## Finite Element Analysis

Using Abaqus, we analyzed eating-related stresses on the utensils and the force of the torsional springs on the release tabs. All the analyzed components are composed of steel, so we assumed a Young’s Modulus E = 29E6 psi and a Poisson ratio = 0.29. See the included screenshots for the Von Mises stress results, the .odb files for the full analysis results, and the .cae files for the analysis construction.

For the eating use case, we specifically analyzed stresses on the fork, spoon, bottle opener, and knife:

* + - * + For the fork, we used a chunk of steak as a baseline: average serving size is ½ lb per person. Since people sometimes pick up the entire chunk and the fork prong surface area is 0.86in2, we have a **0.5814 psi** load.
        + For the spoon, we used twice the load on the fork to approximate scooping hardened ice cream: a **1.1628 psi load**.
        + For the bottle opener, we approximate the point/line load as a pressure on a small surface area of the utensil (surrounding the point of contact). [This article](http://thessalyengineering160.blogspot.com/2016/02/bottle-opener-23.html) estimates the max load at 69 MPa or **10007.6 psi**.
        + For the knife, we have shear stress and normal stress. It requires 11.7 lbs to cut hard steak according to the Warner-Bratzler Shear Force Test and we have ~0.2 in2 for the cutting surface area, so we have a shear stress of **58.5 psi** on the cutting surface. For the normal stress, we approximate with half of bottle opener load at **5003.8 psi**.

For the use case of the assembly at rest, we analyzed the stress of the torsional force on the release tab. In particular, we used this [spring calculator](https://www.thespringstore.com/spring-calculator.html) which yielded a 0.006 in-lbs/degree torque rate per degree (see [Appendix](#_xu4mhjx9y1gj)). This means for a 180 degree bend we have a 1.08 in-lbs torque. Given a radius of 0.165 in for the spring, we have an approximately **6.545 lb** force acting on the utensil and in turn the release tabs (idealized as a point force on the tip of the utensil lock cantilever).

From our results, we can see that the knife experiences the greatest Von Mises stress, approximately 5.833E6 psi. For almost any type of steel we could use, this would result in yielding. For example, A36 steel with a thickness of less than 8 in has a minimum yield strength of 36,000 psi and an ultimate tensile strength of 58,000-80,000 psi. The upper bound for steel yield stress is 240,000 MPa or 348,090.6 psi. However, note that we were extremely conservative in our estimation of the use case-induced loads.

### Appendix

