2.008 Design & Manufacturing II
Spring 2004
Process Planning
CAD/CAM

Ref. 1: CAD/CAM/CAE systems, by K.W. Lee, Addison-Wesley, 1999
Ref. 3: Manufacturing: Design, Production, Automation and Integration, by B. Benhabib, Marcel Dekker, New York, 2003

- Lab starts today.
- Monday 2/16, President's day, a Holiday
- Tuesday 2/17, Monday's lecture & lab group A
- HW#1 due 2/11 (W)

Product Cycle

Functional Requirements

Design Parameters

Design

Synthesis

CAD

Analysis

CAE

Process Planning
CAM
Production

Packaging
Quality control
Shipping

Manufacturing

Geometric Modeling – Historical Development

- 1960-1962: The first Graphical User Interface (GUI), Sketchpad, developed at MIT.
- 1970-1980: Various systems that ran on proprietary hardware – only a handful survived beyond the 1990s.
3D object geometric modeling

Wireframe

Surface modeling

Solid modeling?

Wireframe

- List of
  - Curve equations
  - Coordinates of points
  - Connectivity
  - Easy method
  - Ambiguity
  - No mass, no surface

Conversion to surface

Surface Modeler

- Wireframe data +
- Surfaces
  - Connectivity, Adjacency
  - Interpolation of points, curve nets
  - Translation or sweeping of curves
- Fits to complex free formed surfaces
  - Visual, aesthetic design
  - NC code generation

Solid Modeler
Solid modeler
- Has a closed volume.
- Knows “in” or “out”
- Has a mass and inertia.
- Huge input data, maths.
- User friendliness is a must.
  - Primitives
  - +/- by Boolean operations
  - Sweeping, rounding, lifting
  - Hybrid (solid + Surface, CSG + BREP, Parametric + explicit)

Primitives
- Then
  - Add/subtract
  - Move
  - Modify

Boolean operations
- union
- intersection
- difference

By sweeping, skinning surfaces
- translational
- rotational

By modifying existing shapes
- Edge rounding
- Filleting
- Lifting

Constructive Solid Geometry
- CSG modelers allow designers to combine a set of primitives through Boolean operations:
Boundary Representation

Feature-based Design

Machining Features

Parametric modeling
- Feature-based
- Dimension data
- Geometric constraints

- Assembly modeling
- No standard of data exchange
- IGES (Initial Graphic Exchange Standards)

Geometric Modeling - Curves

Geometric Modeling - Curves

B-spline: more flexibility than Bezier

NURB (non-uniform rational B-spline): Combine all
Geometric Modeling - Free form Surface

NURB (non-uniform rational B-spline): Combine all

Process Planning (CAPP)

- "Act of preparing detailed work instructions to machine or assemble a part or parts" – Chang, Wysk, Wang
- Sequence of manufacturing processes and/or assembly operations
- Operation sheet

Restaurant Owner

- Have customers eat well
- Customers serviced well
  - speed
  - customization
- Affordable tab
- $$$ - profit

What’s the difference between McDonald v.s. Maison Robert?

Super bowl 2004

- Play book
- Play number

Process Planning

- Manual Approach
- Computer Aided Process Planning (CAPP)
  - Variant Approach: Group Technology
  - Generative Approach: features, tolerances

Image removed due to copyright considerations.
Example 1 by manual approach

Setup 1
Chuck the workpiece
Turn S3 to a 100mm diameter
Face S1
Core drill S2
Counter bore S4, S5

Setup 2
Chuck the workpiece on S3
Turn S6 to 50 mm diameter
Undercut the neck
Thread S6
Face S7

Group Technology

Zip code: 02139
Product Classification

Vuoso-Praha coding system

4 digit system
-Kind
-Class
-Group
-Material

Coding system (continued)

Feature-based CAPP

Open slot
Through hole

Chamfering
Pocket
Hole
fillet

Numerical Control

Lathe - conventional
5-axis milling
Motion Control

- Point to point, Continuous
- Interpolation
- Encoders, tachometers and interferometers provide high-precision displacement and velocity feedback:

Adaptable Control

- sense cutting force, torque, temperature, etc.
- tool wear, tool breakage

NC milling machine

Tool path generation

g-code

Statement Number 27 (N0027) a linear-interpolation motion (G01) to a position defined by (X175.25 Y325.00 Z136.50), with a feed rate of 125 mm/min (F125), and a spindle speed of 800 rpm (S800), using a tool Number 1712 (T1712), performing a c/w turn of the spindle (M03), and having the coolant on (M08).
APT –Automatic Programming Tool

- APT developed at MIT in 1956.
- APT II, APT III
  - Identification statement
  - Geometric Statements
  - Motion statement
  - Post-processor statement
  - Auxiliary statement

Geometry statements

Points

- P to P-motion:
  - \texttt{GOTO/Point\_Name; Go to Point Point\_Name.}
  - \texttt{GODLTA/\Delta X, \Delta Y, \Delta Z; Move incrementally.}

- CP-motion:
  - \texttt{GOFWD / Drive\_Surface \quad \text{TO ON PAST TANTO} \quad \text{Part Surface Check}}
**Ending locations**

- CS
- DS
- TO
- ON
- PAST

**Example**

- PROMISP
- GOTO, L1, TO, P5, ON, L4
- GORTOL, L1, PAST, L2
- GOLFL, L2, PAST, L3
- GOLFL, L3, PAST, C1
- GOLFL, C1, PAST, L3
- GOLFL, L3, PAST, L4
- GOLFL, L4, PAST, L1
- GOTOISP

**Tool path interval and Cusp**

- Contour
- Lace
- Parallel
- CUSP

**Machined Surface**

- Machined Surface
- Contour: W = "Width", R = "Roughness"
- Surface: W = "Width", R = "Roughness"
- Material: Rough, Medium, Fine
- Surface Roughness: Rough, Medium, Fine
- Surface Height: Rough, Medium, Fine
- Surface Width: Rough, Medium, Fine

**Cutter Contact, Gouge**

- Contact Point
- Gouging