MECHANICAL ENGINEERING SEMINAR

Wednesday, November 25, 2026, at 14:00 Israel time, 20:00 China time

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Designing What Can Be Built: Physics-Driven Optimization of Materials, Structures, and Systems

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Lighter vehicles and robots, efficient energy and electronic systems, and durable medical devices all depend on materials and structures that are designed, not only analyzed. Computational optimization can discover designs far beyond intuition, yet few optimized designs reach service because current methods often neglect manufacturability, scale poorly with the number of constraints, and rarely account for multifunctionality and coupled physics. This seminar presents a research program that closes this gap by making optimized designs buildable, scalable and multiphysics-aware across materials, structures and systems, with examples ranging from composite aerospace structures designed under the rules of automated fiber placement and stress-constrained metal parts to the layout of battery cells and electronics and pediatric heart valves whose optimized prototype passed fatigue testing.

The talk will then focus on a central obstacle: manufacturing rules impose a constraint at every point of a design, often millions or more in total. It presents the Constraints-Adjusted Material with Penalization (CAMP) method, which enforces these constraints implicitly within the physics solution, at nearly the cost of unconstrained optimization. The effectiveness and efficiency of CAMP are demonstrated in three applications that introduce new constraints or new physics: maximum feature size control in structural design, where CAMP runs up to 40% faster than aggregation-based methods on problems with millions of elements; multi-material design with non-overfilling constraints, which prevent materials from occupying the same space, where CAMP is up to ten times faster when combined with optimality-criteria updates; and heat-sink design, where the optimized needle-like conductors outperform classical tree-like layouts. The seminar will conclude with a vision for a unified design platform at GTIIT serving manufacturing, energy and electronics, robotics and healthcare.

Chuan Luo is a Postdoctoral Fellow in the Department of Civil and Systems Engineering at Johns Hopkins University, where he received his Ph.D. in 2023 under Prof. James K. Guest. He previously held postdoctoral and research positions at Columbia University and the University of Wisconsin–Madison, and earned his M.Eng. and B.Eng. in Mechanical Engineering from Shanghai Jiao Tong University and Nanjing Tech University, respectively. His research combines computational mechanics and multiphysics simulation with scalable optimization algorithms to design high-performing, manufacturable materials, structures and systems for aerospace, energy, electronics and healthcare. He introduced the CAMP method in a sole-authored paper in *Computer Methods in Applied Mechanics and Engineering*, and his work has also appeared in *Materials & Design*, *Journal of Mechanical Design* and *Composites Part B*. He contributed to a team recognized with a NASA Group Achievement Award, received an ASME IDETC Paper of Distinction Award, and has co-organized the topology optimization minisymposium at the ASCE Engineering Mechanics Institute Conference since 2025.