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
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!**
WHAT IS 3D PRINTING?

3D printing is a great tool for rapid prototyping!

THINK

DESIGN

MAKE

TEST

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

YOUR COACHES CAN HELP YOU!
**WHAT IS 3D PRINTING?**

The most common 3D printing types:

<table>
<thead>
<tr>
<th>Type Name</th>
<th>Material extrusion</th>
<th>VAT Polymerization</th>
<th>Material jetting</th>
<th>Powder bed fusion</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fused deposition modeling (FDM)</td>
<td>Stereolithography (SLA)</td>
<td></td>
<td>Selective laser sintering (SLS) or melting (SLM)</td>
</tr>
</tbody>
</table>

**Principle**

| Principle | ![Diagram of material extrusion] | ![Diagram of stereolithography] | ![Diagram of material jetting] | ![Diagram of powder bed fusion] |

**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
- AFA (plastic)
- External partners (metal)
3D PRINTING @SPOT:
THE PRINTERS

- PRUSA MK3S+

  - 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)
    - TPU (on demand) (0,1 CHF/g)
  - Easy to use
  - For 95% of your needs
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.)*
  - Soluble supports*
  - 0.05 ~ 0.2 CHF/g

- 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
3D PRINTING @SPOT: THE SPACE

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

- For what?
  - Make projects
  - Courses
  - Credited Semester/Bachelor/Master projects

- Others:
  - **Ask** for permission for personal projects
  - Go to **AFA** first for any non-credited professional projects (internship, research, private company, etc.)
3D PRINTING @SPOT: THE SPACE

- A modern and evolutionary space
- A high volume workshop
  - 5’900 print jobs
  - 106 km of printed filament (330 kg)
  - 1’500 days of printing
- A community of users
  - 400+ trained users

(Numbers from March 2022 to September 2023)
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.)
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.
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
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
3D PRINTING @SPOT: SAFETY

- 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
STEPS FOR SUCCESSFUL 3D PRINTING

- Each step is important, takes time and determines the others.
- Schedule your prints in advance and take some margin.
- Don’t waste time and materials. A good design and a good slice reduce the number of iterations, failures and breakdowns.
- Some manual finishing work is part of the job.
- Asking for help is always OK.
STEPS FOR SUCCESSFUL 3D PRINTING

- 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
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

V

X
**STEPS FOR SUCCESSFUL 3D PRINTING**

- **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
**DESIGN**
(for manufacturing)

### STEPS FOR SUCCESSFUL 3D PRINTING

- **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.
STEPS FOR SUCCESSFUL 3D PRINTING

- 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
STEPS FOR SUCCESSFUL 3D PRINTING

**PREPARE**
(aka slice)

- Use only the manufacturer’s software > **PrusaSlicer**
- Configure the right printer
  > **Prusa i3 MK3S+** 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
  (never take an SD card on a working printer)

Print settings :

- 0.15mm QUALITY

Filament :

- Generic PETG

Printer :

- Original Prusa i3 MK3S & MK3S+
STEPS FOR SUCCESSFUL 3D PRINTING

- 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**

**PREPARE**
(aka slice)

**Place on face tool:**
Choose which surface will face the printbed. Preferably use this tool!
**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). But remember that you will have to be able to remove supports afterwards. Also, they alter the surface quality or might not print well.
  - **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.
STEPS FOR SUCCESSFUL 3D PRINTING

- **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

**PREPARE**
(aka slice)
3D PRINTING TRAINING

STEPS FOR SUCCESSFUL 3D PRINTING

- **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
- Fill in the **log sheet** properly or unlock a printer on [make.epfl.ch/3dprint](http://make.epfl.ch/3dprint)

- **Stay** for the first layers to check everything is ok and eventually come back from time to time
STEPS FOR SUCCESSFUL 3D PRINTING

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 printbed (soap and water)
- Clean the workplace
- Use the PETG bin!
- Smooth the functional surfaces, correct the holes diameters, assemble, etc. > In the atrium
Your 3D printing coach is Sebastien Martinerie

<table>
<thead>
<tr>
<th>Time</th>
<th>Monday</th>
<th>Tuesday</th>
<th>Wednesday</th>
<th>Thursday</th>
<th>Friday</th>
</tr>
</thead>
<tbody>
<tr>
<td>Morning (9h-12h)</td>
<td>YES</td>
<td>-</td>
<td>YES</td>
<td>-</td>
<td>YES</td>
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<tr>
<td>Afternoon (13h-17h)</td>
<td>YES</td>
<td>-</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
</tbody>
</table>

E-mail: sebastien.martinerie@epfl.ch
Slack, Phone: +41 21 693 99 63

Make.epfl.ch/3dprint
HAVE FUN PROTOTYPING AND 3D PRINTING @ SPOT!
## 2. PRINTERS AND MATERIALS AT SPOT

<table>
<thead>
<tr>
<th>Name</th>
<th>Prusa MK3S+</th>
<th>Raise3D Pro3 Plus</th>
<th>Formlabs Form3+</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technology</td>
<td>FDM – single extrusion</td>
<td>FDM – double extrusion</td>
<td>SLA</td>
</tr>
<tr>
<td>Number</td>
<td>20+</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Security level</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Terms of use</td>
<td>2 Free access after training</td>
<td>3 Under supervision</td>
<td>3 Under supervision</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Contact Sébastien</td>
<td>Contact Sébastien</td>
</tr>
<tr>
<td>Build volume (x,y,z)</td>
<td>250 x 210 x 210 mm</td>
<td>300 x 300 x 605 mm</td>
<td>145 x 145 x 185 mm</td>
</tr>
<tr>
<td>Slicer / Software</td>
<td>PrusaSlicer</td>
<td>ideaMaker</td>
<td>Preform</td>
</tr>
<tr>
<td>Materials</td>
<td>PETG TPU, PLA (on demand)</td>
<td>PETG, PLA, ASA, PC Soluble support, PA12 CF, TPU, etc (under development)</td>
<td>Clear, Grey Pro, High Temp, Rigid 10K Other Formlabs resins on demand</td>
</tr>
</tbody>
</table>