After winnowing down the motor types we can use to DC and stepper, we needed to perform a technical analysis on quantitative requirements for the hard-constraint system. In order to choose the correct motor, a power rating had to be specified. This power rating depends on the torque the motor must be able to provide and the speed the motor must be able to operate at.

**Torque:**

According to last year’s group, the torque the motor needed to supply was 7.5 Nm: “After researching various motor and motor controller combinations, the Maxon EC-Max 25W Brushless DC motor (Figure 47) matched with a 66:1 gearbox was selected. It was selected because it provided sufficient nominal torque, acceleration, and maximum velocity for the experimentally derived expected moment of 7.5 Nm (50 N force at 15cm) discussed in Section 3.” We preformed our own analysis on the newer linkage design and came up with a substantially smaller value of around 1 Nm. This result if most likely due to the fact that the newer linkage design reduces the amount of force needed to be applied at the hard constraint, due to the action of friction on the vertical rod and the partial load-carrying of the rod and linkages. The analysis was preformed with the following linkage design:

L2

Load

Θ1

Θ2

Load

L1

A spreadsheet was made to compute the value of the hard-constraint force that is need at Link 1 (L1) with varying θs. Knowing the moment arm o the motor at that point, we can figure out the motor torque required. This spreadsheet proved to be very useful, as we could easily change the link lengths, the load, and the motor arm and immediately get the corresponding data. With link lengths of L1 = 15 cm and L2 = 10 cm, a load of 15 kg (hand force and the weight of the system), and a motor moment arm of 1 cm, we got back the following torque-theta curve:

\****θ1 (deg) is does not go below 48 degrees due to the different link lengths***

With the same load and moment values, but equal link length of 7 cm, the following curve is obtained (with a max torque of 1.5 Nm). Since the analysis of an optimized size for the workspace has yielded a result of equal linkage length of 7 cm, the maximum torque the motor must be able to counter is confirmed to be 1.5 Nm. The spreadsheet with all the values of thetas, distances and forces can be found in Appendix.