# ED5315 – Field and Service Robotics

# Project Presentation

## Soft robotic surgical tool with embedded actuation

Group No: **7**

Group Members:

| | |
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# Objectives

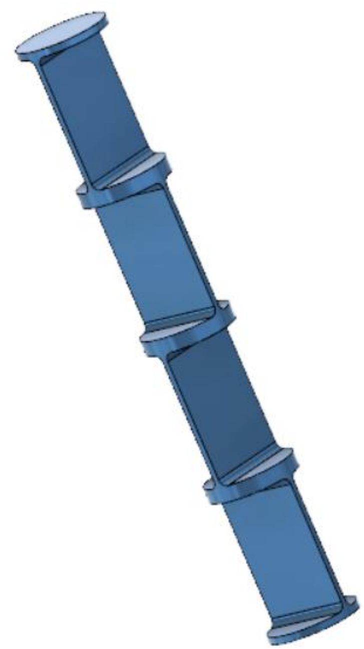
- Develop a workable concept for a soft robotic surgical tool tip with embedded pneumatic actuation
- Discretization based kinematic analysis of the proposed surgical tool tip
- Build a prototype to demonstrate the working of the tool tip

# Introduction

- Surgical tools(MIS) involve rigid mechanisms with actuators located away from the end effector
- Soft surgical tools provide flexibility enabling them to traverse complex trajectories
- They enable actuation to be located within the tool thereby avoiding transmission issues
- Issues with soft surgical tools are that they are inherently force limiting with low stiffness
- The main focus of our project is to develop a tool which can offset these issues

# Methodology

- Conceptualization of the surgical tool
- Selection of backbone:
  - Flexibility
  - Stiffness
  - Manufacturability
- Embedded Actuation:
  - 4 pneumatic inputs
  - 2 Degrees of Freedom
  - Placement of actuator
  - Pressure difference between 2 chambers

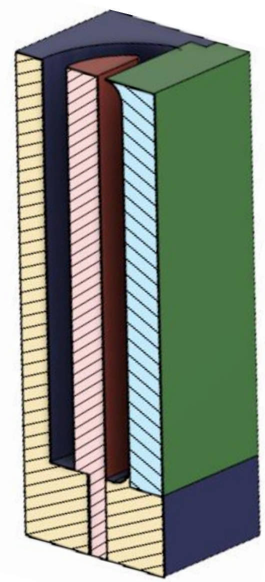


Design 1

Design 2

# Design & Manufacturing

- Backbone:
  - Thickness of flexure = 0.4 mm ( 3D printer resolution)
  - Width of flexure = 20 mm (Tool tip radius)
  - Length of flexure = 40 mm ( For 30 deg deflection)
- Elastomer:
  - Designed to fit around the flexure to provide additional compressive strength
- Fibre:
  - Wound around the elastomer to provide bending properties

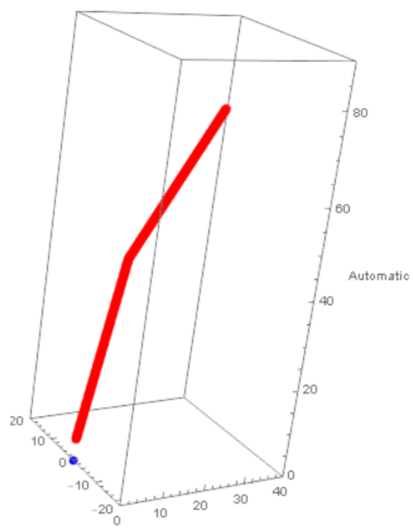


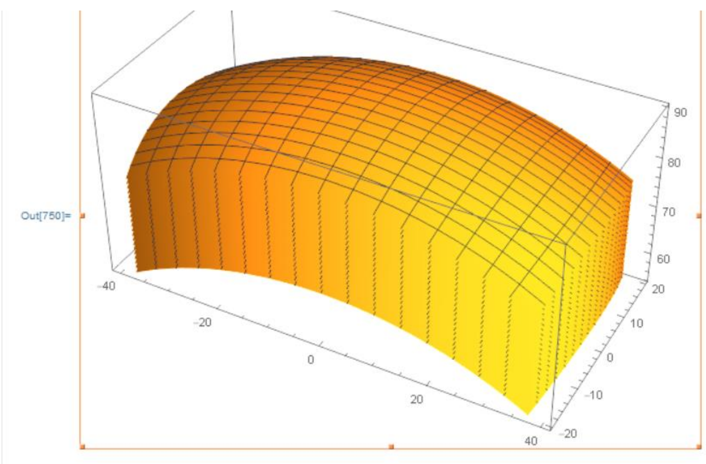
Mould for Elastomer

Tool Design

# Kinematic Analysis

- Discretization based kinematic analysis
  - Actuation pressure is assumed to be directly proportional to deflection of flexure
  - The flexures themselves are assumed to be rigid links with revolute joints at respective centers(Pseudo Rigid Body Model)
  - Forward & inverse kinematic analysis have been performed

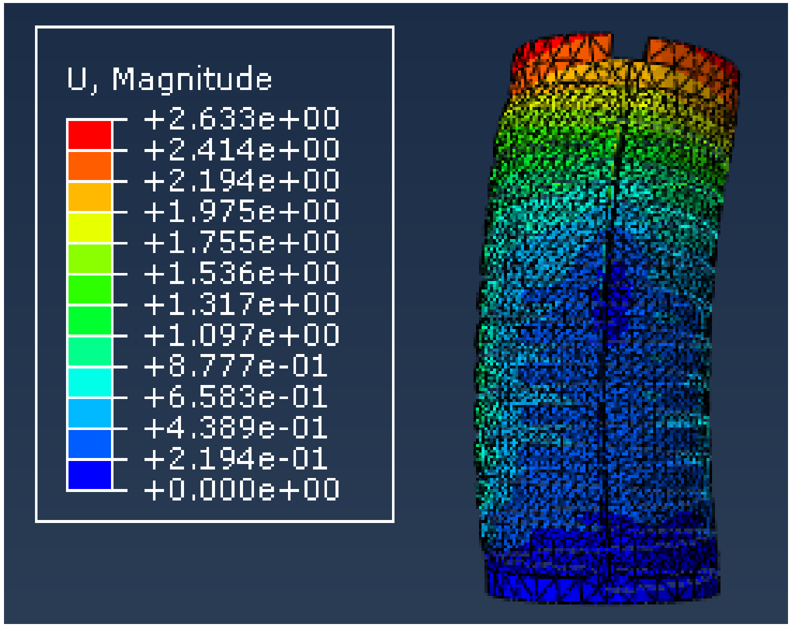


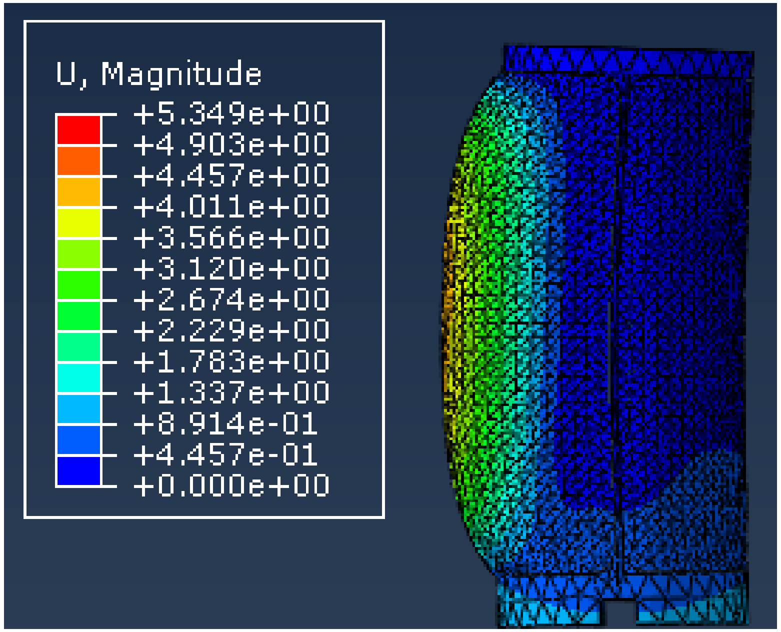




Workspace of the tool

# FEA Simulations

## Fluid structure interaction Modelling



# Results

- A soft surgical tool was conceptualized, designed, simulated, manufactured & tested for desired kinematic properties
- Issues faced:
  - Sealing
  - Cantilever Issues
- Future Aims:
  - Reduce the tool diameter & weight
  - Increase degrees of freedom
  - Incorporate all actuation peripherals within the tool

# Learning Outcome

- Understood working principle of soft robotic surgical tool
- Learnt discretization based kinematic analysis of a soft tool
- Studied design and manufacturing intricacies of compliant mechanisms
- Explored manufacturing techniques of soft pneumatic chambers
- Performed non-linear static FEA simulations using ABAQUS software

# References


- https://softroboticstoolkit.com
- F. Connolly, C. J. Walsh, and K. Bertoldi, "Modeling and Design of Fiber-Reinforced Soft Actuators," ASME International Mechanical Engineering Congress and Exposition. 2014
- F. Connolly, P. Polygerinos, C. J. Walsh, and K. Bertoldi, "Mechanical Programming of Soft Actuators by Varying Fiber Angle," Soft Robotics, vol. 2, no. 1, pp. 26-32, 2015

# Thank You

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