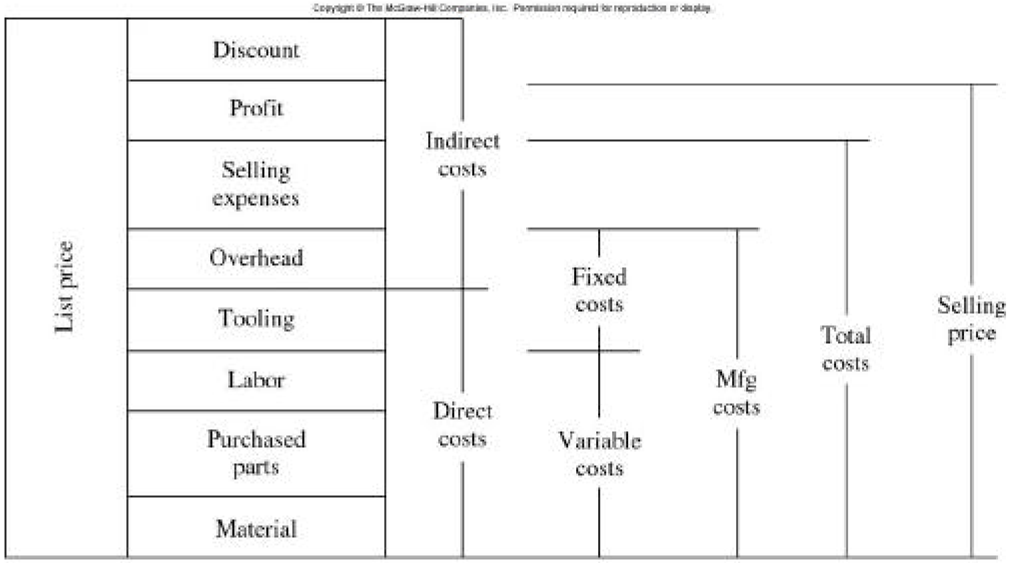
Product Evaluation for Cost, Manufacture, Asembly, and Other Measures

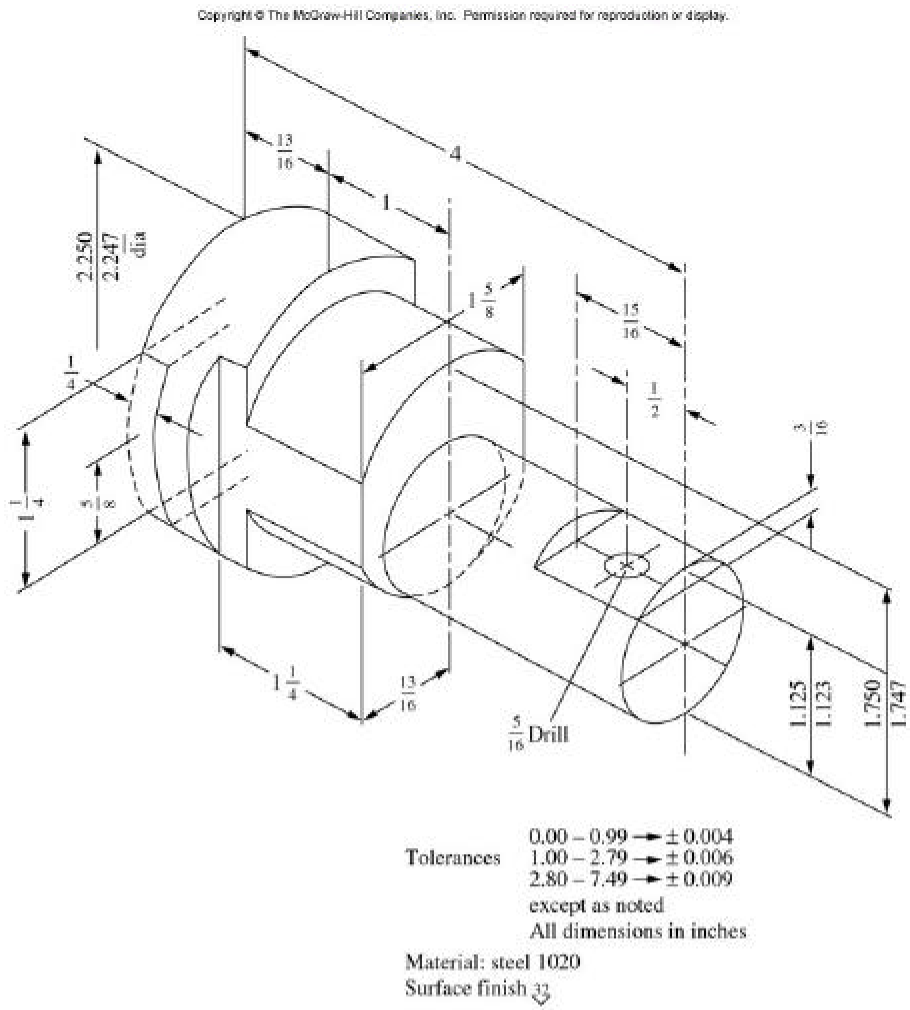
- **Cost Estimating in Design**
  - **Most difficult and yet important tasks**
    - **A rough estimate should be generated in the conceptual phase or at the beginning of the embodiment phase; and**
    - **Cost estimate is refined as the product is refined.**
  - **DFC (Design For Cost): keeping an evolving cost estimate current as the product is refined.**
- **Determining the Cost of a Product:**
  - **Direct Cost**
    - **All costs that can be directly traced to a specific component, assembly, or product**



It is the responsibility of the designer to know the manufacturing cost of components designed.

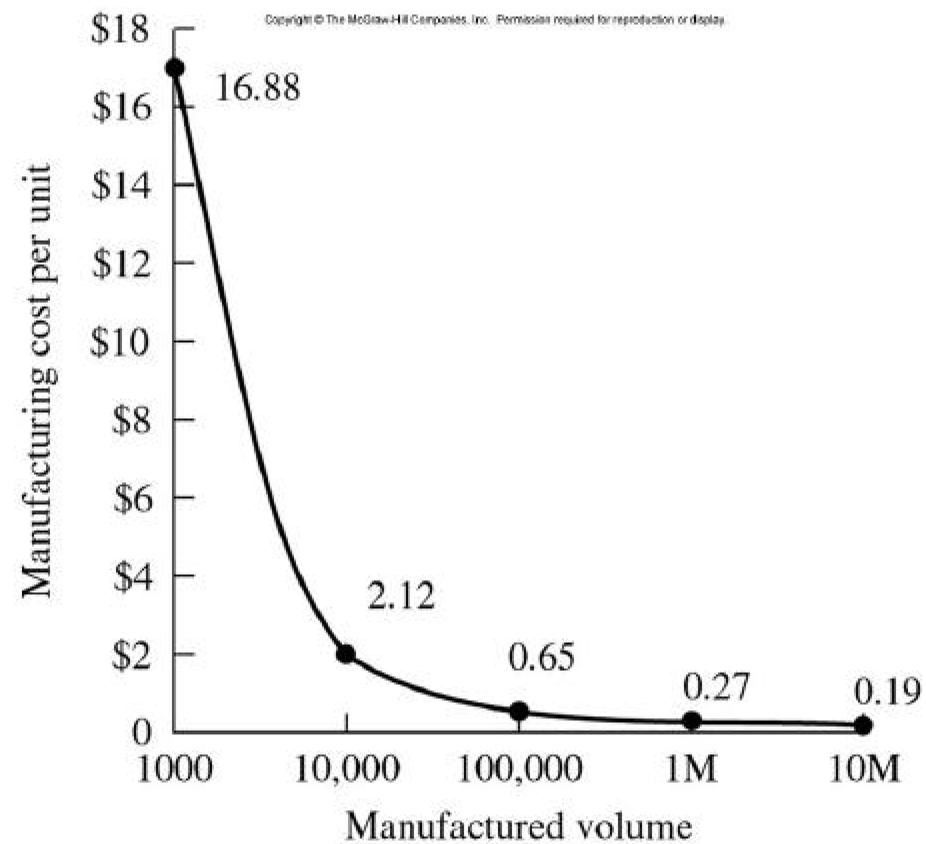
Cost of Machined Components

- **Machining is to remove portions of the material not wanted**
- **7 significant control factors for the machining cost:**
  1. **From what material is the component to be machined?**
  2. **What type of machine is used to manufacture the component?**
  3. **What are the major dimensions of the component?**
  4. **How many machined surfaces are there, and how much material is to be removed?**
  5. **How many components are made?**
  6. **What tolerance and surface finishes are required?**
  7. **What is the labor rate for machinists?**



Cost of Injection-Molded Components

- **Most popular method for making high-volume products with less precision requirements**
- **Factors for Cost:**
  - **All factors for machined component**
  - **Cost for manufacturing the die**
    - **Wall thickness**
    - **component complexity**
  - **Molding time (cooling time)**
  - **Number of components**



Value Engineering

- **Developed by GE in the 1940s and evolved into the 1980s.**
- **How to determine the value of a function in relation to the required cost?**
  - **Value = Worth of a feature, component, or assembly / Cost of it**
  - **Value = function provided per dollar of cost**
- **The worth of the function to the customer must be well identified.**

Design For Manufacture (DFM)

- **DFM is widely used but poorly defined.**
- **DFM is establishing the shape of components to allow for efficient, high-quality manufacture.**
  - **Key concern: Specification of the best manufacturing process**
  - **How to hold the components for machining?**
  - **How to release from the molds?**
  - **How to move components between the processes?**

- **The concurrent engineering philosophy, with manufacturing engineers as members of the design team, help incorporate the DFM.**

Design –for-assembly (DFA) Evaluation

- **DFA is the best practice used to measure the ease with which a product can be assembled in terms of efficiency.**
  - **Assembling a product means that a person must 1) retrieve components from storage, 2) handle the components to orient them relative to each other, and 3) mate them.**
  - **A product with high assembly efficiency has a few components that are easy to handle and virtually fall together during assembly.**

DESIGN FOR ASSEMBLY
INDIVIDUAL ASSEMBLY EVALUATION FOR ______

EVALUATED BY ______ DATE ______
REVIEWED BY ______ DATE ______
TRIAL 01 02 03 04 05

						COMMENTS
OVERALL ASSEMBLY						
1 OVERALL PART COUNT MINIMIZED	POOR	FAIR	GOOD	VERY GOOD	OUTSTANDING	
2 MINIMUM USE OF SEPARATE FASTENERS	POOR	FAIR	GOOD	VERY GOOD	OUTSTANDING	
3 BASE PART WITH FIXTURING FEATURES (LOCATING SURFACES AND HOLES)	POOR	FAIR	GOOD	VERY GOOD	OUTSTANDING	
4 REPOSITIONING REQUIRED DURING ASSEMBLY SEQUENCE	TWO OR MORE REPOSITIONS		REPOSITION ONCE		NO REPOSITIONING	
5 ASSEMBLY SEQUENCE EFFICIENCY	POOR	FAIR	GOOD	VERY GOOD	OUTSTANDING	
PART RETRIEVAL						
6 CHARACTERISTICS THAT COMPLICATE HANDLING (TANGLING, NESTING, FLEXIBILITY) HAVE BEEN AVOIDED	NO PARTS	FEW PARTS	SOME PARTS	MOST PARTS	ALL PARTS	
7 PARTS HAVE BEEN DESIGNED FOR A SPECIFIC FEED APPROACH (BULK, STRIP, MAGAZINE)	NO PARTS	FEW PARTS	SOME PARTS	MOST PARTS	ALL PARTS	
PART HANDLING						
8 PARTS WITH END-TO-END SYMMETRY	NO PARTS	FEW PARTS	SOME PARTS	MOST PARTS	ALL PARTS	
9 PARTS WITH SYMMETRY ABOUT THE AXIS OF INSERTION	NO PARTS	FEW PARTS	SOME PARTS	MOST PARTS	ALL PARTS	
10 WHERE SYMMETRY IS NOT POSSIBLE PARTS ARE CLEARLY ASYMMETRIC	NO PARTS	FEW PARTS	SOME PARTS	MOST PARTS	ALL PARTS	
PART MATING						
11 STRAIGHT LINE MOTIONS OF ASSEMBLY	NO PARTS	FEW PARTS	SOME PARTS	MOST PARTS	ALL PARTS	
12 CHAMFERS AND FEATURES THAT FACILITATE INSERTION AND SELF-ALIGNMENT	NO PARTS	FEW PARTS	SOME PARTS	MOST PARTS	ALL PARTS	
13 MAXIMUM PART ACCESSIBILITY	NO PARTS	FEW PARTS	SOME PARTS	MOST PARTS	ALL PARTS	
	TOTAL × 0	TOTAL × 2	TOTAL × 4	TOTAL × 6	TOTAL × 8	

NOTE:
EVALUATION SCORE TO BE USED ONLY TO COMPARE ONE ASSEMBLY TO ALTERNATE DESIGNS OF THE *SAME* ASSEMBLY

TOTAL SCORE

DFA for Orthopaedic Implants

- **DFA is critical in designing a product for mass production.**

- **For orthopaedic implants:**
  - **Actual assembly is performed during operation by surgeons.**
  - **Easy assembly is one of the major features that surgeons are looking for from an implant.**
  - **Make sure to minimize the number of components, assembling procedures and instruments for assembly.**

Guidelines for better DFA

- **Evaluation of the overall assembly:**
  1. **Overall component count should be minimized.**
  2. **Make minimum use of separate fastners.**
  3. **Design the product with a base component for locating other components.**
  4. **Do not require the base to be repositioned during assembly.**
  5. **Make the assembly sequence efficient.**
- **Evaluation of component retrieval:**
  6. **Avoid component characteristics that complicate retrieval.**
  7. **Design components for a specific type of retrieval handling, and mating.**
- **Evaluation of component handling:**
  8. **Design all components for end-to-end symmetry.**
  9. **Design all components for symmetry about their axes.**
  10. **Design components that are not symmetric about their axes of insertion to be clearly asymmetric.**
- **Evaluation of component mating:**
  11. **Design components to mate through straight line assembly.**
  12. **Make use of chamfers, leads and compliance to facilitate insertion and alignment.**
  13. **Maximize component accessibility.**

Design For Reliability (DFA)

- **Reliability is a measure of how the quality of a product is maintained over time.**
  - **Quality = satisfactory performance under a stated set of operating conditions.**
    - **Unsatisfactory performance = failure**
    - **Mechanical failure = any change or error that renders a component, assembly or system incapable of performing its intended function.**
    - **Typical source of mechanical failure: wear, fatigue, yielding, jamming, bonding weakness, property change, buckling and imbalance**
  - **Failure Modes and Effects Analysis (FMEA):**
    - **Technique for identifying failure potential used in calculating the reliability of a product.**
- **Failure-Potential Analysis**
  1. **identify the function affected.**
  2. **Identify the effect of failure on other parts of the system.**
  3. **Identify the failure modes affecting the function.**
  4. **Identify the corrective action.**
- **Reliability (R(t)) = exp(-Lt), L = failure rate or mean time between failures (MTBF)**
  - **R(t) is the probability that the component has not failed.**
  - **R(8760 hrs) = 0.892 implies that it would be expected that 89.2 out of 100 would still be operating after a year within specifications.**

- **Design for Test and Maintenance (DFTM):**
  - **Testability refers to the ease with which the performance of critical functions is measured.**
  - **Practice following the design process suggested in this class increases the testability.**

- **Design for the Environment:**
  - **Green design, environmentally conscious design, life cycle design, or design for recyclability.**
  - **Guidelines:**
    - **Be aware of the environmental effects of the materials used in products.**
    - **Design the product with high separability**
    - **Design components that can be reused to be recycled.**
    - **Be aware of the environmental effect of the material not reused.**

Launching and Supporting the Product

- **Documentation and communication**
  - **Quality assurance and quality control**
  - **Manufacturing instructions**
  - **Assembly instructions**
  - **Installation instructions**
  - **Operating instructions**
  - **Maintenance instructions**
  - **Retirement instructions**
- **Support**
  - **Vendor relationships**
  - **Customer relations**
  - **Support for manufacturing and assembly**
- **Engineering changes**
- **Patent applications**