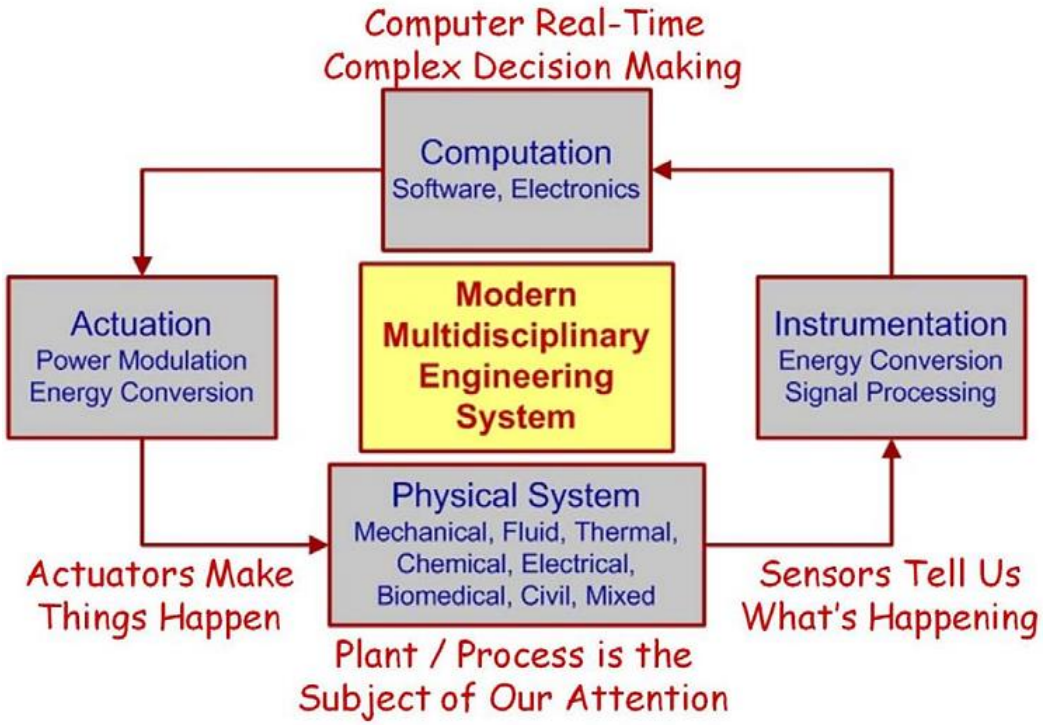
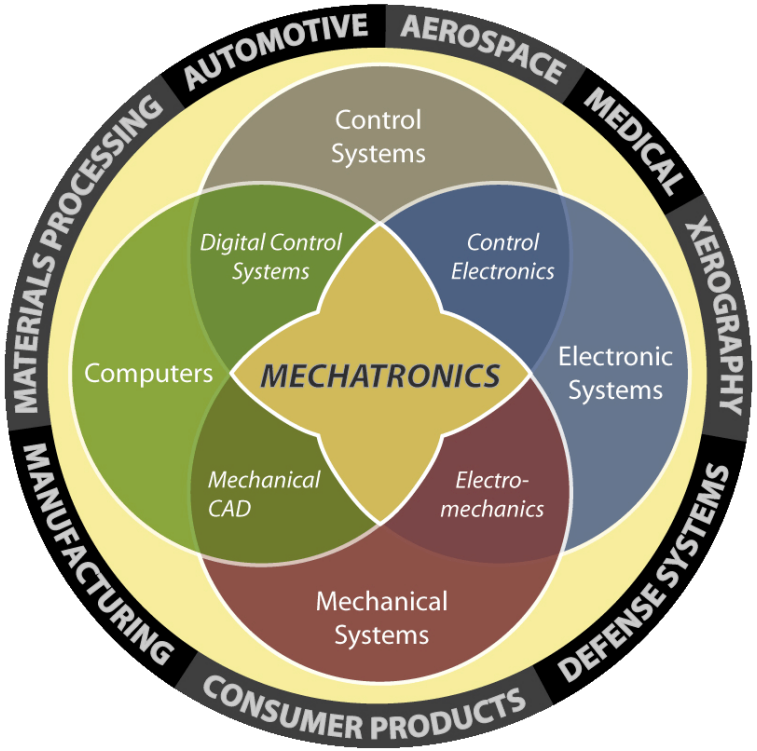
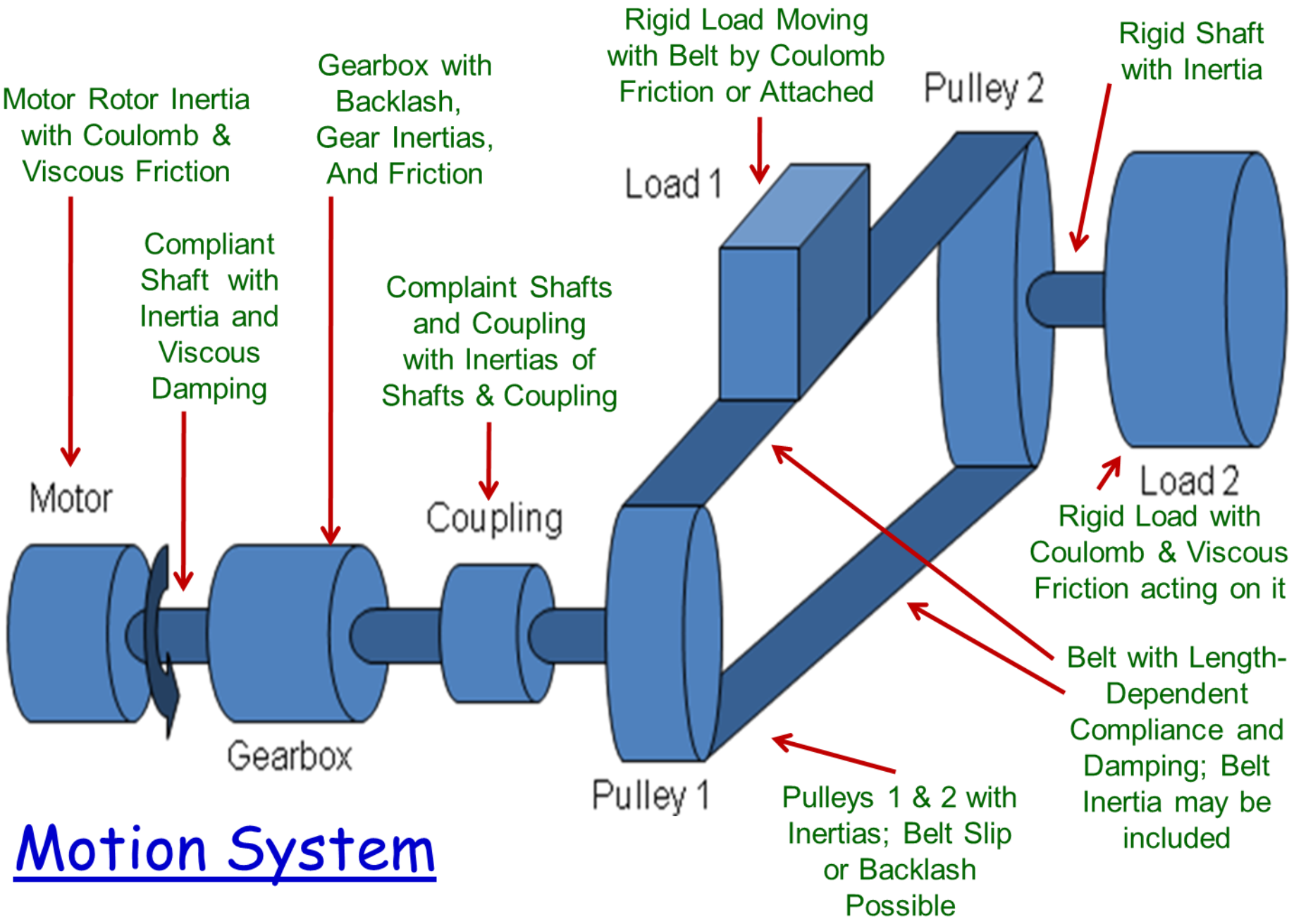
Mechanical System Design for Mechatronic Automation







Motion System

References

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Introduction

- Precision machines are essential elements of an industrial society. Modern industry is critically dependent on them.
- A precision machine is an integrated system that relies on the attributes of one component to augment the weaknesses of another component.
- Here we emphasize the design of mechanical and structural precision machine components and their integration with sensor, actuator, and control systems to maximize performance.
- Emphasis is placed on how the design will affect the overall accuracy, precision, and resolution of the machine.

- Design is a mixture of analysis and creative thought.
  - No matter how creative or analytical you are, you must organize your thoughts. There are six categories of thought that should be accomplished for every deterministic design project. They are:
    - Independent Functional Requirements – things the design must do or the events that the design must accomplish, with ordering if necessary
    - Design Parameters – ideas for how to achieve the functional requirements, as independent as possible
    - Analysis – first words, then equations
    - References – information from everywhere
    - Risks – objectively ascertain what might go wrong
    - Countermeasures – trading off risk for performance or cost

- Society needs design engineers.
  - The resources needed to help people in need can only by created by adding value to natural resources.
  - Society needs new ideas for new products.
  - Jobs are created when there is a desire for products that need to be manufactured.
  - To create jobs, we need people to design products that people want, and then we need people to figure out how to manufacture, distribute, sell, and service these new products.
- Companies can remain competitive only if they develop new technologies and methods to keep one step ahead of the competition.

- New machines need to be designed with increased speed, accuracy, and reliability.
- Analogous to physical exercise, analysis is a form of mental exercise that trains the mind to be strong and swift. Many designs would never have even been conceived of if the design engineer did not understand the basic physics behind the process or machine that prompted the need for a new design.
- Knowing how to build things can enable the design engineer to develop easily manufacturable products that are a pleasure to use.
- Today's design engineer must be a Renaissance person.
- Design engineers must be more creative than their competition and more observant of the world around them.

- How can design engineers be taught to think and be creative? Integrating theory and application with real-world considerations is the best method.
- The design process is a dynamic one where design options are generated and discarded until a working design is finally converged upon. Ultimately, the design must meet specifications for function, safety, reliability, cost, energy efficiency, manufacturability, marketability, and sustainability.
- Design engineers must be good at identifying problems. Once a problem is identified, it will usually yield to an unending barrage of creative thought and analysis.
- In addition to identifying and solving problems, the design engineer must also learn to identify what the customer really needs, which is not necessarily what the customer thinks that he or she needs.

- To keep his or her mind tuned, a good design engineer must always ask: "How does that work?"
- A good design engineer must be observant, patient, and optimistic. Opportunity only knocks for those who listen!
- Designs can be categorized as being original, adaptive, or scaled.
  - Original design means developing a new way of doing something, e.g., cutting material with water jets.
  - Adaptive design means using technology developed for another task and adapting it to perform the task at hand, e.g., using lasers to sculpt wood.
  - Scaled designs means changing the size or arrangement of a design in order to accommodate a similar change in an existing process, e.g., design a bigger version of an existing machine.

- Each of these types of design require a design process - task definition, conceptual design, layout design, detail design, and design follow-up.
- A personal design method should:
  - Foster creativity
  - Acknowledge the creativeness of others; the not-invented-here syndrome is unacceptable.
  - Not depend on luck or ignore a problem in the hope that it will go away.
  - Be disciplined and well organized so the design can be passed onto others for detailing or completion.
  - Respect simplicity and the fundamental knowledge of how and why things work.
  - Continually subject designs to value analysis in an effort to reduce cost with an equal or increased level of quality.

- Designing a product to be safe is of prime importance.
- There are three principal methods that a design engineer can use to increase the safety of a design: direct methods, indirect methods, and warnings.
  - Direct methods require elimination of the hazard.
  - Indirect methods involve the use of guards and shields to prevent operator injury or fouling of other machine components.
  - Warning labels should only be considered as a method for drawing attention to the guards and hazards that may result if the machine is misused.
- Hazards can be created by failure of machine components. These can be prevented by safe-life, fail-safe, and redundant design.

  - Safe-life design requires the part to be designed with infinite life even when subject to overloads and misuse.
  - Fail-safe design means that the part gives ample warning via decreased performance before it breaks.
  - Redundant design implies use of more parts than are necessary for operation of the system. With the loss of one part, decreased performance will be noticed, but the machine should be able to operate long enough to bring the system to a controlled stop.
- Designing for safety also requires the design engineer to think carefully through the operation of the machine. The design engineer must ask: "Would I be willing to operate the machine on a daily basis?"