ME-420
Advanced design for sustainable future

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Last week: Definition of Sustainability

- Meeting current societal, environmental, humanity, and governmental needs without harming future generations.

Last week: The Importance of Sustainability in Mechanical Design

- Environmental Responsibility: Engineers play a crucial role in reducing environmental impacts by designing resource-efficient products
- Quantifiable Metrics: Tracking metrics such as material usage, energy consumption, and component lifespan is essential for sustainable design.
- Focus on the 6 Rs: Refuse, Reduce, Rethink, Reuse, Repair, and Recycle — a comprehensive framework that mechanical designers can adopt, supported by measurable data to gauge impact.

Last week: The Six Rs

Last week: Measurable metrics in sustainable engineering design

- Energy Efficiency:
  - Energy Intensity: Mechanical designs can improve the energy efficiency of machines and systems (e.g., more efficient motors, optimized mechanical layouts).
  - Energy Return on Investment (EROI): By designing energy-efficient systems (e.g., heat recovery systems, advanced thermodynamic cycles), we can increase the energy return from processes

Last week: Material Efficiency

- Material Intensity: Mechanical design can reduce material use through lightweighting (e.g., using advanced materials or optimized structures) while maintaining performance.
- Recycling Rate: Mechanical engineers can design products for easier disassembly, repair, and recycling, improving the overall recyclability of materials.
- Waste Generation: Through precise manufacturing techniques (e.g., additive manufacturing, CNC machining), mechanical design can minimize material waste in production.

Last week: Pollutant Emissions

- Toxic Emissions: Mechanical designs that incorporate cleaner combustion systems or filtration technologies can reduce the release of harmful pollutants (e.g., NOx, particulate matter).
- Noise Pollution: Mechanical systems can be designed to minimize noise emissions by using damping materials or optimizing vibrations in mechanical components.

Last week: Lifecycle Impact

- Lifecycle Assessment (LCA): Design choices such as durability, ease of repair, and modularity can reduce the environmental impact across a product's lifecycle.

Last week: Ecological Impact:

- Land Use Efficiency: Mechanical engineers can design compact machinery or systems that require less physical space for operation, reducing the impact on land use.

Last week: Human and Social Metrics

- Human Health Impact: Mechanical engineers can design safer systems and machinery (e.g., ergonomic tools, improved safety features) that reduce the risk of injury and health issues.
- Fair Labor Practices: Design automation and optimization can reduce dangerous labor tasks and improve worker safety, impacting the overall quality of working conditions.

Conclusion: Sustainable Design as a Competitive Advantage

- Key Takeaway: The 6 Rs framework provides mechanical engineers with the opportunity to design more sustainable products while tracking and optimizing quantifiable aspects like material use, energy consumption, and repairability.
- By integrating sustainability and measurable metrics into the design process, engineers not only meet environmental goals but also improve product efficiency and longevity.
- Action Plans for ME 420 : Start implementing the 6 Rs and track key performance indicators like **energy, component count, and maintenance periods, easy of assembly**, etc — to prove sustainability in a measurable and achievable goal.

This week's lecture

- Hardware and Closed-Loop Control Systems for Automation
  - What is a closed-loop system in mechanical engineering?
  - Why we need closed-loop systems?
  - How to build a closed-loop system in your project?

- Advanced Actuation and Sensing for Sustainable Automation
  - Essential elements in a closed-loop system.
  - SoAs in actuators and sensors.
  - Critical toolkit for your projects.

By next week

- Slide 1: Finalize your product idea (i.e. narrow down your idea to 1 from the 3, describe the Need / Function / Novelty)
- Slide 2: Describe the **quantifiable** sustainability metric of your design (energy emission, resource consumption, assembly, efficiency, full life cycle) in terms of 6Rs, and the scope (human, societal, environmental, economical etc)
- Slide 3: Find 3 approaches (choose a different combination of **sensor** and design) to achieve the improved sustainability.