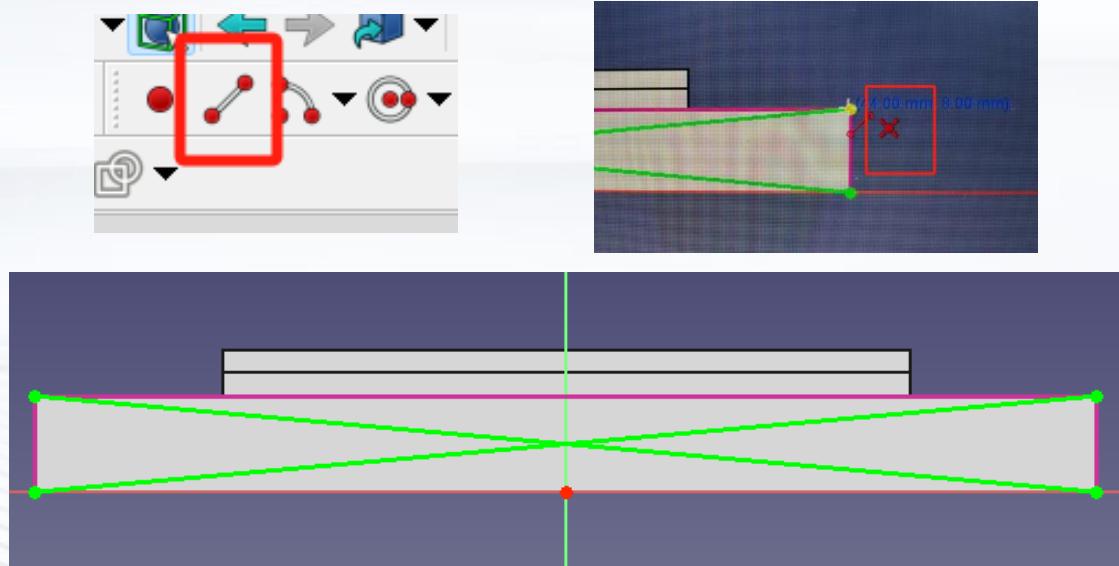
➤ Select the "External References" command, choose the three edges of the top surface, and press Esc to exit the command.



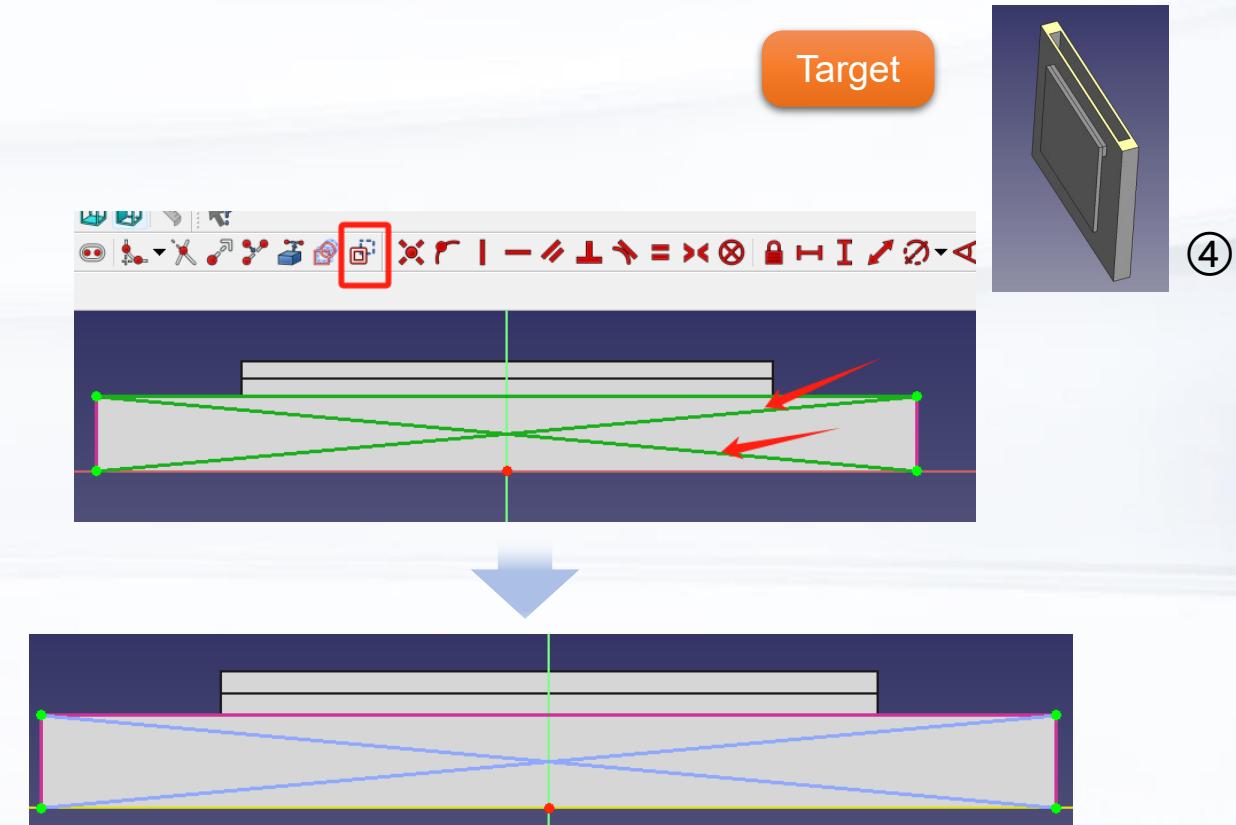
# Modeling Workflow

## • Experiment 2: NFC Card Slot

### » Step4 model a New Slot



- Select the "Line" command and draw the diagonal of the rectangle. Note that when clicking an endpoint each time, a coincident constraint symbol must appear. Press Esc to exit after completing the drawing.



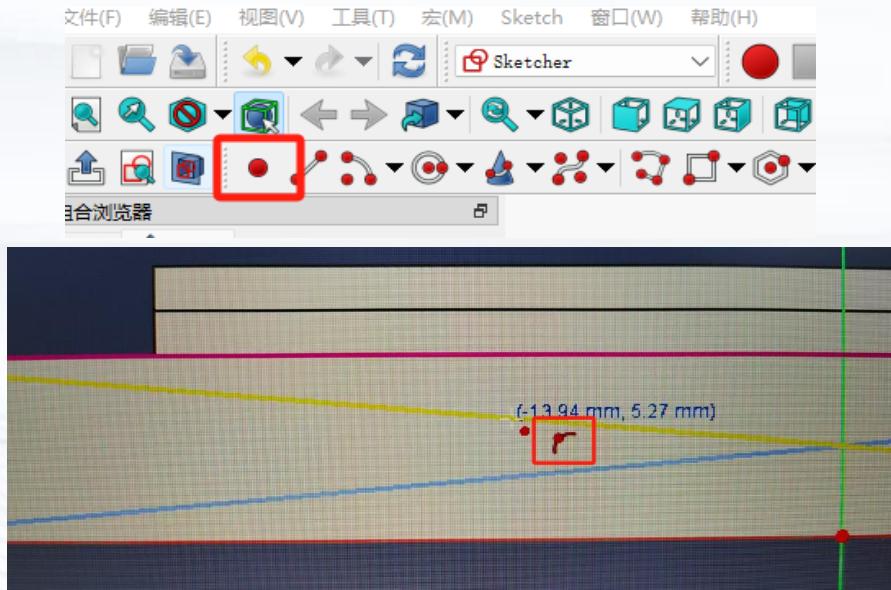
- First select the two lines, then click the "Convert to Reference" command to turn the two lines into reference lines.



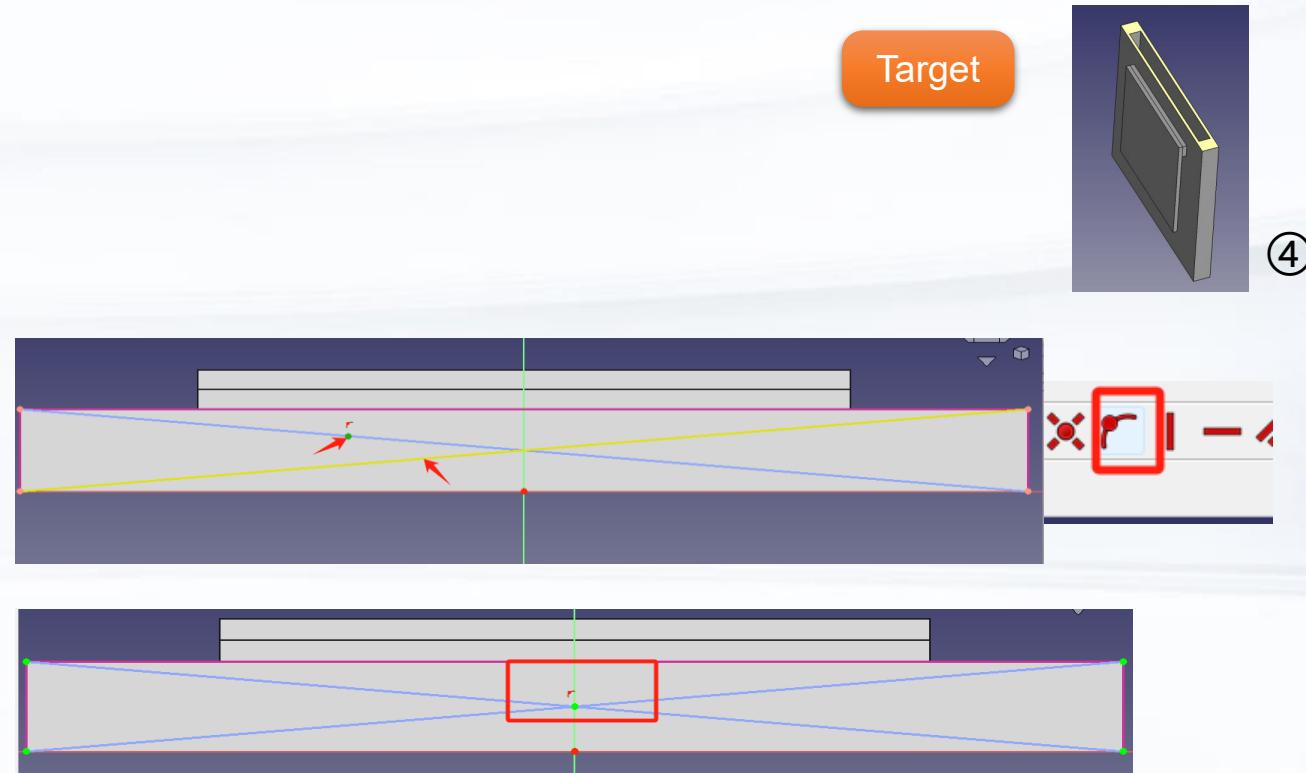
# Modeling Workflow

## • Experiment 2: NFC Card Slot

### » Step4 model a New Slot

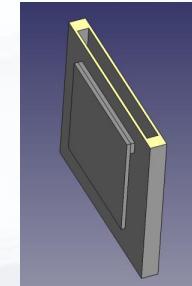


- Select the "Point" command and draw a point on one of the lines (note that an "On Line" constraint symbol must appear). Press Esc to exit the drawing mode after placing the point.



- Select the point and the other line in sequence (no need to press Ctrl; just click them one after another).
- Then select the "Constrain Point to Object" command, and you will see that the point is now at the intersection of the two lines.

Target

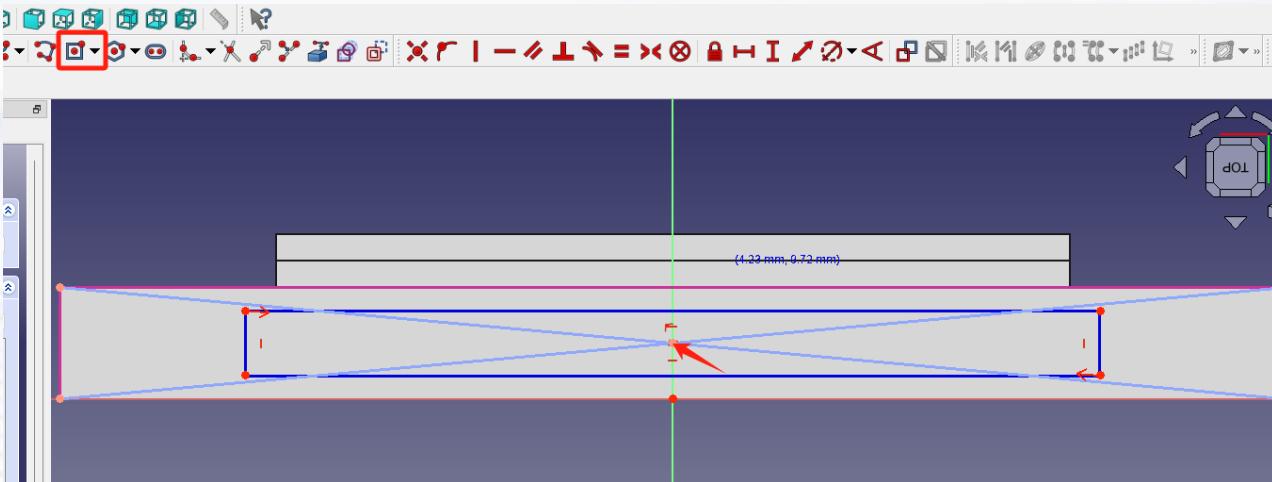


④



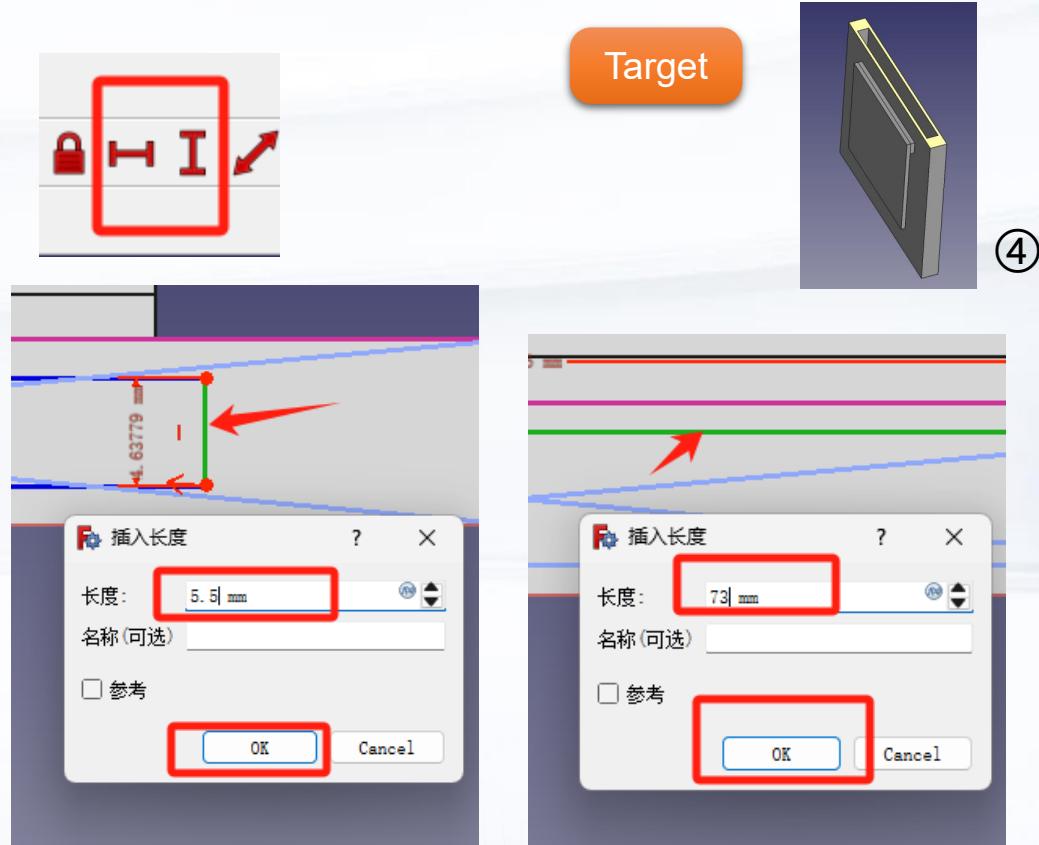
# Modeling Workflow

## » Step4 model a New Slot



- Select the "Center Rectangle" command and draw a rectangle starting from the midpoint (note that when selecting the midpoint, the coincident constraint symbol mentioned earlier must appear).

- Experiment 2: NFC Card Slot



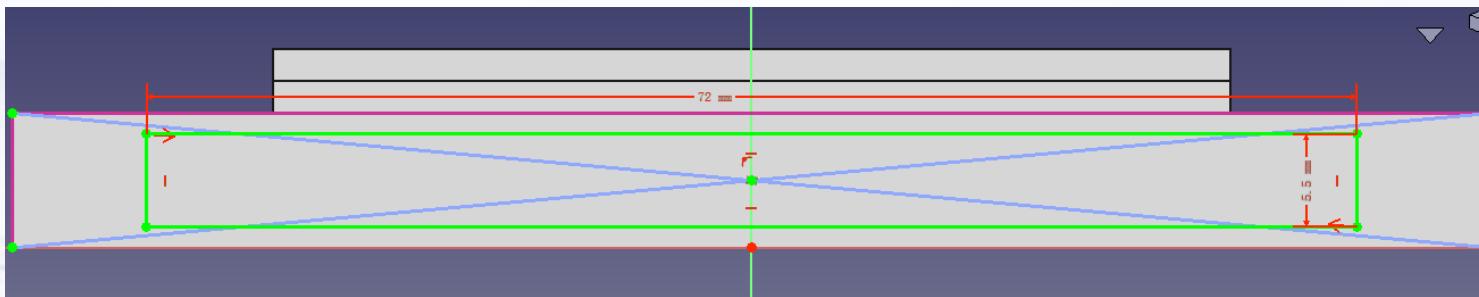
- Use the "Vertical Distance" constraint and "Horizontal Distance" constraint to define the length and width of the rectangular slot, with the length set to 73 and the width to 5.5.



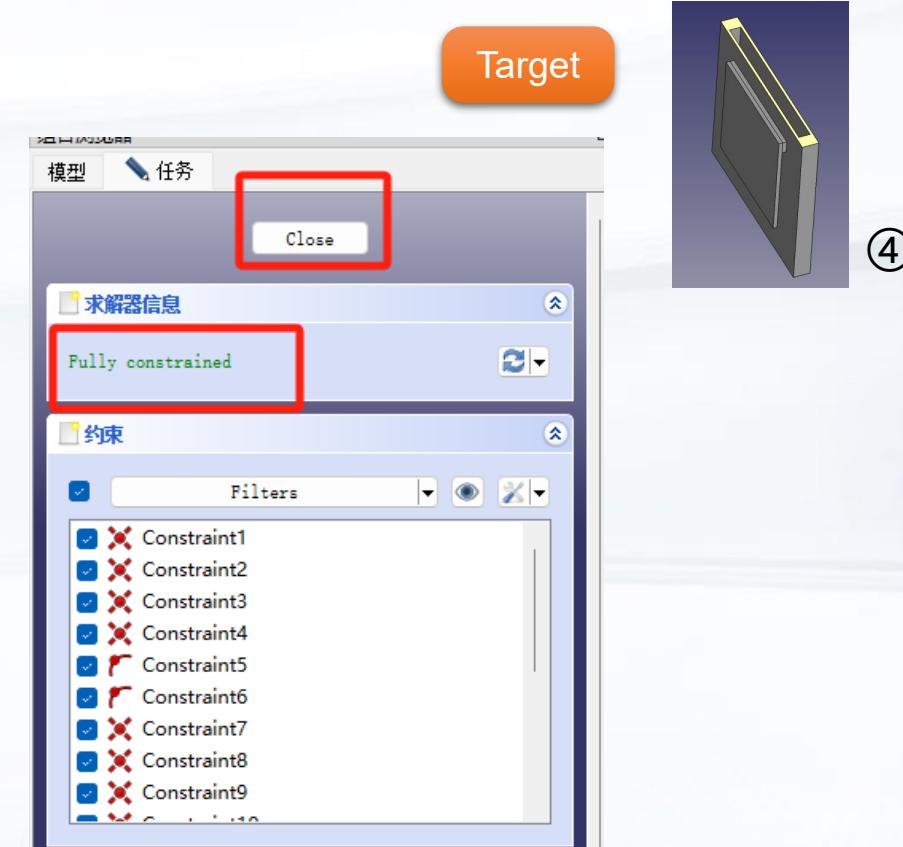
# Modeling Workflow

## • Experiment 2: NFC Card Slot

### » Step4 model a New Slot



- The final sketch is as shown in the figure. Solid lines should be green. If the square is not green, select its four edges in sequence and click the "Toggle Construction" command to convert them to solid lines.



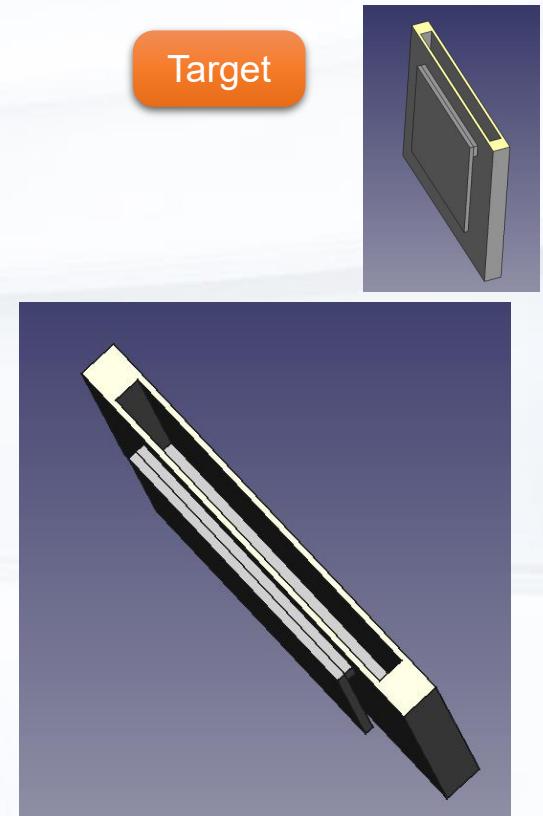
- The solver indicates "Fully Constrained." Click "Close" to exit the sketch drawing mode.



# Modeling Workflow

## • Experiment 2: NFC Card Slot

### » Step4 model a New Slot



➤ Click the sketch and select the "Pocket" command.

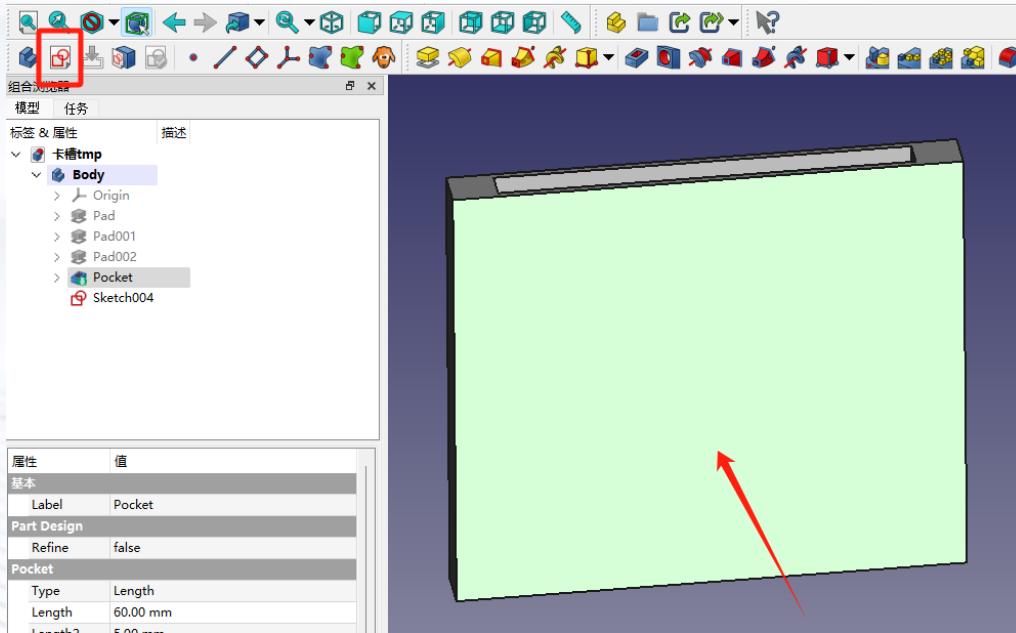
➤ Enter the dimension 60, then click "OK" to complete the feature creation.



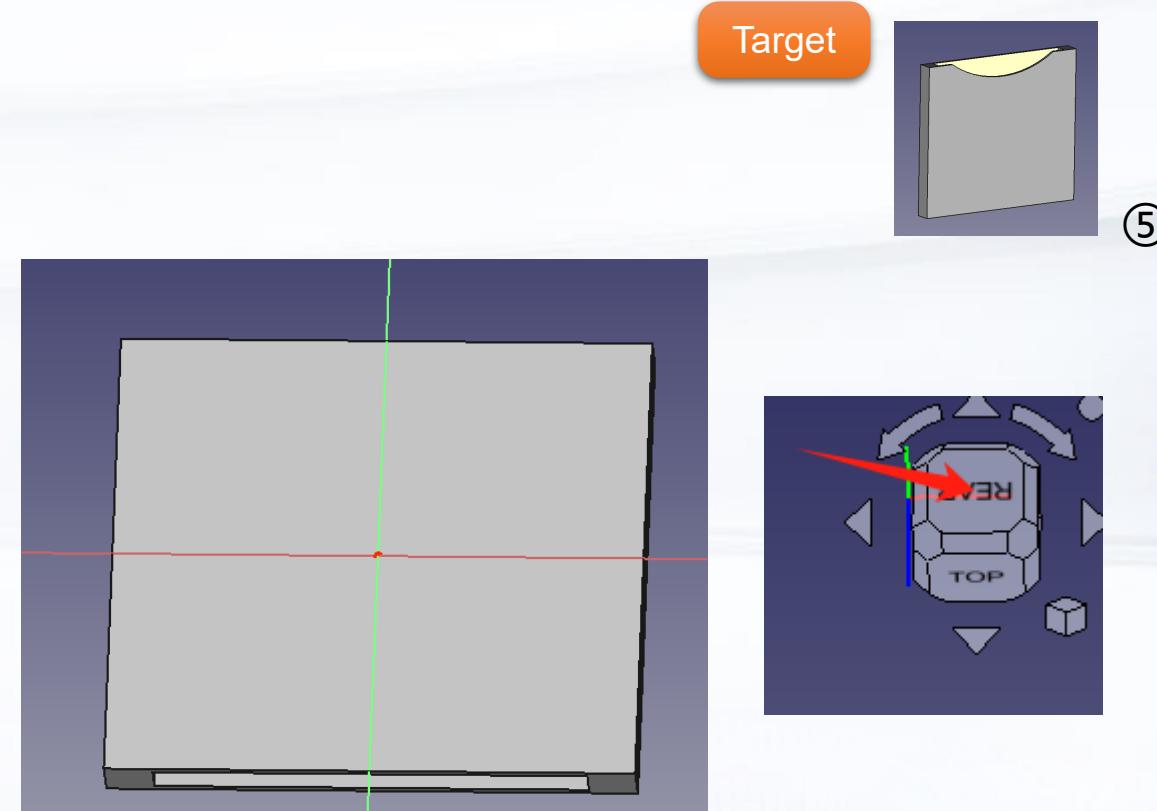
# Modeling Workflow

## • Experiment 2: NFC Card Slot

### » Step5 Model the Arc of the New Slot



- Click to select the front face, then choose the "Sketch" command.



- Press and hold the middle mouse button, drag upward to position the slot, then click the surface marked with the "REAR" label to reset the view to its original orientation.

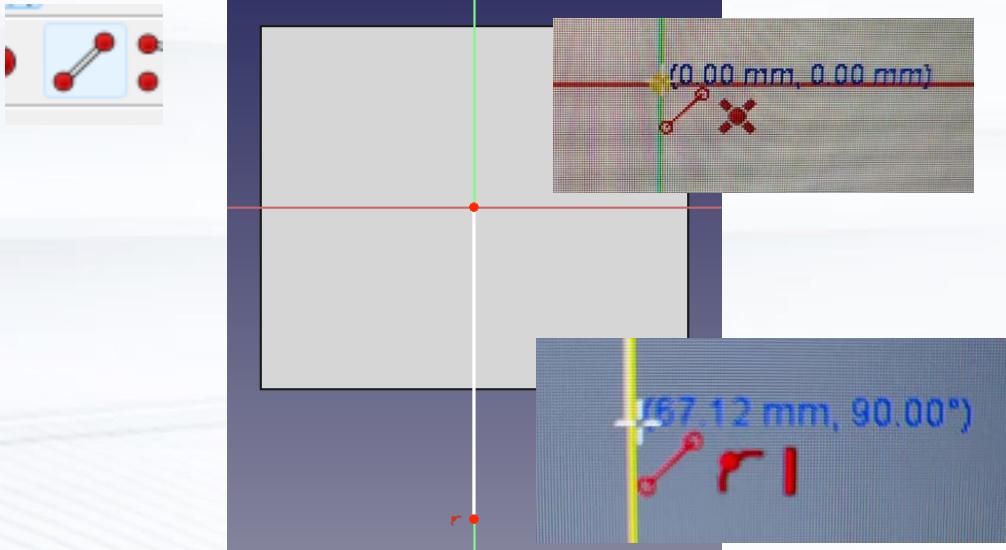


# Modeling Workflow

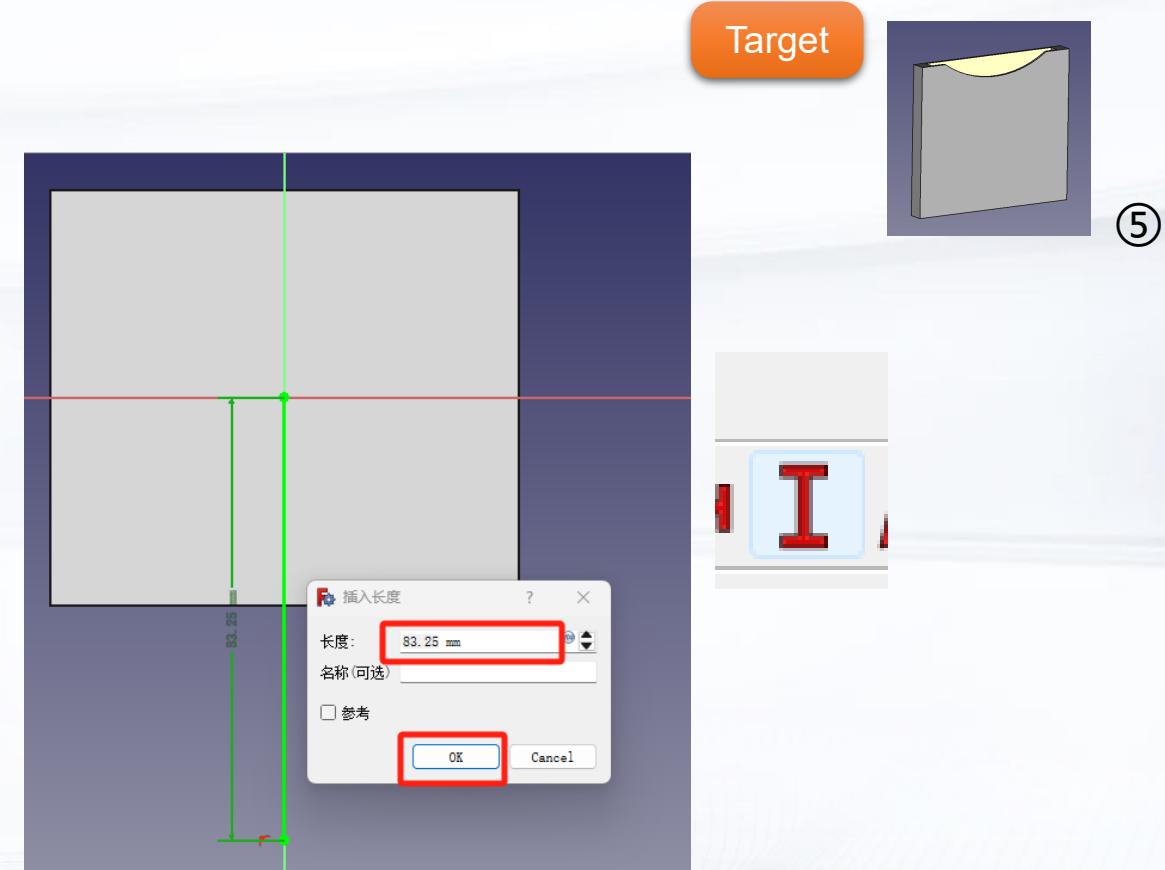
## • Experiment 2: NFC Card Slot



### Step5 Model the Arc of the New Slot



- Click the "Line" command and draw a line toward the edge of the slot opening. Note that the corresponding constraint symbols must appear when placing the start and end points of the line.



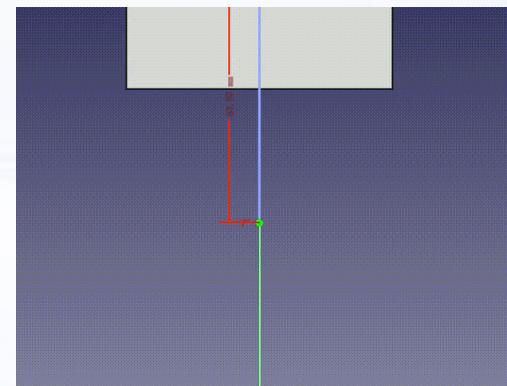
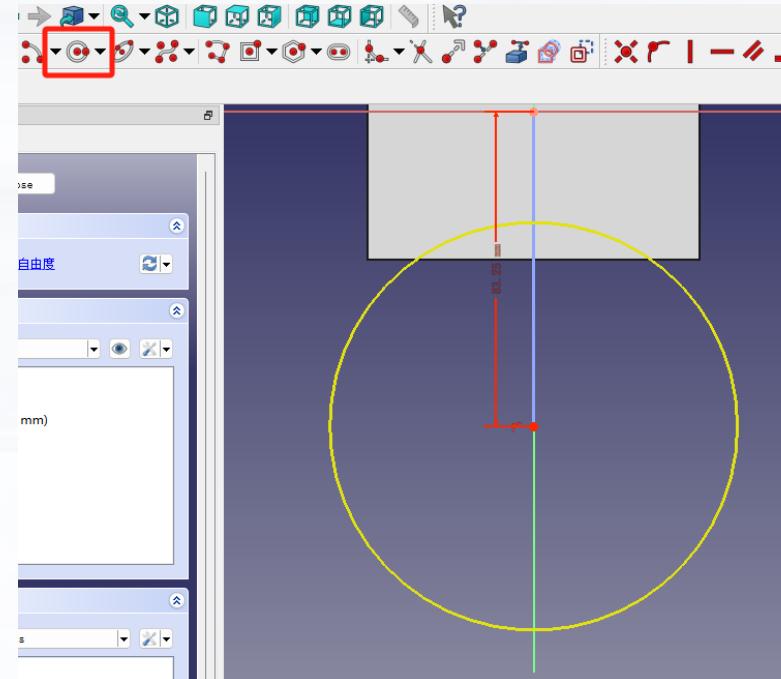
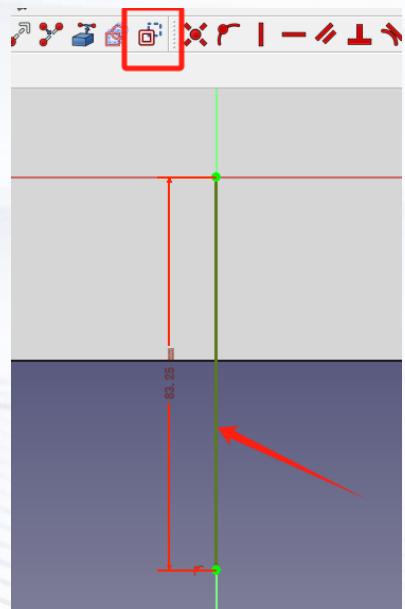
- Use the "Vertical Distance" constraint command to set the distance of the line to 83.25.



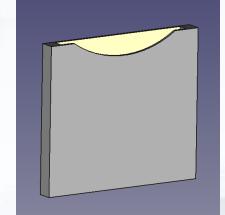
# Modeling Workflow

## • Experiment 2: NFC Card Slot

### » Step5 Model the Arc of the New Slot



Target



(5)

- Select the line and click the "Toggle Construction" command.

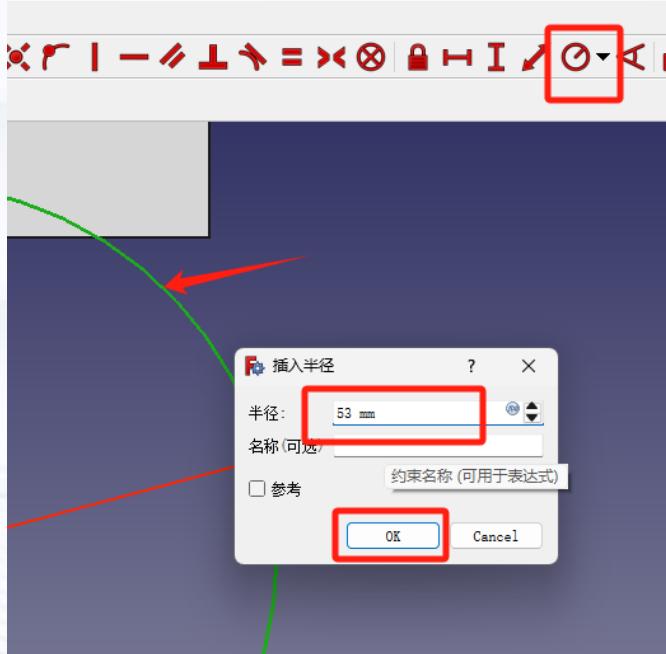
- Use the "Circle" command to draw a circle at the endpoint of the line segment.



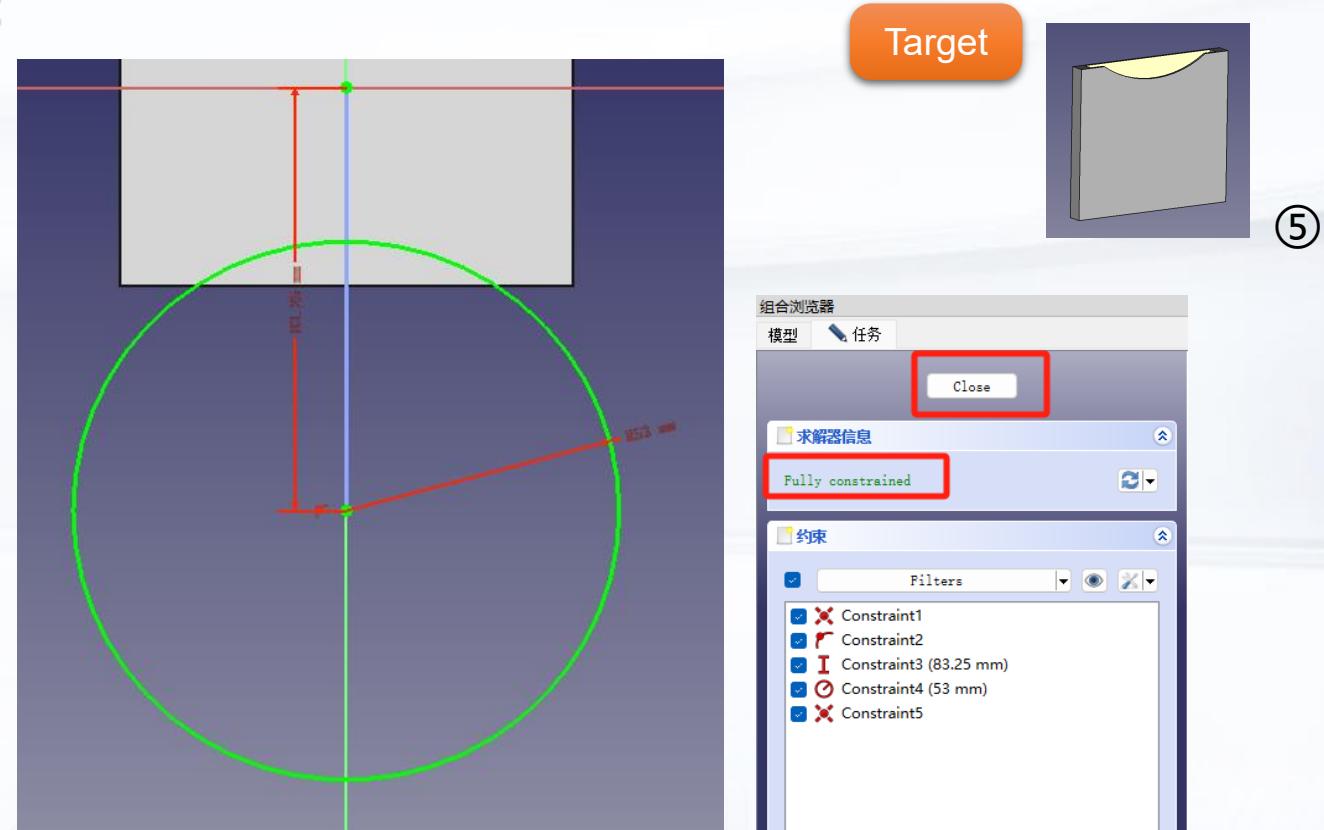
# Modeling Workflow

## • Experiment 2: NFC Card Slot

### » Step5 Model the Arc of the New Slot



- Click the "Radius Constraint" command, select the circle, and enter 53 as the radius.
- If the circle is blue, select the circle and use the "Toggle Construction" command to convert it to a solid line.



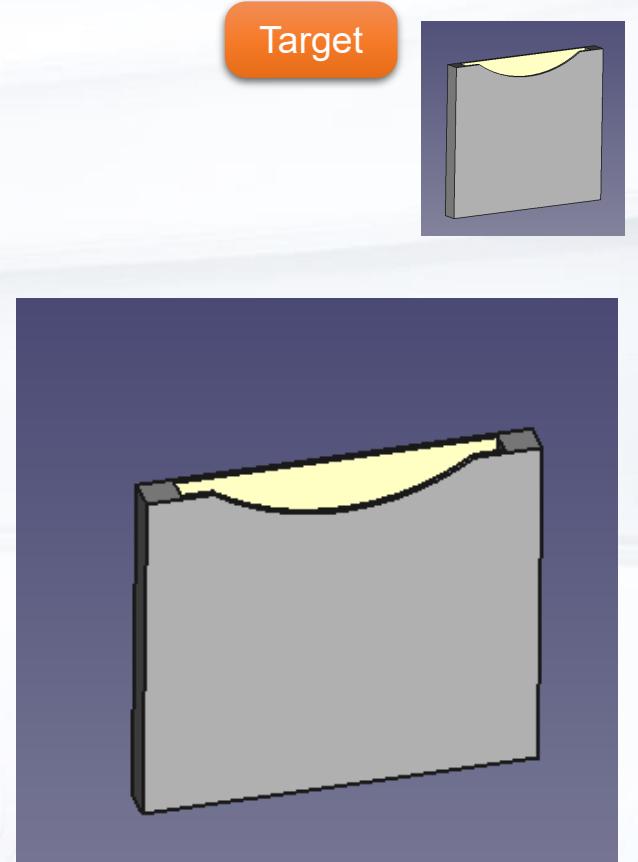
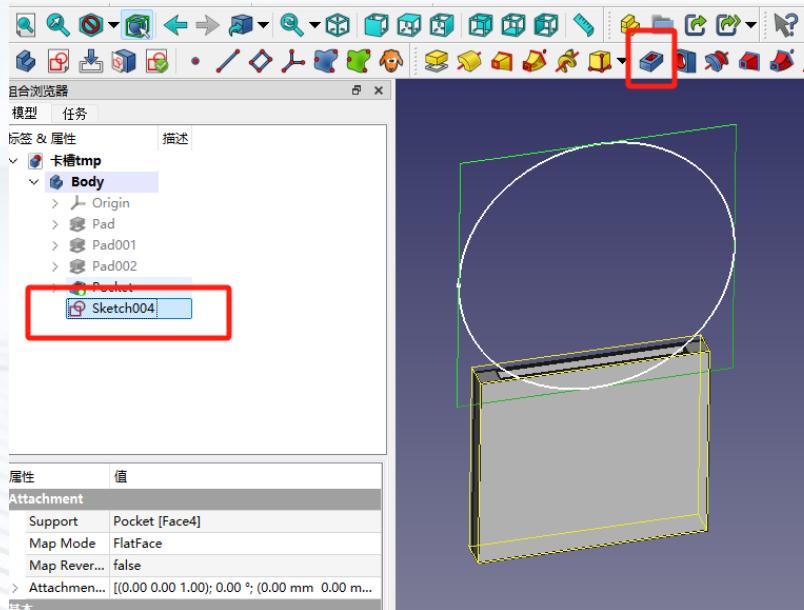
- The completed sketch is as shown in the figure. Confirm that it is fully constrained, then close the sketch drawing (note: the circle must be a solid line, and the line must be a construction line).



# Modeling Workflow

## • Experiment 2: NFC Card Slot

### » Step5 Model the Arc of the New Slot



Target

(5)

- Select the sketch and choose the "Pocket" command.

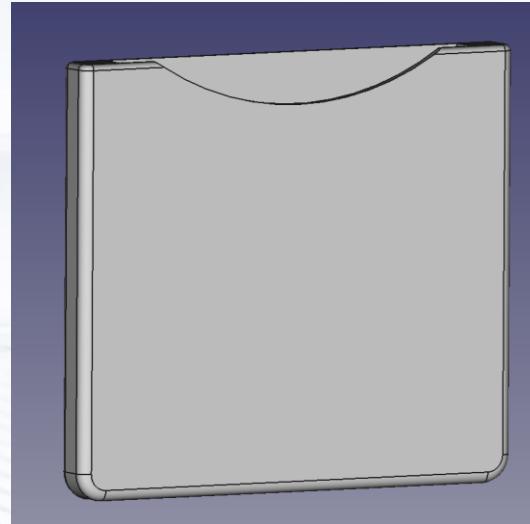
- The dimension marker can remain as default. Click "OK" to complete the feature creation.



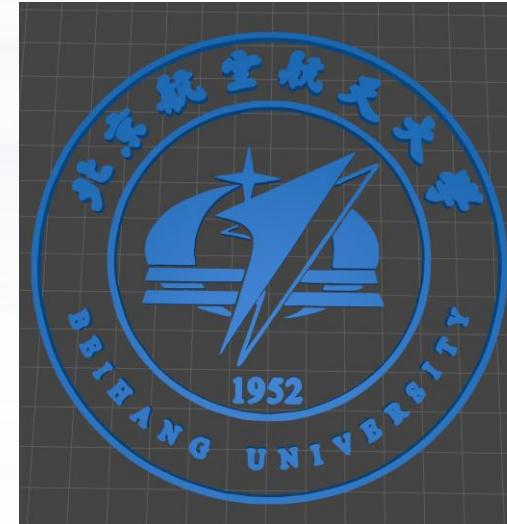
# Modeling Workflow

- Experiment 2: NFC Card Slot

» Using the knowledge learned earlier, add a pattern to the slot extension part.



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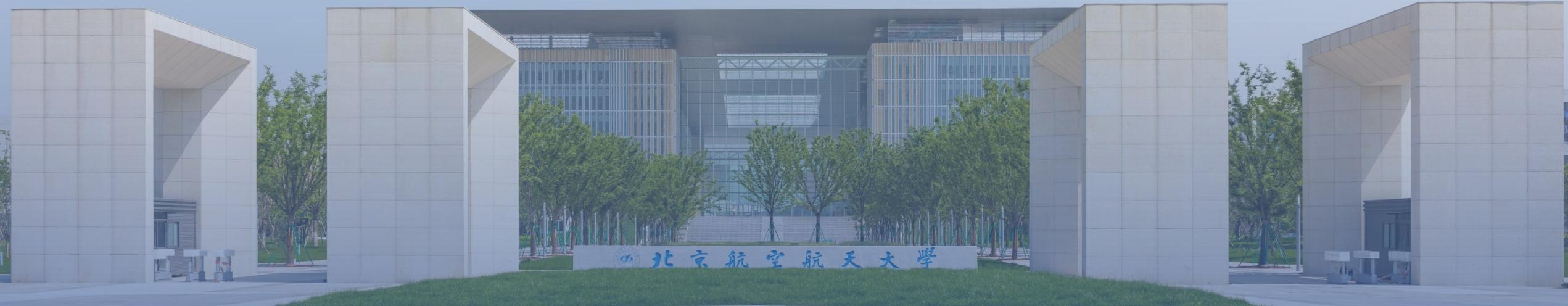


Detailed steps will no longer be provided for the extended experiment. Students are required to apply the methods they have learned.



# Beihang University

## Any questions?



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