



Department Project Information

Department Name	<i>Department of Mechanical Engineering & Engineering Science</i>	Date Submitted	<i>03/10/2021</i>
Project Title	<i>Dynamic responses of advanced materials (UNCC_ME_RESPONSE)</i>	Planned Starting Semester	<i>Fall 2021</i>

Senior Design Project Description

Personnel

Typical teams will have 4-6 students, with engineering disciplines assigned based on the anticipated Scope of the Project.

Please provide your estimate of staffing in the below table. The Senior Design Committee will adjust as appropriate based on scope and discipline skills:

Discipline	Number	Discipline	Number
Mechanical	4	Electrical	0
Computer	0	Systems	0
Other ()	0		

Project Overview:

After millions of years of evolution, natural materials have provided us with novel insights into designing artificial materials/structures with outstanding performances. Nacre, dactyl club, and nutshells are typical natural examples that inspire researchers to propose lightweight structures with high impact resistance and superior energy absorption performances. More recently, a variety of researches have reported mechanical metamaterials with advanced and multifunctional behaviors that are not found in traditional materials, such as negative Poisson's ratio materials and chiral mechanical metamaterials. In the present project, the involved students will focus on the dynamic responses of both bio-inspired structures and mechanical metamaterials. An integrated methodology, including prototype design, finite element analysis, experimental tests, and theoretical analysis, is considered. The results of this project toward a comprehensive understanding of energy absorption performances, impact resistance, and stress wave propagation in proposed structures.

Project Requirements:

In this project, students are required to design 3-5 bio-inspired structures and metamaterials for energy absorption and impact resistance. Meanwhile, they need to investigate the wave propagation behaviors of the proposed structures. Specifically, they will first conduct a comprehensive literature review and get familiar with the fundamental knowledge of this area. Then, it is necessary to complete preliminary designs

and study the performances of each structure using finite element analysis. After mentors evaluate all the designs, students will proceed to the manufacturing process and select the most appropriate approach for the selected designs. Subsequently, a systematic experimental study (e.g. dynamic crushing/impact tests and stress wave propagation) will be carried out to obtain the dynamic responses of the prototypes, which will be used to validate the finite element models as well. Based on the validated models, a parametric study is required to investigate the influences of critical factors on the dynamic responses of the structures. Finally, a theoretical model will be developed to uncover the unique relationship between structural design and mechanical performances.

Expected Deliverables/Results:

- 3-5 bio-inspired structures and metamaterials (original design required; format: CAD model)
- Prototypes of structures (by 3D-printing, EDM, or other manufacturing approaches)
- Experimental results of dynamic responses of these structures (format: technical report)
- Validated finite element models of the structures (format: CAE and ODB files)
- A parametric study indicating the influence of critical factors on the structures (format: technical report)
- A theoretical model describing the dynamic responses of the structures (format: technical report)

Disposition of Deliverables at the End of the Project:

Demonstration of the system.

List here any specific skills, requirements, specific courses, knowledge needed or suggested (If none please state none):

- Finite Element Analysis
- Solid Mechanics
- Material Sciences
- CAD Modelling
- Bonus: familiar with manufacturing and mechanical testing