Manufacturing Laboratory (21-410)

Advanced Manufacturing Laboratory

Department of Industrial Engineering

Sharif University of Technology

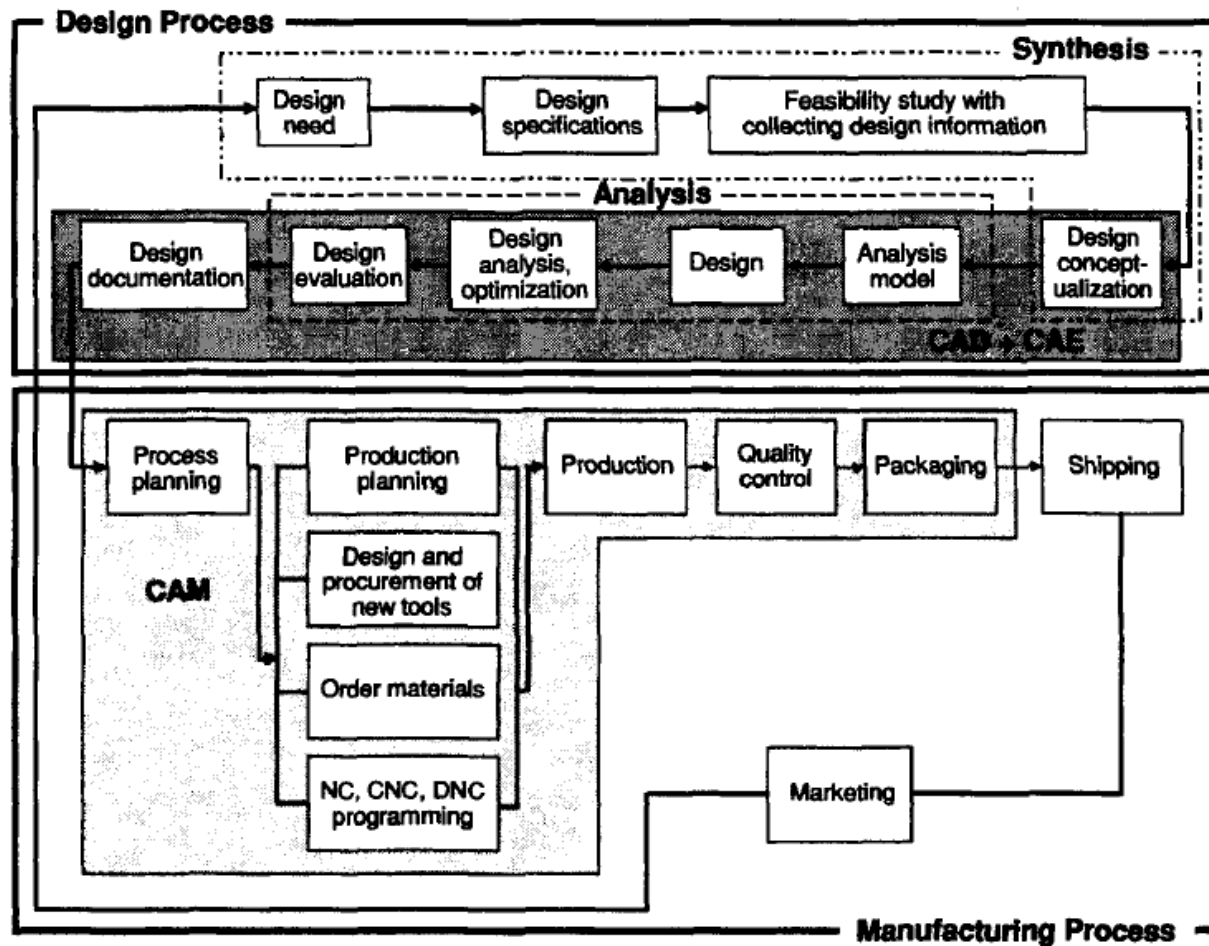*Session # Rapid Prototyping*

Course Description *(Continued..)*

- *Contents:*
  - *Rapid prototyping and manufacturing*

    - *RP primitives*

    - *Application of RP*

# Introduction to CAD/CAM/CAE systems

Rapid prototyping and manufacturing

- *RP primitives*
  - *Rapid prototyping' is a group of techniques used to quickly fabricate a scale model of a physical part or assembly using three-dimensional computer aided design (CAD) data.*

  - *Construction of the part or assembly is usually done using 3D printing or "additive layer manufacturing" technology.*

    - *Alternatively, it is also called:*
      - *Layered manufacturing*
      - *3D printing*
      - *Desktop manufacturing*
      - *Solid free form manufacturing*

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Rapid prototyping and manufacturing

- *RP primitives*
    - *The process of RP is consists of three steps:*
        - *Form the cross sections of the part to be manufactured*

        - *Lay the cross section layer by layer*
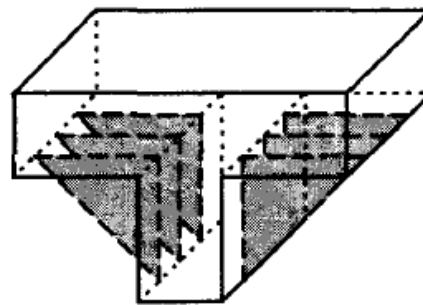
        - *Combine the layers*
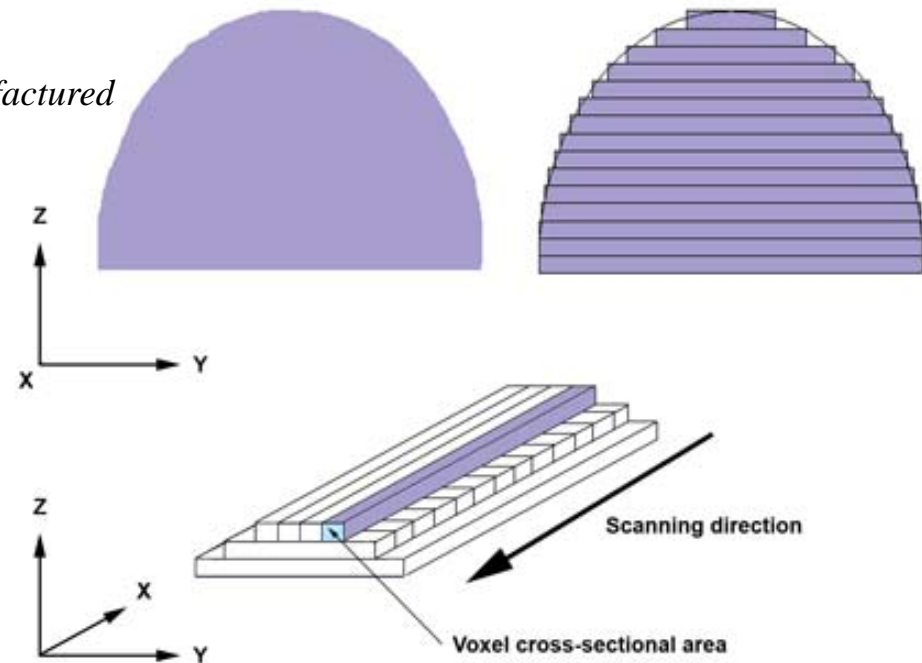
Rapid prototyping and manufacturing

- *RP*
  - *Stereo Lithography:*
  - *In late 1970s and 1980s:*
    - *A photosensitive polymer that solidifies when exposed to a lightening source is maintained in liquid state*

    - *A platform as an elevator*

    - *The UV laser scans the polymer layer above the platform to solidify the polymer and give it the shape of the corresponding cross section*

    - *The platform is lowered in the polymer bath based on the layer thickness*
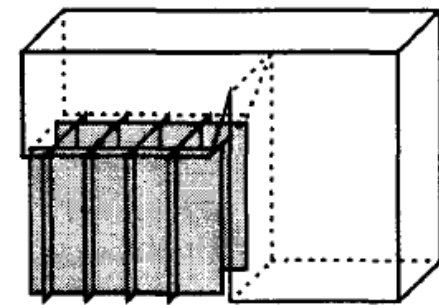

Scanner system

Laser

Laser beam

Layers of solidified resin

Liquid resin

Platform and piston
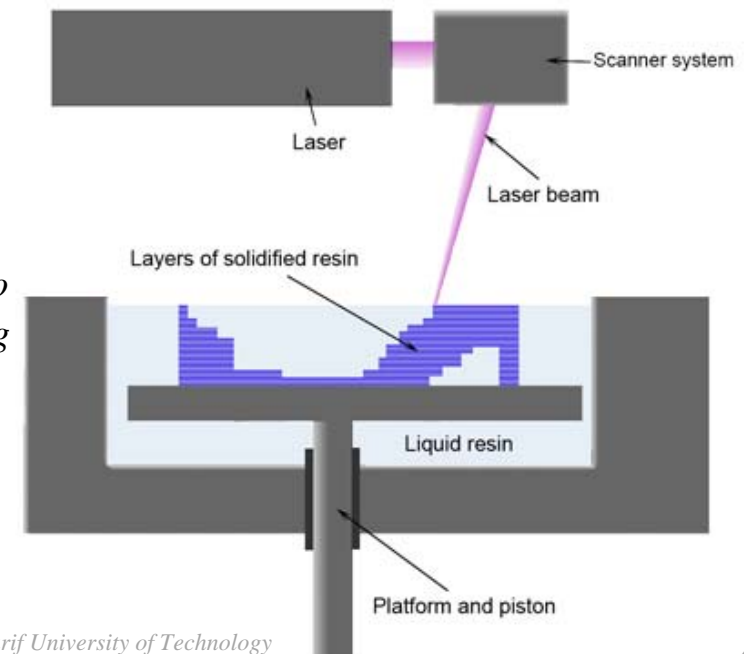
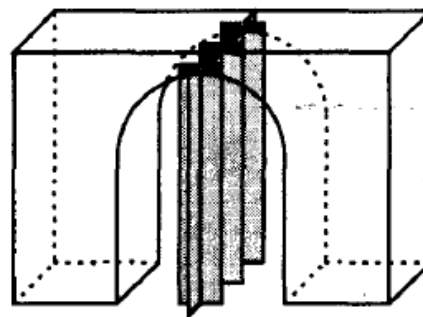# Rapid prototyping and manufacturing

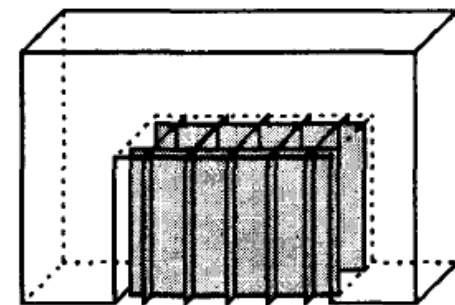- RP
  - *Stereo Lithography:*

(a) Gusset

(b) Island

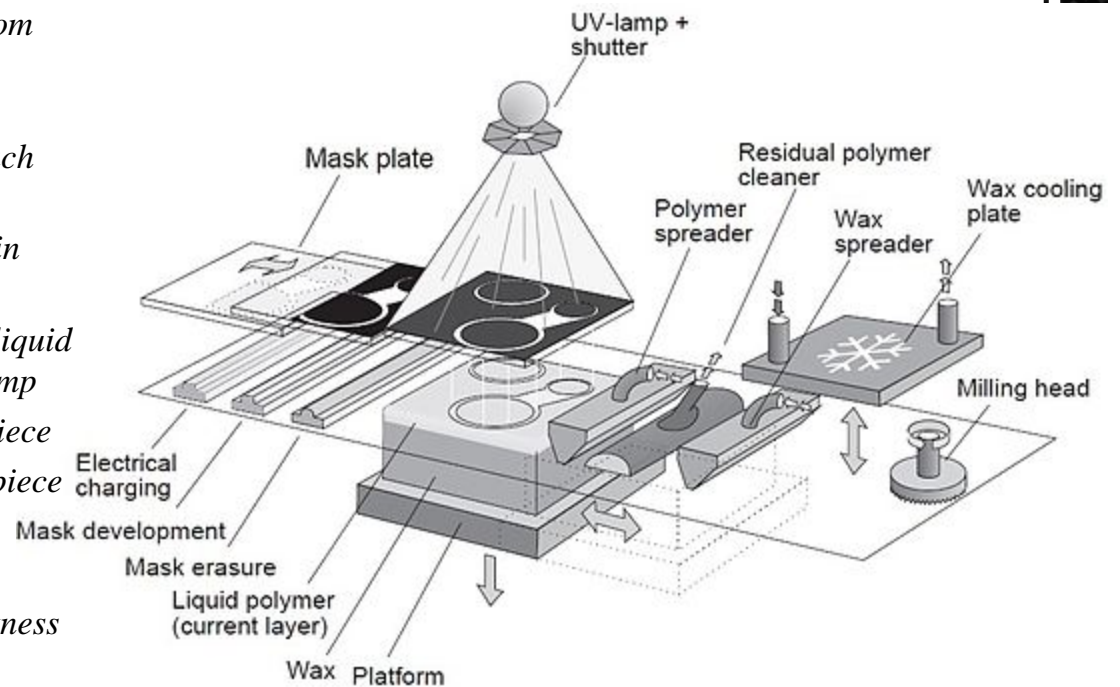(c) Ceiling within an arch

(d) Ceiling

Rapid prototyping and manufacturing

- *RP*
  - *Solid Ground Curing (SGC):*
    - *The cross section of each layer is calculated from the geometric model of the pat and the desired thickness*
    - *The optical mask is generated comforting to each section*
    - *After leveling the platform is covered with a thin layer of the liquid photopolymer*
    - *The mask is positioned over the surface of the liquid resin, the resin is exposed to high power UV lamp*
    - *The residual liquid is removed from the work piece*
    - *A layer of melted wax is spread over the work piece to full the voids*
    - *The wax is solidified*
    - *The layer surface is trimmed to the desire thickness*
    - *At the end the wax is melted*

UV-lamp + shutter

Mask plate

Residual polymer cleaner

Polymer spreader

Wax spreader

Wax cooling plate

Milling head

Electrical charging

Mask development

Mask erasure

Liquid polymer (current layer)

Wax   Platform

Rapid prototyping and manufacturing

- *RP*
  - *Solid Ground Curing (SGC):*

(a) Leveling
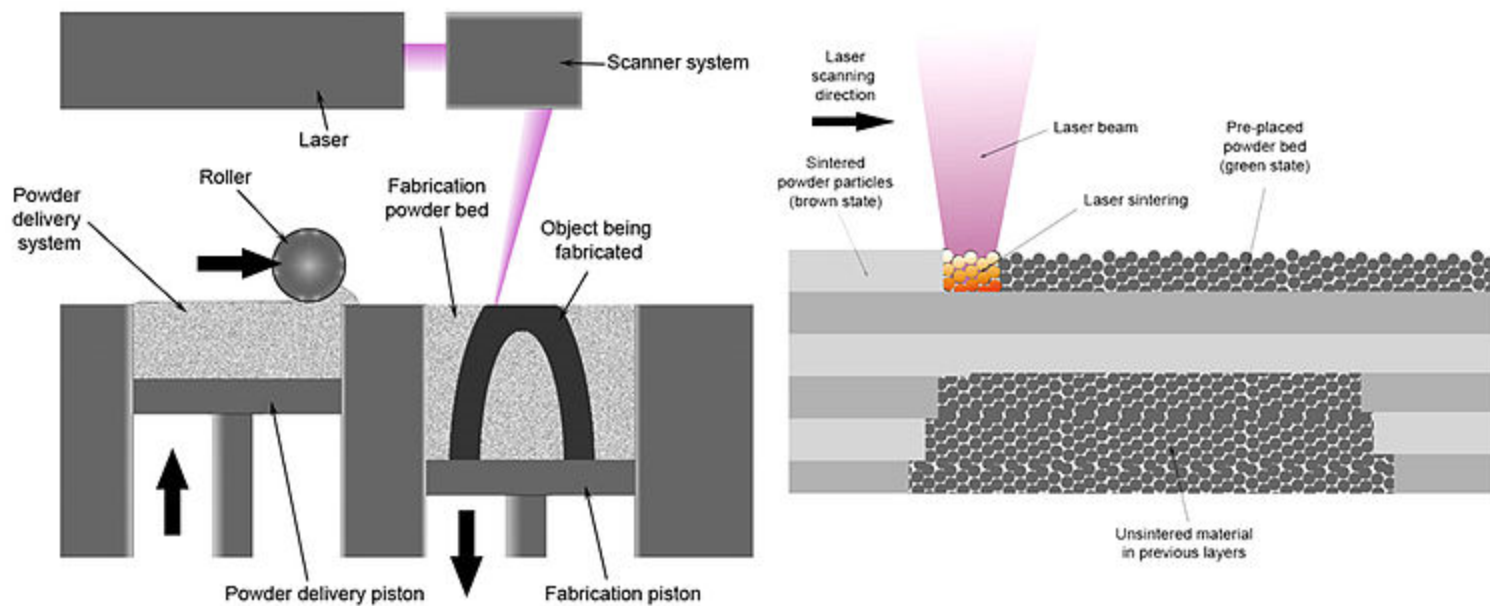
(b) Spreading

(c) Exposing

Complete part

(d) Wiping

(e) Filling

(f) Milling
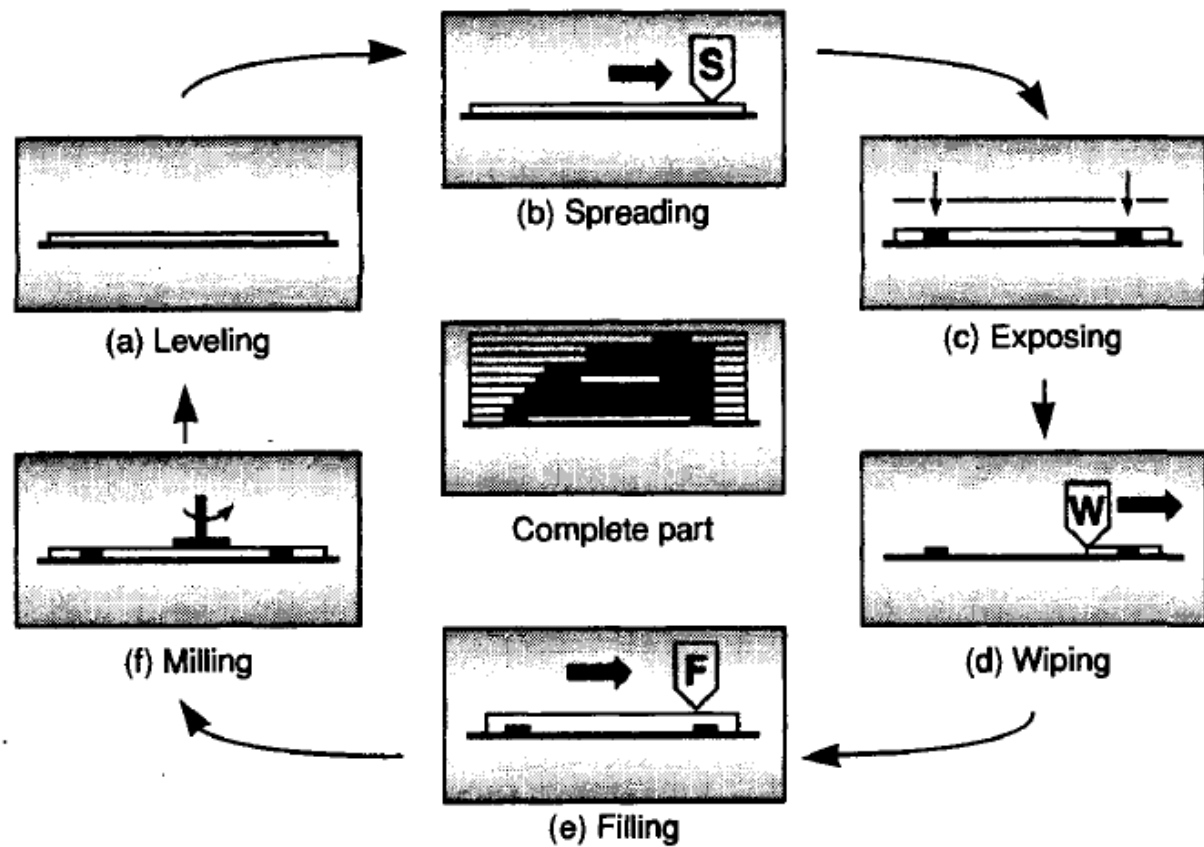
Rapid prototyping and manufacturing

- *RP*
  - *Selective laser sintering :*

Rapid prototyping and manufacturing

- *RP*
  - *Selective laser sintering :*
    - *Selective laser sintering (SLS) is an additive manufacturing technique used for the low volume production of prototype models and functional components.*

    - *Selective laser sintering uses lasers as its power source to sinter powdered material, binding it together to create a solid structure.*

    - *Compared with other methods of additive manufacturing, SLS can produce parts from a relatively wide range of commercially available powder materials.*
      - *These include polymers such as nylon (neat, glass-filled, or with other fillers) or polystyrene, metals including steel, titanium, alloy mixtures, and composites and green sand*
      - *SLS technology is in wide use around the world due to its ability to easily make very complex geometries directly from digital CAD data.*

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Rapid prototyping and manufacturing

- *RP*
  - *Selective laser sintering :*
    - *A support structure is not needed because the voids are filled by the unprocessed powder at each layer*

    - *The integration with the CAD model is achieved well in this method.*

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- RP
  - 3D printing:

Spread powder → Print layer → Drop position

Repeat cycle
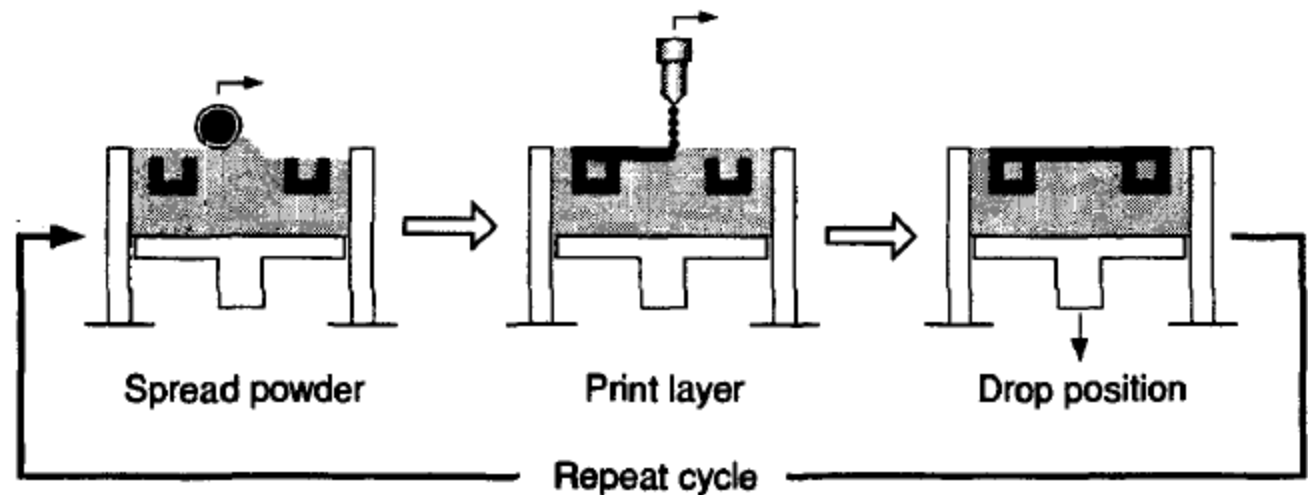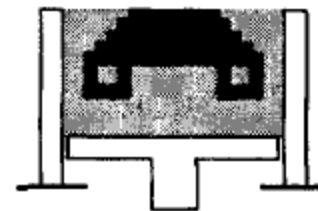
Intermediate stage — Last layer printed — Finished part

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Rapid prototyping and manufacturing

- *RP*
  - *3D printing:*
    - *In 3D printing a liquid binder instead of ink in common printers is ejected.*

    - *The layer of ceramic powder is selectively raster-scanned with a print head that delivers a liquid binder causing the particles to adhere to each other*

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CAD/CAM (21-342), Session# 11

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- *RP*
  - *Laminated-Object manufacturing*
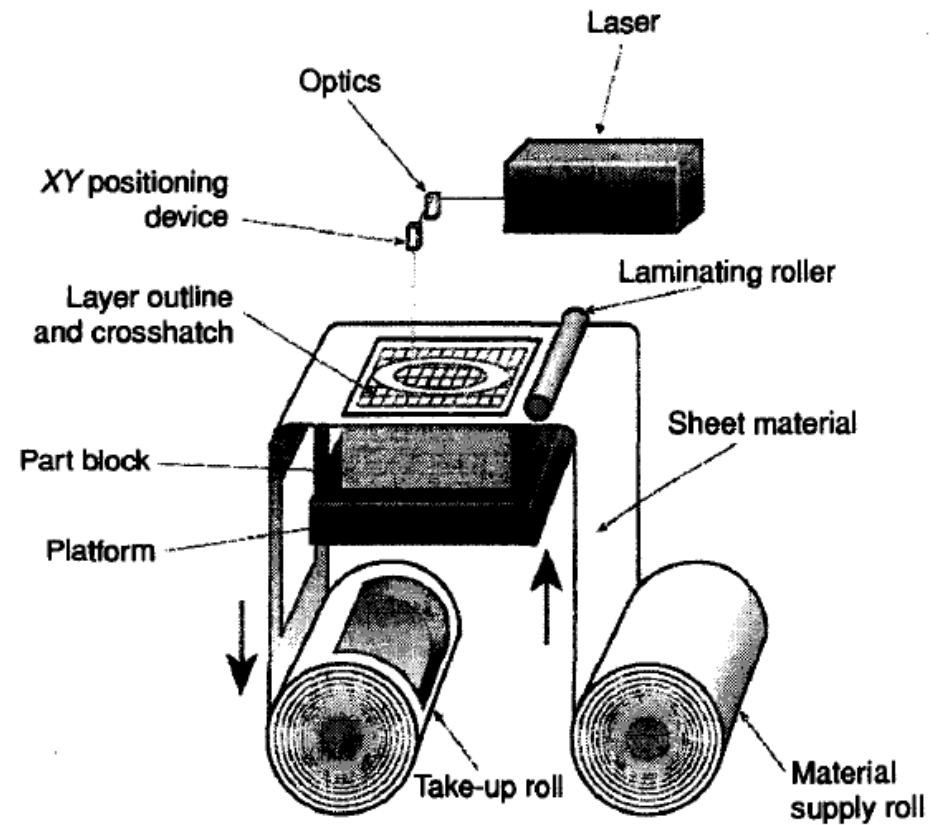
Rapid prototyping and manufacturing

- RP
  - *Fused Deposition modeling*

Support material filament
Build material filament
Extrusion head
Drive wheels
Liquifiers
Extrusion nozzles

Part
Part supports

Foam base
Build platform

Support material spool

Build material spool
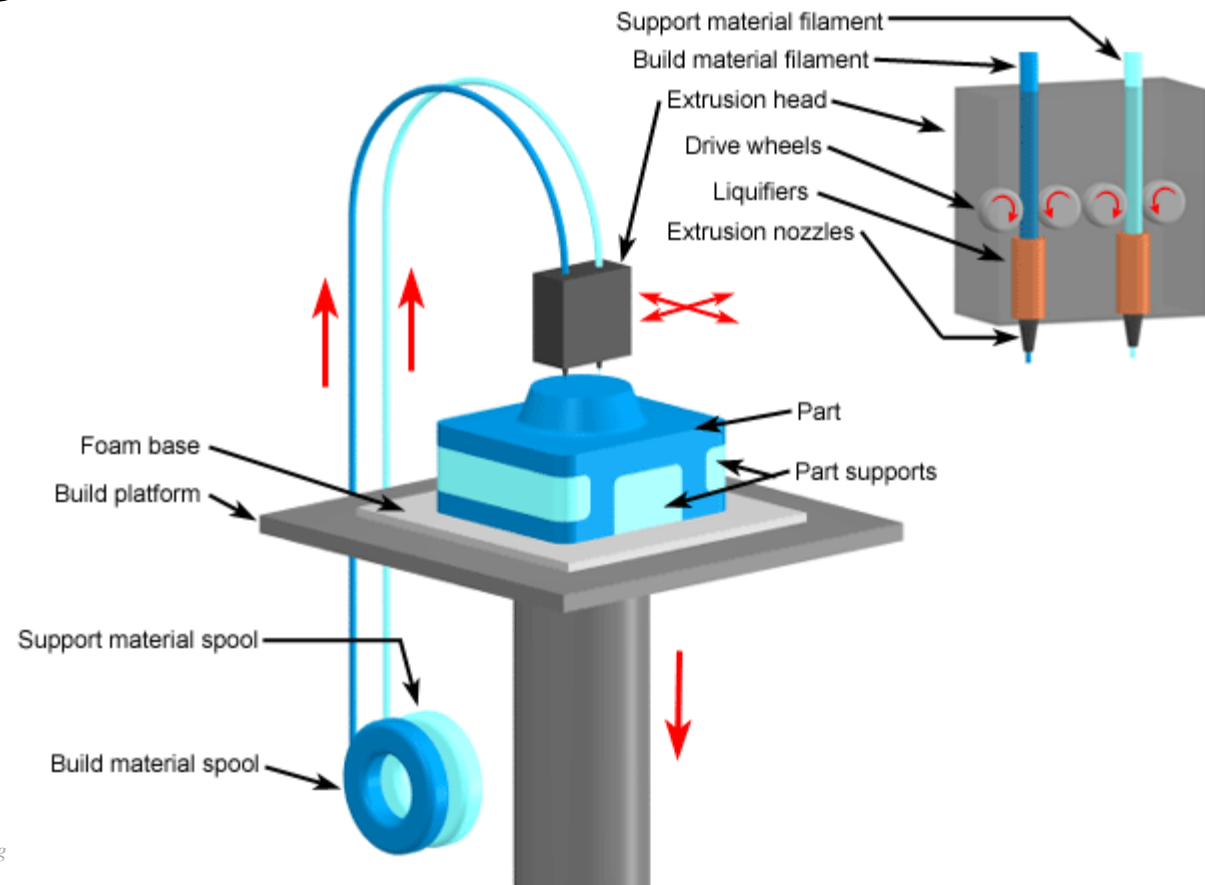
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Rapid prototyping and manufacturing

- *Application of RP*
  - *Reverse engineering*
    - *Reverse engineering is the process of discovering the technological principles of a device, object, or system through analysis of its structure, function, and operation.*

    - *There are two phase in reverse engineering*
      - *The digitizing or measuring of a part and the three dimensional modeling of a part from the digitized data.*

    - *Processing the digitized data into a solid model*
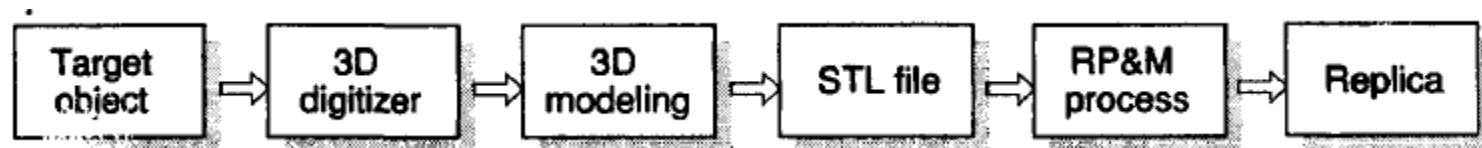
Target object → 3D digitizer → 3D modeling → STL file → RP&M process → Replica

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Rapid prototyping and manufacturing

- *Application of RP*
  - *STL format*
    - *The STL fle format (.stl) was established by 3D systems in 1987*

    - *An STL file represents an object (tessellated, faceted) as a mesh of connected triangles.*

```
solid example
    facet normal 6.89114779E-02 -9.96219337E-01 -5.28978631E-02
    outer loop
        vertex 2.73239994E+01 1.08957005E+01 4.57905006E+01
        vertex 2.81019993E+01 1.09582005E+01 4.56250000E+01
        vertex 2.75955009E+01 1.09116001E+01 4.58456993E+01
    endloop
    endfacet
        :
        :
endsolid example
```

Rapid prototyping and manufacturing

- *Application of RP*
  - *STL format*
    - *The STL fle format (.stl) was established by 3D systems in 1987*
      - *Easy conversion*
      - *Wide range of input*
      - *Simple-slicing algorithm*
      - *Splitting STL models*

      - *Verbosity and data redundancy*
      - *Error due to approximation*
      - *Truncation errors*
      - *Lack of information*

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