Design for Manufacturing

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2. Mechanical Design Problems and Process

- Concurrent engineering relies on communication
- Communication depends on a shared understanding of terminology
- Define some of the terminologies that we should be using in this course.

Decomposition of Mechanical Systems

- Mechanical – Parts and assemblies all mechanical in nature
- Electromechanical – mechanical and electronic
- Mechatronics – mechanical, electronic and software

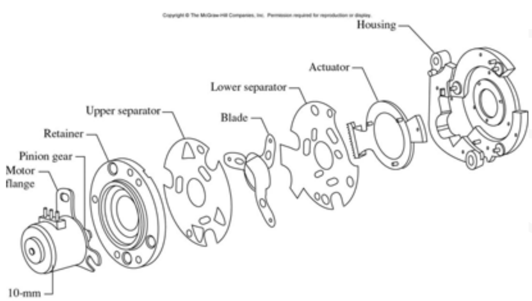
Decomposition of Mechanical Systems

- Decomposing a product by parts is great for manufacturing, but design focuses on function
- Example of a mechatronic system – Automatic Camera and its shutter assembly

Fig. 2-1
A Kodak Cameo 300M zoom camera

Courtesy: David Ullman – Mechanical Design Process, McGraw Hill, 2003

Fig. 2-2 The shutter assembly



Courtesy: David Ullman – Mechanical Design Process, McGraw Hill, 2003

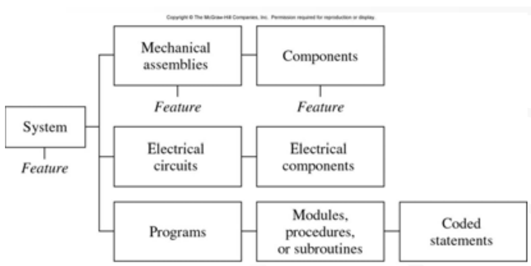
Decomposition of Mechanical Systems

- A system is a grouping of objects that perform a specific function
- Camera – is a photographic system to record images
- Shutter – control light coming through the lens
- Exposure system – auto focus system, light meter, controller and shutter system

Decomposition of Design disciplines

- Assemblies – Parts or Components
- Function of the system is decomposed first
- For the finest subsystems – develop components and assemblies

Fig. 2-3 Decomposition of design disciplines



Courtesy: David Ullman – Mechanical Design Process, McGraw Hill, 2003

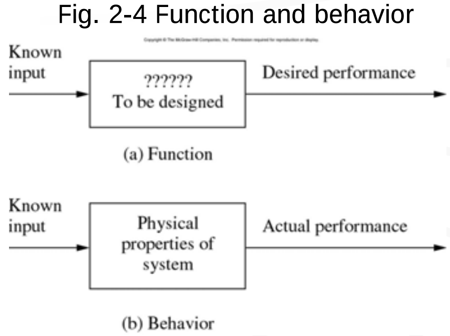
Product function and behavior

- Function, Operation and purpose are used synonymously in relation to mechanical components
- Screw driver
- Handlebar of a bicycle
  - Steer the bicycle
  - Support the rider
  - Support the brake lever
  - Transform the gripping force

Product function and behavior

- Handlebar of a bicycle
  - Is apart of a number of assemblies in performing all those functions
- In mechanical systems form enables function, and function determines form

Fig. 2-4 Function and behavior



Courtesy: David Ullman – Mechanical Design Process, McGraw Hill, 2003

Function and behavior

- Function is the desired output
- Behavior is the actual output
- Performance is the measure of function and behavior

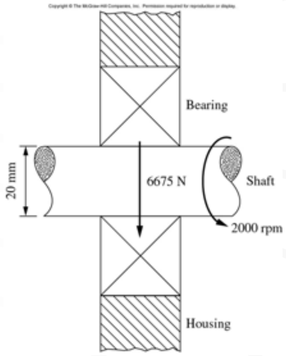
Mechanical Design Problems

- There a number of approaches to design
- Selection design
  - Correct bearing from a catalog
- Configuration design
- Parametric design
- Original design
- Redesign

Selection design

- Choosing an item from a list of similar items
- Use catalogs

Fig. 2-5
Load on a shaft



Using catalogs identify all the bearings that satisfy the requirements

Courtesy: David Ullman – Mechanical Design Process, McGraw Hill, 2003

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Table 2.1 Potential bearings for a shaft

Type	Outside diameter (mm)	Width (mm)	Load rating (lb)	Speed limit (rpm)	Catalog number
Deep-groove ball bearing	42	8	1560	18,000	6000
	47	14	2900	15,000	6204
	52	15	3900	9000	6304
Angular-contact ball bearing	47	14	3000	13,000	7204
	37	9	1960	34,000	71,904
Roller bearing	47	14	6200	13,000	204
	52	15	7350	13,000	220
Needle bearing	24	20	1930	13,000	206
	26	12	2800	13,000	208
Nylon bushing	23	Variable	290 ⋮ 8	10 ⋮ 500	4930

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Configuration design

- Packaging design
- Subsystems are fully designed
- For example, Computer sub systems

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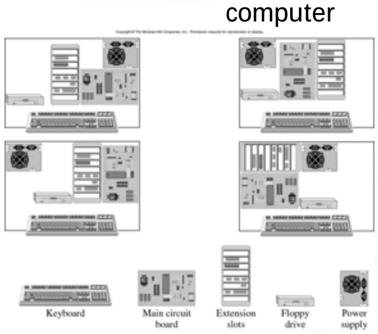
Fig. 2-6 Possible configurations for a computer



Courtesy: David Ullman – Mechanical Design Process, McGraw Hill, 2003

Parametric design

- Use design equations, to get the solutions
- Design a cylindrical tank with a volume of 4 m^3
- Volume = $\pi r^2 l = 4$
- r = radius of the tank
- l = height of the tank

Original design

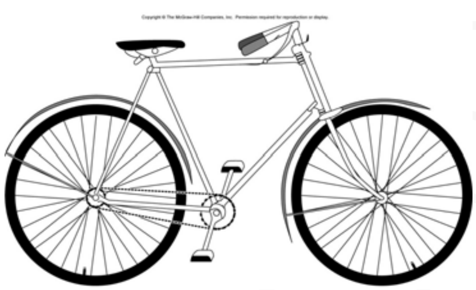
- Entirely new

Redesign

- Improvement or modification of an existing design
- Most design problems are redesign since they are based on prior, similar solutions. Conversely, most problems are original as they contain something new that makes prior solutions inadequate.

- Bicycle design is well advanced by the end of 19th century. Not much changes since then in the conventional bike design

Fig. 2-7 1890 Humber bicycle



Courtesy: David Ullman – Mechanical Design Process, McGraw Hill, 2003

Fig. 2-8
The Otto
dicycle

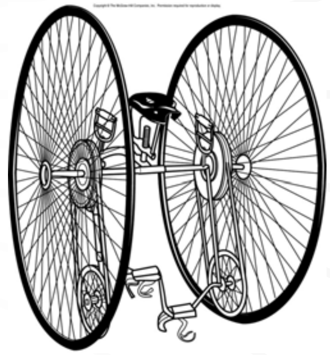


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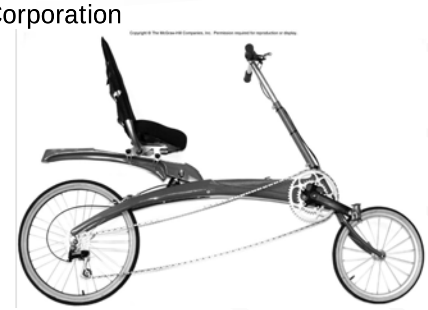
Fig. 2-9 The FantasE from BikeE Corporation



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Languages of Mechanical Design

- Semantic: verbal presentation
- Graphical: drawing of the object
- Analytical: equations, rules, etc.
- Physical: hardware of the object

Fig. 2-10 The value of information

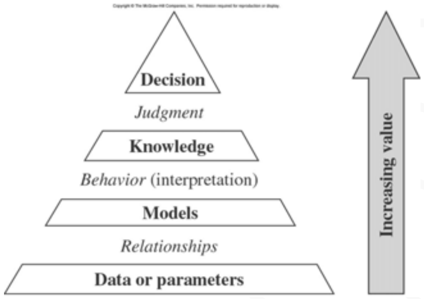

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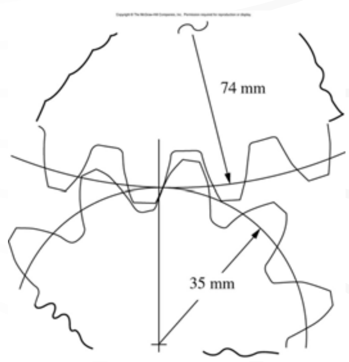
Fig. 2-11
A gear set



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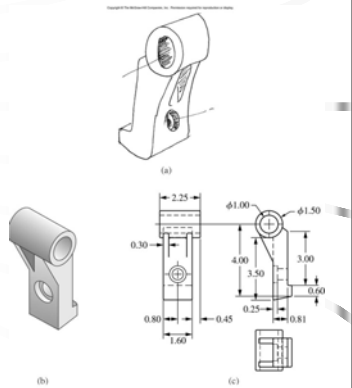
Design Refinement

- The process of making an object less abstract is called refinement

Fig. 2-12
Abstract sketch and final drawing of a component

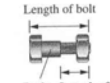
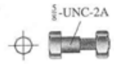


Courtesy: David Ullman – Mechanical Design Process, McGraw Hill, 2003

Table 2.2 Levels of abstraction in different languages

	Level of abstraction		
Language	**Abstract**	⟶	**Concrete**
Semantic	Qualitative words (e.g., *long, fast, lightest*)	Reference to specific parameters or components	Reference to the values of the specific parameters or components
Graphical	Rough sketches	Scale drawings	Solid models with tolerances
Analytical	Qualitative relations (e.g., *left of*)	Back-of-the-envelope calculations	Detailed analysis
Physical	None	Models of the product	Final hardware

Table 2.3 Levels of abstraction in describing a bolt

	Level of abstraction		
Language	**Abstract**	⟶	**Concrete**
Semantic	A bolt	A short bolt	A 1″ 1/4-20 UNC Grade 5 bolt
Graphical		 Length of bolt; Body diameter; Length of thread	 $\frac{5}{8}$-UNC-2A
Analytical	Right-hand rule	$\tau = F/A$	$\tau = F/A$
Physical	—	—	

Summary

- Decomposing a product by its form (i.e. components and assemblies) is great for manufacturing and assembly, but design focuses on function.
- Form enables function and function underlies form.

Summary

- Most design problems are redesign problems since they are based on prior, similar solutions. Conversely, most design problems are original as they contain something new that makes prior solutions inadequate.
- Design is the technical and social evolution of information punctuated by decision-making.

Questions and Comments