MECHANICAL ENGINEERING SEMINAR

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Nonlinear mechanics of thin structures and their applications

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Thin structures are experiencing a revival in designing novel deployable systems, soft robotics, and stretchable electronics through manipulating geometric nonlinearity and elastic instabilities. However, understanding the nonlinear mechanical behavior of thin structures can be challenging due to large deformations and potential complex bifurcation and stability landscapes. This lecture will address several novel bistable and multistable thin structures through mechanical modeling and tabletop experiments. In the first part, a novel Kirchhoff-rod-based numerical framework is proposed for studying the large deformations and bifurcations of *bigon* and *bigon ring* structures, with the former consisting of two thin strips joined to form two edges and the latter being a series of bigons connected to form a closed loop. Both experiments and numerical results demonstrate multistable and looping behaviors in bigon rings.

In the second part, I will discuss generic bistability of creased thin sheets, with a pressed-through state possessing a localized elastic singularity. We found that bistability can be destroyed by cutting off the singularity and the surrounding material. Further, numerical solutions of an inextensible strip model will be examined through varying the hole geometry, indicating reasonable qualitative agreement with experimentally determined bistability boundaries. Finally, a continuous description of creases/kinks in thin strips will be proposed and applied to *creased annuli*, constructed by introducing radial creases to annular strips. Using an anisotropic rod model, we found that creased annuli have generic bistability and can be folded into various compact shapes, depending on the crease pattern and the flat annuli overcurvature. Several novel multistable structures and modeling frameworks proposed in this talk could benefit to the mechanical design of developable thin sheets, origami/kirigami, and morphable structures.

Biographical Sketch: Tian Yu joined the Form Finding Lab at Princeton University in the Department of Civil and Environmental Engineering as a postdoctoral associate in spring 2020. He received his B.E. in Civil Engineering from Beihang University in 2011 and his M.S. in Structural Engineering from Zhejiang University in 2014. In 2019, he graduated from Virginia Tech with a PhD degree in Engineering Mechanics. His research focus on the nonlinear mechanics of thin rods/strips/sheets, thin structures based elastic systems, and their applications in soft robots, deployable structures, and medical devices.

Seminars Coordinator: Assoc. Prof. Matthew Suss.