Course: Robotics Systems Engineering (16-450 A)

"**This course in systems engineering examines the principles and process of creating effective robotic systems to meet application demands. Concepts, problems, and methods of systems engineering are introduced in lectures and discussions and applied in assignments and through semester-long group projects.**"

Existing course objectives [Students will be able to]:

- Elicit, prioritize, and formalize system requirements based on assumptions and constraints
- Iteratively validate system requirements, concepts, design, and testing by developing a prototype
- Plan and manage an appropriate systems engineering process across multiple perspectives and disciplines
- Document designs at appropriate levels of detail and quantify system risks to mitigate failure modes
- Architect and formulate robotic system concepts and develop the concept of operation
- Create models of system function and performance

Constraints

❏ Course is usually **12-24 students**

❏ Ethics instruction must fit into **80 minute** class periods; there are no labs.

❏ Majority of ethics information must come in **second half of course**

❏ Ethics instruction must be integrated into existing modules in the form of **"mini-modules"**

❏ Ethics module must include **interactivity**

❏ David is the only professor who teaches this course, so the lesson plan to supplement the course must be **tailored** to his specific teaching style

Ethics Mini-Module Learning Objectives

By the end of Mini-Module #1, students should…

- ★ **articulate the importance of diversity in both experience and background for engineers involved in systems engineering**
- ★ **be able to provide concrete examples of how that diversity benefits system development**

By the end of Mini-Module #2, students should…

- ★ **be able to recognize the realist and idealist limitations of ethical intervention**
- ★ **be able to develop priorities of functional and nonfunctional requirements**

By the end of Mini-Module #3, students should…

- ★ **Understand the consequences of unethical behavior**
- ★ **Contextualize their final project's place in society**
- ★ **Enumerate ethical priorities and verify that they have been followed**

Ethics Mini-Module Topics

➤ **Mini-Module #1: The Value of Diversity**
- Students will understand their own contributions to a group and blind-spots
- Students will be able to concretely benefit from diversity by observing complementary strengths and weaknesses

➤ **Mini-Module #2: Idealism vs Realism**
- Students will understand the limitations of ethical intervention
- Enhances students' ethical purview by observing the impact of systems engineering from different perspectives

➤ **Mini-Module #3: Context & Reinforcing Intent**
- Societal context allows students to see if their ethical priorities have been met
- Project benefits and consequences will become more clear

Implementation Design for Mini-Module #1:
The Value of Diversity

- **Couple with the following course lectures:** 1, 6, & 9

- **Modify group introductions in lecture 1 (+10 minutes)** to include potential contributions and experiences with technology that was not designed for the student

- **Extend lecture 6 scenario analysis activity (+15 minutes)** to include both a nominal scenario and an exceptional scenario

- **Discuss requirements memos (20 minutes)** that students completed for homework prior to lecture 9 with the project group about which they wrote the memo.

- Homework 1 will include a reading on improving fairness in machine learning systems, as well as a discussion question.
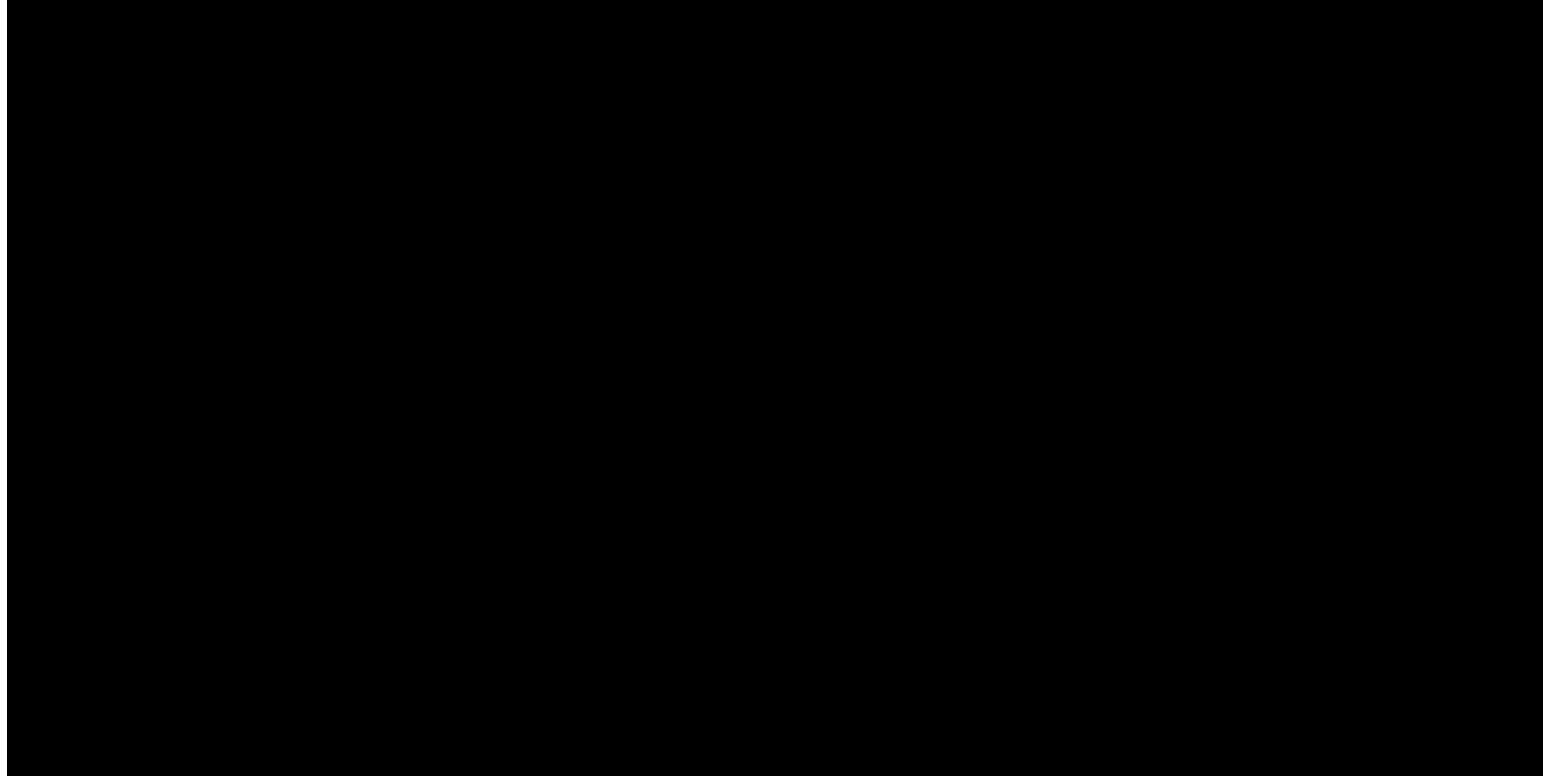
Implementation Schematic for Mini-Module #1:
The Value of Diversity
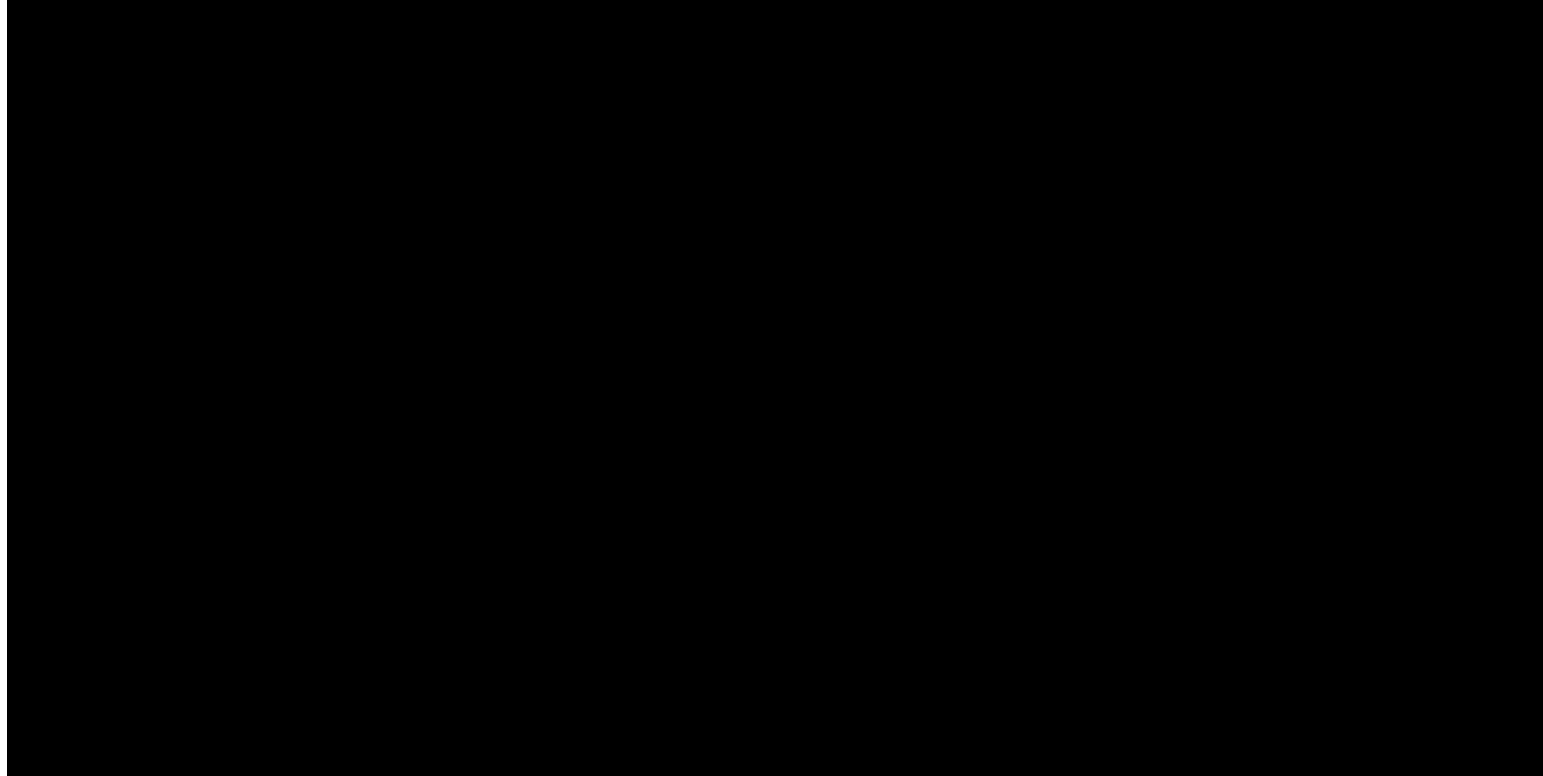
Implementation Design for Mini-Module #2:
Idealism vs. Realism

- **Couple with any of the following course lectures:** 6-10, 15-16

- **Lecture on the philosophical view of idealism vs realism (20 minutes)**
  - Showcase the timeline of incremental vs transformational change

- **Class Discussion (10 minutes):** the socio-economic and humanitarian trade-offs, as well as their benefits and consequences

- **Class Activity (20 minutes):** Split into groups and describe the perspective of a designated actor in the scenario. Students will then have the opportunity to switch perspectives and describe another designated actor

- **Post-Lecture Discussion(15 minutes):** Split into final project teams and assess the expectations and standards set for their prototype

Implementation Schematic for Mini-Module #2:
Idealism vs. Realism

Implementation Design for Mini-Module #3:
## Context & Reinforcing Intent

- **Couple with lecture 20**

- **Lecture on unintended consequences of new technologies (+20 min)**
  - Provide humanitarian, societal, and economic perspectives of engineering systems (e.g. the flexible use of drone technology)

- **Class Activity (+10 min):** Create a simple consequence web diagram to portray how one of the examples fits the societal context

- **Homework Activity:** Split into final project groups and create a more complex consequence web diagram for their final projects.

- **Bonus Post-Course Activity (Lecture 21):** Kahoot! game will reinforce module and course learning emphasizing ethics questions

Implementation Schematic for Mini-Module #3:
## Context & Reinforcing Intent
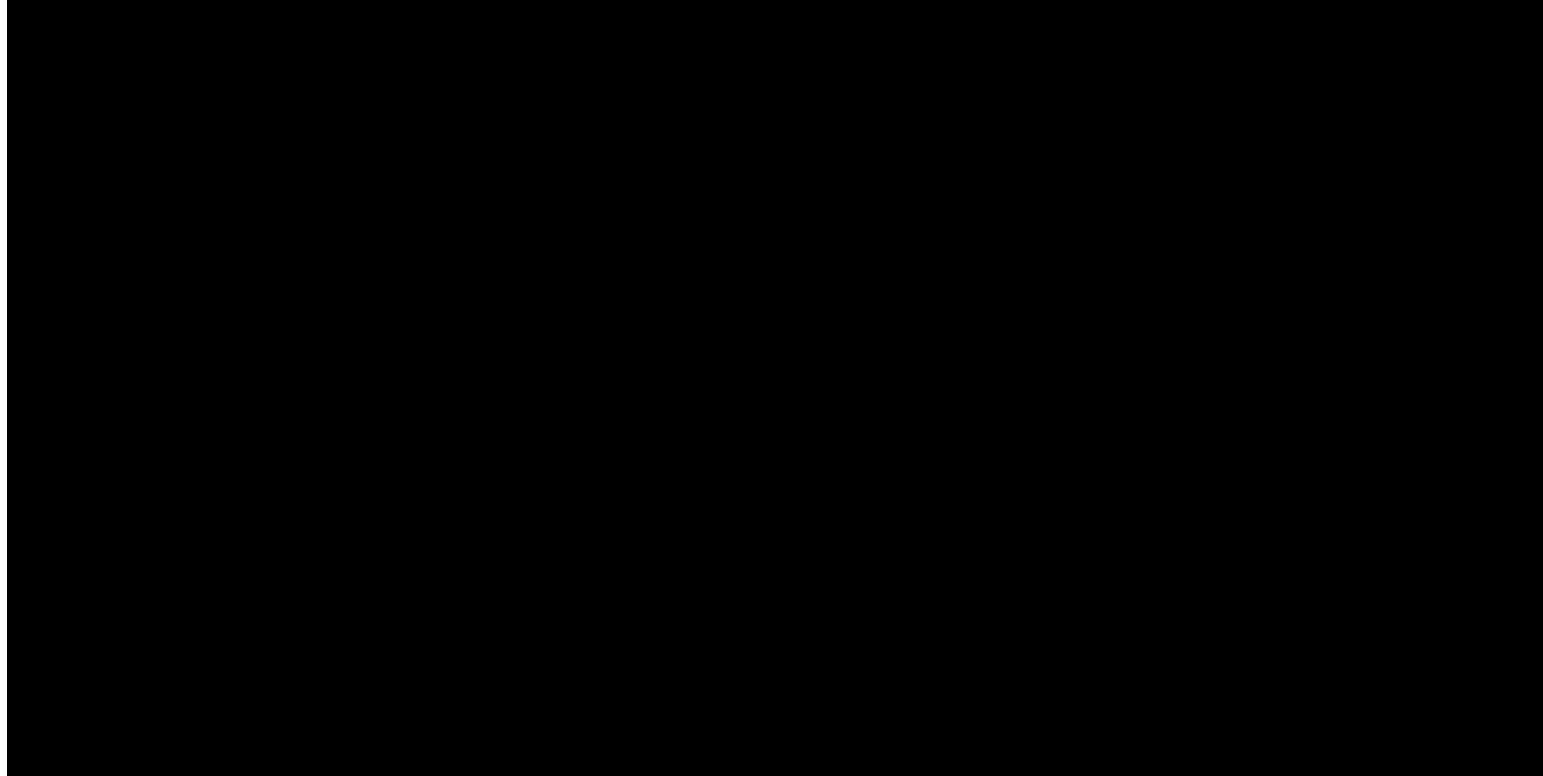
Ethics Mini-Module Lesson Plan

- Comprehensive overview of mini-modules 1-3
- Aligns lecture content with learning objectives
- Provides slide-by-slide context of key concepts to encourage critical thinking
- Descriptions of pre-lecture, in-lecture, and post-lecture readings and activities
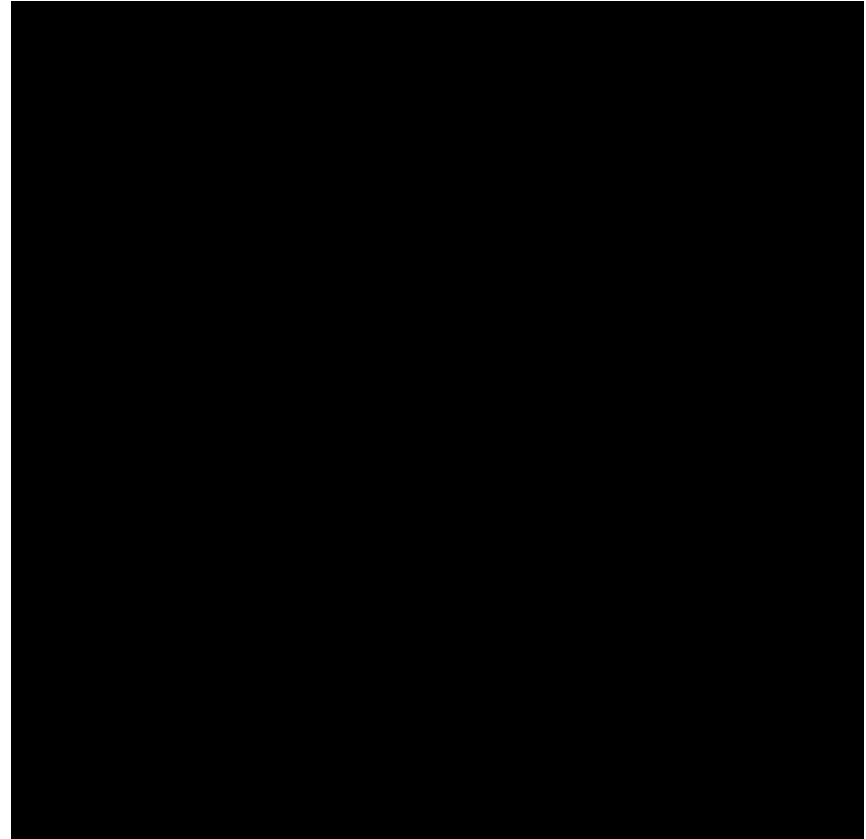
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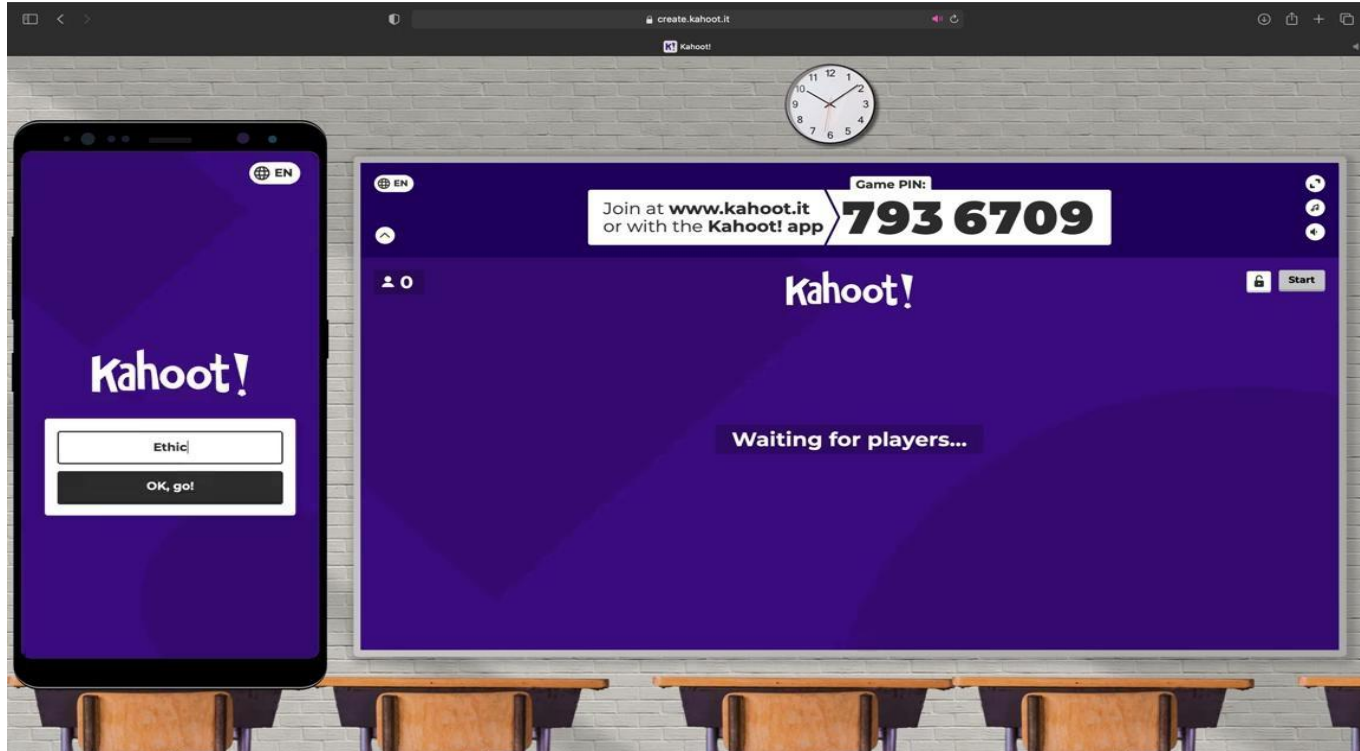
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Acknowledgements