Prototypes : Prototypes are early models of a product that simulate its design and functionality. They are created to test concepts, gather feedback, and iterate on the design before the final product is developed. Prototyping, on the other hand, is the experimental process of making prototypes

Types of prototype :

By Fidelity : high mid low

By purpose/function : feasibility, functional working, user Experience, horizontal, verticle, video

By process or methodology :

1. Rapid - Fast creation other fast methods to get physical models quickly.
2. Evolutionary - Prototypes are built upon and refined into the final product, not thrown away.
3. Incremental : The system is built in pieces, with each piece prototyped and integrated.
4. Throwaway - Prototypes are built to test a concept and then discarded

Alternatives to 3D printing for rapid prototyping include CNC Machining for high-accuracy metal/plastic parts, Laser/Waterjet Cutting for 2D profiles, Vacuum Forming/Casting for detailed plastic/silicone parts, and Subtractive Methods like photo-etching, often combined with Assembly of Flat-Cut Layers, offering diverse options for material, accuracy, and complexity.

8 Types of 3d printing and its process :

1. Polyjet printing :
   These machines use print heads to sprinkle tiny droplets of photopolymer resin onto a build plate, which then get hardened by a UV light in layers. PolyJet machines are capable of full-color and multi-material prints, making them ideal for creating lifelike models and visual prototypes. Be warned, though, PolyJet materials are not known for durability and are not suitable for end-use components.
2. Fused deposition modelling (FDM) : Fused deposition modeling (FDM) machines can be found anywhere from a desk of a hobbyist, to the manufacturing floors of production facilities. This popular method involves moving a thermoplastic filament through a heated nozzle to melt it and build up a part layer by layer until the final product is finished. There are many different filament materials to choose from for FDM printing, whether you're after a more rigid plastic or bendy thermoplastic elastomer.
3. Stereolithography (SLA) : Stereolithography (SLA) was the first kind of 3D printing that everyday people could get their hands on. This printer uses a high-powered

laser to cure thermosetting liquid photopolymer on its build plate. The laser zips around in the shape of the part's cross-section, curing it and getting it ready for the next layer. It works with a process called polymerization to build the item you've designed layer by layer. It's a great printing option if you want to build intricate models or products

4. Selective Laser Sintering (SLS): Selective laser sintering (SLS) swaps in those well-known plastic filaments for thermoplastic powder ; typically nylon. This machine spreads a thin layer of this powder using a device called a recoater, then traces out the part's cross-section with a laser. During the tracing, the heat from the laser melts the powder and it fuses together. The build chamber piston will then lower slightly, and another layer of powder will be spread across, and the process repeats until your product comes to life. This type of printing method does not require support structures as the un-sintered powder encases the parts throughout the medium, supporting them. For this reason, many parts can be built simultaneously in a single build which makes SLS printing superb for creating lots of parts at the same time, while retaining accuracy and quality.
5. Multi-Jet Fusion (MJF) : Multi-jet fusion printing has a lot of moving parts. On these machines, a layer of plastic powder is deposited that's then warmed up by a heating head. An inkjet-style array hovers over top and precisely sprays fusing and detailing agents into the powder. The heating elements fuse it all together, and the process repeats. Like SLS printing, MJF parts do not require support structures due to the powder-based method, and therefore many parts can be printed simultaneously both horizontally and vertically in the build chamber.
6. Direct Metal Laster Sintering (DMLS): When you're in the market for a process that can 3D print directly in metal, look to direct metal laser sintering (DMLS) services. Similar to selective laser sintering, DMLS machines deposit a thin layer of metallic powder, then use their powerful lasers to trace out each part's cross section layer by layer, fusing the metallic particles together to form parts. Unlike SLS, support structures are required as the heat and stress generated by sintering metal is much greater than with plastics. Due to their size, high cost, and the extensive post-processing steps required on parts after printing is completed, DMLS machines tend to only be found in industrial shops,
7. Eectron Beam Melting (EBM) : If you dial up the difficulty level, you'll come across printing methods such as electron beam melting (EBM). Like DMLS, these machines fall into the industrial category and require the related expertise. Its process is all in the name—it uses electron beams to fuse metal particles together. The machine puts down a layer of metal powder, then the beam does the tracing and melting. The beam can even be split to tackle multiple areas all at once.
8. Digital Light Process (DLP) : Some 3D printing options are similar to others, which is the case with digital light process (DLP) and SLA printers. The main

difference is that a DLP machine will project an image using a UV light across the entire material vat at one time, instead of drawing the cross section one point at a time with a laser. Digital light processing has made access to photopolymer printing more accessible. It's cheaper and faster than SLA, but it can still make high-quality parts.

Table 1 : Different types of 3D printing with their advantages

Type of 3D printing	Material used	Strengths	Common applications	Dimensional accuracy
Polyjet printing	Rigid photopolymers, Shore A Rubber-Likes, Clear photopolymer	High resolution, Multi-material, full-color	Overmold prototypes, full-color concept models, educational models	+/- 0.004" for the first inch, plus +/- 0.002" for every inch thereafter
Fused Deposition Modeling (FDM)	ABS, PLA, PC, ULTEM, and more	Low-cost, large print volumes, material variety	Prototyping, Hobbyist parts, Manufacturing Jigs	+/- a single build layer thickness for the first inch and +/- .002" for every inch thereafter
Stereolithography (SLA)	Polycarbonate-Like, ABS-Like, Polypropylene like	High resolution/detail, accurate, large print area	Casting patterns, Prototypes, Concept models	+/- 0.002" - +/- 0.010"
Selective Laser Sintering (SLS)	Nylon 11, Nylon 12, Filled Nylon (e.g. Glass-Filled)	No support structures needed, complex geometries, durable parts	Concept models, end-use parts, medical devices	+/- 0.002" - 0.003" per inch
Multi-Jet Fusion (MJF)	Nylon PA 12, Polypropylene, Glass Filled Nylon, TPU 88A	Highly Accurate, Fast, Low-cost	Visually accurate prototypes, End-use parts	+/- 0.7mm

Direct Metal Laser Sintering (DMLS)	Stainless Steel, Aluminum, Nickel Alloys, Titanium	Stainless Steel, Aluminum, Nickel Alloys, Titanium	Stainless Steel, Aluminum, Nickel Alloys, Titanium	Stainless Steel, Aluminum, Nickel Alloys, Titanium
Electron Beam Melting (EBM)	Chromium, Titanium	Faster than DMLS	Aerospace, medical, & petrochemical components	N/A
Digital Light Process (DLP)	Polycarbonate-Like, ABS-Like, Polypropylene like	Faster than SLA	Jewelry Casting, Dental Splints, Miniature Figurines	0.1 mm

Plastic 3D Printing process

Types of plastics :

1. Thermoplastics : are the most commonly used type of plastic. The main feature that sets them apart from thermosets is their ability to go through numerous melt and solidification cycles. Thermoplastics can be heated and formed into the desired shape. The process is reversible, as no chemical bonding takes place, which makes recycling or melting and reusing thermoplastics feasible. A common analogy for thermoplastics is butter, which can be melted, re-solidify, and melted again. With each melting cycle, the properties change slightly.
2. Thermosetting plastics : (also referred to as thermosets) remain in a permanent solid state after curing. Polymers in thermosetting materials cross-link during a curing process that is induced by heat, light, or suitable radiation. Thermosetting plastics decompose when heated rather than melting, and will not reform upon cooling. Recycling thermosets or returning the material back into its base ingredients is not possible. A thermosetting material is like cake batter, once baked into a cake, it cannot be melted back into batter again.

The three most established plastic 3D printing processes today are the following:

1. FMD 3D printers 2. SLA 3D printers 3. SLS 3D printers

FMD : The most common FDM 3D printing materials are ABS, PLA, and their various blends. More advanced FDM printers can also print with other specialized materials that offer properties like higher heat resistance, impact resistance, chemical resistance, and rigidity.

Material	Features	Application
ABS (acrylonitrile butadiene styrene)	Tough and durable Heat and impact resistant Requires a heated bed to print Requires ventilation	Functional prototypes
PLA (polylactic acid)	The easiest FDM materials to print Rigid, strong, but brittle Less resistant to heat and chemicals Biodegradable Odorless	Concept models Looks-like prototypes
PETG (polyethylene terephthalate glycol)	Compatible with lower printing temperatures for faster production Humidity and chemical resistant High transparency Can be food safe	Waterproof applications Snap-fit components
Nylon	Strong, durable, and lightweight Tough and partially flexible Heat and impact resistant Very complex to print on FDM	Functional prototypes Wear resistant parts
TPU (thermoplastic polyurethane)	Flexible and stretchable Impact resistant Excellent vibration dampening	Flexible prototypes
PVA (polyvinyl alcohol)	Soluble support material Dissolves in water	Support material
HIPS (high impact polystyrene)	Soluble support material most commonly used with ABS Dissolves in chemical limonene	Support material

Composites (carbon fiber, kevlar, fiberglass)	Rigid, strong, or extremely tough Compatibility limited to some expensive industrial FDM 3D printers	Functional prototypes Jigs, fixtures, and tooling

SLA : SLA parts have the highest resolution and accuracy, the clearest details, and the smoothest surface finish of all plastic 3D printing technologies. Resin 3D printing is a great option for highly detailed prototypes requiring tight tolerances and smooth surfaces, as well as functional parts, such as molds, patterns, and end use parts. SLA 3D printed parts can also be post-processed after printing by polishing, painting, coating, and more, resulting in client-ready parts with high-quality finishes. Parts printed using SLA 3D printing are isotropic — their strength is consistent regardless of orientation because chemical bonds happen between each layer. This results in parts with predictable mechanical performance critical for applications like jigs and fixtures, end-use parts, and functional prototyping.

Material	Features	Application
General Purpose Resins	High resolution Smooth, matte surface finish	Concept models Looks-like prototypes
Clear Resin	The only truly clear material for plastic 3D printing Polishes to near optical transparency	Parts requiring optical transparency Millifluidics
Fast Model Resin	One of the fastest materials for 3D printing 2-3x faster than standard resins, up to 10x faster than FDM	Initial Prototypes Rapid Iterations
Color Resin	Custom colors Bright, colorful parts	Rapid prototyping with matching color, material, and finish (CMF) Color-coded jigs and fixtures Custom-colored end-use parts
Tough Resins	Strong, robust, functional, and dynamic materials	Housings and enclosures Jigs and fixtures

	Can handle compression, stretching, bending, and impacts without breaking Various materials with properties similar to HDPE, ABS, or PP	Connectors Wear-and-tear prototypes
Rigid Resins	Highly filled, strong and stiff materials that resist bending Thermally and chemically resistant Dimensionally stable under load	Jigs, fixtures, and tooling Turbines and fan blades Fluid and airflow components Electrical casings and automotive housings
Clear Cast Resin	Clean burnout Low thermal expansion Highly accurate	In-house production of industrial investment casting patterns for end-use metal parts
Polyurethane Resins	Excellent long-term durability UV, temperature, and humidity stable Flame retardancy, sterilizability, and chemical and abrasion resistance	High performance automotive, aerospace, and machinery components Robust and rugged end-use parts Tough, longer-lasting functional prototypes

SLS : s trusted by engineers and manufacturers across different industries for its ability to produce strong, functional parts. Low cost per part, high productivity, and established materials make the technology ideal for a range of applications from rapid prototyping to manufacturing aids, and low volume, bridge, or custom manufacturing. As the unfused powder supports the part during printing, there's no need for dedicated support structures. This makes SLS ideal for complex geometries, including interior features, undercuts, thin walls, and negative features. Just like SLA, SLS 3D prints are also generally isotropic. SLS parts have a slightly rough surface finish due to the powder particles, but almost no visible layer lines, and SLS 3D prints can be post-processed easily to further improve the mechanical performance and appearance.

Material	Features	Application
Nylon 12	Strong, stiff, sturdy, and durable Impact-resistant and can endure repeated wear and tear Resistant to UV, light, heat, moisture, solvents, temperature, and water	Functional prototyping End-use parts Medical devices
Nylon 11	Similar properties to Nylon 12, but with a higher elasticity, elongation at break, and impact resistance, but lower stiffness	Functional prototyping End-use parts Medical devices
Nylon composites	Nylon materials reinforced with glass, aluminum, or carbon fiber for added strength and rigidity	Functional prototyping Structural end-use parts
TPU	Flexible, elastic, and rubbery Resilient to deformation High UV stability Great shock absorption	Functional prototyping Flexible, rubber-like end-use parts Medical devices

Metal 3D printing

Beyond plastics, there are multiple 3D printing processes available for metal 3D printing.

Metal FDM:

Metal FDM printers work similarly to traditional FDM printers, but use extrude metal rods held together by polymer binders. The finished “green” parts are then sintered in a furnace to remove the binder.

Selective Laser Melting (SLM) and Direct Metal Laser Sintering (DMLS) :

SLM and DMLS metal 3D printers work similarly to SLS printers, but instead of fusing polymer powders, they fuse metal powder particles together layer by layer using a laser. SLM and DMLS 3D printers can create strong, accurate, and complex metal products, making this process ideal for aerospace, automotive, and medical applications.

Metal 3D Printing Materials :

1. Titanium is lightweight and has excellent mechanical characteristics. It is strong, hard and highly resistant to heat, oxidation, and acid.
2. Stainless steel has high strength, high ductility, and is resistant to corrosion.
3. Aluminum is a lightweight, durable, strong, and has good thermal properties.
4. Tool steel is a hard, scratch-resistant material that you can use to print end-use tools and other high-strength parts..
5. Nickel alloys have high tensile, creep and rupture strength and are heat and corrosion resistant.

Material and process

Different 3D printing materials and plastic 3D printing processes have their own strengths and weaknesses that define their suitability for different applications. The following table provides a high level summary of some key characteristics and considerations.

	FDM	SLA	SLS
Pros	Low-cost consumer machines and materials available	Great value High accuracy Smooth surface finish Range of functional materials	Strong functional parts Design freedom No need for support structures
Cons	Low accuracy Low details Limited design compatibility High cost industrial machines if accuracy and high performance materials are needed	Sensitive to long exposure to UV light	More expensive hardware Limited material options
Applications	Low-cost rapid prototyping Basic proof-of-concept models Select end-use parts with high-end industrial machines and materials	Functional prototyping Patterns, molds, and tooling Dental applications Jewelry prototyping and casting Models and props	Functional prototyping Short-run, bridge, or custom manufacturing
Materials	Standard thermoplastics, such as ABS, PLA, and their various blends on consumer level machines. High performance composites on high cost industrial machines	Varieties of resin (thermosetting plastics). Standard, engineering (ABS-like, PP-like, flexible, heat-resistant), castable,	Engineering thermoplastics. Nylon 11, nylon 12, glass or carbon-filled nylon composites,

		dental, and medical (biocompatible). Pure silicone and ceramic.	polypropylene, TPU (elastomer).

Brands selling 3d printers :

Creality

Bambu lab

Anycubic

Elegoo

Flashforge

Prusa

Phrozen & formlabs

Qidi tech creatbot

Checkbox :

3d printers

1. Why are we buying 3d printers (purpose) – rapid prototyping – what product are focusing to preparing– if we are concentrating only on prototyping we can also see cnc machines then why only 3d printer- which models are you focusing on low mid high performance models -what materials do you want metal/ plastic – if metal which material do you want and why (show the list) – if plastic what filament do you prefer and why – in this process are we focusing on - environment concerns – budget for 3d printers (does this include the designing software, STL files, slicing software?)– quantity – there is even an option of making 3d printers from scratch since we are at the research phase why aren't we thinking about this option
2. What are we making using 3d printers (because cnc and 3d printers both are used for rapid prototyping) and Applications of 3d printers (and its application in our company)
3. Why are we choosing rapid prototyping and not other
4. What are your requirements (type of plastic-type of 3d printer-type of filament acc to -low performance, high performance, moderate performance to)for a 3d printer what material are you going to use metal/plastic if plastic what type of filament you want and if metal what kind of metal do you want
5. What is the budget for buying 3d printers
6. There is an option to even make 3d printer from scratch then why are we opting to buy one
7. Alternatives for 3d printers
8. What are 3d printers
9. Alternatives for rapid prototyping
10. Types of 3d printers
11. Printing Materials used (what material we are using) (details of all the materials)
12. What are STL files (are we buying or making)
13. Slicing software (paid or unpaid)
14. Which brands sell 3d printers and where are these brands available (online/offline if offline location)
15. Which gives good servicing
16. What are or requirements based on the above information (based on requirement choose 3D printer fdm, sla, sls, fdm metal, slm, dmls)