Technical Elective: Cellular Solids
Syllabus for 2025 Spring

Instructor: Dr. Yingjie Wu (Office: SCUPI N405; Email: yingjie.wu@scupi.cn)

Lecture: 3 Credits, Wednesday, 8:15 pm – 11:00 pm, SCUPI N212
Office hours: Friday, 9:15 am – 11:55 am, SCUPI N405
TA: Tianyang Li (Email: 1024711589@qq.com)
QQ Group: 982313077

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 chare
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%
Quizzes (3)	15%
Term Paper	30%
Term Paper Presentation	25%
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 (***8:15 am***) 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 (8:15 am) 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 (8:15 am) 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.

Term Paper Objective:
The term paper is designed to deepen your understanding of cellular solids by allowing you to investigate a specific topic of interest within the course. You will critically analyze the structure, properties, and applications of cellular materials, and explore their potential for innovation in engineering, biomedicine, or other fields.

Term Paper Guidelines

1. Topic Selection
Choose a specific topic related to cellular solids. Examples include:

- The mechanics of honeycomb-like materials (e.g., wood, cork)
- Foam-like materials in nature (e.g., trabecular bone, plant parenchyma)
- Composites of cellular and dense materials (e.g., bamboo, animal quills)
- Biomedical applications of cellular materials (e.g., metal foams, porous scaffolds)
- Biomimicking and modeling of cellular materials
- The role of cellular materials in tissue regeneration or orthopedic applications

2. Paper Structure
Your paper should include the following sections:

- **Title Page:** Include the title of your paper, your name, course name, and date.
- **Abstract:** A concise summary (150–200 words) of your paper's objectives, methods, and key findings.
- **Introduction:** Provide background information on your topic, its significance, and the research question(s) you aim to address.
- **Literature Review:** Summarize and critically analyze relevant studies, theories, and findings related to your topic.
- **Methods:** Describe the approach you used to investigate your topic (e.g., literature

review, case studies, modeling).
- **Results and Discussion:** Present your findings and discuss their implications. Compare your results with existing research.
- **Conclusion:** Summarize your key findings, their significance, and potential future research directions.
- **References:** Cite all sources used in your paper in a consistent format (e.g., APA, IEEE).

3. Length and Formatting

- **Length:** 8–10 pages (excluding references and appendices)
- **Font:** Times New Roman, 12-point
- **Line Spacing:** 1.5 Lines-spaced
- **Margins:** 1 inch on all sides
- **Citations:** Use in-text citations and include a complete reference list.

4. Research and Sources

- Use at least 30 credible sources, including peer-reviewed journal articles, books, and reputable online resources.
- Avoid relying solely on non-academic websites or Wikipedia.

5. Originality and Plagiarism

- Your paper must be original and written in your own words.
- Properly cite all sources to avoid plagiarism.
- Submit your paper through a plagiarism detection tool if required.

6. Submission Deadline

- Submit your term paper ***before the start of the class (8:15 am) on Wednesday (06/04/2025)***, ***Week 15*** via Blackboard.

7. Grading Criteria

Your paper will be evaluated based on the following criteria:

- **Content and Depth:** Thoroughness of research, clarity of arguments, and relevance to the course.
- **Organization and Structure:** Logical flow, coherence, and adherence to the required format.
- **Critical Analysis:** Ability to critically evaluate and synthesize information.
- **Writing Quality:** Grammar, clarity, and professionalism.
- **References:** Proper citation and use of credible sources.

8. Suggested Topics

- The role of cellular materials in natural load-bearing structures (e.g., bamboo, bone).
- Design and optimization of porous scaffolds for tissue engineering.
- Biomimicking cellular materials for lightweight engineering applications.
- The mechanics of trabecular bone and its implications for orthopedic implants.
- Comparative analysis of cellular materials in plants and animals.
- The use of metal foams in biomedical and industrial applications.

9. Additional Resources

- Course lecture notes and recommended textbooks.
- Online databases such as PubMed, ScienceDirect, and Google Scholar.
- Consult with the instructor for guidance on topic selection and research.