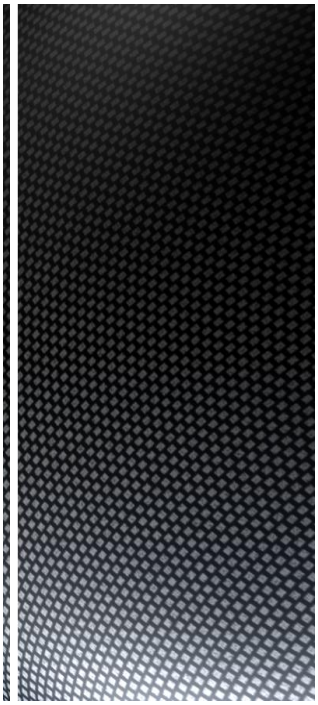


CAD/CAM (21-342)

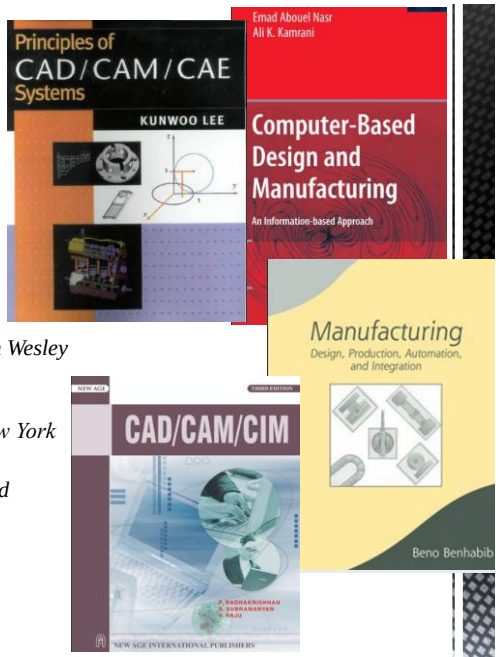
Advanced Manufacturing Laboratory
Department of Industrial Engineering
Sharif University of Technology

Session # 8

Course Description

- *Instructor*
  - *Omid Fatahi Valilai, Ph.D. Industrial Engineering Department, Sharif University of Technology*
  - *Email: FValilai@sharif.edu , Tel: 6616-5706*
  - *Website: Sharif.edu/~fvalilai*
- *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:*
  - *Lee, Kunwoo; "Principles of CAD/CAM/CAE systems", 1999, Addsion Wesley*
  - *Abouel Nasr, Emad; Kamrani, Ali K.; "Computer-Based Design and Manufacturing: An Information-Based Approach", 2007, Springer, New York*
  - *Benhabib, Beno; "Manufacturing: Design, Production, CAD/CAM, and Integration", 2003, Marcel Dekker Inc, New York*
  - *Radhakrishnan, P.; Subramanian, S.; Raju, V.; "CAD/CAM/CIM", 3rd edition, 2005, New age international (P) limited publishers, New York*

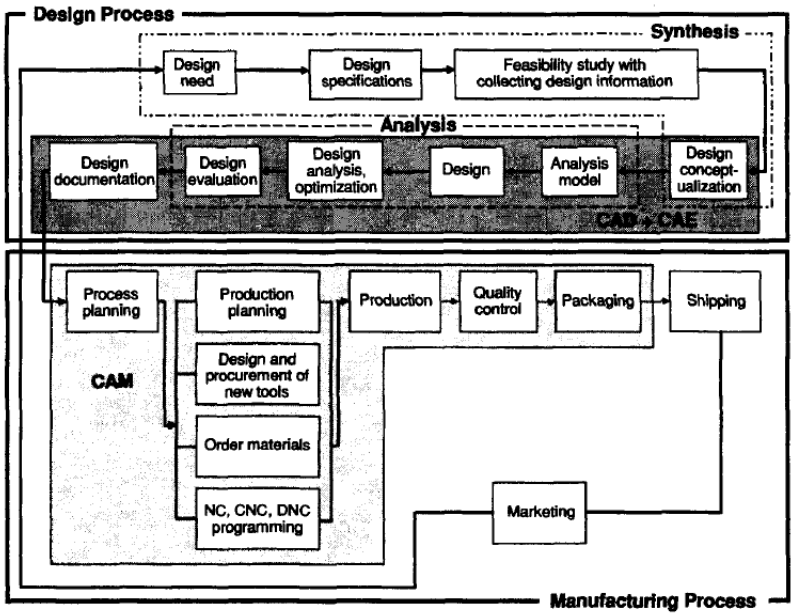
Course Description *(Continued..)*

- *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..)*

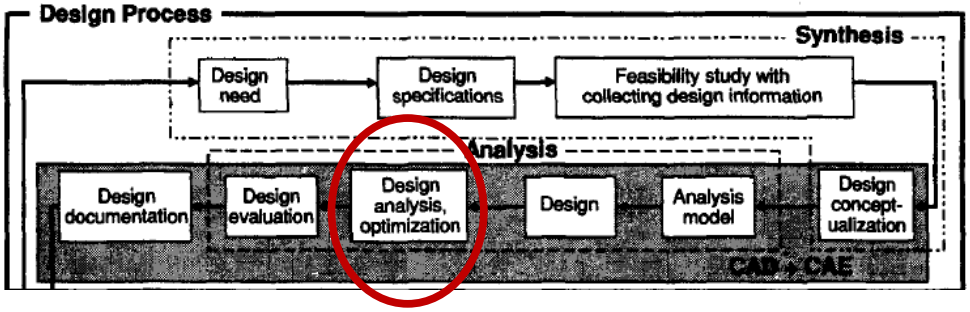
- *Contents:*
  - *Optimization in CAD* *(5 sessions)*
    - *Optimization of optimization problems*
    - *Treatments of constraints*
    - *Search models*
    - *Simulated annealing*
    - *Genetic algorithms*
    - *Structural optimization*

Introduction to CAD/CAM/CAE systems



Geometric modeling systems

- *Optimization in CAD*



Geometric modeling systems

- *Optimization in CAD*
  - *Design parameterization*
    - *Designing a cylindrical pressure vessel: the parameter would be the mean diameter , the thickness, the height*
    - *Depending on the situation some parameters can have constraints.*
    - *The parameters which are going to be optimized are called Optimization Variables and the performance index is called Objective Function.*

Geometric modeling systems

- *Optimization in CAD*
  - *Design parameterization*

$$\mathbf{X}^* \in R^n \text{ so that } F(\mathbf{X}^*) = \min F(\mathbf{X})$$

subject to

$$\mathbf{X}_l \le \mathbf{X}^* \le \mathbf{X}_u$$

$$G_i(\mathbf{X}^*) \ge 0 \qquad i = 1, 2, \ldots, m$$

and

$$H_j(\mathbf{X}^*) = 0 \qquad j = 1, 2, \ldots, q$$

Geometric modeling systems

- *Optimization in CAD*
  - *Design parameterization*
    - *Terms:*
      - *Feasible design (acceptable design)*
      - *Regional constraints (Side constraints)*
      - *Behavior constraints (functional constraints)*
    - *The objective function F(X) can be interpreted to be a surface face of dimension "n" embedded in a space of dimension "n+1"*

Geometric modeling systems

- *Optimization in CAD*
  - *Design parameterization*
    - *Treatment of constraints*
      - *For bounds we can restricts the design variables to stay within the specified bounds*
      - *For equality constraints the dimension of the design space is reduced by one for each constraint*
        - *Hence we may try to eliminate one design variable for each equality constraint.*
      - *For inequality constraints, we can modify the objective function to include the effect of the constraints*
        - *A penalty function may be added*

Geometric modeling systems

- *Optimization in CAD*
  - *Design parameterization*
    - *Treatment of constraints*
      - *For inequality constraints, we can modify the objective function to include the effect of the constraints*
        - *A penalty function may be added*

$$P(\mathbf{X}) = \begin{cases} 0 & \text{for } \mathbf{X} \in R_f^n \\ +\infty & \text{for } \mathbf{X} \notin R_f^n \end{cases}$$

$$D(\mathbf{X}) = F(\mathbf{X}) + P(\mathbf{X})$$

Geometric modeling systems

$$S(X) = \sum_i \delta_i |G_i(\mathbf{X})|^\alpha + \sum_j |H_j(\mathbf{X})|^\beta$$

- *Optimization in CAD*
  - *Design parameterization*
    - *Treatment of constraints*
      - *Exterior penalty function*

$$\delta_j = \begin{cases} 0 & \text{if } G_j(\mathbf{X}) \geq \mathbf{0} \\ 1 & \text{if } G_j(\mathbf{X}) < \mathbf{0} \end{cases}$$

$$S(X) = 0 \quad \text{if } \mathbf{X} \in R_f^n$$

$$D(\mathbf{X}, \rho) = F(\mathbf{X}) + \frac{1}{\rho} S(\mathbf{X})$$

$$S(X) > 0 \quad \text{if } \mathbf{X} \notin R_f^n$$

$$\min D(\mathbf{X}, \rho_k) = \min\left[F(\mathbf{X}) + \frac{1}{\rho_k} \left(\sum_i \delta_i |G_i(\mathbf{X})|^\alpha + \sum_j |H_j(\mathbf{X})|^\beta \right) \right]$$

Geometric modeling systems

$$\min F(\mathbf{X})$$

- *Optimization in CAD*
  - *Design parameterization*
    - *Treatment of constraints*
      - *Interior penalty function (no equality constraint may exist)*

$$G_i(\mathbf{X}) \geq 0 \qquad i = 1, 2, \ldots, m$$

$$B(\mathbf{X}) = \frac{1}{G_i(\mathbf{X})}$$

$$D(\mathbf{X}, \rho) = F(\mathbf{X}) + \rho B(\mathbf{X})$$

$$\min D(\mathbf{X}, \rho_k) = \min\left[F(\mathbf{X}) + \rho_k \sum_i \frac{1}{G_i(\mathbf{X})} \right]$$