Executive Summary

Our sponsor, Professor Coleman, has asked us to construct a mechanical device that fits within an incubator that can apply cyclic compressive and shear strains to tissue samples. This mechanism operating while attached to the inside of an incubator will be a cyclic shear bioreactor. These tissue samples will be kept in an incubator at conditions analogous to the human body. There are no commercially available bioreactors on the market today that can achieve what Professor Coleman has asked us to do, which is why we have been tasked with building this device. After background research and multiple interviews with our sponsor, we were able create engineering specifications and targets from the user requirements that our bioreactor needs to attain. A full list of our user requirements can be seen in our QFD chart in Appendix D.

In order to identify a product that would meet all of these customer requirements, we generated concepts that could function to meet our needs. We also determined three subsystems necessary for our design to fulfill all of the requirements and specifications: force application, well plate security, and force and displacement validation. The force applicator will be the subsystem that exerts the compressive and shear forces on the tissue samples. Well plate security refers to a mechanism that will hold the well plates in place while the samples are being stimulated. The force and displacement measurement will give us our desired outputs of load and displacement on the samples. By using a Pugh chart to analyze each subsystem where each concept was rated on a scale of one to five on how they fulfilled each of our user requirements, we found that the best concept that fulfilled our force application used highly accurate step motors; for well plate security a prefabricated well plate holder would be used; and for measurement and validation a load cell along with optical encoders would be used. Requirements were weighted based on relative importance and then scores multiplied by their relative weight gave us a final outcome.

After this design concept was approved by Professor Coleman, an intensive analytical design phase began where we modeled the design using CAD SolidWorks. This phase was crucial because the high cost of the materials involved makes mid-stream redesigns infeasible. After all of the design work had been done on CAD, we came up with a manufacturing plan to construct all of the necessary components. Some components will have to be manufactured in the machine shop while others can be purchased with no need to further modification. Rigorous calculations have been done to make sure that our device will be able to withstand the conditions within the incubator while applying forces onto tissue samples. Dimensions for various components and with material selection preferences were determined from these calculations and were implemented into the final design.

Once the necessary components had been machined we were able to build our prototype as it was displayed at the design expo. Although the prototype lacked the motors and stages needed to complete the project in its entirety the device still underwent validation testing for all of the specifications that we could test to ensure that it fulfilled our engineering specifications. These validation tests and their results can be seen in the Validation Plan and Results section below.

Our prototype for this project was successful in completing all of the specifications that did not involve actually operating the device. However, the device has been designed to meet the specifications and our analysis indicates that our device will be able to perform as requested.