Northwestern 3D Printing & Rapid Prototyping Lab

Northwestern | ENGINEERING
Mechanical Engineering

Additive Manufacturing Capabilities:

Process	Machine	Product Example	Description	Material	Layer Thickness	Min feature size	Max build area	Support Type	Speed	Cost of material	Cost of support	General use/notes:
Fused Deposition Modeling (FDM)	**Stratasys Fortus 250mc** **Stratasys Fortus 380mc** **Prusa Mk3S+**		FDM (a.k.a FFF) extrudes a filament through a heated nozzle, depositing the material on a surface/part where it cools and bonds into a solid part. Parts modeled as solid may be printed with partial infill, from roughly 10% - 100% full solid. (Full solid only available on Stratasys machines)	Stratasys: White or colored ABS Prusa: PLA (multiple colors), Polycarbonate Blend, TPU. Other materials available on request	Stratasys: 0.25, 0.33 mm Prusa: 0.10mm - 0.25mm	0.5mm	Fortus 250: 254 mm x 254 mm x 305 mm Fortus 380: 356 x 305 x 305 mm	Stratasys: Secondary material, dissolved in cleaning tank. Prusa: Primary material, must be manually removed.	Slow	Stratasys: $4.75 - $5.25/cubic inch Prusa: $0.12 - $0.17 /gram	$7.50 - $8.35/cubic inch Prusa: n/a (same as material)	• Best used for large, functional components. • Can print in only one color. • Direction of build influences strength of part.
Fused Deposition Modeling (FDM) + Continuous Fiber Reinforcement	**Markforged Mark2**		Process is identical to FDM (FFF). Markforged utilized a specialized secondary nozzle to include continuous fiber into the component, allowing for tensile strength to match or exceed Aluminum.	Fiber Reinforcement: Fiberglass, Kevlar, Carbon Fiber	0.1, 0.125mm	0.5mm	320 x 132 x 154 mm	Primary material, must be manually removed.	Very Slow	Base Material: $0.45/cc Fiber Reinforcement: $2.00 -$3.75 / cc	n/a - same as base material	• Fiber reinforcement adds significant cost to parts • Fiber reinforcement can not be added to features below 3.6mm wide • Fiber reinforcement fill percentage may range from 5% - 100%
Stereolithography (SLA)	**FormLabs Form 2** **Formlabs Form 3B+**		Stereolithography (SLA) functions by curing a photosensitive resin via a laser. Layers are generally finer than FDM printers, resulting in a smoother part appearance	• Standard Resin (Acrylic-like) - Clear, White, Gray, Black • Engineering Resins - Durable (PE-like), Tough (PP & ABS-Like), Rigid (Nylon-like) • Flexible Resins - Shore 50A (Silicone-like), Shore 80a (rubber-like) • High Temp, Surgical Guide	0.025 (some resins), 0.05, 0.1mm	0.2mm	145 × 145 × 175 mm	Primary material, must be manually removed.	Medium	$0.39 - $0.50/mL	$.39 - $0.50/mL (same as base material)	• High resolution features • Small feature material properties & strength equal to bulk part. • Internal geometry and channels possible - Liquid resin must be able to be flushed out.
Polyjet - Droplet Deposition Stereolithography (SLA)	**Stratasys Connex 350**		DDS uses uses 8 print heads to exponge a photocurable resin and support, onto a build plate. These materials are then cured via a UV light to solidify the part. 2 Core material types can be combined during a single print, allowing up to 14 different digital materials to be included in a single part.	• Standard Rigid Opaque (Acrylic-like) - Clear, White, Gray, Black • Polypropylene-Like (Rigid & Flexible Blend) • Flexible rubber-like - ShoreA 27 - 95 • Two-part resin - High Strength ABS	.025mm	.050mm	340 x 340 x 200 mm	Secondary material. Gel-like, removed via high pressure waterjet. Must be accessable by line-of-sight	Fast	$0.35-0.40/gram	$.28/gram	• Can print multiple materials in the same print. • Highest resolution features only available without support material • Highest resolution layers, resulting in best-finish and appearance.
Selective Laser Sintering (SLS)	**Formlabs Fuse 1+ 30W**		Selective laser sintering uses a high powered laser to fuse fine powder into a solid layer & part. This process is able to produce parts with minimal anisotropy, and is well suited to multiple quantities of similar parts. No support material is required for printing part overhangs	• Nylon 11	0.11mm	.25mm	165 x 165 x 300	No support required - complementary unsintered powder support	Medium	$0.26/gram	n/a - no support used	• Surface finish is rougher compared to other printing methods • An additional ~1.5x print time is required for part cooling following printing
Direct Metal Laser Sintering (DMLS)	**3D Systems Phenix PXS**		DMLS uses a focused laser beam to cure metal powder to a solid part through a melting process. Successive metal powder layers are then deposited on top of a solidified layer, allowing the laser to bond material to previously formed layers of metal.	Stainless Steel 17-4 PH 94 - 98% dense	0.001"	0.004"	3.9" x 3.9" x 3.1"	Yes. Support structure is metal - removal is done manually by requesting party.	Slow	$.50-.60/ gram + $50 setup fee	$.50-.60/gram	• Highest strength parts - truly usable in high load and real-world applications. • Support structure is firmly attached, and requires manual finishing.

Last Update: April 3, 2023

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Rapid Prototyping Part Request Process:

1. Generate ".STL" files of each individual part to be prototyped.
2. Contact the Lab Email Address: **rp.lab@northwestern.edu**. Initial request email should include the following:

- STL File of each individual part to be printed
- Quantity of each part file to be printed
- Machine & Material choice for each part file to be printed
- Chartstring account number to charge build costs

3. Meet with RP lab staff during office hours to review machine and material options, and finalize remaining details.

- A meeting is only required for first-time requests of each part. Iterations & revisions may be requested without requiring a meeting.
- Precise quotes can be provided at this meeting
- Significant part changes or new part requests require a new meeting.

4. Your part will be added to the build queue, and printed once the selected machine is available.
5. The lab will notify the requestor via email when the part is ready for pickup.