Connected and Autonomous Vehicles: Challenges and Design
Winter 2026 Course Project

1. Project Objective: In this project, you will act as safety engineers for a company developing modern autonomous vehicles (AV). Your goal is to "red team" the AV system by systematically identifying, analyzing, and documenting "corner scenarios" (corner cases) where the AV may be unsafe. More specifically, your team will:

- **Identify safety vulnerabilities:** Move beyond average-case performance to find "corner scenarios" where the AV stack may fail and lead to safety risks, endangering the driver, passengers, surrounding vehicles, bicyclists, pedestrians, or other entities in the transportation system.
- **Analyze safety failures:** Technically dissect *why* the identified safety failures may occur. Is it due to perception limitations, prediction inaccuracies, planning challenges, or other reasons?
- **Propose mitigation strategies:** Discuss potential fixes and explain why they may improve the AV safety under those corner scenarios.

2. Project Requirements:

- **Team size:** Each team should include 1-2 members. You are encouraged to team up, but one-person teams are allowed.
- **Number of corner scenarios:** Each team member should present at least 2 distinct scenarios (i.e., a team of 2 should present at least 4 distinct scenarios).
- **Target AV architectures:** You should consider two common AV architectures: *camera-only*, and *multi-modal* with cameras, LiDARs, and radars. Explain whether both will be unsafe under those scenarios or only one of them.
- **Optional usage of simulators:** To demonstrate those corner scenarios, you may use sketches, diagrams, or simulation screenshots. Possible simulators that can be leveraged include NVIDIA AlpaSim (https://github.com/NVlabs/alpasim), CARLA (https://carla.org/), etc.

3. Deliverables:

- **Final report:** Your team will need to submit a single final report. The report should be at least 3 pages for a single-person team, and 5 pages for a two-person team, in IEEE/ACM double-column format excluding references. The report should include an *Abstract*, an *Introduction* section that gives an overview of the entire report, a *Literature Review* section that cites and discusses papers, industry reports, or news articles that are related to your identified scenarios, an *Unsafe Scenarios* section that details the identified corner scenarios through sketches, diagrams, or simulation screenshots, along with your reasoning on why they may be unsafe, a *Mitigation Strategies* section that discusses the potential

fixes for those unsafe scenarios, and a *Conclusion* section that summarizes the report. You are welcome to add more sections if you think they are helpful (e.g., a section to discuss simulation results in more detail if you use simulators).

- **Presentation:** Your team will schedule a time with me to present your work, explaining the corner scenarios you identified and the mitigation strategies you propose, and answering the questions I may have. The presentation will be 10 minutes for a single-person team and 15 minutes for a two-person team. You may schedule it for Week 10 or Week 11.

4. Grading Criteria:

- Your project will be evaluated based on 1) the quality of identified corner scenarios—are they non-obvious and realistic? 2) the technical depth of your analysis and your mitigation strategies; and 3) the clarity of your narrative and demonstration.
- For a two-person team, please clearly specify the contribution of each team member in the report (you can add it at the end of the *Abstract* section). In general, both team members will receive the same score on the project, unless there is significant difference in the degree of contribution.