EPFL

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Student Prototyping
and Outreach Tank

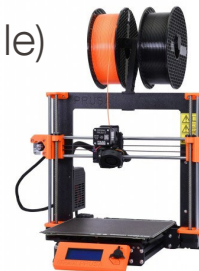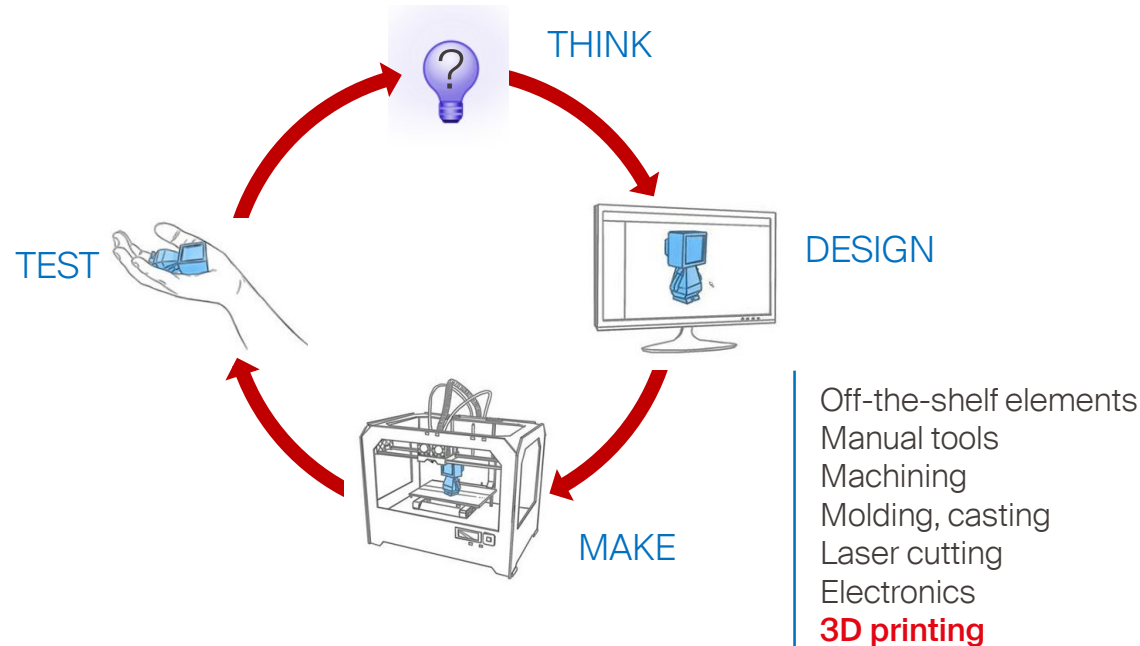# 3D PRINTING TRAINING

make.epfl.ch/3dprint

Sébastien Martinerie

V4.1

3D PRINTING @SPOT: WELCOME

- How to get the access?

  - First, do the prototyping **online training** (general **AND** safety)
    https://make.epfl.ch/training
    This will give you access to the prototyping spaces (SPOT and SKIL)

  - Then, follow the dedicated on-site training (register on Doodle)
    This will give you access to
    the 3D printing room (@SPOT) and **level 2** printers

SPOT

WHY 3D PRINTING?

3D printing is a great tool for rapid prototyping!

THINK

DESIGN

TEST

MAKE

Off-the-shelf elements
Manual tools
Machining
Molding, casting
Laser cutting
Electronics
3D printing

YOUR COACHES CAN HELP YOU!

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3D PRINTING TRAINING

WHAT IS
3D PRINTING?

3D printing, also known as **additive manufacturing**, is a family of manufacturing methods to create 3D objects, directly from a CAD model,
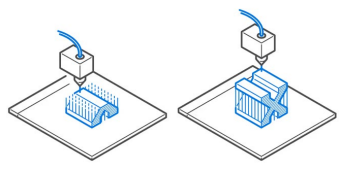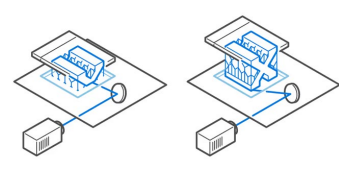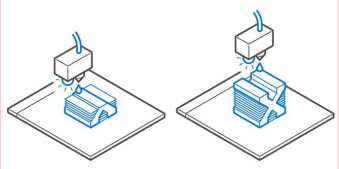
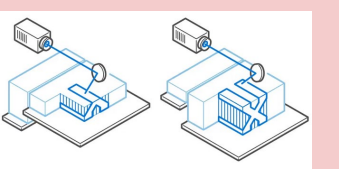# Layer by Layer

Main advantages:

- Complex geometries capability

- Fast "design to production"

- Efficiency (energy, wastes...)

Some limitations:

- Materials and properties

- Dimensions, accuracy

- **NO 100% SUCCESS RATE!**

3D PRINTING TRAINING
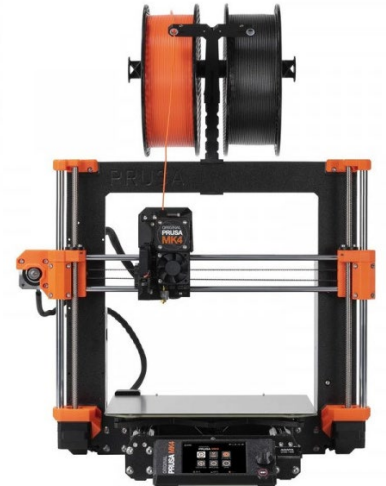
SPOT

WHAT IS 3D PRINTING?

The most common 3D printing types:

Type Name	Material extrusion Fused deposition modeling (FDM)	VAT Polymerization Stereolithography (SLA) Digital light processing (DLP)	Material jetting	Powder bed fusion Selective laser sintering (SLS) or melting (SLM)
Principle				
Materials	Polymer filaments	Photopolymer resins	Photopolymer resin	Thermoplastic, metal or ceramic powder
Strengths	Lowest cost, wide range of functional materials, simple	Smooth surface finish, fine details, complex geometries, special properties	Surface finish, multicolor and multi-material	Functional parts, mechanical properties, complex geometries
Availability	SPOT SKIL AFA	SPOT AFA	AFA	AFA (plastic) External partners (metal)

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3D PRINTING @SPOT:
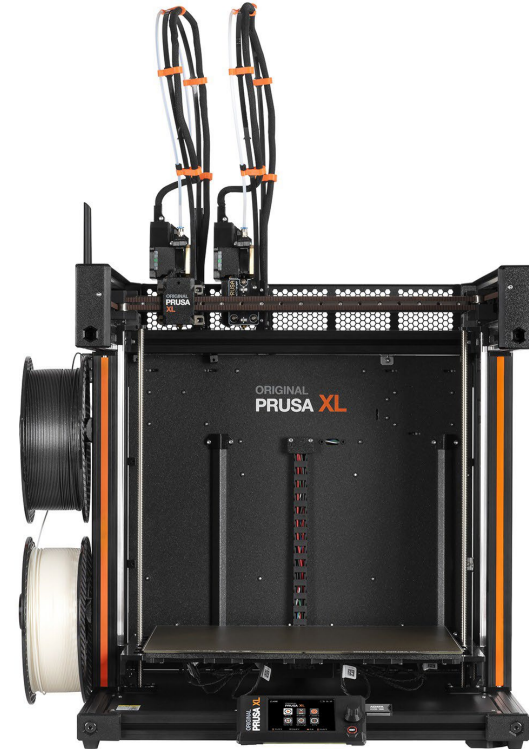# THE PRINTERS

▪ PRUSA MK3S+ AND MK4

- Open access printers (level 2)

- Technology: FDM (filament)
- Build volume (x,y,z) : 250 x 210 x 210 mm
- Materials:
  - ▪ **PETG** (0,05 CHF/g)
  - ▪ Technical PETG (HT, PTFE, CF)
  - ▪ TPU (0,1 CHF/g)

- Easy to use
- For 95% of your needs

3D PRINTING @SPOT:
THE PRINTERS

- **PRUSA XL**

  - Only under supervision (level 3)

  - Technology: FDM (filament) – 2 extruders
  - Build volume (x,y,z) : 360 x 360 x 360 mm
  - Materials:
    - PETG
    - Technical PETG (HT, PTFE, CF)
    - Soluble supports
    - TPU

  - For bigger and multi-material parts

3D PRINTING @SPOT:
THE PRINTERS

- **RAISE3D PRO 3+**

  - Only under supervision (level 3)

  - Technology: FDM (filament) – 2 extruders
  - Build volume (x,y,z) : 300 x 300 x 605 mm
  - Materials:
    - PETG
    - Technical materials (ASA, PC, etc.)

  - For bigger and eventually more durable parts

3D PRINTING @SPOT:
THE PRINTERS

▪ **FORMLABS FORM3+**

- Only under supervision (level 3)

- Technology: SLA (resin)
- Build volume (x,y,z) : 145 x 145 x 185 mm
- Materials:
  - ▪ Standard
  - ▪ Clear, high rigidity, elastic, high temp, etc.
  (0,3 ~0,4 CHF/ml)

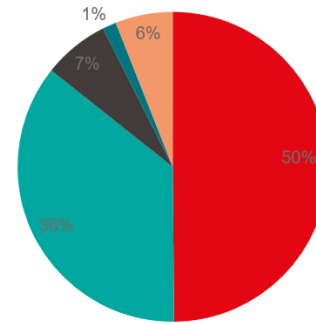- For high quality surfaces, precision, details, specific properties
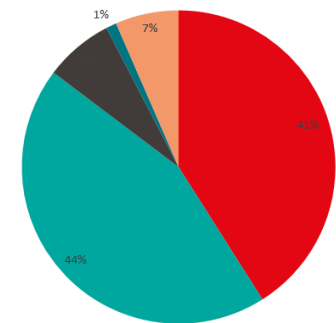
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3D PRINTING @SPOT:
THE SPACE

- For who?
  - **Every** Bachelor and Master students of EPFL

- For what?
  - Make projects
  - Courses
  - Credited Semester/Master projects
  - Other accredited projects

- Others:
  - Go to **AFA** first for any non-credited professional projects (internship, research, private company, etc.)
  - **Ask** for permission for personal projects

Filament usage since March 2022

Number of cycles since March 2022

1% 6%
7%
50%
38%

1% 7%
41%
44%

■ Projets Make ■ Cours ■ PDS / PDM ■ Perso ■ Autres

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3D PRINTING @SPOT:
THE SPACE

- A modern and evolutionary space

- A high volume workshop
    - **7'400** print jobs
    - **120 km** of printed filament (400 kg)
    - **1'800 days** of printing

- A community of users
    - **425+** trained users

(Numbers from March 2022 to January 2024)

Number of printers

Cumulated printing days

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3D PRINTING TRAINING

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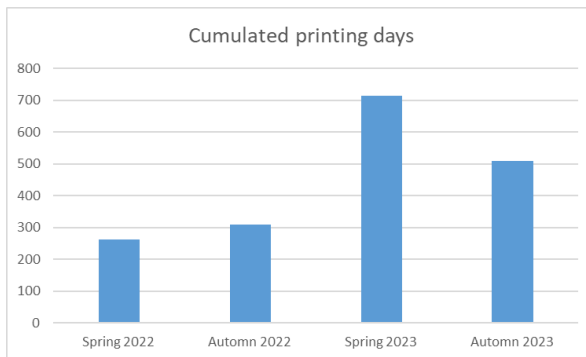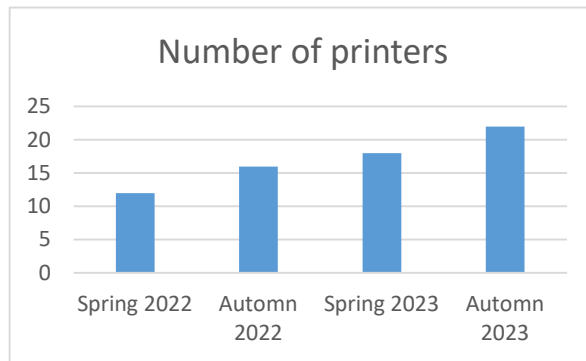
3D PRINTING @SPOT:
EXPECTED BEHAVIOR

You're part of a community, respect the others!

You are not the only one to use this place.

The rules are the same for everyone and are put in place so that it works and serves everyone equally and continuously.

- **Share** the printers
- **Help** each other, share your experience
- **Don't judge**
- Handle other people's parts **carefully**
- You cannot reserve the machines for now. First come, first served.
- **Ask for help**

3D PRINTING @SPOT:
EXPECTED BEHAVIOR

We are lucky to have these tools, let's take care of them!

- No dust, no food, no drink
- Keep the place and the printers **clean**
- **Communicate** if something is broken or missing and if you have suggestions
- Don't use other materials or tools other than available here
- Don't take materials or tools out of the room
- Don't print Gcodes from someone else
- **Ask for help** (coach, assistants, etc.)

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3D PRINTING TRAINING

3D PRINTING @SPOT:
EXPECTED BEHAVIOR

Finally, respect the coach ;-)

- I'm **not a cop.**
- I'm **not a cleaner.**

- I'm an experienced engineer, specialized in 3D Printing for 20+ years.
- I've got many tips and experience to share with you, at each step of your project.
- I'm here to help you, not to judge you.

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3D PRINTING @SPOT: SAFETY

- Respect the "access restrictions"
  - Don't enter the "under supervision" area without the coach's permission
  - Don't let unauthorized people enter the room
  - Don't work alone in the space after 8pm and during weekends

- Flammable products
  - No open flame and no smoking

3D PRINTING @SPOT: SAFETY

- Use the appropriate PPE when indicated

IMPORTANT: Safety glasses are mandatory

for post processing (part and support removal)

- Hot surfaces and moving parts
  - Don't touch the printers while running
  or before proper cooling (hotend + printbed)
  - Tie your hair and be careful with loose accessories
  - Do not put your computer and personal objects near the printers

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3D PRINTING @SPOT: SAFETY

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- Locate the safety elements of the space

  - **Phone**
    For all emergencies, **24h/24:**
    From an EPFL landline: **115**
    From a personal mobile phone: **021 693 30 00**
    From the EPFL Campus app: **SOS**
  - **First aid kit**
    - To treat minor injuries. For major injuries: call **115**
    - Please let your COSEC (coach) know if you used it
  - **Eye/face wash kit**
    - In case of splashing in the eyes:
    1. Act quickly
    2. A colleague calls **115**
    3. Flush your eyes thoroughly until help arrives
    - Notify the COSEC (coach) so that the bottles can be replaced

  - **Fire blanket**
  - Locate the **fire alarm** and the **fire extinguisher** in the corridor

- **Most important: give the alarm and help people out**

3D PRINTING TRAINING

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STEPS FOR
SUCCESSFUL 3D PRINTING

DESIGN
(for manufacturing)

PREPARE
(aka slice)

3D PRINT

FINISH
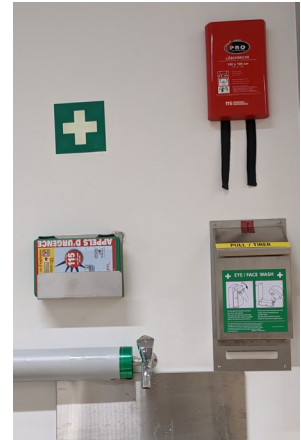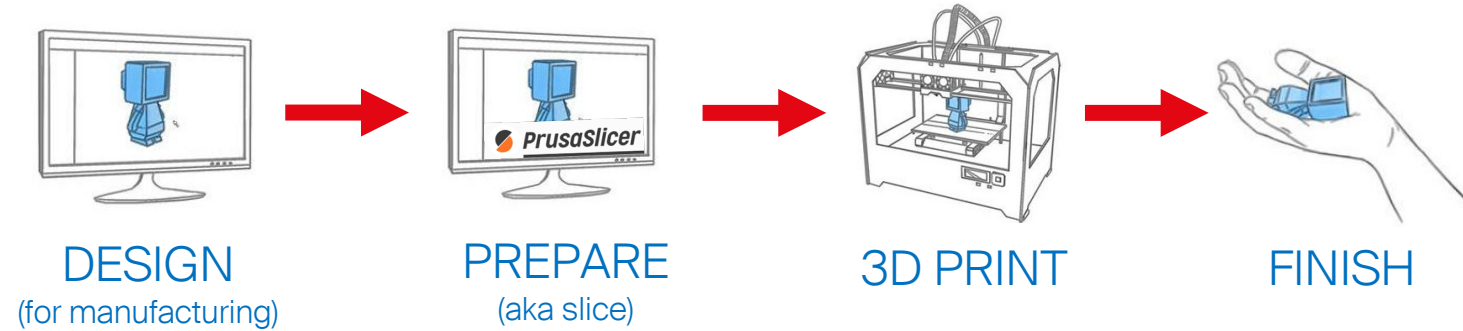
- Each step is important, takes time and determines the others.
- Don't waste time and materials. A good design and a good slice reduce the number of iterations, failures and breakdowns.
- Schedule your prints in advance and take some margin.
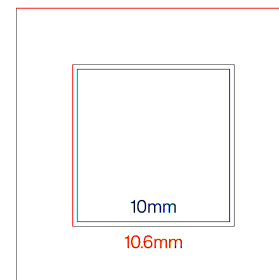- Some manual finishing work is part of the job.
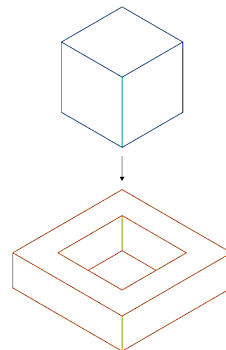- Asking for help is always OK.

STEPS FOR SUCCESSFUL 3D PRINTING
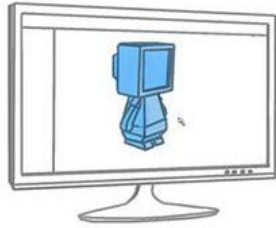
DESIGN
(for manufacturing)

- Use your favorite **CAD software**
- Think about how you will **slice and print** the part
- **Know your printer** and its limitations, such as maximum part dimensions > **250 x 210 x 210 mm** precision and details size.
- Keep in mind the **layer by layer** process
  - > **Orientation, transition between layers**
- Think about how you will **use and assemble** the part
  - > **Min. clearance: 0,15 mm**
  - > **Several positioning and fixing options**
- Export your file in **.STL or .STEP format**

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STEPS FOR
SUCCESSFUL 3D PRINTING
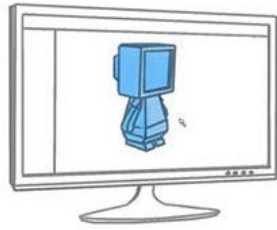
DESIGN
(for manufacturing)

Wall thickness
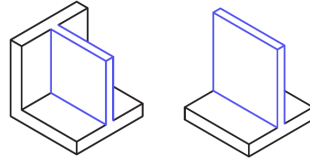
Min. 0.6 mm

Min. 0.8 mm

Hole and pin diameter
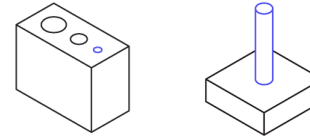
Min. 2 mm

Min. 3 mm

Embossed and engraved details
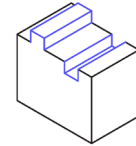
Min. 0.6 mm wide and high

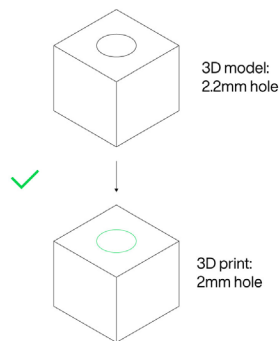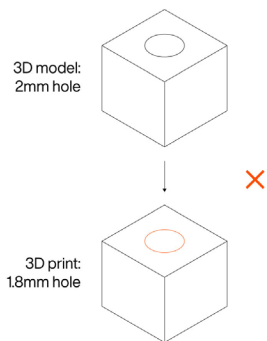Add filets and ribs
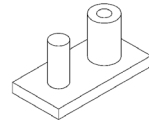
X
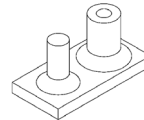
V
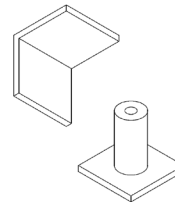
X
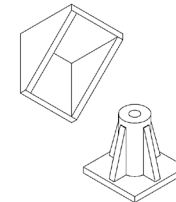
V

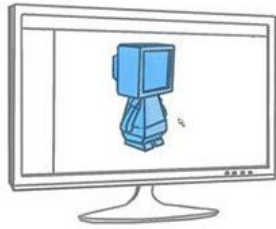# STEPS FOR
SUCCESSFUL 3D PRINTING
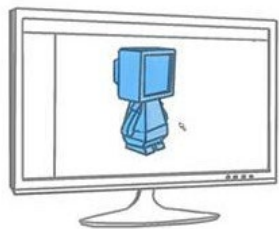
DESIGN
(for manufacturing)

- **Assemblies > Tolerances**
  - The printed dimensions are generally larger than the 3D model (about 0.1 mm everywhere).
  - Leave a distance between parts for easy assembly. Typical value for FDM 3D printing: **0.2 – 0.3 mm**
 - See the tolerance test parts in the room, or print your own to determine precise tolerances

3D model:
2mm hole

3D print:
1.8mm hole

3D model:
2.2mm hole

3D print:
2mm hole

10mm

10.6mm

3D PRINTING TRAINING

SPOT

STEPS FOR
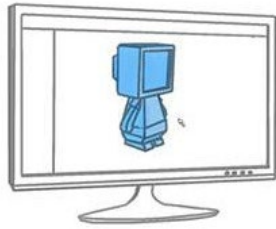# SUCCESSFUL 3D PRINTING

DESIGN
(for manufacturing)

- ▪ **Assemblies > Positioning elements**
  - • If you need to assemble parts together, you should not forget to assure a good positioning by designing **pins and holes or any other positioning element**.
  - • Don't forget the tolerance consideration of previous slide.

SPOT
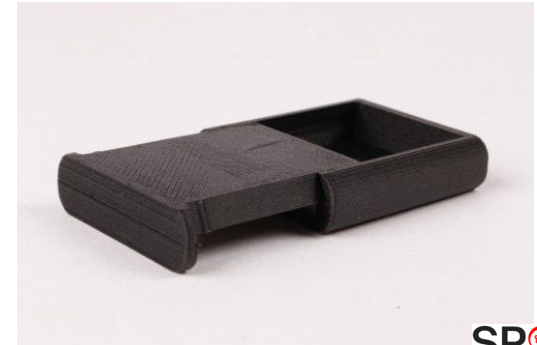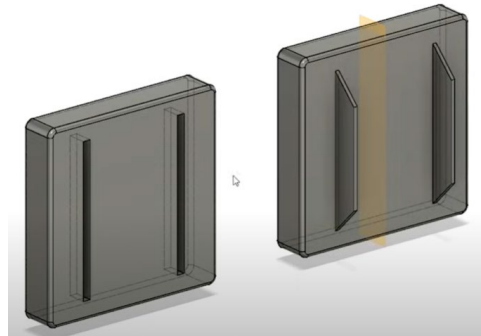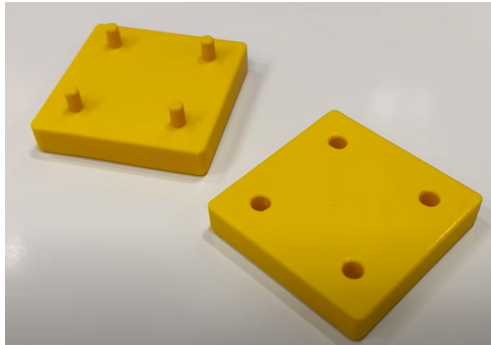
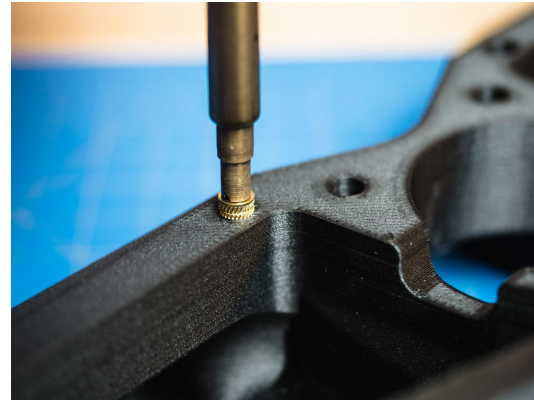# STEPS FOR
SUCCESSFUL 3D PRINTING

DESIGN
(for manufacturing)

- **Assemblies > Screwed assembly**
  - There are many options to add threads and screwing possibilities to your parts. 3D printing threads or threading 3d printed parts is generally not a good idea.
  - We strongly advice to add **threaded inserts or nut pockets**.
  - Tips and samples coming soon > Ask your coach

3D PRINTING TRAINING

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STEPS FOR
SUCCESSFUL 3D PRINTING

PREPARE
(aka slice)

Print settings :
⚙ 🔒 0.15mm QUALITY

Filament :
🔒 Generic PETG

Printer :
🔒 Original Prusa i3 MK3S & MK3S+

- Use only the manufacturer's software > **PrusaSlicer**
- Configure the right printer
  ➢ **Prusa i3 MK3S+** with **0.4 mm nozzle**
  ➢ **Prusa MK4 Input Shaper** with **0.4 mm nozzle**
- Work in Expert mode
- **Orient** your part for better
  - > **Strength**
  - > **Precision, surface quality**
  - > **Support optimization**
- Place the **supports**
- Choose the right **material** > **Generic PETG**
- Choose the right printing **parameters** > **Quality over Speed**
- Slice and check the printability
- Export the **G-code** on an SD card (MK3) or USB stick (MK4)
(never take an SD card or USB stick on a working printer)

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STEPS FOR
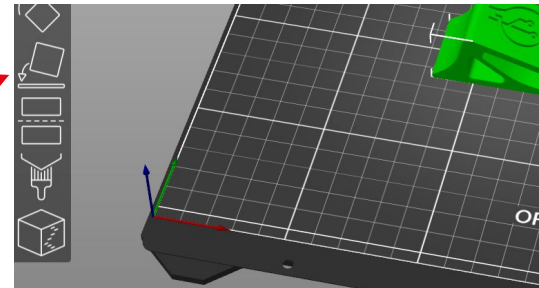# SUCCESSFUL 3D PRINTING

PREPARE
(aka slice)

- **Orient your part:**

   A good part orientation is decisive for a successful print.
   Keep in mind the following factors

   - **Tensile strength** is lower in the direction of layers
   - The **best precision** is in XY plan
   - **Supports** affect the surface quality once removed
   - Faces printed directly on the printbed have the **best quality**

Place on face tool:
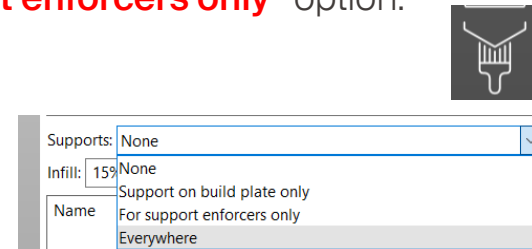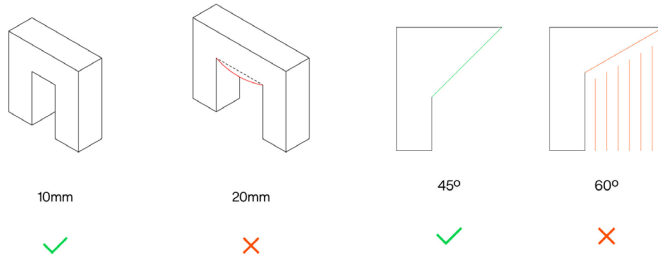Choose which surface will face the printbed.
Preferably use this tool!

STEPS FOR
SUCCESSFUL 3D PRINTING

PREPARE
(aka slice)

- Generate **supports: You can't print in the air!**
  - Find the good balance: Surfaces that are not supported enough **can ruin your print** (and the printer).
  - **Warning**: avoid supports printed on top of a flat printed surface.
  - The need for supports can be decreased by changing:
    - your **design**
    - and/or your part **orientation**
  - In case of doubt, place supports **everywhere.** You can also place supports selectively using the **paint-on supports tool** and the **"For support enforcers only"** option.

10mm   20mm   45º   60º

Supports: None

None
Support on build plate only
For support enforcers only
Everywhere

Infill: 15%

Name

SPOT

STEPS FOR SUCCESSFUL 3D PRINTING

PREPARE
(aka slice)

- **Increase strength**
  - **Part orientation**
    - Avoid layers delamination
  - **Infill**
    - Small strength increase
    - Big time increase
  - **Perimeters**
    - **Big strength increase**
    - Also increases print time
    - Allows you to correct the part afterward (increase a hole diameter)
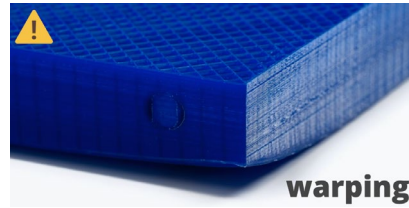   - > Print settings > Layer and perimeters > 2 (default) -> **4 to 6**

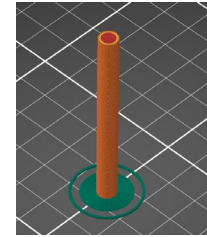# STEPS FOR
SUCCESSFUL 3D PRINTING

EPFL
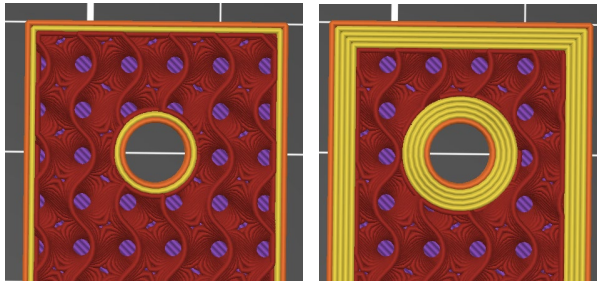
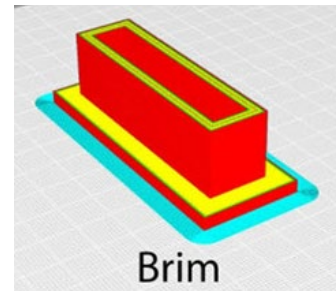## PREPARE
(aka slice)

- **Prevent warping or bad adhesion to the bed**

warping

Big parts

Small and high parts

- **Add a brim**

Supports: None
Infill: 15%   Brim: ☑
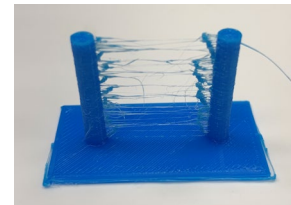
Brim
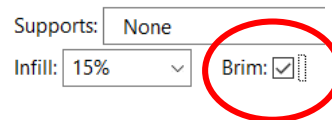
STEPS FOR
SUCCESSFUL 3D PRINTING

PREPARE
(aka slice)

- **Prevent stringing**

(especially when you print multiple parts)

- Increase retraction length > 3 mm (max)

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STEPS FOR
SUCCESSFUL 3D PRINTING
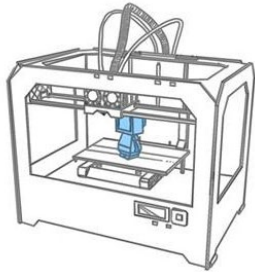
3D PRINT

- **Respect** the tools and the rules
- Don't take other user's parts off the printbed. Put it on the table and take a **new clean printbed**.
- Place the printbed properly

- Check the filament (type and amount)
  - > video tutorial for filament change
- Check if the nozzle is clean
  If not, remove excess filament with a plier or ask for help

- MK3: Unlock a printer on make.epfl.ch/3dprint
- MK4: Fill in the **log sheet** properly
- **Stay** for the first layers to check everything is ok and eventually come back from time to time

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STEPS FOR
SUCCESSFUL 3D PRINTING

EPFL

FINISH / ASSEMBLE

- **After printing**

  - Remove the printbed from the printer

  - Remove your part from the printbed
    Please, avoid scratching the surface
  - Remove the **supports** > use pliers

  - **Clean** the workplace
  - Use the **PETG bin**!
  - **Clean** the printbed (soap and water)

  - Smooth the functional surfaces, correct the holes diameters, assemble, etc. > **In the atrium**

3D PRINTING TRAINING

SPOT

RESSOURCES

- Your 3D printing coach is Sebastien Martinerie

	Monday	Tuesday	Wednesday	Thursday	Friday
Morning (9h-12h)	YES	-	YES	-	YES
Afternoon (13h-17h)	YES	-	YES	YES	YES

- E-mail: sebastien.martinerie@epfl.ch

- Slack, Phone: +41 21 693 99 63

make.epfl.ch/3dprint

3D PRINTING TRAINING

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HAVE FUN PROTOTYPING AND 3D PRINTING @ SPOT!

SPOT / Sébastien Martinerie

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