IO2-A2: DUAL EDUCATIONAL PACK

3D2ACT:

FOSTERING INDUSTRY 4.0 AND 3D TECHNOLOGIES THROUGH SOCIAL ENTREPRENEURSHIP: AN INNOVATIVE PROGRAMME FOR A SUSTAINABLE FUTURE

Author (s): **NATIONAL CENTER FOR SCIENTIFIC RESEARCH "DEMOKRITOS"**

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PROJECT INFORMATION

PROJECT ACRONYM:

3D2ACT

PROJECT TITLE:

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PROJECT NUMBER:

2020-1-EL01-KA202-078957

WEBSITE:

https://3d2act.eu/

CONSORTIUM: PARTNER LIST

- **NATIONAL CENTER FOR SCIENTIFIC RESEARCH "DEMOKRITOS" (GREECE)**
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- **UNIVERSITY OF CRETE** (Greece)

LESSON PLAN 1.1.2

TEACHING MODULE 1.1.2	
Chapter 1.1	Introduction to 3D printing
Equipment (if needed)	Projector Optional: PC with access to the internet
Duration	1 Hour
Short Description	In this worksheet students will learn about the different 3D printer types and materials and 3D printing limitations as well as example applications of 3D printing in the Industry and in other sectors.
Learning Outcomes	At the end of this chapter, students must be able to: Identify the different types and methods of 3D printing Recognize the basic components and functionality of a 3D printer
	Understanding of the basic scientific principles behind 3D printing Apply their knowledge in order to select the appropriate material in relation to the use of the object they want to construct
	Imagination, Critical Thinking
Activities	
Activity 1	Activity 1.1.2.1
Aim of the Activity	The general aim of the Activity is to familiarize students with the main types of 3D Printing Technologies
Duration	45 minutes
Type of Activity	Presentation
Teaching Objectives	After completing the Activity, students will be able to: • Identify the different types and methods of 3D Printing

	• Explain the basic operating principles of a 3D printer (FDM) • Recognize the basic components of a 3D Printer (FDM) and their functionality • Identify the different types of Filaments and their uses • Apply their knowledge in order to select the appropriate material in relation to the use of the object they want to construct
Resources	Worksheet 1.1.2 / Presentation 1
Further Reading	
	https://all3dp.com/2/3d-printer-bed-how-to-choose-the-right-build-plate/ https://apm-designs.com/3d-printer-main-components/#flat-bed https://www.pcmag.com/how-to/3d-printer-filaments-explained https://www.lpfrg.com/guides/3d-printer-filament-types/ https://e3d-online.com/blogs/news/anatomy-of-a-hotend https://apm-designs.com/3d-printer-main-components/

Activity Worksheet 1.1.2

Level 1 (Novice Level: Basic Competences)
Chapter 1.1: Introduction to 3D Printing
Activity Worksheet 1.1.2

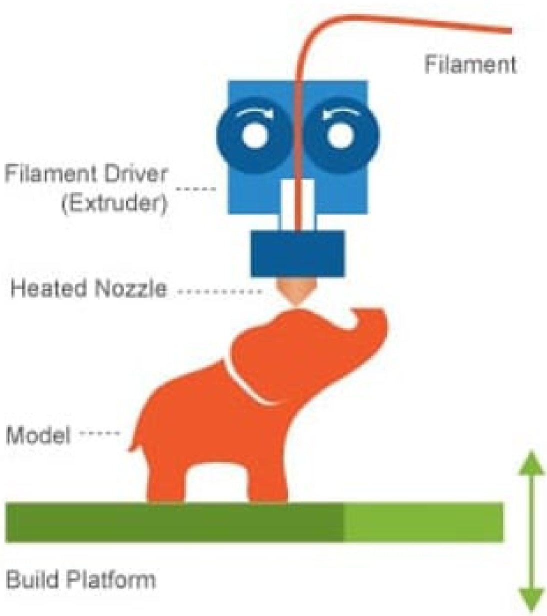
Presentation 1: 3D Printers Types

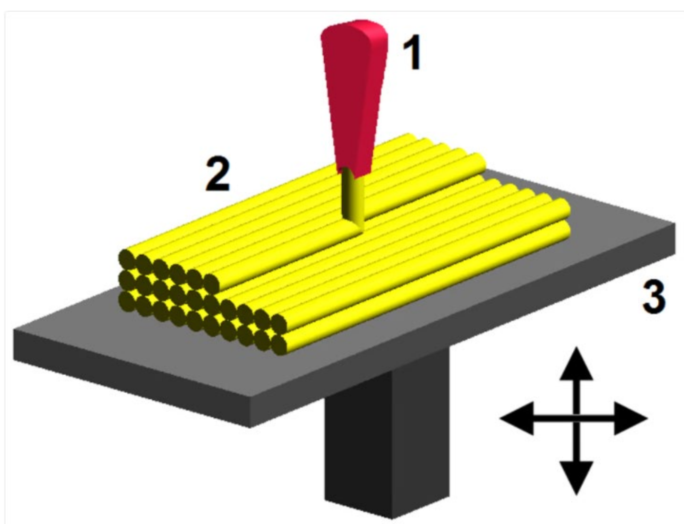
Types of 3D Printers

3D Printing refers to a wide variety of technologies that are used to recreate Computer Generated Models using a material. It is an umbrella term and it includes a lot of deferent technologies that manipulate materials in order to form 3D objects. Some of the more popular technologies include:

Fused Deposition Modeling (FDM)

Fused Deposition Modeling (FDM) is a common desktop 3D printing technology for plastic parts. The printers that work with this technology melt plastic and push it out of a nozzle to form 2D layers that combine to form a 3D object.

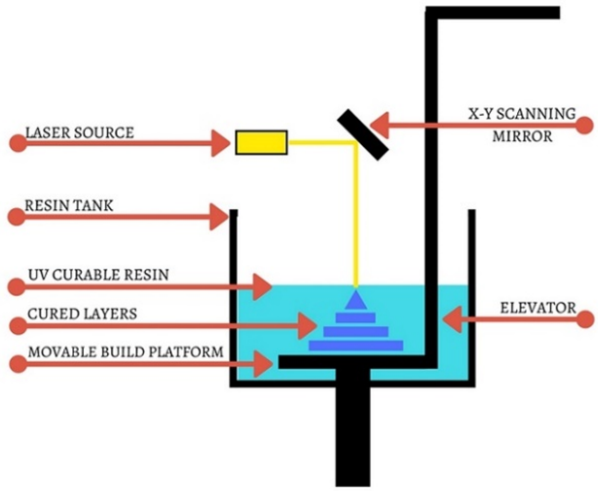




A heated nozzle (1) ejects molten plastic, depositing it in thin layers, one on top of another (2), onto a print bed (3), eventually forming the 3D printed part.

Stereolithography (SLA)

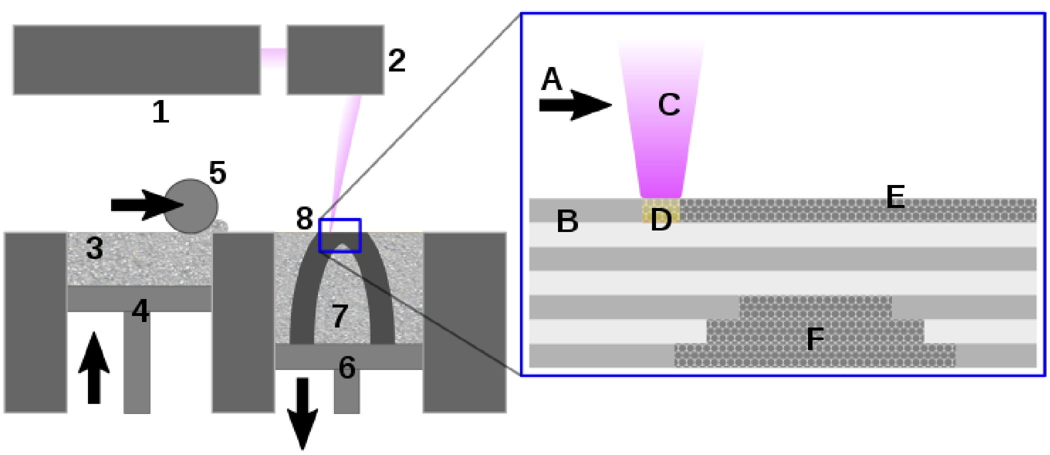
Stereolithography printing uses accurate Laser lights to change the properties of photopolymer resin.



It works by using a high-powered laser to harden liquid resin that is contained in a reservoir to create the desired 3D shape. In other words, this process converts photosensitive liquid into 3D solid plastics in a layer-by-layer fashion using a low-power laser and photopolymerization.

Selective Laser Sintering (SLS)

Selective Laser Sintering (SLS) 3D printers make use of a laser and a thermoplastic polymer powder to build parts. Because of the high-power laser, it's generally considered more complicated than both FDM and SLA.



Selective laser sintering process
1 Laser 2 Scanner system 3 Powder delivery system 4 Powder delivery piston 5 Roller 6 Fabrication piston 7 Fabrication powder bed 8 Object being fabricated (see inset)
A Laser scanning direction B Sintered powder particles (brown state) C Laser beam D Laser sintering E Pre-placed powder bed (green state) F Unsintered material in previous layers

SLS 3D printers consist of a powder bin, a build platform, a powder re-coater, a laser (either CO2, diode, or fiber), a set of galvanometers, a set of heaters and a powder feeder.

All of these 3D Printing technologies rely on one important technique and that is layering 2D slices on a 3D shape together and joining them together via some means.

The one that we are really interested in these courses is the Fused Deposition Modeling (FDM) 3D Printers which is one of the most popular type of 3D Printers.

How 3D Printing through FDM Works / FDM 3D Printers Hardware Parts

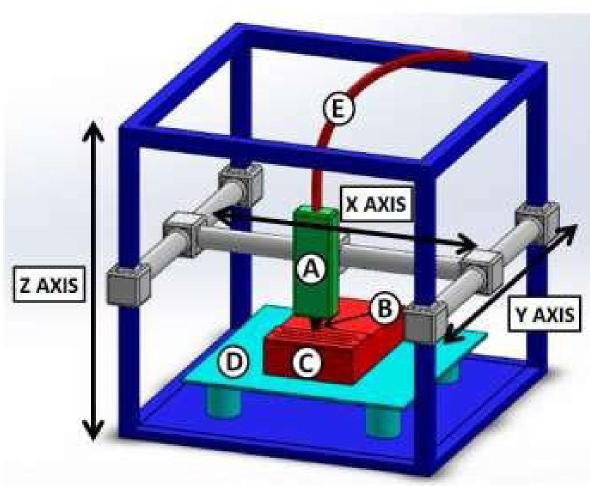
As mentioned before, an FDM Printer works by melting plastic and pushing it through a nozzle in order to create 2D layers. Then by combining those layers together a 3D object is formed. In this section we are going to see this process in more details and discuss about the main parts that an FDM Printer consists of. By understanding the components of a 3D printer will enable you to produce higher-quality printed models, but by understanding the finer points of what each component accomplishes, can assist you in the following ways:

- Improve the quality of your prints
- Fine tune printing speeds
- Maintain your printer for greater longevity
- Upgrade and modify parts where needed

FDM 3D Printers Hardware Parts

The most basic 3D printing process is FDM. A printing plate (D) on which the object is printed, a filament coil (E) that serves as printing material and an extrusion head, also known as an Extruder (A) and Nozzle (B), are the three essential components of FDM.

The filament is melted by the printer's extruder, which deposits the material on the plate layer by layer.



Most 3D Printers are using the Cartesian Coordination system in 3-Dimensional Space. Typically, the Printing Plate or Bed (D) can move along the Y axis while the Extruder (A) can move on the X and Z axes. The printer is starting by printing the first Layer by moving on the X and Y axes (The height remains constant in the lower position for Z axis) and after moves to the next by raising the Extruder in the Z axis by just a little in order to print the next one and so on.

You can imagine it as a Lego construction, when you have to finish the lowest (First) Layer to move to the second and so on until you finish the construction. You always have to finish each layer in order to proceed to the next one.

Watch the following time-lapse video of 3D Printing a miniature of the Eiffel's Tower.

Discuss with your Classmates:

The miniature of Eiffel's Tower has four "legs". Why did the printer did not print the first "leg" and then move to the second and so on until all four "legs" were printed?

Bear in mind that the way each printer "moves" along the axes may differ. Some models keep the extruder steady and the Printing Plate moves along all axes. Some models use the opposite way by keeping the Printing Plate steady and the Extruder moves along the three axes. Whatever the way, the idea is the same, print a layer and move on to the next.

Printing Plate (Bed)

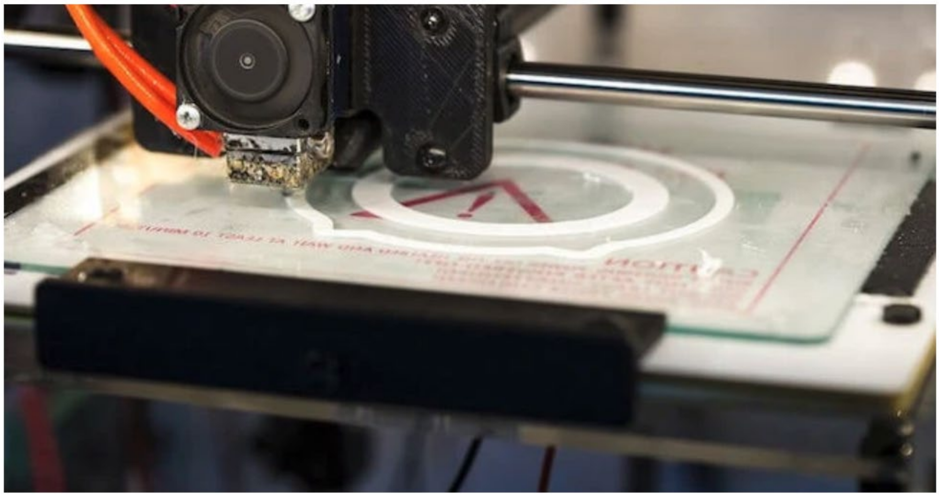
The build plate is arguably one of the most important parts of any 3D printer, as you can't print without it. They come in a variety of shapes and sizes, as well as differing surfaces, thermal properties and price tags.

A build plate's main purpose is to offer an (ideally) flawless flat surface for your print's first layer. The second purpose is to offer an adhesive surface for the extruded plastic to make a temporary bond with it during the printing process, or a surface on which an adhesive can be applied. A lot of times the materials used in 3D Printing require a Heated Bed in order to "Stick" to it. A **Heated Bed** is a heated surface with a temperature starting from 40 to 110 degrees Celsius, depending on the material to be used.

The Bed can be made up of different materials such as:

- Glass
- BuildTak
- FlexPlate
- Metal

Each material has its advantages and disadvantages.



3D Printing Filament Coil

The thermoplastic filaments used in 3D printing are plastics (aka polymers) that melt rather than burn when heated, may be shaped and molded, and solidified when cooled. There are two "standard" diameters of filament that can be used for FDM printers, 1.75mm & 3mm. These diameters will depend on the printer you have available.

There are a lot of filaments in the market with different capabilities and uses but here we are going to have a look at a few of the more popular and important filament types.

- **PLA:**

  Polylactic acid, also known as PLA, is a thermoplastic monomer derived from **renewable, organic sources** such as corn starch or sugar cane. Using biomass resources makes PLA production different from most plastics, which are produced using fossil fuels through the distillation and polymerization of petroleum. PLA has a relatively **low melting point**, with usable temperatures between **180 degrees and 230 degrees Celsius**.

- **ABS:**

  Acrylonitrile Butadiene Styrene, or ABS is a common thermoplastic well known in the injection molding industry. It is used for applications such as LEGO, electronic housings and automotive bumper parts. Objects printed from ABS are **tough**, **durable**, and **nontoxic**. It has a relatively **high melting point**, with a print temperature ranging from **210 degrees to 250 degrees Celsius**. The bottom corners of objects being printed with ABS tend to curl upward a bit, especially if you are using a non-heated print bed. During printing, ABS can emit an acrid, unpleasant odor, so it's best used with a **closed-frame printer** in a **well-ventilated room**.

PLA and **ABS** are the most common materials that almost every, even entry level, printer can print.

When should I use PLA and when ABS?

For most applications' **PLA** is a very good choice.

But compared to other types of 3D Filaments, PLA is brittle, so **avoid using** it when making items that might be bent, twisted, or repeatedly dropped, such as phone cases, high-wear toys, or tool handles.

You should also avoid using it with items that need to withstand higher temperatures, as PLA tends to deform around temperatures of 60°C or higher.

ABS is robust – able to withstand high stress and temperature. It's also moderately flexible. Together these properties make ABS a good general-purpose 3D printer filament, but where it really shines is with items that are frequently handled, dropped, or heated. Examples include phone cases, high-wear toys, tool handles, automotive trim components, and electrical enclosures.

In addition to these two materials there is a huge variety of materials available in the market. But we must be very careful since not all printers have the ability to print these materials. An indicative list of materials is presented below.

- **PETG:** Many models degrade if left out in direct sunlight. PETG is the main exception in 3D printing. PETG models can be used to store liquids or be submerged without degrading.
- **Carbon Fiber:** Carbon is added to a base filament to increase strength and rigidity in the final model.
- **Nylon:** Great for models that require movement without degrading.
- **FLEX:** Elastic parts like phone cases and grips can be made with flex.
- **HIPS:** HIPS is highlight impact resistant and can withstand forces for various functional applications.
- **PVA:** PVA dissolves in water and is used for complex geometric models.

FDM Extruder

The extruder in a 3D printer is a set of components that move and process plastic filament. The motor and other elements that push and pull the filament are referred to as the "extruder" by some people, while others, name as extruder, the complete assembly, including the hot end, which is where the filament is melted and deposited.

We'll refer to the complete system as the extruder to make things simple. Explanation of the extruder necessitates a thorough examination of two critical assemblies known as the "cold end" and "hot end."

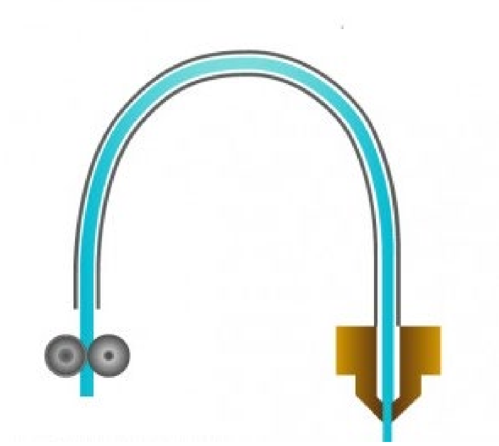
<u>"Cold End"</u>

Cold end refers to the **upper portion** of the 3D printer extruder system where the filament **is fed and passed along into the hot end** (the lower portion of the extruder system) for melting and extrusion onto the print bed. The cold end consists of an **extruder motor** and **gearing,** which are **mounted** to either the printer's frame or the print head itself, depending on the style of the extruder.

For FDM there are two extruder types, the Bowden extruder and the Direct Drive extruder. This component, by means of a motor, feeds the filament to the hot end ready for melting.

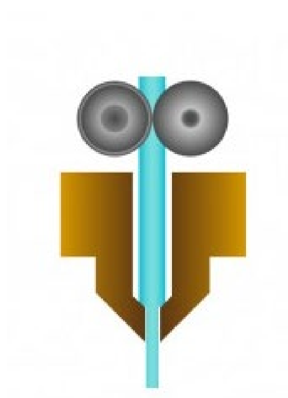
Bowden Extruder

The motor on Bowden extruders are located away from the hot end which reduces the weight of moving parts. This allows for more accurate prints as momentum is greatly reduced, particularly at higher speeds (less momentum to overcome during instant changes in direction).



Direct Extruder

For direct feeders, the extruder pushes the filament directly into the nozzle as it is located directly above the hot end.

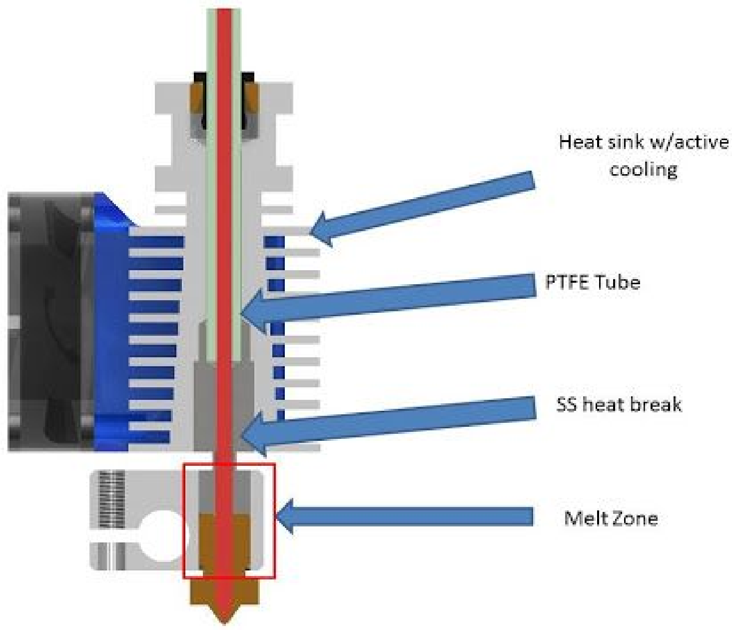


<u>"Hot End"</u>

Hot Ends act as a 'glorified glue gun', which is fed with the filament by the extruder. Sometimes these two components are one and the same, sometimes they're fixed together and sometimes they're a distance away and are connected by a tube of PTFE.

Either way, the filament is driven by the extruder into the top orifice of what's known as the Hot End's 'cold side', through the Hot End, and into the 'hot side'. Here the plastic becomes sticky, and then viscous, before eventually extruding through the **nozzle** at the bottom of the Hot End'.

Once extruded, filament is laid down into a path; this path will eventually form one layer (or one slice) of the print.



References

https://all3dp.com/2/3d-printer-bed-how-to-choose-the-right-build-plate/

https://apm-designs.com/3d-printer-main-components/#flat-bed

https://www.pcmag.com/how-to/3d-printer-filaments-explained

https://www.lpfrg.com/guides/3d-printer-filament-types/

https://e3d-online.com/blogs/news/anatomy-of-a-hotend

https://apm-designs.com/3d-printer-main-components/