Alternative Design 1

1.1 Overview

The gastrocnemius muscle from a frog *Rana pipiens* will be used to perform the isometric and isotonic experiments of muscle contraction. A National Instruments interface will connect the experimental setup to a computer and the lab group will conduct and record the experiments using a custom written LabView interface. The lab group will then write a LabView protocol which will analyze the data and determine the length tension and force velocity curves for their muscle. These curves will be submitted to the TA and run through an optimization program to parameterize the muscle model proposed by Dr. Enderle for the lab groups muscle. These parameters will be returned to the lab group which will use them to simulate the isotonic experiment.

1.2 Electrical Activation

Activation of the muscle will be achieved directly stimulating the muscle with the voltage output from the National Instruments interface. The end fixture will consist of two wires which will contact opposite sides of the muscle. A voltage pulse train will be delivered to the muscle in order to achieve maximum fused tetanus contraction for each experiment. The exact voltage and frequency will need to be determined by each lab group as each muscle will respond differently.

1.3 Isometric Experiment

The isometric experiment is designed to determine the active length tension relationship of the muscle. The muscle is stimulated to contract and held at constant length over the course of the contraction. The force time history is recorded from this experiment. The procedure is then repeated at different muscle lengths. The maximum force recorded at each length is plotted against the muscle length to construct the length tension curve.
The physical apparatus to conduct the isometric experiment will be rather simple, as there are no moving parts required. The muscle will be fixed between a custom built load cell and a lower stage of adjustable height. The lower stage will consist of a clamp which will be used to secure the femur of the muscle preparation. A small hook and Kevlar thread will be used to secure the tendon of the muscle preparation to the load cell (Fig 1.1 shows the experimental apparatus).

![Diagram of experimental apparatus](image)

*Figure 1.1*

A FlexiForce sensor, by Tekscan, will be used as the force transducer for the load cell. It will be sandwiched between two plates which will be squeezed together upon contraction of the muscle. The voltage output of the sensor will be connected to the National Instruments interface and recorded by the LabView program.

### 1.4 Isotonic Experiment

The isotonic experiment is designed to determine the active force velocity relationship of the muscle. The muscle is stimulated to contract and the load is kept constant over the course of the contraction. The length time history is recorded from this experiment. The procedure is
then repeated under different loads. The maximum velocity of each contraction is calculated and plotted against the load to construct the force velocity curve.

The physical apparatus to conduct the isotonic experiment is as follows. The muscle will be fixed between a lever arm and a lower stage of adjustable height. The lower stage will consist of a clamp which will be used to secure the femur of the muscle preparation. A small hook and Kevlar thread will be used to secure the tendon of the muscle preparation to the lever arm. A mass hung on the other end of the lever will provide the constant load for the experiment. The rotation time history of the lever during muscle contraction will be recorded by a rotation sensor, 1109-Rotation Sensor by Phidgets. The voltage output of the sensor will be connected to the National Instruments interface and recorded by the LabView program. (Fig 1.2 shows the experimental apparatus).

![Experimental Apparatus](image)

**Figure 1.2**

1.5 National instruments and LabView

The LabView program provided to lab groups will allow them to directly stimulate the muscle and acquire the force and rotation data from the isometric and isotonic
experiments respectively. Lab groups must then write their own LabView or Matlab programs to process the data in order to determine the length tension and force velocity relationships for their muscle. The length tension and force velocity data will then be submitted to the TA for use in the optimization program.

1.6 Model Optimization

The optimization program is a modification on that presented by Dr. Daniel Sierra, which will optimize the parameters of the muscle model presented by Dr. Enderle. The optimization will use the length tension and force velocity relationships determined by the lab group to estimate the model parameters (Fig. 1.3 shows the muscle model). After the optimization is complete the model parameters will be returned to the lab group. The optimization program will be written using the Matlab programming language by Mathworks Inc.

![Muscle model](image)

Figure 1.3 Muscle model consisting of two ideal elastic elements, two ideal viscous elements, and an active state tension generator.

1.7 Simulation

Using the optimized model parameters, the lab group will then simulate the isotonic experiment using Simulink by Mathworks Inc. to recreate the length time history of the experiment and the force velocity curve. In order to properly execute the simulation, the lab
group must first analyze the model and determine the differential equations necessary to simulate the isotonic experiment. Once this has been performed the model can then be constructed in Simulink and run under different load conditions to replicate multiple trials of the isotonic experiment. Multiple trials under different loads will allow the lab group to recreate the force velocity curve for their muscle.