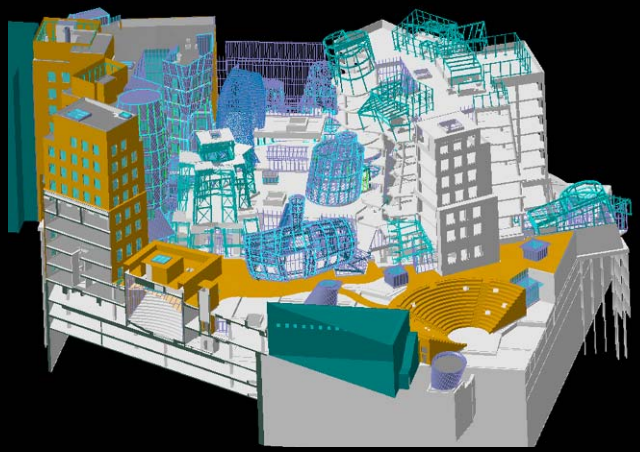
4.510 Digital Design Fabrication
Fall 2008

lecture 2

Background on Design and Digital Manufacturing

Prof. Larry Sass
Department of Architecture



Computer modeling = Description

- *Geometry*
- *Application of Geometry to a Design problem*

Terminology

- CAD Computer Aided Design
- CAM Computer Aided Manufacturing
- CAE Computer Aided Engineering
- CNC (NC) Computer Numerically Controlled Machines

Origins of CAD/CAM

1952

- Numerical Control machines are widely used to operate a tool positioning through computer commands. MIT's Servo Mechanisms Laboratory demonstrated a numerically controlled 3 axis milling machine.

1959

- Control digital computer. The first application of a control using a digital computer occurred at a Texaco refinery located in Port Author Texas where a catalytic cracking unit was optimized using a linear programming algorithm

Origins of CAD/CAM

1960
Robotic Implementation – The precursor to widespread use of robots in manufacturing processes

1970
Computer Numerical Control – The advent of the mini computer where tools could have there own memory.

1980
Flexible Manufacturing System – The idea of sets of machines to make a relatively wide variety of products with automatic movement of products through any sequence of machines this lead to Computer integrated Manufacturing

2000

Variety of Machine Sizes and Types

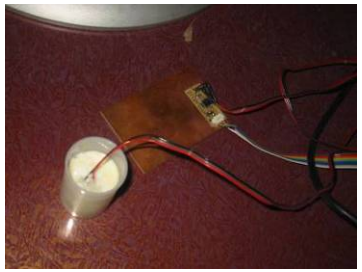
CBA Fab Labs

cba.fab.mit.edu

THE CENTER FOR BITS AND ATOMS
Massachusetts Institute of Technology

India

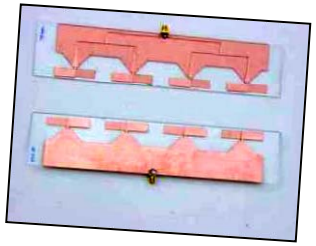




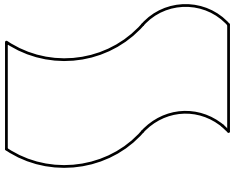
South Africa


Ghana

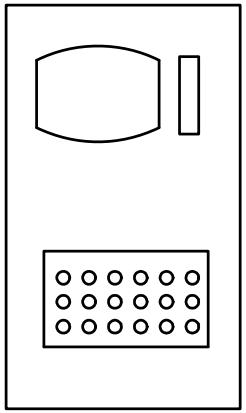
Norway

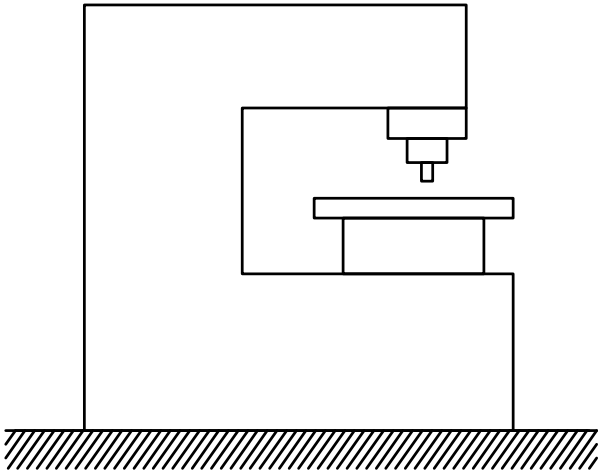
Basic Components of an NC Machine



[1]
Program



[2]
Machine Control Unit

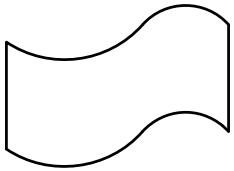


[3]
Processing Equipment

1952 - MIT Servo Lab - Numerically Controlled Machines

- *Began with the US Air Force*
- *The work Started at the Parsons Lab in the 1940s*
- *Developed the idea of Positional Data on Punch Cards*
- *1949 MIT Servomechanism Laboratory to develop a prototype*
- *The first NC machines was presented in 1952 – 3 Axis milling machine*
- *Work led to the development of the APT (Automatically Programmed Tooling)*

Basic Components of an NC Machine



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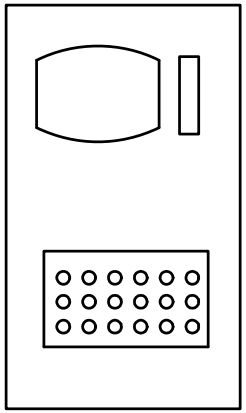
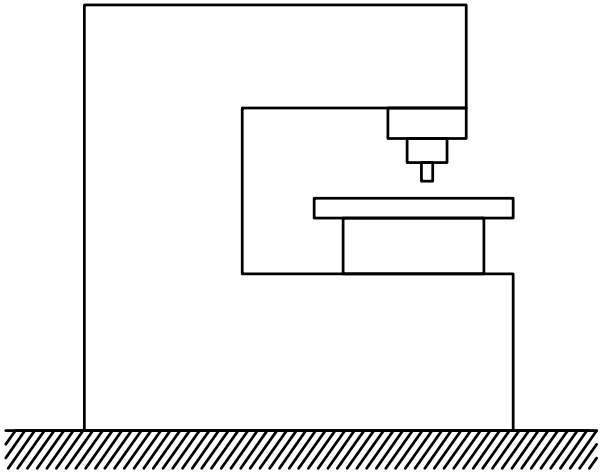
Program



[2]
Machine Control Unit



[3]
Processing Equipment

[PROGRAM]

Origins of CAD

1963
MIT

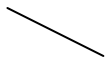
1963 – Sketch Pad

A Man Made Graphical Communication System

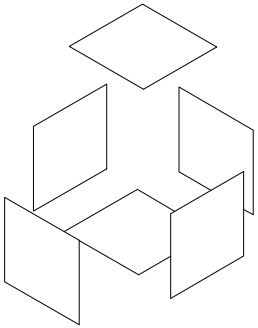
Parametric Modeler for Engineers

- *Small changes to existing drawings*
- *Great for the creation of small scientific operations that can only be understood graphically*
- *For highly repetitive drawings*

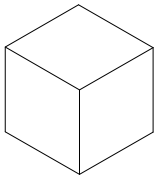
Design Descriptions



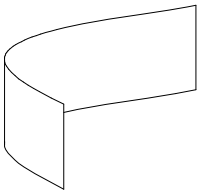
Lines



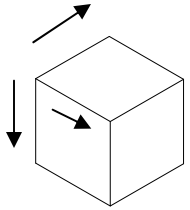
Surface Models



Solid Modeling

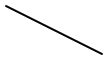


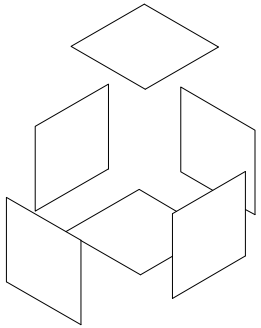
NURB Surface Modeling

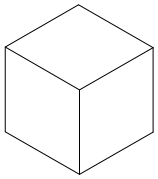


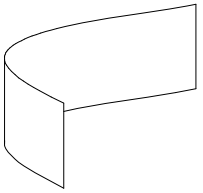
Parametric Modeling

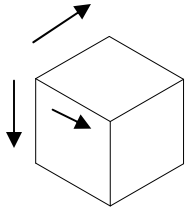
Design Description





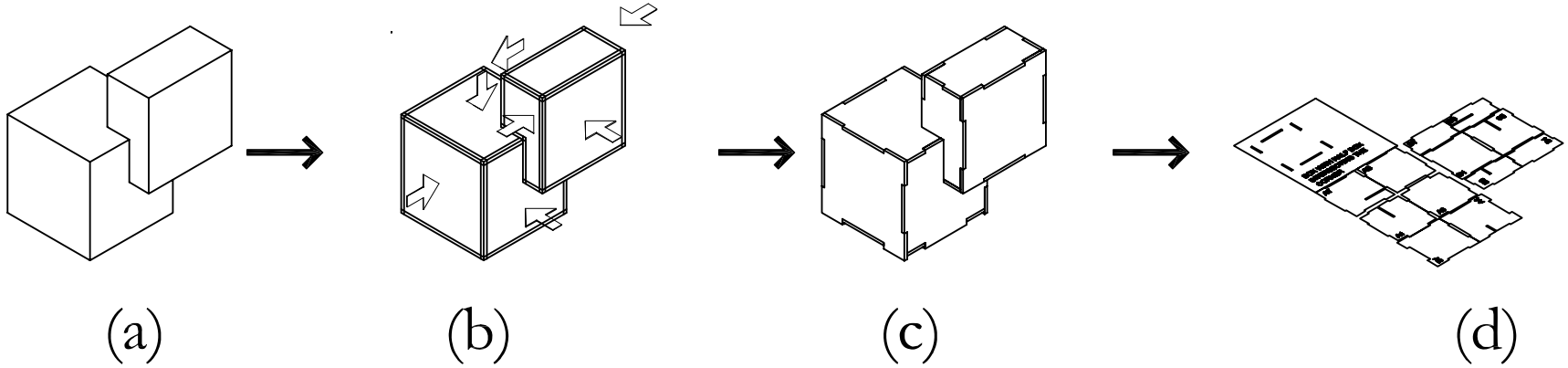






Discovery	1960s	1970s	1980s	1960s-80s	80s

Descriptions for Fabrication

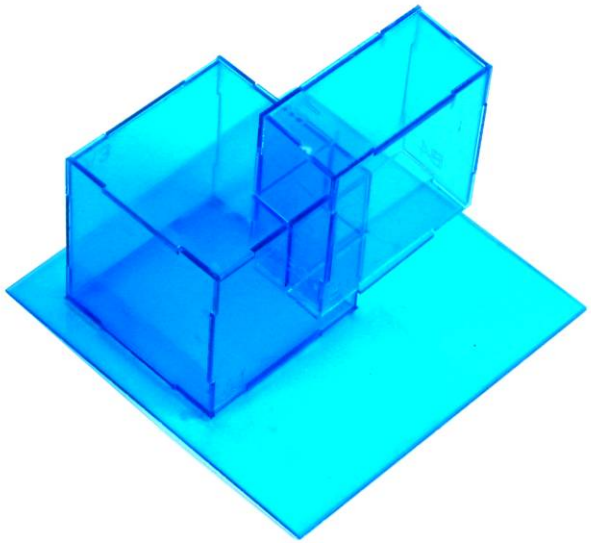


Principles of Making

1 - Measure

2 - Cut or Build

3 - Assembly



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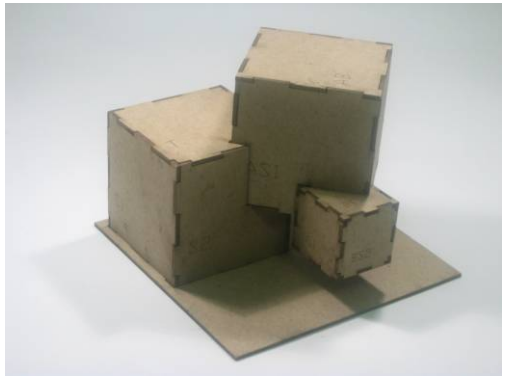
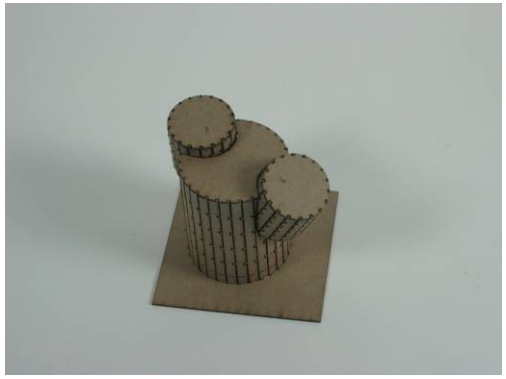
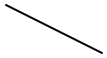
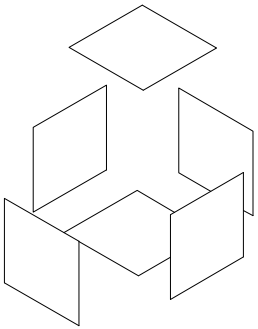




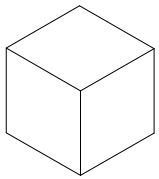
Design Description



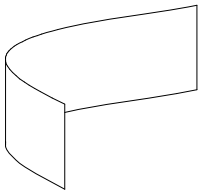
1960s



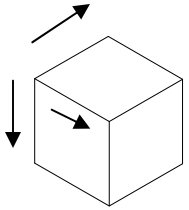
1970s



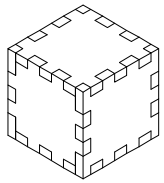
1980s



1960s-80s



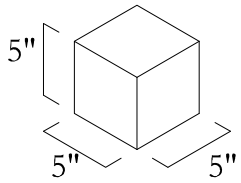
1980



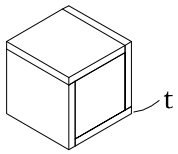
2000

Analogue

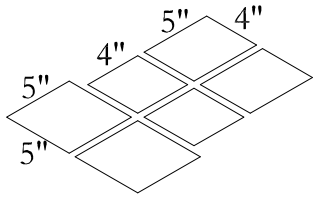
I
starting
shape



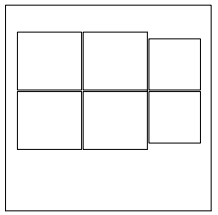
II
working shape
(1-modeling)



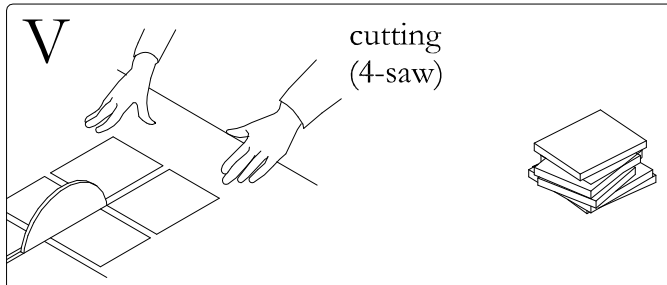
III
working documents
(2-drafting)



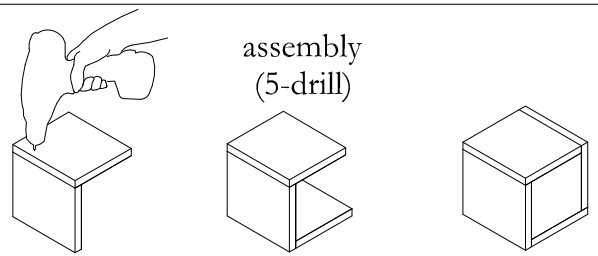
IV
drawing translation to material
(3-ruler/pencil)



V
cutting
(4-saw)



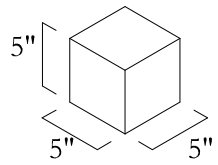
VI
assembly
(5-drill)



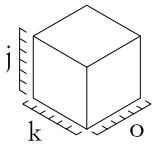

GP
GLASS GOLD
HomeWrap
DU PONT

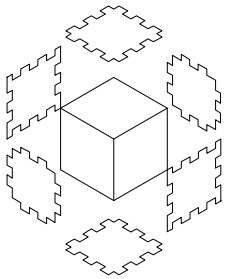
Digital

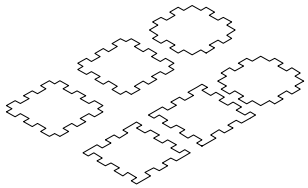
I
starting
shape

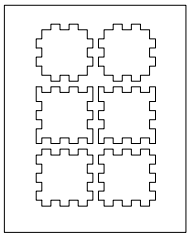


II
computer base shape
interpretation & translation
(1-modeling)

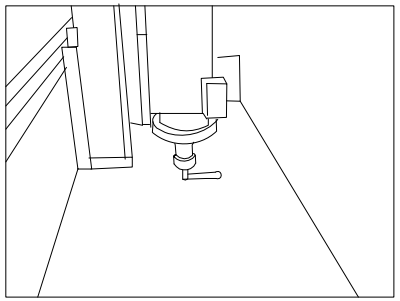




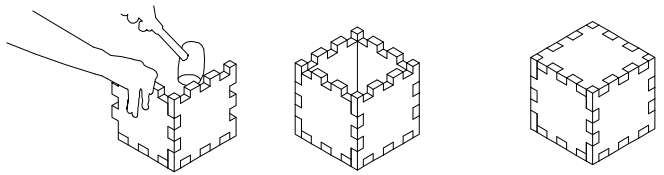




III
computer controlled
cutting
(2-cnc mill)



IV
self guided
assembly



Production Systems

Symbolic System

1973 Carnegie Mellon

•A production system is a schema for specifying an information processing system.

•Symbolic Production System – Artificial Intelligence – Text based outcomes (the web)

- *Q. Do you know which restaurant you want to go to?*
- *A. No*
- *Q. Is there any kind of food you would particularly like?*
- *A. No*
- *Q. Do you like spicy food?*
- *A. No*

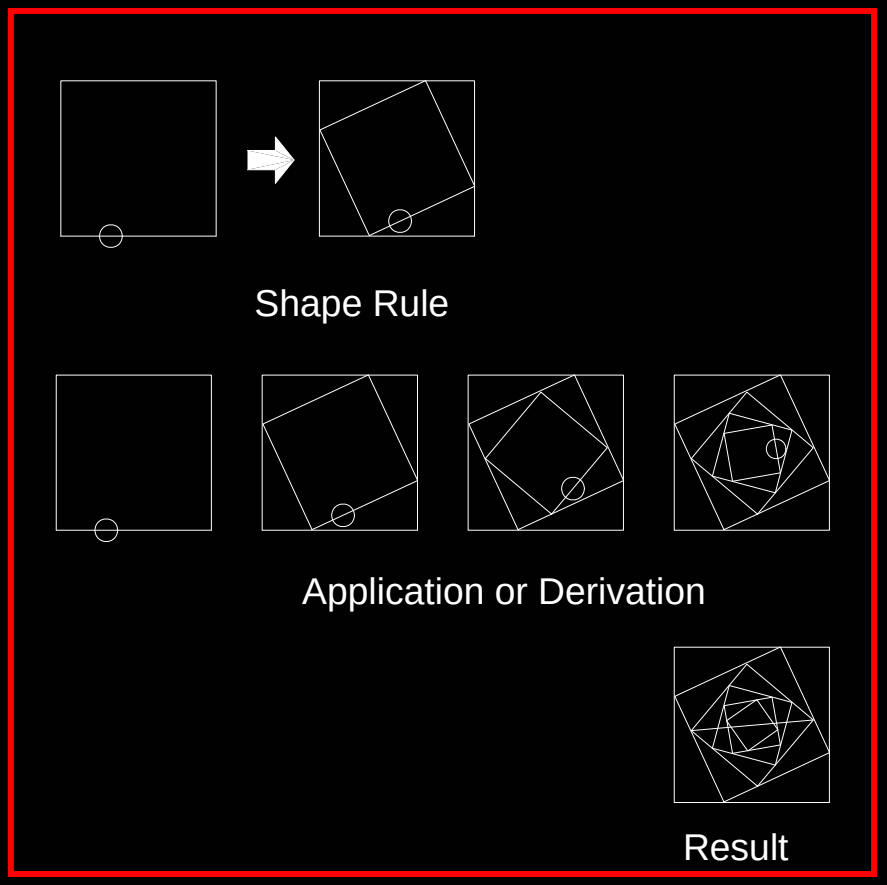
• *A→B*

Production Systems

Shape Production System

1975 UCLA & Open University

- A Shape Grammar is a Visual Production System



A Physical Production System

- **Physical Design Grammar**
  - A physical design grammar is a production system with descriptions as object opposed to layers
- Benefits:
  - Cross scale production
  - Working Models - Reflect the behavior of a building not its image
- Challenges:
  - Compliant subdivision of an initial shape
  - How to manage construction behaviors

Summary

- Background
  - *CAD was invented to run CNC machines*
    - *Drawings are after effects*
    - *Parametric modeling was invented by Ivan Sutherland in 1963*
  - *Design Description = CAD document (Compliant)*
    - *CAD Programs were used to generate information for machines – 1960's*
    - *CAD Programs were used to generate information for visualization 1980-2000*
    - *CAD programs will be used to generate information for fabrication*
  - *Production Systems*
    - *Text*
    - *Shape*
    - *Object*

Future

- Procedural Processes
  - *Algorithms for Production*
  - *Jove – Medical*
  - *Grammars for Components*