MAE Department Integrated Design-I and -II
ME445 and 446

Two-semester ‘capstone’ course for mechanical engineering design

Emphasis on system engineering:

MAE 445/6 incorporates:

- Environmental and ethical considerations for design
- Tools for creativity, fact-finding, decision-making, design methods
- Capturing users’ true requirements
- Design processes including TQM, functional decomposition, TRIZ and technical mechanical design
- Project and team management
- Verification and validation
- Communication

Two ‘streams’ for ME 445/6:

- Academic study
- Design projects

Projects led by, or done for, industry

Projects requiring only standard “good” eng. practice

Projects requiring invention

Projects done by interdisciplinary teams

Futuristic projects

Fall 2019 Poster Session water desalination team
**Environment:** Earth’s current challenges: Current and near-future role of engineering design for mitigation and adaptation to a changed climate, *Design for Environment* (DFE). And engineering ethics, codes and standards, patents.

![Prof. Susan Powers, Dec. 2017](image1)

![Student-made novel bicycle, April 2018](image2)

![Parabolic solar concentrator, Dec. 2018](image3)

**Creativity and Design methods:** Biomemetic design, functional decomposition, TRIZ, decision theory, weighted decision matrices, AHP.

![Bio-Med Team, ME446](image4)

![Fire Prevention invention, Dec. 2018](image5)

![Prof. Helenbrook discussing with a student a team, Dec. 2018](image6)
Capturing Users’ *true requirements*, Focused listening, Kano’s four criteria, writing ‘good’ design requirement specifications, surveys, benchmarking, TQM including House-of-Quality, RFPs, RFQs and RFIs, writing winning proposals

**Design processes (technical):**

- **Skills:** sketching, problem-solving, modeling, analyzing, parametric analyses, CAD, technical decision-making, detailing, tolerances, GD&T.

- **System engineering:** interfaces, trade-off studies, system boundaries, system budgets e.g. for mass, electrical power demand etc.
• **Selecting materials**: Fracture mechanics, fatigue, creep, temperature sensitivity, corrosion, wear, lubrication, cost.

• **Designing for Manufacturing and Assemble (DFMA)**: e.g. casting, welding, machining, additive manufacturing. And assembly methods.

• **Designing for reliability and quality**: Instilling long-life, availability, redundancy, cross-strapping, FMECA, FTA. Process control for fabrication, trouble-shooting tools e.g. Ishikawa diagrams. “6-sigma” design and fabrication.

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Inter-vertebral injection device FTA ME-446 2019-2020
**Project and Design Team management:** Stage-gate (i.e. waterfall, shown) I, spiral and SCRUM models. WBS project management, team dynamics, scheduling, estimating cost, managing technical risk. TRL and the role of R&D.

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**Verification and validation:** five verification methods including testing, simulation etc. “3D Verification space” (shown).

Verification of truck cab lifter, ME446 – April 2019

Verification of low frequency speaker ME-446 – April, 2019
**Communication:** weekly reports, presentations, final reports, poster sessions

*Poster Session, CAMP Atrium, Dec. 2018*

*Prof. Tom Ortmeyer with student team*

*Prof. Kevin Fite with ME-446 team Dec. 2017*

*ME-446 team Dec. 2017*
**S2020 ME-445/6 feedback:**

**Collective Lessons Learned:**
Lessons learned collectively include how to collaborate using digital tools, how to distribute the workload, and how to balance numerous projects with competing deadlines. The transition to online learning also demonstrated the need to be able to quickly adapt plans to meet project goals. It also revealed the importance of timely, thorough, and clear communication between team members and the FM. From a practical standpoint, this project provided insight on the service conditions of a dairy farm and the degree of ruggedness equipment must have to remain reliable on a dairy farm.

**Individual Lessons Learned:**

**Luke:**
This project gave me valuable project management experience. I gained exposure to many aspects of typical engineering projects, including schedules, work packages, site visits, conceptual designs, detailed designs, CAD models, and analysis. Specific knowledge I developed throughout this project and this course include how to perform reliability analysis (particularly FMECA) and how to select from conceptual design alternatives. In future design projects, I plan to use a similar template for documentation as was used in this project.

**Derrick:**
While working with this group to complete our goal I learned many valuable lessons that I will take with me throughout my engineering journey. Most importantly I learned to listen to what peers and mentors had to say and respect their ideas in order to create the best design for the end user.

**Nick:**
While working on the limit switch project for the dairy farm I learned that there are many ways to do the project. It is a matter of doing calculations and research to slowly narrow down the options till you just have a couple left. Then once you have it narrowed down to the last couple go with the one that feels like it would work best and has the least amount of uncertainty.

**Lucian:**
I learned how to perform reliability analysis, especially fault tree analysis. I also learned how to work effectively in a group.

**Jacob:**
This project taught me that even though our design is good in our eyes, with no ways to make it better; there is always a way to make it better. With help from the professor, someone with more knowledge on this project than us, was really beneficial.