Assumptions and Biases

- Every design and system has multiple phenomena operating at the same time
- This has several consequences
  - Parts must be designed and tested separately and then tested together
  - Analytical models and simulations will not be able to encompass all the important things that could happen or must be understood
  - A “digital” plug-play or modular approach will not work and may not even lead to a good design

Things That Are Important

- Geometry, geometric relationships, and visualization
- Mass and space occupancy
- Motion (dynamic space occupancy, acceleration loads)
- Forces, loads, load paths
- Tight coupling that's unavoidable: propagation of loads, heat, fluid, vibration, fatigue - generally linkage of effects and time-driven effects
- Ever-present constraints
  - Generic: the laws of physics
  - Specific, often enterprise-driven: space, weight, cost in this particular design

Things We Usually Don't Think About Because They Won't Happen

- A theory that will tell us the right way to design something, tell us how far off the optimum we are, or tell us what to do to get to the optimal design
- The idea that it will be right the first time
- The idea that we will have time to be sure it is right
- The idea that you can get it done without someone who really knows what they are doing

Other Thoughts

- The “right way” usually is found and after a while a search is no longer needed (airplane wing, car engine); no canonical architectures exist, such as trees, but consensus architectures for specific kinds of things emerge
- No single part is the hero that makes the product work; the product’s architecture, the way the parts work together, is the key thing
- Sometimes no agreement or convergence occurs (car door design)
- More design and testing time are devoted to finding and mitigating side effects than in assuring achievement of basic function and performance

What's Basic to MechE

A. Analytical
   1. Need to consider basic physical phenomena as part of every design exercise
   2. Must know the limits of the models
   3. Must do geometric reasoning
   4. Each phenomenon has its own detailed models
   5. "Stochastic world" not a high priority

B. Design
   1. Main functions and failure modes involve multiple interacting phenomena and constraints in every design
   2. Side effects operate at high power
   3. Good designs are "elegant"
   4. "System view" not a high priority in education or most practice areas - combination of good components will do
   5. Integrated models are unreliable or do not exist