**ENME 416/744: ADDITIVE MANUFACTURING**

**FINAL TEAM PROJECT**

**DESCRIPTION**

**Undergraduate Students | ENME 416**

The objective of the final project is to design a new type of soft robotic finger – one that is comprised of at least two distinct materials and manufactured using the Objet500 Connex3 Polyjet 3D Printer. Specifically, the printing materials will include a flexible, rubber-like material and at least one rigid, plastic-like material. The goal of the design challenge is to invent a novel soft robotic “finger” actuator that exhibits the largest *deflection* (δ) in response to the smallest *source pressure* (*PS*). To do so, students will work in teams to design their soft robotic fingers (a maximum of 4 different designs per team) and submit two self-referenced STL files corresponding to the two materials. The files will be 3D printed 

and then returned to the students along with a

port interface and a syringe. Student teams will

then experimentally test their designs on their

own by measure the magnitude of δ

corresponding to varying amounts of syringe

based inputs (*i.e.*, compressing the syringe by set

amounts to pressurize the soft finger).

*Note:* The project should include a ***quantitative***

***experimental study*** with appropriate controls (*e.g.*, printing a positive and/or negative control design) and statistical analysis.

**Graduate Students | ENME 744**

**Figure 1 | (a)** Polyjet 3D printing of multi material soft robotic “finger” actuator designs. **(b)** Applied pressure results in finger deflection.

The objective of the final project is to propose and provide a proof-of-concept demonstration of an additive manufacturing-enabled technology that exemplifies how the unique capabilities of a specific additive technology can overcome critical limitations of a conventional manufacturing approach. To do so, students will work in teams propose three potential ideas through three referenced abstracts in “Nature Summary Paragraph” format (*see* https://go.umd.edu/Nat-Sum

Para). The instructor will then provide guidance regarding which ideas are most suitable as a final project. *Note:* The project should include a ***quantitative experimental study*** with appropriate controls (*e.g.*, printing at least one positive and one negative control design) and statistical analysis. Students will design the proof-of-concept prototypes for printing using the Objet500 Connex3 Polyjet 3D Printer. Student teams will submit up to three self-referenced STL files corresponding to up to two plastic-like rigid materials and one rubber-like flexible material as desired. The files will then be 3D printed and returned to the students.

**Both Sections | ENME 416 & 744**

At the end of the semester, students will present their designs, methods, results, and conclusions as both a ‘conference-style’ oral presentation (***Examples***) and a 4-page ‘journal-style’ written manuscript (*Ex.* ***1*** *and* ***2***). The journal manuscript must be formatted similar to a *Communication* for an **RSC journal** (https://go.umd.edu/RSC-info). Each manuscript should include 3-4 figures (with multiple panels in each figure), approximately 20-30 references, and the following sections: abstract, introduction, materials and methods, results and discussion, conclusions, and references.

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**PROJECT TIMELINE AND DELIVERABLES**

The project will consist of the following stages (*see Syllabus for exact due dates*): 1. (*Graduate Student Only*) Submission of Final Project Abstracts

2. Submission of Final STL Files as a single ZIP File

• Using SolidWorks computer-aided design (CAD) software, students must export their STL files and submit them online *via* Canvas. *(Only one member of each team needs to submit the ZIP file.)*

3. 3D Printed Parts Returned to Students

• The TA will schedule pickup times for each Team to pick up their printed parts (and for undergraduate students, the syringe and port).

4. ‘Conference-Style’ Oral Presentations

• Student teams will present their work as a ‘conference-style’ oral presentation (12 minutes + 3 minutes Q&A). Undergraduate students will participate in reviewing the presentations of their peers.

5. Submission of Final ‘Journal-Style’ Manuscripts

• Students will submit their final PDFs online on Canvas. *(Only one member of each team needs to submit a PDF file.)*

6. Submission of Peer Review of Teammates

• Students will submit their final peer reviews of their teammates after all deliverables have been turned in.

**DESIGN RULES**

There are four rules for the final 3D printed device or prototype:

1. Size & Shape

• The two or three self-referenced STL files together (all assembled) must be able to fit in a volume on the Objet500 Connex3 build plate of 100 L mm × 100 W mm × 40 H mm. As many components as desired can be placed in this volume.

2. Naming

• The submitted STL files must be in the format Section\_Team#\_Material.stl. For example, ENME416\_Team1\_Plastic1.stl, ENME416\_Team1\_Plastic2.stl, and ENME416\_Team1\_Rubber.stl.

3. (*Undergraduate Students Only*) Port Integration

• All input/output ports must utilize the port file that will be provided on Canvas to ensure successful connections to the syringe.

4. Support Considerations

• Water-dissolvable support material will be used, so appropriate considerations for support removal should be taken into account.

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**CONFERENCE-STYLE PRESENTATION GRADING METRIC**

| **Topics** | **Score** |
| --- | --- |
| **Background |** How was the general area introduced? Were relevant works from the literature appropriately discussed and cited? Were the key challenges clear? | /20 |
| **Concept |** Were the design concepts explained well (*e.g.*, with illustrations and/or conceptual animations)? Were the experimental controls also explained? | /20 |
| **Fabrication |** Were the fabrication protocols (including support removal) explained clearly? (Someone with basic 3D printing knowledge can understand.) | /10 |
| **Theoretical & Experimental Results |** Is it clear how the design(s) is expected to function? Was the experimental set-up and/or methods explained? Were the results presented clearly and accurately? Was there statistical analysis? | /25 |
| **Future Work/Conclusions |** Were the results given context? Were the next steps/future directions logical? Were the key results succinctly summarized? | /10 |
| **Professionalism |** Were the slides meticulously put together? Were the presentation and ‘presenting style’ appropriate for a technical conference? | /15 |
| **TOTAL** | /100 |

**JOURNAL PAPER GRADING METRIC**

| **Topics** | **Score** |
| --- | --- |
| **Abstract |** Was the general field introduced well? Was the specific problem dis cussed? Was the approach explicitly stated? Were key results briefly discussed? | /10 |
| **Introduction |** How was the general area introduced? Were relevant works from the literature appropriately discussed and cited? Were the key challenges clear? | /20 |
| **Materials and methods |** Were the design concepts explained well? Is it clear how the designs are novel and/or effective? Were the fabrication protocols (both demo and ideal) explained clearly? Were theoretical and/or experimental methods explained? Were methods of statistical analysis explained? | /20 |
| **Results and discussion |** Is it clear how the design/device is expected to function? Were the results presented clearly and accurately? How do the results compare to prior works? Were appropriate controls and statistical analysis used? | /20 |
| **Conclusions |** Were the results given context? Were the next steps/future directions logical? Were the key results succinctly summarized? | /10 |
| **Format |** Was it in the RSC format and exactly 4 pages long? | /5 |
| **Figures |** Were there 3-4 figures in total? Were the figures prepared properly? | /5 |
| **References |** Were appropriate works from peer-reviewed scientific journals cited properly (not websites, blogs, or companies)? | /5 |
| **Professionalism |** Were the subsections appropriately named? Was the writing and overall formatting appropriate for a technical audience? | /5 |
| **TOTAL** | /100 |

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