Teaching Statement by Hussein Sibai

Teaching is an enjoyable art and a noble profession that fundamentally transforms human lives for the better. I am excited to start my journey as a teacher. I want to help people join the engineering workforce skillfully and effectively. Engineering theory and practice are evolving rapidly, expanding to new horizons, and having a global impact. Consequently, there is an increasing societal demand for representative, capable, and responsible future engineers. My research, teaching, and mentoring experiences have prepared me as a junior instructor who can effectively contribute to meeting that demand.

Teaching and mentoring experiences: I have had the opportunity to teach students at various academic levels from different backgrounds. At the American University of Beirut (AUB), I was a lab instructor for the *ECE 230 Introduction to Programming* course designed for electrical and computer engineering students and the *ECE 231 Introduction to Programming in C++ and Matlab* course intended for civil and mechanical engineering students. At UIUC, I was a teaching assistant for the senior-level course *ECE 486 Control Systems* lab for the Spring 2020 and Spring 2021 semesters, during which COVID-19 lockdown happened, and instruction moved online. My duties included managing lab sessions, giving lectures, grading homework, projects, and exams, and holding office hours. Also, I had been invited multiple times to lecture for the graduate-level *ECE 584 Embedded System Verification* class at UIUC. In 2018, I volunteered to teach middle school students programming using Scratch in the UMS SPLASH program funded by the NSF. I was fortunate to mentor four diligent undergraduate and graduate students from different engineering majors to accomplish various research tasks, including developing software, running experiments, designing algorithms, deriving theoretical proofs, and publishing research papers. Finally, I was a 2020-21 Mavis Future Faculty Academy fellow, a UIUC program that prepares promising Ph.D. students for careers as faculty. A primary focus of which is effective teaching and mentoring.

Teaching plan: My Ph.D. research has spanned a range of theoretical and practical projects in formal verification, control, and machine learning. My research, teaching, and mentoring experiences have prepared me to teach undergraduate- and graduate-level courses on programming, control theory, hybrid systems, formal methods, and machine learning. In addition, I plan to design a new advanced undergraduate or first-year graduate-level course on Trustworthy Autonomy. The course will cover the active research areas on the safety assurance of autonomous systems, including testing, falsification, synthesis, verification, and robustness evaluation. The students will learn the diverse theoretical and experimental problem formulations, solution approaches, and open questions. They will 1) learn about the history of the discussed topics, the contributing research groups, and their traditional research areas, 2) critique research papers and have in-class group discussions to ensure concepts' grasp by all students, and 3) draw connections with their research projects, then create skill and interest-based teams to pursue their projects.

Teaching and mentoring philosophy: I developed a philosophy that: 1) utilizes remote learning technologies to include previously marginalized groups, 2) emphasizes context with concepts for easier grasp and retention, 3) follows effective active learning methods such as peer instruction for deeper understanding, and 4) personalizes mentoring to students' aptitudes for fruitful training.

1. **E-learning**: With the urgency created by the COVID-19 pandemic and the boom of online educational technologies, this is the right time to adjust our instruction to expand access to education, even for advanced courses. I foresee teaching hybrid (online and in-person) engineering classes with in-class interactive quizzes for real-time feedback with Kahoot or Piazza; peer discussions in Zoom breakout rooms; hands-on sessions with affordable shipped engineering hardware kits, such as those recently sent by ECE UIUC; in-class experiments with Gazebo or AirSim; inclusive environment with accessible computation power using cloud platforms such as Amazon AWS and Microsoft Azure.

   I will harness the experience of similar other successful attempts such as the Duckietown initiative from MIT and the Principles of Safe Autonomy class by my advisor Sayan Mitra at UIUC as a starting

point to design my courses. I had a related experience teaching UIUC ECE 486 in Spring 2020. Upon lockdown, we prepared videos of us performing the remaining lab experiments, collected experimental data, switched assignments and projects to be simulation-based in Matlab/Simulink, continued lab sessions over Zoom, and managed discussions over Piazza. Despite the demanded extra effort and the uncertainty in the transition, it was an enjoyable and rewarding experience, which I happily repeated in Spring 2021. The students' positive feedback reinforced my passion for being an educator.

2. **Storytelling teaching**: Instead of presenting sufficient conditions for weak minima in the calculus of variations as just an inequality with additional conditions, Daniel Liberzon, in his Optimum Control Systems class, shows first how Legendre derived the inequality in 1787. Then, he describes a flaw in the proof: an assumption that the solutions of a differential equation used in the proof exist is not valid. The differential equation is quadratic, and its solutions might have a finite escape time. Lagrange discovered that flaw in 1897. He later presents the fix found by Jacobi in 1837 by reducing the equation to a second-order linear one resulting in the additional conditions that ensure that the solutions exist. That association of ideas with people, events, and dates provided me with association markers to better grasp the proof. Such learning experiences convinced me to follow the same strategy and offer historical stories behind concepts as examples of research efforts. This will better train students to become researchers who address first-class research problems.

3. **Peer instruction**: I plan to learn and investigate innovative teaching strategies for large introductory classes such as peer instruction formalized by Eriz Mazur at Harvard. It is more effective than traditional lecturing methods with affordable cost and effort. It asks students to prepare for class and the teacher to frequently ask conceptual questions during lectures. After each question, the students discuss, teach and assess each other, and answer in groups. It has been recently renovated to suit online learning. In ECE 486, we followed a similar strategy. Students had to finish pre-lab homework. They can get help during office hours. During lab sessions, students work in pairs. I would start with a brief overview lecture. During experiments, I would frequently ask each group about the meaning and intuition behind the task they are currently performing, for which they can discuss and answer. I can see from their lab reports that they significantly deepened their conceptual understanding after these interactions.

4. **Personalized mentoring**: I mentored four bright students with diverse backgrounds at different academic levels for various projects. For example, Navid Mokhlesi was finishing his undergraduate studies and starting his master's when we began our collaboration. He excelled in programming, had theoretical interests, and planned for a master's degree. Initially, I gave him pseudocode to implement in the verification tool DryVR. He found difficulty getting started with the new concepts in formal verification. We arranged for a series of meetings where we discussed the algorithm behind DryVR, the functionality of each file, and where our code would fit. In a year, we published two papers in top venues (ATVA and TACAS), one of which was nominated for the best paper award. Later, he developed a significantly improved version of DryVR as part of his master's thesis. We conducted successful projects by knowing his interests, communicating progress, and building an effective mentoring strategy.

   I will mentor students in a personalized manner. I will better understand their goals, academic backgrounds, expectations, and constraints. Together, we will develop a strategy to build their independent researcher character that collaborates with others effectively. We will regularly assess and refine our approach based on skills, academic requirements, projects, well-being, and paper-writing progress.

Looking forward: I am eager to teach diverse future engineers capable of tackling the complex global problems we face effectively and ethically. I realize the challenges ahead. I have broad training, and I will learn and utilize innovative approaches to overcome them more efficiently.