Course Description

- **Instructor**
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- **Class time**
  - Saturday- Monday 10:30-12:00

- **Course evaluation**
  - **Mid-term** (25%)
  - **Final exam** (40%)
  - **Quiz** (5%)
  - **Exercise** (30%)
Course Description (Continued...)

- **Mid-term session:**
  - Monday: 8th Ordibehesht 1393, 10:30 ~ 12:30

- **Final Exam:**
  - Saturday: 24th Khordad 1393, 15:00 ~ 17:30

- **Reference:**
  - Benhabib, Beno; “Manufacturing: Design, Production, CAD/CAM, and Integration”, 2003, Marcel Dekker Inc, New York

Course Description (Continued...)

- **Contents:**
  - Introduction to CAD/CAM/CAE systems (5 sessions)
  - Components of CAD/CAM/CAE systems (2 sessions)
  - Geometric modeling systems (3 sessions)
  - Optimization in CAD (5 sessions)
  - Rapid prototyping and manufacturing (3 sessions)
  - Virtual engineering (2 sessions)
  - Product Life Cycle Cost Model (2 sessions)
  - Computer-Based Design and Features/Methodologies of Feature Representations (5 sessions)
  - Feature-Based Process Planning and Techniques (3 sessions)
  - Collaborative Engineering (2 sessions)
Course Description (Continued..)

* Contents:
  * Geometric modeling systems  (3 sessions)
  * Wireframe modeling systems
  * Surface modeling systems
  * Solid modeling systems
  * Non-manifold modeling systems
  * Assembly modeling systems

Introduction to CAD/CAM/CAE systems
**Geometric modeling systems**

- **Feature based modeling**
  - Enables the designer to model solids by using familiar shape units.
  - “a hole of a certain size at a certain place”
  - “a chamfer of a certain size at a certain place”

- **Popular manufacturing features:**
  - Hole
  - Fillet
  - Slot
  - Pocket
  - Chamfer

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**Geometric modeling systems**

- **Feature based modeling**
  - **Feature-Based Design**
    - Features can be seen as specific geometric shapes on a part that can be associated with certain fabrication processes.
Geometric modeling systems

* Feature based modeling
  * Feature-Based Design
    * Features have been commonly classified as
      * Form,
      * Material,
      * Precision,
      * and technological features.

  * It has been long advocated that if these features were highlighted during the modeling phase of a product’s design process, in the subsequent production-planning phases, engineers could take advantage of this information in accessing historical data regarding the production of these features.

Geometric modeling systems

* Feature based modeling
  * Feature-Based Design
    * The objective of design by features is:
      * To increase the efficiency of the designer during the geometric-modeling phase

      * To provide a bridge (mapping) to engineering-analysis and process-planning phases of product development.
Geometric modeling systems

- Feature based modeling
  - Feature-Based Design
    - In feature-based design, parts’ solid models are configured through a sequence of form-feature attachments (subtractions and additions) to the primary (base stock) representations of the parts, which can be as simple as a rectangular box.
    - These features could be chosen from a library of predefined (and sometimes application dependent) features or could be extracted from the solid models of earlier designs.

Geometric modeling systems

- Data Structures
  - Trying to make a mathematical description of a solid geometry
    - CSG representation: a tree and the history of applying the Boolean operations
    - B-Rep: boundary information of a solid
    - Decomposition model: Aggregation of simple solids such as cubes
Geometric modeling systems

Data Structures

CSG representation: a tree and the history of applying the Boolean operations

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```c
struct operator {
    int  op_type; /* union, intersection or difference operator */
    int  L_type; /* left node type: 0=operator, 1=primitive */
    int  R_type; /* right node type: 0=operator, 1=primitive */
    void *L_ptr; /* left node */
    void *R_ptr; /* right node */
    void *p_ptr; /* parent node */
}

struct primitive {
    int  prim_type; /* type of primitive */
    double pos_x, pos_y, pos_z; /* position of instance */
    double ori_x, ori_y, ori_z; /* orientation of instance */
    void *attribute; /* the value of dimensions of the primitive */
}
```

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(a) [Diagram of CSG representation]
(b) [Diagram of CSG representation]
(c) [Diagram of CSG representation]
Geometric modeling systems

- Data Structures
  - CSG representation: a tree and the history of applying the Boolean operations
    - It is simple and stores compact data
    - It always describe a valid solid
    - It can be easily converted
    - It supports the parametric modeling
    - It is limited by the defined Boolean operators (no lifting or other operator can be applied)
    - A great amount of computations is needed to discover the boundary information

Geometric modeling systems
- Data Structures
  - B-Rep: boundary information of a solid
    - The basic elements of the boundary are vertices, edges and faces
    - B-Rep needs to stores the abovementioned data and the interconnected information

Three tables for storing B-Rep

<table>
<thead>
<tr>
<th>Face</th>
<th>Edges</th>
<th>Edge</th>
<th>Vertices</th>
<th>Vertex</th>
<th>Coordinates</th>
</tr>
</thead>
<tbody>
<tr>
<td>F₁</td>
<td>E₁, E₂, E₆</td>
<td>E₁</td>
<td>V₁, V₂</td>
<td>V₁</td>
<td>x₁, y₁, z₁</td>
</tr>
<tr>
<td>F₂</td>
<td>E₂, E₆, E₇</td>
<td>E₂</td>
<td>V₂, V₃</td>
<td>V₂</td>
<td>x₂, y₂, z₂</td>
</tr>
<tr>
<td>F₃</td>
<td>E₃, E₇, E₈</td>
<td>E₃</td>
<td>V₃, V₄</td>
<td>V₃</td>
<td>x₃, y₃, z₃</td>
</tr>
<tr>
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<td>E₄, E₈, E₅</td>
<td>E₄</td>
<td>V₄, V₁</td>
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<tr>
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<td>E₈</td>
<td>V₄, V₅</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Geometric modeling systems

- **Data Structures**
  - **B-Rep**: boundary information of a solid
    - Curved faces and edges are problems
  - External and internal boundaries for faces are problems
  - Number of the edges for faces may be different
  - Deriving the information among the tables may be difficult