ECCE 550/ME595R-006 Simulation Lab 2: Matlab Design of a Bistable Mechanism

September 25, 26, and Oct. 2, 3, 2006

1 Introduction

In the last lab, you wrote a Matlab function to describe the force and deflection behavior of a bistable mechanism. In this lab, you will use that function, together with the optimization capabilities of Matlab, to design two new bistable mechanisms with desirable properties.

2 Optimization in Matlab

Matlab offers many tools for optimization-based design. In this lab, we will use the `fmincon` function. This function will allow minimization of any bistable mechanism parameter you choose, subject to any constraints you impose. Type "`help fmincon`" at the command prompt to see more information about `fmincon`. The TA will also give you more help and instruction on how to use this function.

The SU-8 mechanism you analyzed last week has a deflection of approximately 63 μm between its first and second stable positions. For your first optimal design, find mechanism parameters which will give a displacement of only 30 μm between stable positions. Table 1 gives a list of which parameters you can vary, and the limits they can take. For Young's modulus, use 4.4 GPa. For this problem, the TA can help you to apply the constraint that the mechanism remain bistable. You will need to figure out how to find the distance the

Table 1: Parameters to vary and their limits

Variable	Lower Limit	Upper Limit	Units
w	5	30	μm
t	20	40	μm
l	10	200	μm
r_{10}	100	500	μm
θ_0	0.001	0.25	rad

mechanism moves between stable positions. You will want to minimize the square of the difference between that distance and 30 μm. Note that not all starting designs will lead to good optimized designs. You will probably want to try several different starting designs.

Next, change your objective to minimize the force required to switch from the first to the second positions. Be careful! If you just look at the maximum force, the optimization will not work right. This is because your bistable mechanism function will return forces beyond the second stable position in some cases. Some of these forces may be higher than the switching force. Instead, use the algorithm you developed previously to find the second stable position. The switching force will then be the largest force encountered between the two stable positions.

3 Deliverables

Turn in a professional memo (approximately one page) that describes the two new designs you found. Report variable values, as well as the distance between stable positions for the first design and the switching force for the second design. In your memo, discuss any important characteristics of your two designs. Did the optimizer return designs with behavior similar to what you expected, or were you surprised at some things?