ALL ARE WELCOME

Ph.D. SEMINAR TALK - 1

Title: Investigation on Multi-stage Energy Absorption Performance of In-Plane Loaded Bio-Inspired Hierarchical Structures

Speaker: Mr Shreyas Nandakumar Harithsa (Roll no.- ME23D008)

Biography of the Speaker:

PhD Research Scholar for the Department of Mechanical Engineering

Date and time: 21/01/2026 10:30 am

Venue: https://meet.google.com/agn-jtwy-nrm

Abstract:
Efficient energy absorption is paramount protective engineering applications, particularly in transportation where lightweight structures are essential for safety and fuel economy. Multicellular thin-walled tubes have traditionally been used for this purpose owing to their stable deformation and high crashworthiness. Recent advances show that introducing hierarchical architecture further elevates their energy absorption toward an ideal force–displacement response. Automotive bumper systems subjected to frontal impacts require adaptive structures that can simultaneously satisfy the contradicting requirements of pedestrian safety during low-severity impact and occupant protection during severe collisions. To address this need, this work proposes a novel hierarchical design inspired by dual branching scheme of giant water lily leaf venation creating a fractal-like material distribution within a square tube. The structures of varying hierarchical orders were designed to provide a multi-stage energy absorption and were fabricated using material extrusion additive manufacturing. The results showed an order dependent improvement with specific energy absorption (SEA) increasing and initial peak crushing force (IPCF) decreasing as hierarchy increased. Second-order structures provided 282% enhancement in SEA over simple square tubes due to their controlled local buckling behavior. Modified second-order variants further stabilized the plateau region and avoided catastrophic fractures which prematurely compromised structural integrity. Multi-criteria decision-making algorithms assessed with different weight sets consistently ranked these modified second-order structures as the most promising configuration for superior multi-stage crashworthiness.