OBJECTIVE
The objective of this project is to design a 3 segment manipulator with similar capabilities to a 5 segment manipulator described in the paper “Design and Analysis of a Robust, Low-cost, Highly Articulated Manipulator enabled by Jamming of Granular Media.” During this term, I am focusing on designing the manipulator and constructing a functioning, jamming segment. Dimensioned CAD models and assembly drawing for the parts are also being made.

IMPORTANT TERMS AND CONCEPTS
• A manipulator is a robotic arm capable of reaching a set of locations.
• Selectively compliant manipulators control the state of a few of its parts, while letting the rest move freely.
• An applied pressure difference causes granular media, such as coffee and sawdust to transition between a jammed and unjammed state. In the unjammed state, particle motion is unrestricted. In the jammed state, frictional forces that develop between grains restrict the motion of particles.

FEATURES OF FIVE SEGMENT MANIPULATOR
The 5 segment manipulator described in the previous paper utilizes:
• Tension cables
• Large diameter springs
• A thin membrane, and
• Selective jamming of segments filled with coffee grains to achieve a wide variety of configurations, such as those shown in figure below.

SUCCESSFUL SECTIONS HAVE THE FOLLOWING PROPERTIES:
• Each segment can jam: A successfully jammed segment will not conform significantly to the environment or tension cables.
• Segments can be independently jammed: Vacuum pressure applied to one segment does not affect or leak to other segments.
• Segments retain their cross sectional shape.

CURRENT DESIGNS
Figures to the left show detailed models or drawing of custom-built parts.
• End caps will be used to guide tension cables and pass 1/8 inch tubing to appropriate segments for applying a vacuum.
• Early tests performed suggest that larger diameters enable stronger jamming forces and that the restoring force of tubes with thick walls impede a segment from jamming. As shown in the figure to the left, walls approximately as thick as latex sheets are capable of jamming. For this reason, thinner, .030” thick latex sheets are used.
• Commercially available springs with a 1.5 inch diameter have very strong restoring forces. Wound buswire behaves similarly, and is used instead.

FUTURE WORK
1. Controls will be added to solenoids to enable segments to be selectively jammed.
2. 3D models of spools will be made an interfaced, with spooler motors and tension cables.
3. Controls will be added to spooler motors to create a fully functioning manipulator.
4. The 3 segment manipulator will be adapted to create a 5 segment manipulator.