This week, my primary focus was on the control lever system of our project. Most importantly was whether or not this control is following the concept of extended physiological proprioception (EPP). Dictionary.com defines extended physiological proprioception as, “a concept pioneered by D.C. Simpson (1972) to describe the ability to perceive at the tip of the tool”. This means that a tool will act in a manner so that it is intuitive to use, and it provides some form of feedback to the user such that the user is innately aware of the tool’s motion. In our case, the lever which controls the bed is the “tool” in question. The current design uses a pivoting lever which turns a potentiometer as it turns. To produce feedback, the lever will push against springs. As a force is applied, the spring will be compressed until it counteracts the moment produced about the potentiometer, as shown in Fig1. Since a spring produces a force directly proportional to its compression, this relationship is highly predictable and regular. Last, since the spring will be compressed more with a greater force applied, this translates to a greater rotation of the potentiometer. The change in resistance of the potentiometer can be converted into a voltage by an electric circuit, and eventually drive the electric motor. The greater the rotation of the potentiometer, the faster the motor will be driven. If the lever is pushed down, it will lower the bed back, and if it is pulled up, it will raise the bed back.
I also have brought back another idea which we had toyed with early last semester. In place of the potentiometer, two strain gages can be used to measure the force applied to the end of the handle. With a somewhat flexible metal, when a force is applied to the end of a cantilever it will bend slightly, putting the convex side in tension, and the concave side in compression. In this design the strain due to tension will be measured. When a force is applied to a cantilever, a moment is applied at every point along the cantilever, and can be found by multiplying force by the distance between the end of the bar and the point in question, L-x in Fig 2. With the moment known, and the dimensions of the bar known, the stress (σ) on the surface can be found by \( \sigma = \frac{M \cdot c}{I} \) (Eq1), where \( c \) is half the height of the bar, and \( I \) is the moment of inertia. Using this stress, and Hooke’s Law (\( \sigma = E \varepsilon \)), the strain (\( \varepsilon \)) can be found for a given material with a young’s modulus (\( E \)). This strain can be detected by a strain gage, which will change resistance, much like a potentiometer, with an induced strain. With a strain gage on both the top and the bottom of the bar, the circuit can use only a positive or tensile strain for the control. The circuit will first determine the direction of the motor by the strain gage which is positive strain. For example, if the bar is being pushed down on, the bar will deflect downward, putting the top strain gage in tension, and the bottom gage in compression. The top gage would then measure a positive strain due to the tensile stress applied on it, causing the bed to be lowered. Depending on the amount of force applied to the bar, the strain will vary. With an increase in applied force, the bar will be deflected more by a greater moment. By Eq1, it is easy to see that with an increase in moment
(M), the stress at the surface in increased. Therefore, by the linear relationship between stress and strain shown by Hooke’s Law, strain would also increase. The circuit for both control systems can be identical, except for how they differentiate between driving the bed up or down.

![Figure 2: Cantilever Diagram](image)

Although both of these control systems are very similar in that they translate the mechanical force applied to a bar into a displacement or deformation, and then turn these changes into a change in resistance, the strain gage system can have two potential advantages over the potentiometer system. First off, the strain gage system uses a bar which is fixed at one end, making it a cantilever. These avoids the complications of pinning a bar while still rotating a potentiometer with it, as well as the use of springs which can only be compressed a fixed amount, and sustain a fixed force. Also, the displacement of the bar does not need to be as dramatic as the rotation of the potentiometer. Strain gages are capable of detecting minute changes in strain. However, since the bar will not deflect a large amount, this may give the patient the impression that they are not pushing hard enough, causing the bed to be moved at a faster speed than intended. Strain gages may also be less consistent than a potentiometer especially with very small deflections. This would add to complications while fine tuning the final prototype.

**Future Work**

In the following week, I would like to explore the use of strain gages further, while meeting with Ray about the problem which would be faced by this change from a potentiometer. I also hope to put together the motor fixation to the scissor jack, so that we have a single operating lifting system, which can be easily operated for trials in the motion of the bed back, and speed tests. Also we will begin to order metal for the bed back and the caster wheel so that the track can be planned better.

**Project Review**

At this point all ordered parts have been received and the bed frame has been modified so that we can start to put together our device together. The DC motor has also been modified so that the there is a nut attached to the rotating shaft for easy connection to the screw jack. We have tested this connection and
learned that it can withstand the torque. The purchase order for the wheel castor has been submitted and we expect to receive it in a few weeks. We are still within budget with about $672 remaining. We have currently spent about $1328 of our $2,000 budget.

**Hours Worked**

13 hours