any intelligent fool can make things bigger and more complex
it takes a touch of genius to move in the opposite direction

Albert Einstein
14 March 1879 – 18 April 1955
2.009 Product engineering processes today

product architecture
product form

design for assembly making things easier for yourself

thinking about designing this week
Last class...
what is an ethic?

A code of behavior or conduct justified according to a reasoned value system

“something all politicians are lacking”
Product architecture

name two product architectures

modular

integral

number of students

none

one

both
Modular architecture

advantages

decoupling facilitates task allocation and out-sourcing
economies of scale
standardization for developing new products
maintenance
adaptation/mass customization (combinatorial design)
Integrated architecture

advantages

**Performance:** modularity can mean performance sacrifices especially when performance is a function of size, shape, and mass and highly coupled.

It is easier to optimize overall system with an integrated architecture.
Product architecture
list an advantage for each architecture

inherent to design, not an add-on
probably modular unless it can’t be

- Number of students
- Number of advantages/disadvantages
Form follows function

**Sullivan’s intent** (father of modernism, skyscrapers)

"make it pretty later"

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- **Number of students**
- **Number of instructors**

- **Number of functions**
  - Instructs how to use/interact
  - Instructs how it works/purpose
  - Design inspired by function
  - Function comes first/is more important
Mini quiz

yep, another one!

form follows function means?

the principle of pragnanz is…

KISnS stands for…?
Product development process
so far...

rigor in breadth
Product development process so far…

exploring options and deciding where to invest

information-based decisions

needs and value propositions

realistic risk-taking

facilitating difficult decisions through process
Product development process now...

rigor in depth
Workflow now...
Prototype development countdown
design for assembly

so what?
Design for assembly
screw 4 fasteners, exercise

assembly times

- 4 no predrill (phillips)
- 4 phillips
- 4 slot
- 4 mixed (two phillips, two slot)
- 4 blind (phillips)
- 4 upside-down (phillips)
- 4 upside-down, blind (phillips)
- 4 mixed, upside-down, blind
- 4 holes, almost symmetric
Design for assembly

why care?

thinking about it will save you time, and now is the time to think about it

typically consider things like production volume, part count, capital investment, per product cost, and payback period when deciding how to assemble
Design for assembly

manual assembly

manual almost always chosen method for low volume (few thousand per year)

human assembly with simple, low cost fixtures

low initial capital outlay compared to automated systems
high flexibility and adaptability
assembly cost stays the same regardless of volume
it can be error prone
it can be a really tough job
Design for manual assembly

overall procedure

i) for each part, decide if it is really necessary

ii) if a part is necessary…
    design it so that it is easy to assemble
Design for manual assembly guidelines

reduce part count

  is there relative motion during use?
  is a different material needed?
  does it need to separate for assembly, maintenance or end-of-life? (debugging)
  will it be difficult to make?
Design for manual assembly

guidelines

reduce part types

standardize fasteners (Robertson, Phillips, Allen)

eliminate unnecessary product features

avoid wiring harnesses, connecting cables
Design for manual assembly

guidelines

eliminate adjustments (design to fit):

judgment and decisions during assembly take time and lower reliability

avoid joining parts if they can be made from one piece

use locating pins or features (e.g., for bolted elements)
Design for manual assembly guidelines

design parts to be self locating/aligning
parts that do not have to be held in place during assembly (e.g., spot face)
use chamfers or tapers to guide parts into one and other
avoid multiple surfaces that need to be aligned simultaneously
let gravity work for you
Design for manual assembly guidelines

consider access

provide adequate space for hands, tools, and post assembly operations (lubricating, debugging, batteries)
ensure that there is a direct line of sight for mating surfaces during each assembly step
adopt a single assembly direction (e.g., vertical stack)
Design for manual assembly
guidelines

make parts easy to handle
  avoid heavy, sharp, fragile, awkward parts
  avoid parts that require special tools for gripping or insertion (e.g., e-clips)
  avoid flexible parts
  avoid parts that tangle easily (e.g., open-end springs)
Design for manual assembly guidelines

design parts so they can only be installed correctly
- make parts fully symmetric
- make parts clearly asymmetric
- make it obvious if parts are not correctly aligned (no almost fits)
- add features to block incorrect assembly (e.g., memory chips)
- provide registration marks
- avoid flexible parts since they almost always can be installed incorrectly
Last coming up!

**Monday:** we start in 10-250 and then will have consulting sessions in your team areas
discussion related to your design and the assembly review