INDUSTRIAL SOLUTIONS LABORATORY

Department Project Information

Department Name	*Mechanical Engineering and Engineering Science Department*	**Date Submitted**	*4/29/2022*
Project Title	*Design and Fabrication of an Auxetic Metamaterial Based Soft Actuator* **(UNCC_ME_AUXETIC)**	**Planned Starting Semester**	*Fall 2022*

Funding

What is the source of funds that will be used to cover all direct costs of this project? MEES Departmental funding

Is this source of funds already secured? Yes__X__ No____

Work Space

Have you secured a lab/work space for the project to be built? Yes__X__ No____

Faculty Mentor/Grading Instructors *

	Name	Email	Phone
1	Erina Baynojir Joyee	ejoyee@uncc.edu	7046878930
2	Towfiq Rahman (Grader)	mrahma18@uncc.edu	7046878932

*List any graduate student that will be working on the project as a grading instructor so that they may be added to Canvas.

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Senior Design Project Description

Personnel

Typical teams will have 4-6 students, with engineering disciplines assigned based on the anticipated Scope of the Project. Assume 10 hours per week per student.

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	2	Electrical	1
Computer	2	Systems	
Other ( )			

Project Overview and Requirements:

In order to expand the human robot interaction, soft materials are being adopted to achieve varied stiffness. Designing the soft robot's body using 'smart materials' can facilitate diverse functionalities and furthermore provide new opportunities for material development and application such as biomedical devices, civil structures, and aerospace.

Meta-materials are such engineered smart materials designed to induce customized properties in a material by manipulating micro or local scale structures. Meta-materials possess superior properties in regard to static modulus (axial stress divided by axial strain), density, energy absorption, smart functionality, and negative Poisson's ratio (NPR). However, despite recent developments, it has only been feasible to fabricate a very few numbers of meta-materials and implement them in practical applications. Recent advances in Additive manufacturing or 3D printing can be advantageous in fabrication of such metamaterials, as they have demonstrated success in facile fabrication of special materials with complicated microstructures.

Against this background, in this project students will develop a conceptual design for a cellular structure that consists of two 3D-printed metamaterial structures that implement auxetic and normal elastic properties.

The objective of this research project is to develop a cellular auxetic structure for mechanical metamaterials which will offer unique functional characteristics, such as high specific strength and stiffness, and enhanced absorption of mechanical energy.

The overall tasks for completing this project can be divided into three main tasks.

Task 1: Conceptual design - At first students will investigate all the optimized dimensions for design to achieve the desired Poisson's ratio and desired shape transformation. Then they will use any design software (suggested Creo, Solidworks, Autodesk) to draw the final 3D structure.

Task 2: Fabrication/ 3D printing - Students will study the material properties of photopolymer to find out the suitable material for this application. They will use a rheometer (at LAMBDA) to identify the proper rheological properties of the polymer matrix. After that they will use SLA based 3D printer to print the 3D metamaterial with the defined cellular structure.

Task 3: Characterization and validation for application in soft robotic actuation - After printing, the

students will evaluate the mechanical properties by performing a Free Compression Test. Auxetic structures are known for damping shocks that are induced due to impact. To gain a better understanding of this, cellular and solid samples will be tested to evaluate their characteristic when subjected to impact by a square projectile that will impact their top surface.

Finally, students will design and fabricate a pneumatic linear actuator to validate the study.

Expected Deliverables/Results:

Deliverables include:

- 3D design of the cellular structure using any design software
- Fabrication of cellular structure with optimized polymer matrix
- Characterization and validation of printed parts for application in soft robotic actuation.

Disposition of Deliverables at the End of the Project:

The hardware developed in this project will be the property of the mentor and the department.

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

- Familiarity or interest in 3-D printing
- Understanding mechanical behavior and characterization of polymer materials. (MEGR 3162 and MEGR 3233