ECOR 1010
Lecture 9

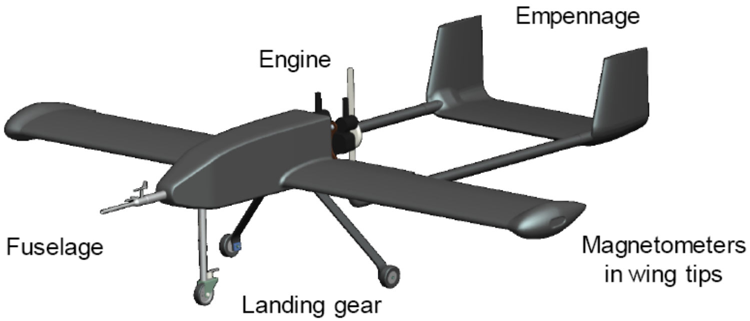
Part 1 - 3D Computer-based Rendering with Pro/E Wildfire

Pro/Engineer Wildfire

- Pro/Engineer® is a set of programs used in the design, analysis, and manufacturing of products
  - Developed by Parametric Technologies Corporation (PTC), MA, USA

Pro/Engineer Wildfire

- Pro/Engineer revolutionized the CAD world in the late 1980s
- PTC was the first vendor to offer a ***parametric***, feature-based solid-modeling design platform
- Pro/E Wildfire includes visual realism with real-time photo rendering
  - adds textures, reflections, shadows, and backgrounds to your model



Parametric

- The values of the parameters assigned to the different attributes/dimensions of the model features define the physical shape of the part
- Important changes can be easily incorporated at any point during the design process
- The changes propagate through the model automatically

Pro/Engineer Wildfire

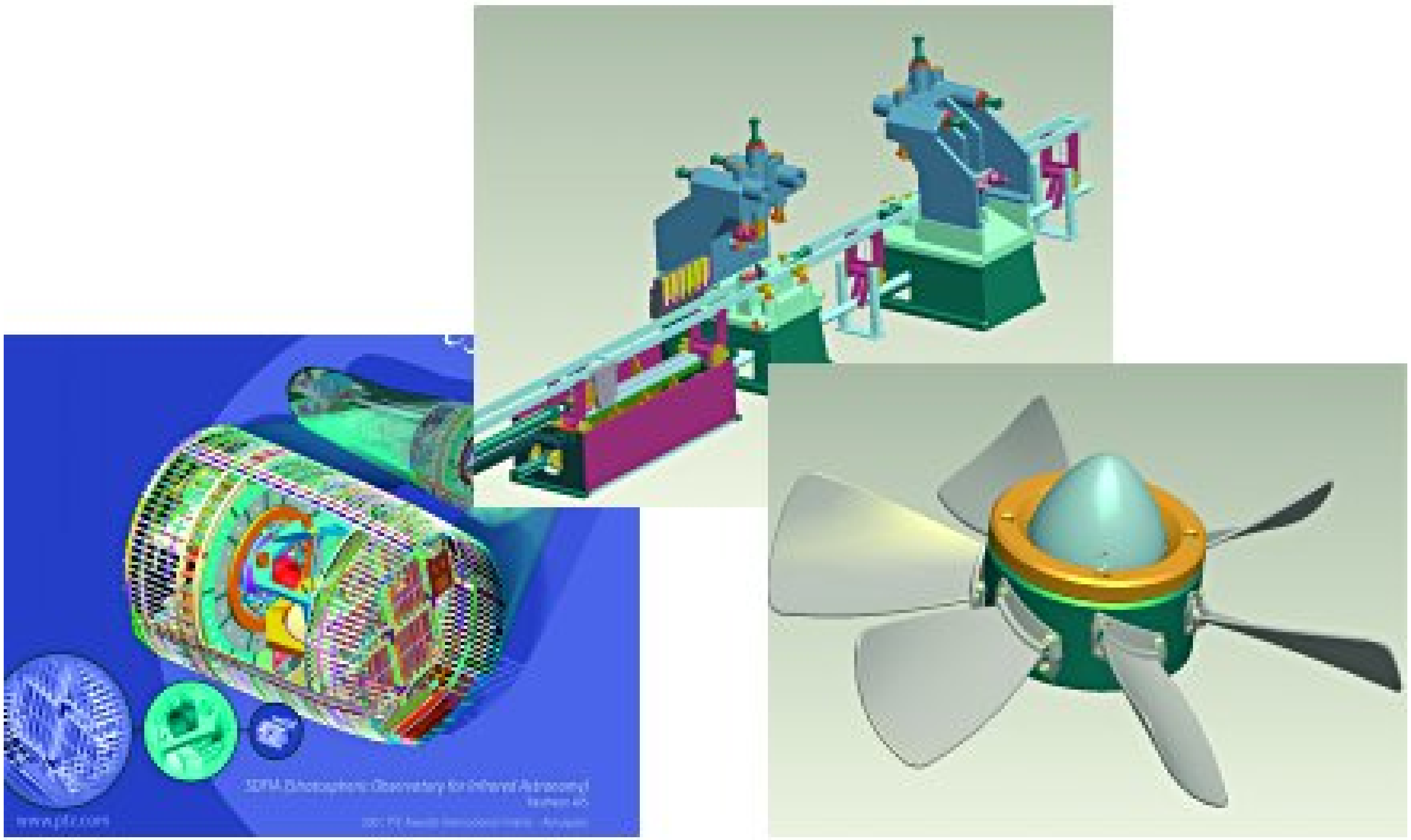
Who Uses Wildfire?

- Pro/E is often the software of choice for product development because it is ‘relatively’ easy to use and you can work with people over the Web
- Used in aerospace, automotive, consumer products and electronics, defence, education, heavy equipment, industrial equipment, life sciences, plastics, shipbuilding, telecommunications, transportation, and more …

Pro/E as an Industry Standard

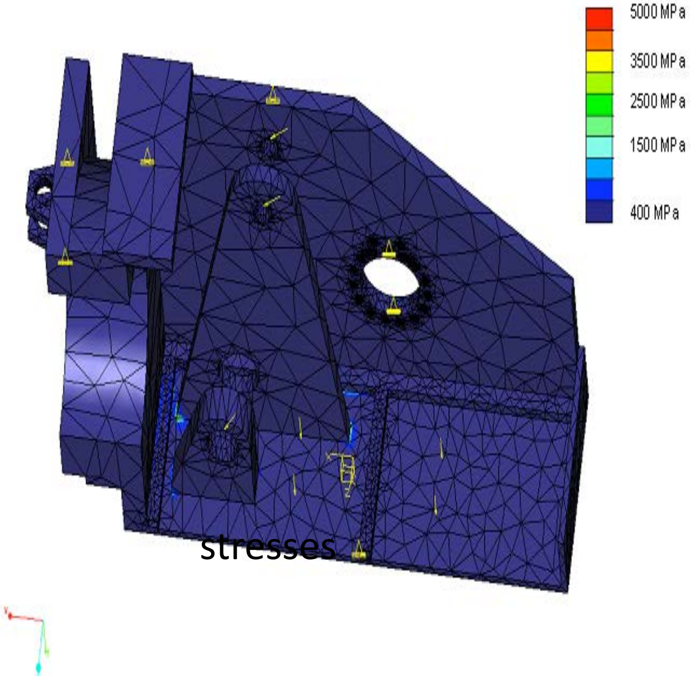
- Since its first release, PTC has developed an assortment of additional software modules for just about every product development industry
  - sheet metal operations,
  - piping layout,
  - mold design,
  - wiring harness design,
  - NC (numerical control) machining,
  - etc ...

Wide Range of Products designed with Pro/E

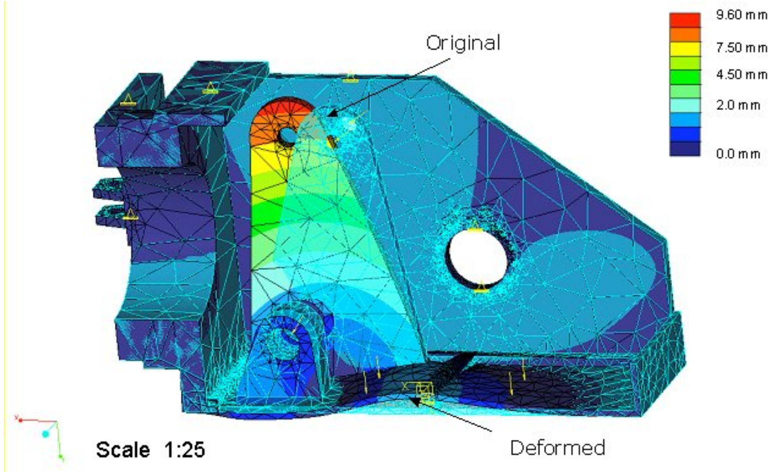


Pro/E as an Industry Standard

Pro/MECHANICA
FEM analysis



stresses



deformations

Pro/E as an Industry Standard

- Pro/E enables the user to create fully detailed standard engineering working drawings almost automatically after model generation

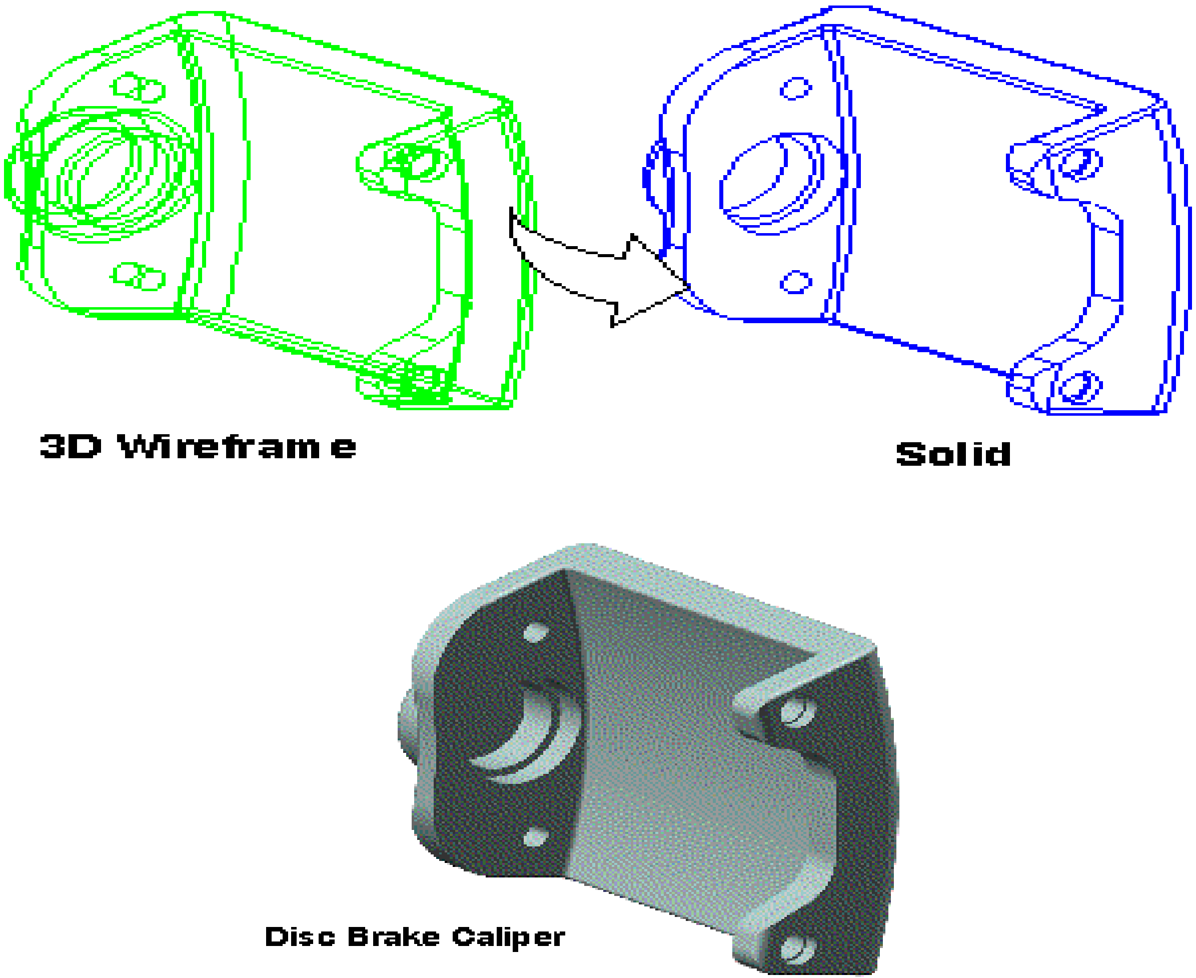
Pro/E as an Industry Standard

- 3D visualization and modeling capabilities save time during the design phase – you can see what you are proposing
- If a dimension is changed, the solid model will be automatically upgraded
- Prototypes can be produced directly from solid models because they are based on highly accurate geometric models

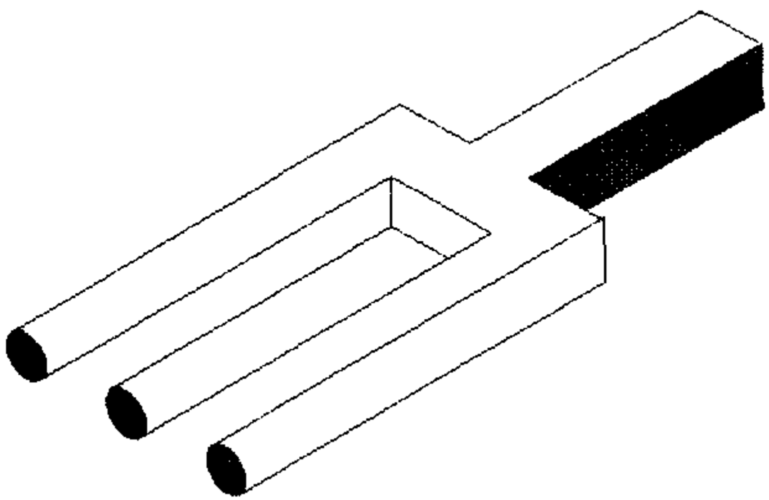
Solid Modeling

- Solid models are representations of the part or product as it will appear when manufactured
- Solid models are a collection of elements that act as a single object
  - A Pro/E solid has the intelligence to understand that it is a single body with volume, and mass (if assigned density)
- The computer model will contain all the ***parametric*** information that a real solid object has
- Wireframe models (as done with 2D CAD systems) are inadequate for many design, manufacturing and visualization tasks

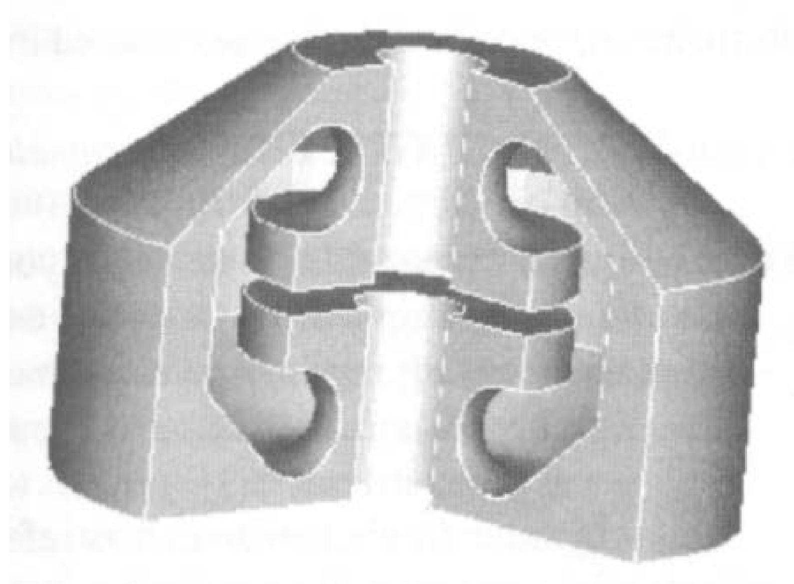
Solid Modeling



Solid Modeling



The 3-Pronged Blivot -
A Non-realizable Object



Could your machine shop make this?

Today you can !

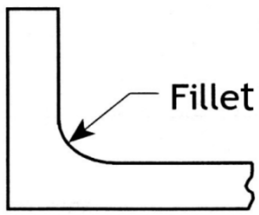
Feature-Based

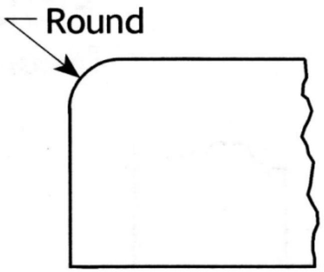
- In Pro/ENGINEER, solid parts (or bodies) are constructed with a series of geometric operations, much like a sculpting process
- Each separate operation (or shape) is called a “feature”
  - Each feature has its own defining characteristics
- A model is created by defining a series of features which can be added to, or subtracted from, the previous set of features

Feature-Based

There are many types of features that you can use…

- **Protrusion** is a profile used to add material.
- **Cut** is a profile used to remove material from an existing body
- **Rounds** and **Fillets** are added to strengthen the part





- **Holes** can be created using a number of different options

Reading Assignment

- Read Chapter 16
  - It will help you in your labs and in your project
  - Check out the Pro/E primer slides on WebCT

Pro/E Video

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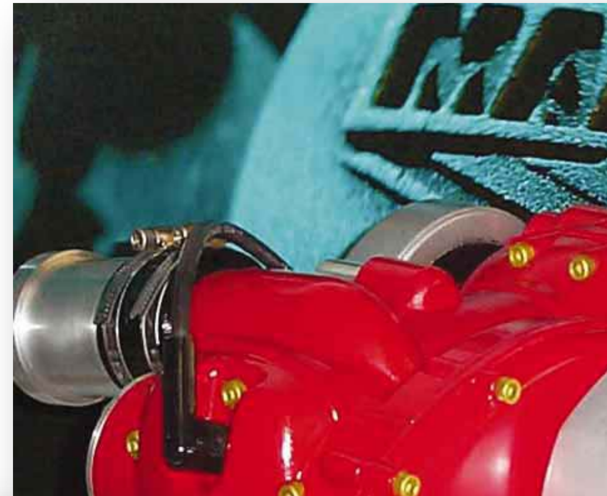
Part 2 - Rapid Prototyping
with 3D Printing

What is 3D Printing?

Like the 'Replicator' in StarTrek



What is 3D Printing?

See: **Lisa Harouni: A primer on 3D printing**
http://www.ted.com/talks/lisa_harouni_a_primer_on_3d_printing.html
or
http://www.youtube.com/watch?v=OhYvDS7q_V8

3D Printing means we can Rapidly make Prototypes

- Ideal complement to CAD
- Process to build concept and working models from 3D CAD data
  - Several different techniques available
- Used for
  - Communication/collaboration
  - Time reduction
  - Cost reduction

Benefits of Rapid Prototyping

- Real-time prototype design
- Better communication and collaboration
  - Allows design participants to view design iterations, offer firsthand input
  - Allows designers/developers to go from flat screen to exact part
  - Participants can make better informed design decisions throughout a faster product development cycle (reduced costs, fewer engineering changes)
  - Can examine more concepts, check design changes

Benefits of Rapid Prototyping

- Time reductions
  - Life spans shorter (6 months)
  - Design cycles, time-to-market shorter
  - Multiple design iterations and immediate feedback are possible during the early stages of the development process
  - Quickly refine “form, fit, function”
    - Affects production costs and time to market

Benefits of Rapid Prototyping

- Cost reductions
  - Design changes
    - proof-of-concept - $100
    - development - $1,000
    - production - $100,000
    - field - $1,000,000
  - You can afford to do numerous design iterations
  - Can explore more designs more efficiently
    - Can do this without extensive time or tooling expense

The Basic Process of Rapid Prototyping with 3D Printing

- All current rapid prototyping techniques employ the same basic five-step process
  1. Create a CAD model of the design
  2. Convert the CAD model to STL format
  3. Slice the STL file into thin cross-sectional layers
  4. Build the model one layer atop another
  5. Clean and finish the model

STL Files

- Stereolithography (STL) files were introduced in software by 3D Systems of Valencia, CA, as a method for storing info about 3D objects
- The STL (.stl) file format is an industry standard data transmission format
  - Used in Rapid Prototyping to produce physical 3D models or replicas

STL Files

- STL files reproduce an object's 3D geometry by storing a set number of facets or 3D triangles in a complex digital model
- After storing the outer and/or inner surface of a 3D object as facets in an STL file, the digital model can be manipulated, and a physical representation of a 3D model can be made

STL Files

- The more complex the model, the more triangles produced, and the larger the STL file

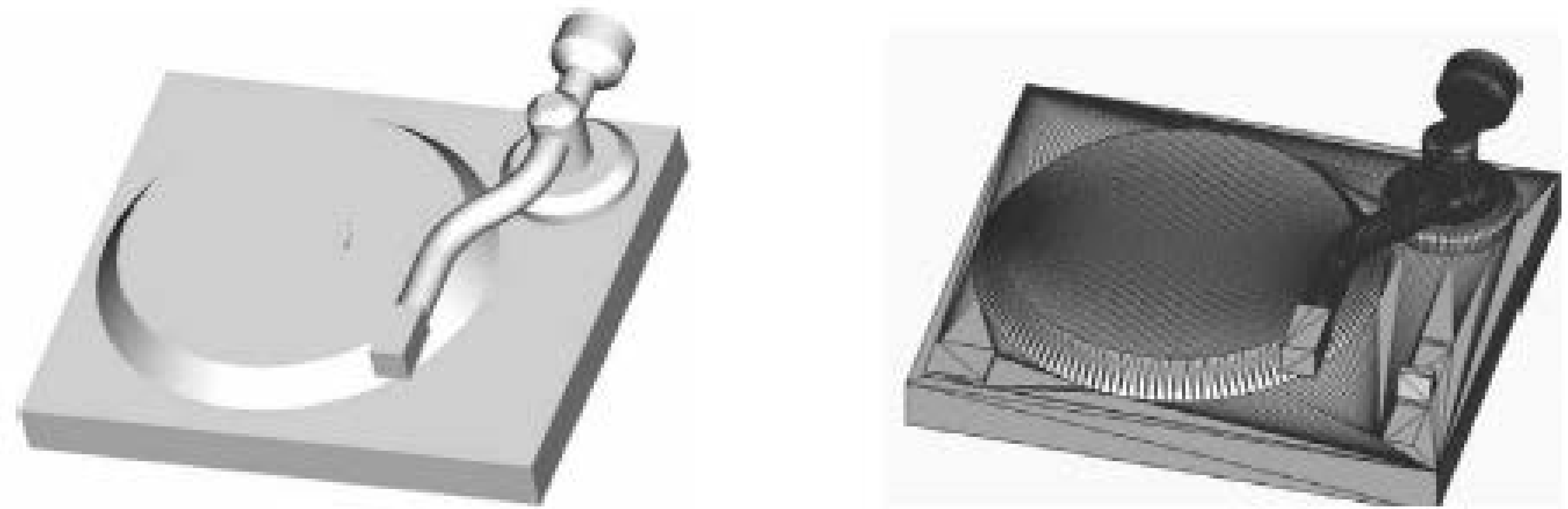


Figure 17.1 Conversion from Pro/E. prt file to. stl file.

Additive and Subtractive RP

- There are two main methods of rapid prototyping, which are derived from similar approaches in sculpture
  - Additive Rapid Prototyping (ARP)
  - Subtractive Rapid Prototyping (SRP)

Additive and Subtractive RP

- Subtractive Rapid Prototyping (SRP):
  - The machine starts out with a block of plastic and uses a delicate cutting tool to carve away material, layer by layer to match the digital object; this is similar to numerical controlled (NC) machining
- Additive Rapid Prototyping (ARP):
  - The machine reads in data from a CAD drawing, and lays down successive layers of liquid plastic, or some other building material, and in this way builds up the model from a long series of planar cross section layers

Subtractive Rapid Prototyping

- Great for testing as the final material can be milled
- Uses a wide variety of inexpensive materials, including polyurethane, resin, ABS* plastic, aluminum and brass
- Prototypes take less time to produce and also are less expensive
- When the prototype is done, it requires no hand finishing

* (acrylnitrilebutadene styrene)

Subtractive Rapid Prototyping

Subtractive Rapid Prototyping Machine

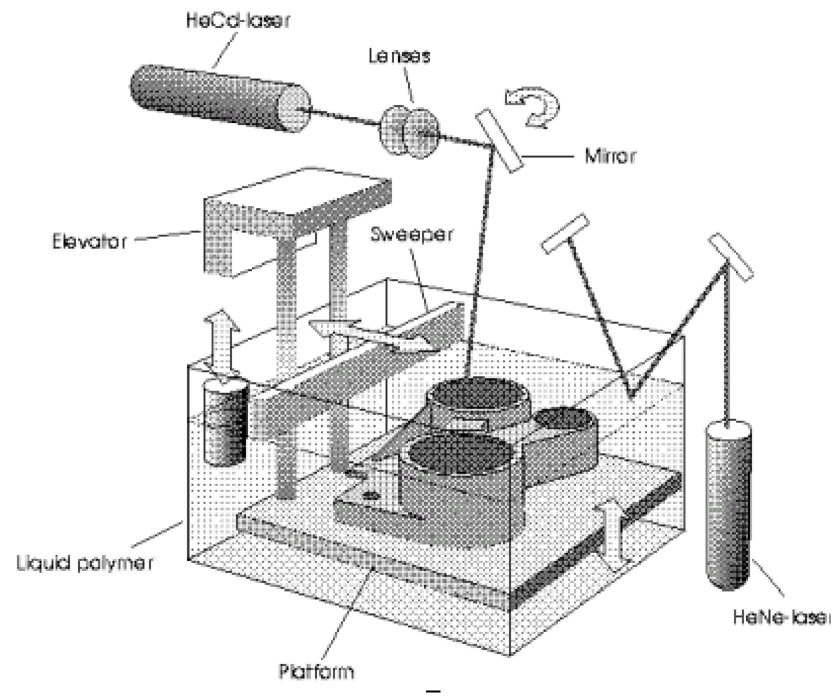
Roland DG – MDX 540

Additive Rapid Prototyping Techniques

- Most commercially available additive rapid prototyping machines use one of 6 techniques:
  1. Stereolithography
  2. Laminated Object Manufacturing
  3. Selective Laser Sintering
  4. Fused Deposition Modeling
  5. Solid Ground Curing
  6. 3-D Ink-Jet Printing

1: Stereolithography (SL)

- Patented in 1986, stereolithography started the rapid prototyping revolution
- Uses a light-sensitive liquid polymer
- Builds 3D models from liquid photosensitive polymers that solidify when exposed to ultraviolet light



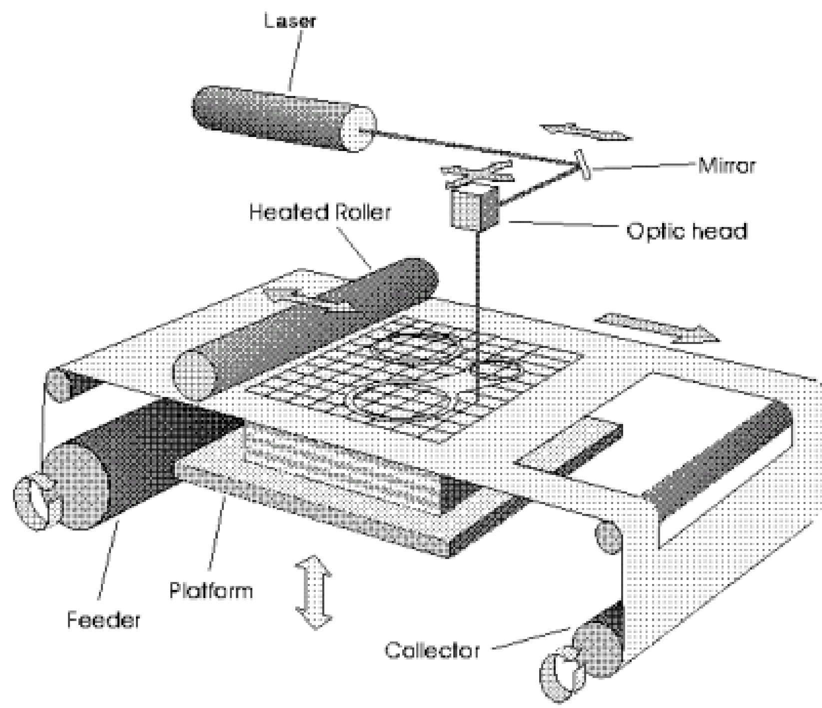
Schematic diagram of the stereolithography process

1: Stereolithography (SL)

- Excellent for making complex prototypes with fine details
- Favourite in the aerospace industry
  - the most common application is producing wind tunnel models
- Inexpensive compared to traditional machining

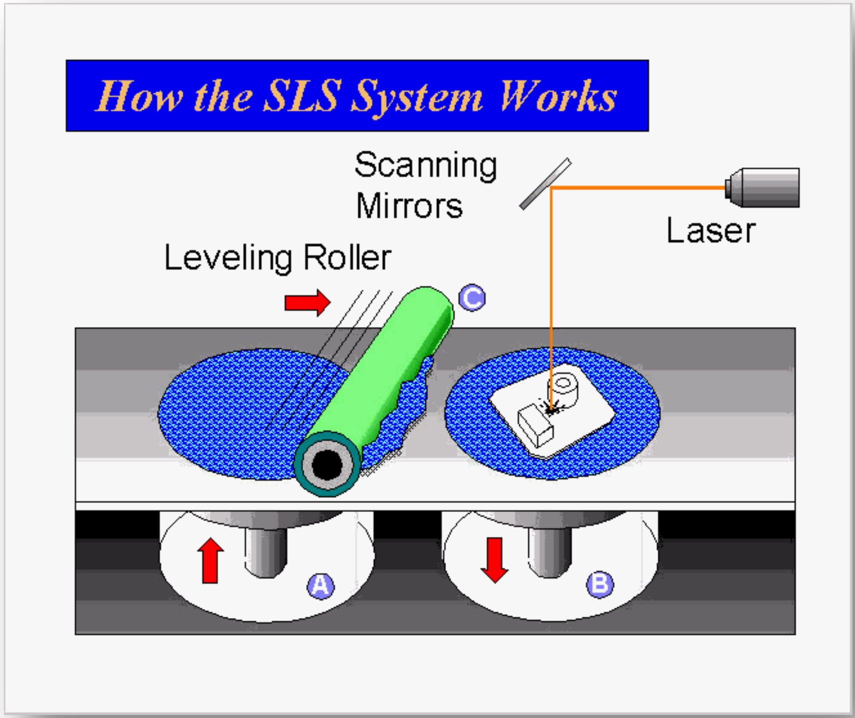
2: Laminated Object Manufacturing

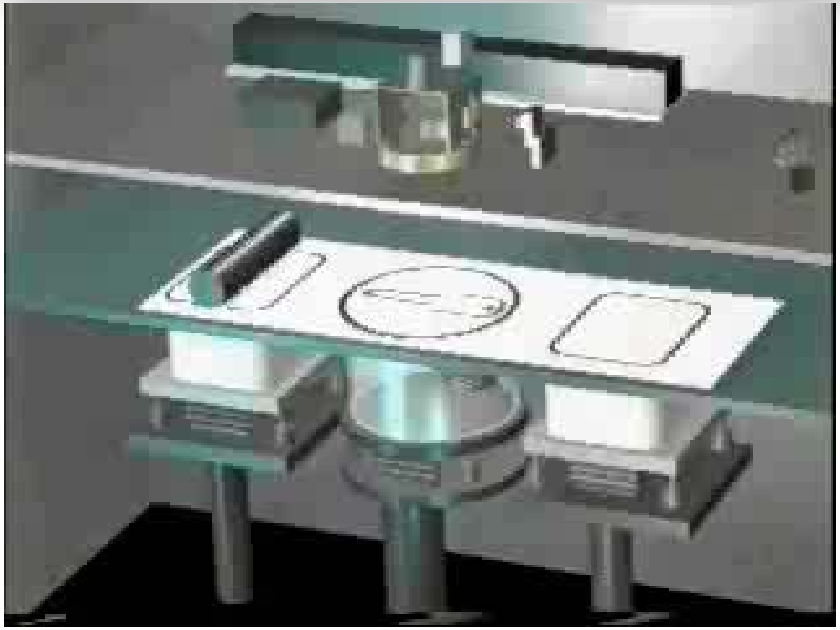
- Developed by Helisys of Torrance, CA
- Layers of adhesive-coated sheet material are bonded together to form a prototype
- Low cost as raw material is readily available
- Because there is no chemical reaction involved, parts can be made quite large



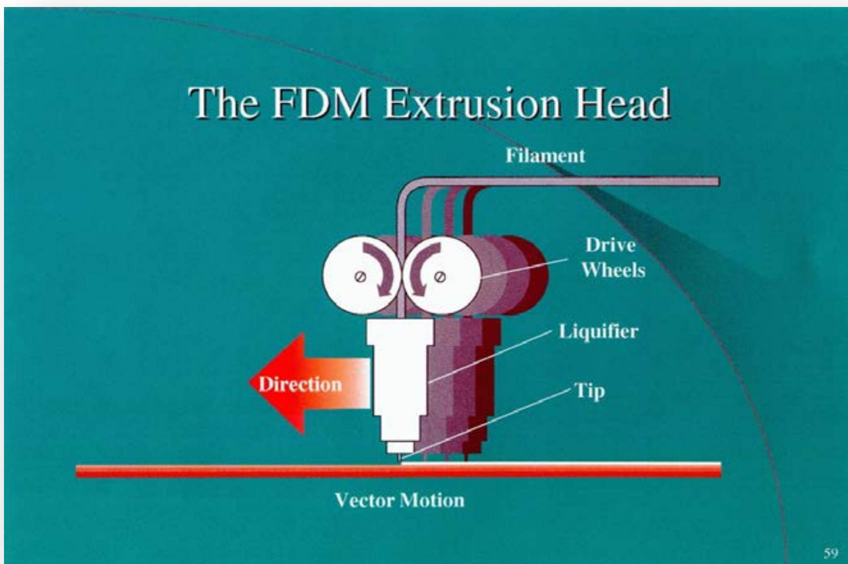
3: Selective Laser Sintering

- Developed by Carl Deckard for his master's thesis at the University of Texas and patented in 1989
- Uses a laser beam to selectively fuse powdered materials, such as nylon, elastomer, and metal, into a solid object





4: Fused Deposition Modeling (FDM)

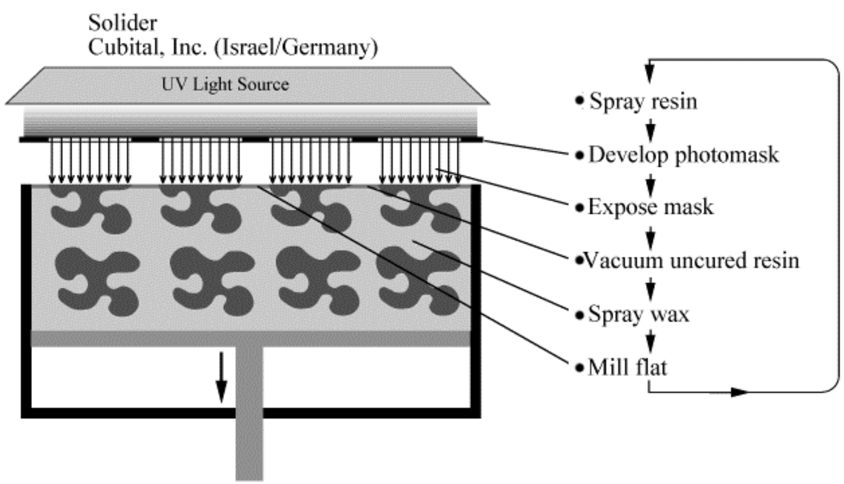


- Developed by Scott Crump in 1988
- Stratasys, of Eden Prairie, MN makes a variety of FDM machines ranging from fast concept modellers to slower, high-precision machines
- Materials include ABS, elastomer, polycarbonate, polyphenolsulfone, and investment casting wax

4: Fused Deposition Modeling (FDM)

- Specializes in building small, durable, handheld components
- Although improved in recent years, surface finish and accuracy are not among the strongest points of FDM
- The Dimension BST 3D-Printer in 2230 uses the FDM Process

5: Solid Ground Curing (SGC)



- Invented and developed by Cubital Inc. of Israel
- Similar to stereolithography (SL) in that both use ultraviolet light to selectively harden photosensitive polymers
- Unlike SL, SGC cures an entire layer at a time

6: 3-D Ink-Jet Printing

- Ink-Jet Printing refers to an entire class of machines that employ ink-jet technology
- The first was 3D Printing (3DP), developed at MIT and licensed to several selected companies
- Parts are built upon a platform in a bin of powder material selectively hardened with binder deposited with the print head
  - This process is very fast, but produces brittle parts with a slightly grainy surface
- The 3D-Printer Z-Corp 400 in 2260 is an example of this technology

3D Printing

- 3D printing is a variation of rapid prototyping
- A 3D printer is less expensive, easier to use and usually faster than a RP system

3D Printing

- Most importantly a 3D printer can fit in an office environment
- Unlike a big rapid prototyping system a 3D printer can be located next to the design engineers so they can turn around jobs promptly and efficiently

The Dimension BST

- One of the 3D-printers available for your use

The Dimension BST

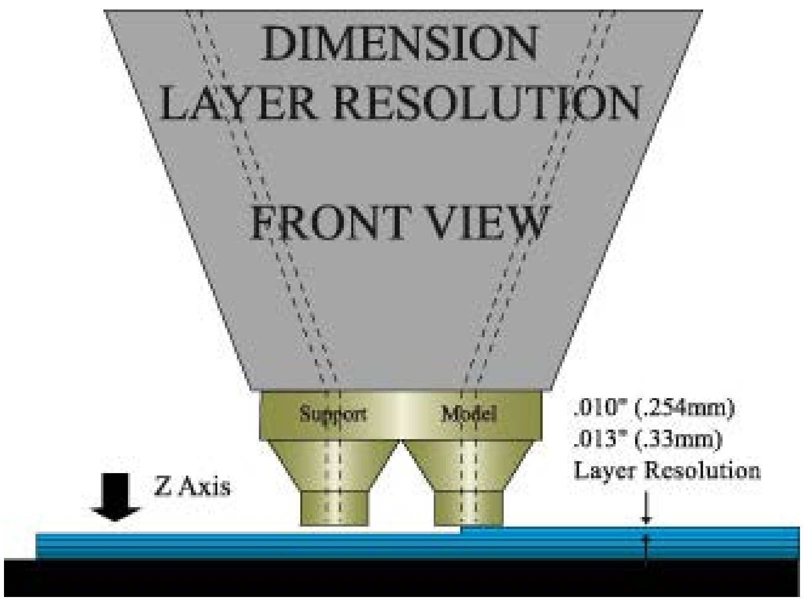
- Dimension is a business unit of Stratasys, Inc., located at Eden Prairie, Minnesota
- The Dimension 3D Printer is a networked, desktop modeling system
- Used in evaluating design concepts, testing 3D models for functionality, form and fit

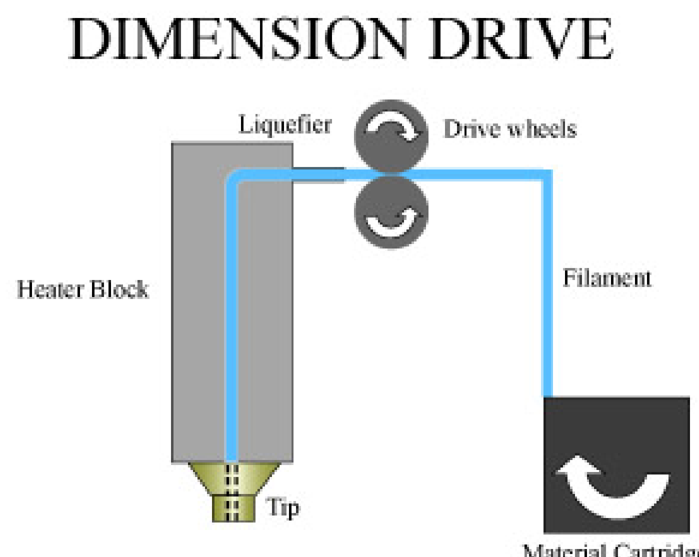
The Dimension Process

- Based on the patented Stratasys FDM process, Dimension builds functional 3D models from the bottom up, one layer at a time using ABS (acrylnitrilebutadene styrene) plastic
- STL files are imported into Catalyst™ software which automatically slices and orients the parts and creates any necessary support structures

The Dimension Process

- A thin filament of ABS plastic is passed through a liquefier
- An extrusion head deposits the material in layers in a semi-molten state and the prototype is produced
- After completion of the build, support structures are simply removed





The Dimension Process

- Two materials are used: one for the prototype and one for the breakaway supports
- The Catalyst software determines where ABS plastic should be deposited and where the support material should be deposited

The Z400 3D-Printer

- One of the 3D printers available for your use

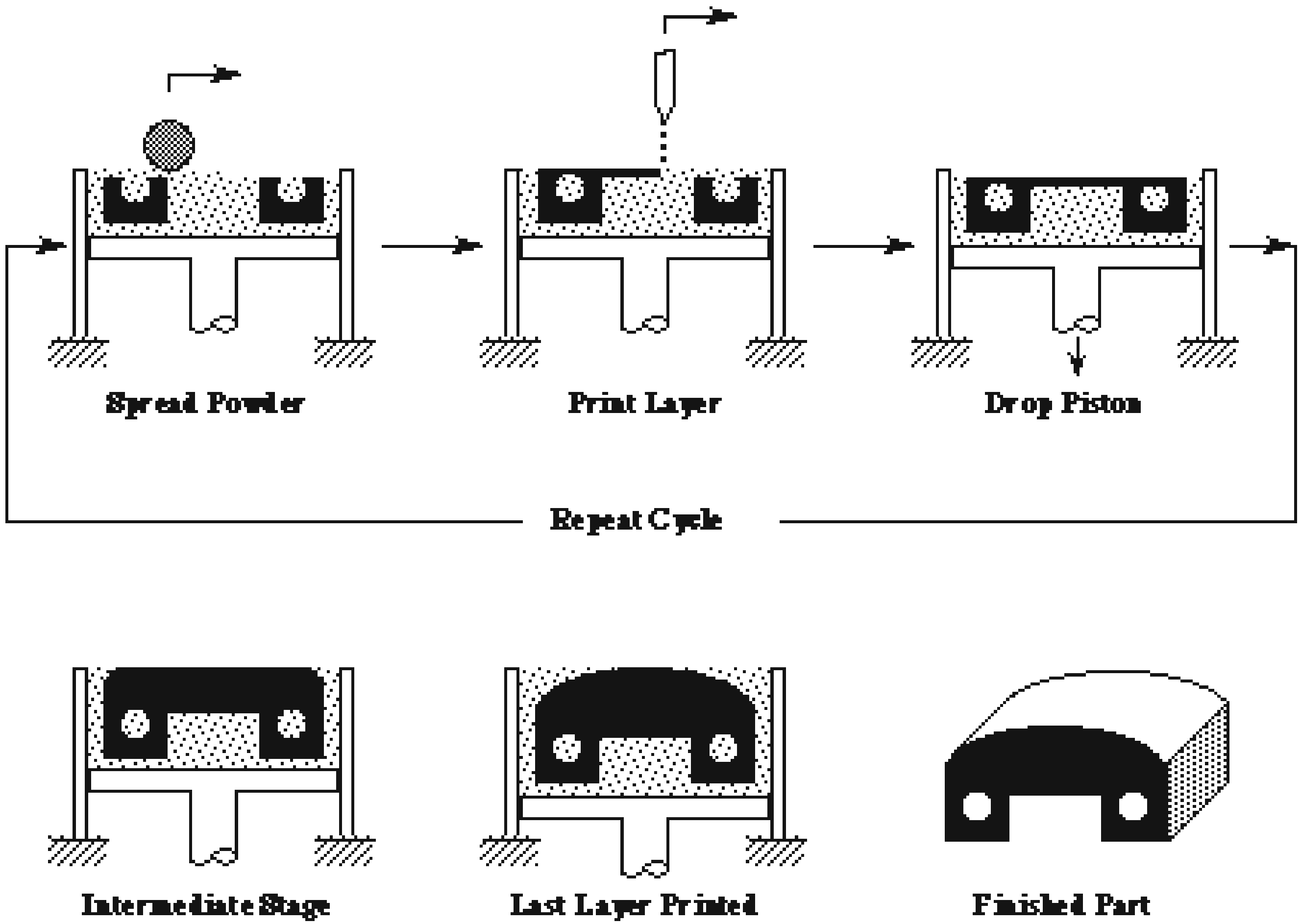
The Z400 3D-Printer

- Developed by Z-Corporation in Burlington, MA
- This system is fast, convenient and easy to operate
- Used in concept modeling, functional testing, model presentation and finite element analysis

3-D Ink-Jet Process

- An ink-jet printing head selectively deposits or "prints" a binder fluid to fuse the powder together in the desired areas and unbound powder remains to support the part
- After each layer is complete the platform is lowered, more powder added and levelled, and the process repeated

3-D Ink-Jet Process



3-D Ink-Jet Process

- When finished, the part is then removed from the unbound powder, and excess unbound powder is blown off
- Finished parts can be infiltrated with wax, glue, or other sealants to improve durability and surface finish

Efficient Use of RP

- Different RP systems yield prototypes best suited for different applications. Selecting the right one will help you save time and money and achieve better results as an engineer

See:
http://www.ted.com/talks/anthony_atala_printing_a_human_kidney.html

Reading Assignment

- You should have now read Chapters 12 to 17

Mid-Term Exam Thursday Oct. 11

- All Lecture Material to today
- All Textbook Reading Assignments
- Laboratory Assignments 1 to 3
- Review Class Next Week