

Technical Elective: Cellular Solids
Syllabus for 2023 Spring

Instructor: Dr. Yingjie Wu (Office: 4-226; Email: yingjie.wu@scupi.cn)

Lecture: Monday, 1:50 pm – 5:30 pm, Room 4-203

Office hours: Monday, 9:15 am – 11:55 am, Room 4-226

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Course Description:

This course provides an overview of the structure and processing of natural building materials such as structural proteins, polysaccharides, and minerals, as well as the mechanics of cellular materials. Students will be introduced to a diverse range of cellular materials found in nature, including honeycomb-like materials like wood and cork, foam-like materials such as trabecular bone, plant parenchyma, coral, and sponge, and composites of cellular and dense materials like iris leaves, skulls, palm, bamboo, animal quills, and plant stems. The course also covers the biomedical applications of cellular materials, including metal foams for orthopedic applications and porous scaffolds for tissue regeneration, and investigates the effect of scaffold properties on cell behavior. Modeling of cellular materials applied to natural materials and biomimicking is explored.

Course Objectives:

In this course, students can (i) understand the mechanics of cellular materials and their diverse range found in engineering, medicine, and nature; (ii) explain the properties and applications of honeycomb-like and foam-like materials, as well as composites of cellular and dense materials; (iii) evaluate the biomedical applications of cellular materials, such as metal foams and porous scaffolds for tissue regeneration, and the effect of scaffold properties on cell behavior, and (iv) apply the principles of modeling of cellular materials to natural materials.

Applicable ABET Outcomes:

1. An ability to apply knowledge of mathematics, science, and engineering
2. An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
3. An ability to identify, formulate, and solve engineering problems
4. An ability to communicate effectively
5. An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice

Required Resources:

1. Gibson, L. J. and M. F. Ashby, *Cellular Solids: Structure and Properties*. 2nd ed., Cambridge: Cambridge University Press, 1997. Print.
2. Gibson, L. J. and M. F. Ashby, and B. A. Harley, *Cellular Materials in Nature and Medicine*. 2nd ed., Cambridge: Cambridge University Press, 2010. Print.

Course Content (tentative):

1. *Processing and structure of cellular solids*
2. *Honeycombs: In-plane behavior*
3. *Honeycombs: Out-of-plane behavior*
4. *Natural honeycombs: Wood, cork*
5. *Foams: Linear elasticity, strength, densification, fracture*
6. *Foams: Microstructural design, lattice materials, property change*
7. *Foams: Thermal properties*
8. *Trabecular bone*
9. *Osteoporosis and evolution*
10. *Tissue engineering scaffolds: Processing and properties*
11. *Tissue engineering scaffolds case study: Osteochondral scaffold*
12. *Cell-scaffold interactions: Attachment, morphology, contraction, migration, differentiation*
13. *Applications: Energy absorption in foams*
14. *Applications: Sandwich panels*
15. *Natural sandwich structures + Density gradients*
16. *Biomimicking*

Grading Policies:

Requirements	Corresponding Percentages
Assignments (5)	25%
Term Paper	35%
Term Paper Presentation	35%
Participation	5%

Grading Scale:

100% ≥ A ≥ 90%; 90% > A- ≥ 85%; 85% > B+ ≥ 80%; 80% > B ≥ 76%; 76% > B- ≥ 73%; 73% > C+ ≥ 70%; 70% > C ≥ 66%; 66% > C- ≥ 63%; 63% > D ≥ 60%; 60% > F.

Homework:

There will be about 5 homework assignments that will be submitted on Blackboard either as Word document or as pdf before the start of the class (1:50 pm) on the due day. If you are unable to attend a class, you may attach a note to your homework and submit it in advance. ***If homework is submitted late, you would lose 10% per day. You may receive no credit if homework is not submitted within a week from the due day.***

Term Paper:

A term paper on a certain type of cellular solids in engineering field, medicine or nature should be completed by individual student. The term paper will be submitted on Blackboard either as Word document or as pdf. The document needs to be submitted to Blackboard ***before the start of the class (1:50 pm) on the due day.***

Term Paper Presentation:

Each group needs to give a 15-min presentation in the last class. The slides need to be submitted to Blackboard the ***before the start of the class (1:50 pm) on the due day*** as a zip or rar file. Timing, presentation, style, and content will be considered for the grade.

Participation:

Participation through presence but also answering questions, asking questions, contributing to activities is very important to improve active learning for each student. Therefore, your participation will be graded during each lecture starting with the second week.