Analysis for Engineering Design

XYZ – 487 Senior Design

School of Engineering
Mercer University

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Typical Design Processes

Creating a high-quality idea

Engineering Analysis – predictions, calculations, etc. leading to final specs

Realizing a high-quality device

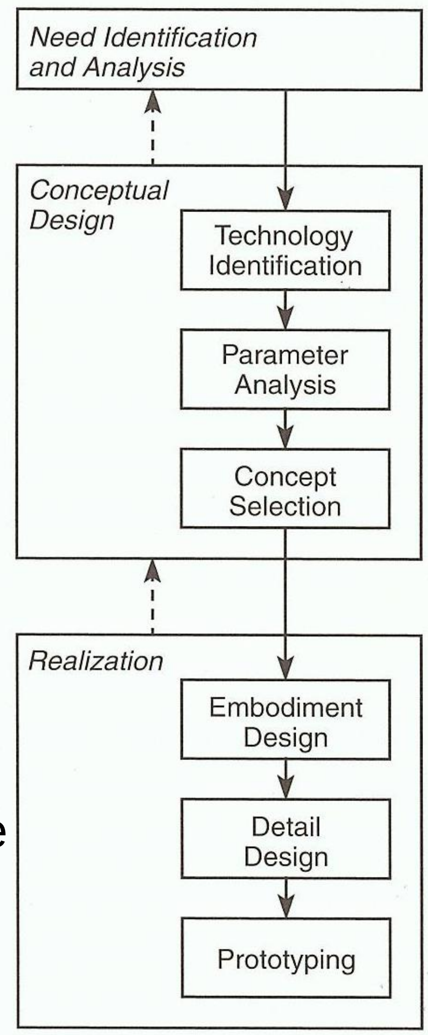


Figure 1.1 Overview of the engineering design process.

Background research
(fundamental science; technologies)

Innovation
(EGR 107 - Brainstorming)

Preferred/Best Alternatives
(EGR 107 – Merit Analysis)

Details for reality of concept
(identify the device to achieve concept; meets constraints and challenges of reality)

Final Specs (PDR) – end 487

Prototyping(Testing) - XYZ 488

Kroll, Condoor, and Jansson, Innovative Conceptual Design, Theory and Applications of Parameter Analysis, Cambridge, 2001

Achieving functionality is incomplete success

- Engineering design seeks to balance four main goals (Dieter and Schmidt, Engineering Design,5th ed., McGraw-Hill, 2013)
  1. Proper function and safety
  2. Optimum performance
  3. Adequate reliability
  4. Low cost
- How does a design team ensure and assess success towards each of these four goals?
- Methods available to the design process
  1. Planning
  2. Analyses (Predicting, Testing)
  3. Codes and standards
  4. State-of-the-art in technology

What does my senior design team offer our client that requires an engineering education?

What can we offer that CLA graduates are not trained to offer?

Engineering Perspective/Expertise:

- Problem investigation and needs identification
- Conceptual design and innovation
- Professional evaluation of engineering alternatives
  - documented substantiation of decisions
  - evaluation of effectiveness and quality regarding objectives
  - consideration of realistic constraints – safety, environmental, ethical, economic

Realization:

- Predictions/analysis of design, esp. the final design
  - engineering fundamentals (practical application of sciences)
  - simulations and analyses of critical issues lead to worthy prototypes
- Complete set of final-design specifications
  - information necessary for construction/implementation
  - requires foresight of the issues associated with fabrication, assembly, scheduling, etc.
  - CAD drawings/ visualization

Analyses guide projects:
(w/ science, technology, standards, etc.)

Design Teams - Pratt and Whitney (UTC)

1. Design engineer – coord. design plan and team effort, facilitate innovation, final design and documentation (not working drawings)
2. Project engineer – problem identification / needs analysis / budget and rationale
3. Analysis engineer – prescribes & completes analysis tasks / returns with presentation of findings (FEA experts, etc.)
4. Draftsman – final working drawings & tolerancing
5. Performance engineer –performance analysis, predictions
6. Materials engineer – expert on material capabilities, availability, costs
7. Field engineer - experimental analysis, testing & prototyping, instrumentation, uncertainty
8. Manufacturing engineer – expert on manufacturing capabilities, constraints, quality control, process analysis

Analysis for Engineering Design

Discover and investigate that having consequences

- **analyze** (anʹl īzʹ), *v.* **1.** to separate into constituent parts or elements; determine the elements or essential features of. **2.** to examine critically, as to bring out the essential elements or give the essence of. **3.** to examine carefully and in detail so as to identify causes, key factors, possible results, etc.
- Analysis for Engineering Design is motivated
  - Question/motivation
  - Predictions/Simulations/Experiments/Estimates
  - Interpretation of findings
    - consequences of model and limitations of results
    - make observations of results and report key findings
  - Impact on Design Process/Decisions

Make informed, substantiated decisions with professional responsibility

- Components of Analyses for Engineering Design
  1) reason and relevant technical questions
  2) mathematical modeling or experimentation
  3) solution/simulations predicting results
  4) presentation of results (written explanation with graphs)
  5) discussion of the meaning/limitations/impact of results
  6) conclusions and decisions (final consequences of results)

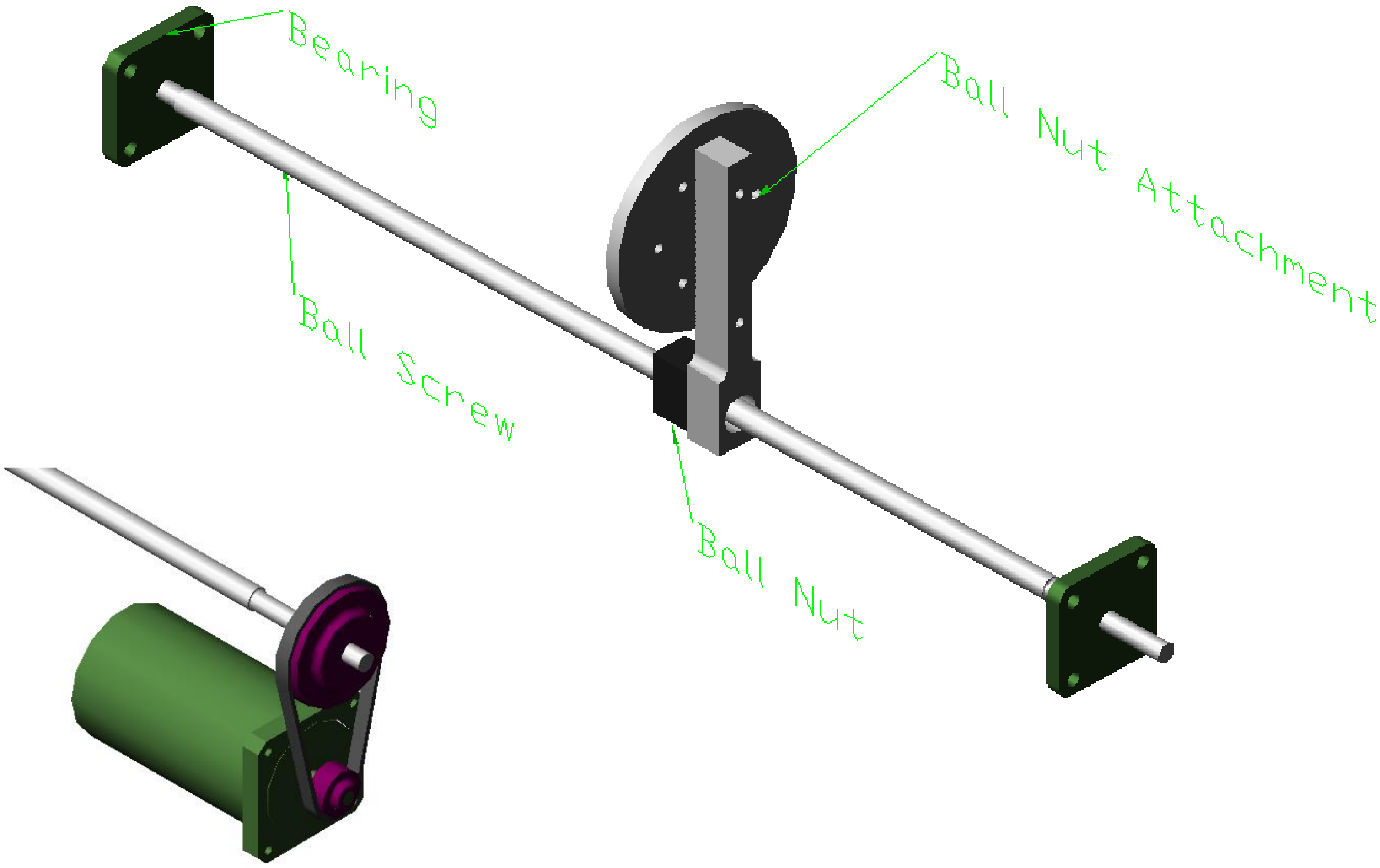
- Responsibility and communication
  - Technician's work: 3) and 4) (typical course work like HW/projects)
  - Engineer's work: 2) and 5) (details require thought / engineer's expertise)
  - Professional engineering team: 1) and 6) (shared wisdom of team)
  - Communicate your engineering merit –
    - Explaining components 3) and 4) proves technical merit
    - Explaining components 2) and 5) demonstrates responsibility (understanding of limitations and meaning of results and regards the physical meaning of mathematics - Don't restate math of equations and not redirected in the appendix)
    - Explaining components 1) and 6) ensures professional/global perspective

Capstone Engineering Design: Demonstrated application of what you've learned at MUSE

- Analog Filter Design
- Bioremediation
- Biological Fluids
- Biomechanics
- Chemical Processes
- Diagnostic Imaging
- Digital Logic and Comp. Organization
- Dynamics
- Electrical Fundamentals/ Circuits
- Electromagnetic Field Theory
- Engineering Design
- Engineering Economy
- Ergonomics
- Feedback Controls
- Fluid Mechanics/ Hydraulics
- Heat Transfer
- Human Factors Engineering
- Instrumentation/ Data acquisition
- Manufacturability
- Materials
- Mirocomputer Fundamentals
- Probability and Statistics
- Power Electronics
- Robotics
- Signal Processing
- Solid Mechanics/ Structural analysis
- Quality Control
- Statics and Solid Mechanics
- Thermodynamics
- Vibrations

Topics are comparable with all accredited engineering schools across the country.

Example. Ball Screw and Nut Drive Assembly



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Grading:

- Clearly identified concerns: a) compress within 5 secs, b) figure required torque, c) withstand torsion and bending
- Well explained modeling, calculations and results
- Discussed meaning and impact of analysis – (not so much results)
- Conclusions? – failed to state the conclusion "although obvious"
- High credibility and value for explaining components 1)-5)
- Nice use of CAD
- Analysis Grade: A

In-Class Team Assignment

Report 3 needed analyzes specific to your project

1) Choose a main objective or your project the poses significant issues/questions/concerns:
2) Identify those issues/questions/concerns:
3) What design specifications/decisions are affected?
4) State(or propose) a current best design concept:
5) What analysis could help to make informed decisions?
6) What results/predictions will the analysis provide?
7) State any potential best/worst-case scenarios for findings?
8) Explain the work/challenges required to accomplish this analysis?

Final Question

If you don’t understand part or all of your analysis or results, you should:

a) Try to fake it in your PDR.
b) Present it with a disclaimer… because my advisor said so.
c) Put it in an appendix and don’t discuss.
d) Find another comparable/conservative approach
e) Find more resources and work to figure it out