

Plant biomimetics: how engineers can learn from mechanical strategies of plants

Instructor

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Course Description

It is possible to study the mechanical strategies of plants in order to find materials and structural systems in fields like engineering, architecture and industrial design. On that line of thought, the idea is to emulate structural strategies of plants from a biomimetic point of view, in order to develop technological solutions. From a technical point of view, the structural and mechanical success of organisms is due to the arrangement of biological materials: the internal structure, the morphology, the adaptation, the evolution. In particular, the plants have used a huge variety of adaptive structural strategies in order to take advantage of biological materials and natural morphology. Thereby, trees and shrubs could be taken as natural references for developing both materials and structural systems. This activity of emulating nature's structural strategies has a high innovation potential.

Finally, the next generation of materials, mechanical, and civil engineers will require more than ever the breathe of knowledge and skills from both theoretical and applied sciences. This workshop is design to equip the next generation of engineers with experimental techniques behind this promising and interesting field, i.e. plant biomechanics, and to train them for multidisciplinary research.

Course Outcomes

Performing engineering analysis of a plant is a technical exercise that can benefit engineering students and practicing engineers. More importantly, a deeper understanding of plants can help us to create multifunctional designs that are in a symbiotic relationship with other members in the system. Studying Plant biomechanics can help us to become better engineers.

Upon successful completion of this course, students will be able to:

1. Comprehend morphological, material and functional aspects of some herbaceous stems (observed)
2. Understand and use equipment utilized in mechanical characterization laboratory (measured)
3. Evaluate mechanical behavior of some herbaceous stems (measured)
4. Fabricate by additive manufacturing processes some bio-inspired stems (manufactured)
5. Analyze data obtained from lab exercises and experiments (evaluate)
6. Prepare a technical laboratory report (written)
7. Present their data in a roundtable presentation format (disseminated)

Prerequisites

Engineering materials

Mechanics of materials

Grading Policy

Reports and Presentation

Project report – 70% (25% of the grade will be from peer evaluation)

Project Presentation – 30%

Course Outline

ACTIVITY	AIM	TIMELINE
Principles of plant biomechanics	Receive an introductory lecture	1.0 h
Sample collection	Discover the natural surroundings	1.0 h
Morphological, material and functional aspects	Learn biology of plants	0.5 h
Mechanical experimental evaluation	Characterize mechanical behavior	2.0 h
Additive manufacturing	Fabricate bio-inspired by 3-D printing	3.0 h
Analysis of results	Analyze experimental results	0.5 h
Technical laboratory report	Prepare technical report	1.0 h
Roundtable presentation	Present and disseminate technical work	1.0 h
		10.0 h

Textbooks

Ennos R. *Solid biomechanics*. Princeton: Princeton University, 2011.

Jeronimidis J. Structure-Property Relationships in Biological Materials; Design and Function of Structural Biological Materials. In: Structural biological materials: Design and structure-property relationships. Ed: Elices M. Amsterdam: Pergamon, 2000. p. 3-29.

Niklas K.J. *Plant biomechanics: an engineering approach to plant form and function*. Chicago: University of Chicago, 1992.

Raven P.H., Evert R.F., Eichhorn S.E. *Biology of Plants*. New York: W.H. Freeman, 1998.

Vogel S. *Cats' Paws and Catapults: Mechanical Worlds of Nature and People*. New York: W. W. Norton, 2000.

Vogel S. *Comparative biomechanics: lifes physical world*. Princeton: Princeton University, 2006.