The Device:

The automated syringe loading device is an aid for diabetes patients who live with common conditions typical of the disease. These conditions include, but are not limited to, arthritis, hemiplegia, Parkinson’s disease, tremors, neuropathy, and vision and hearing impairment. The device will assist these patients by filling syringes with their required dose of insulin. To operate the device, the user will input the amount of insulin required, and the device will then fill the syringe to that amount within a tolerance of $1/1000 \text{mL}$. To make the device more user friendly, it will hold any size insulin bottle, store up to 10 syringes for loading, and alert the user when the current bottle of insulin is near empty. For the doctor’s records, the device will also maintain a time stamped account of the volume of each syringe filled.

Work Done:

After learning about resources available in the Castleman Machine Shop, and undergoing training to utilize these resources, the list of required parts to be ordered was reevaluated. It was determined that several parts could be built by the team while saving money and not using too much time. These parts included the lead screw, sleeve nut, and clips. While the lead screw was later purchased at Mansfield Supply, the designs for the clips and the sleeve nut were planned and drafted.

The clips, seen in figure 1, were designed to replace the ones found online. These premade clips were too big, too expensive, and required modification to fit the design needs. Using one sheet of aluminum, the clips will be made by bending the metal according to figure 2 and three, shown below.

**Figure 1:** Clip and Syringe. This figure shows the newly designed clip, and how the clip will expand to hold the syringe.

**Figure 2:** Folding the clip. This figure shows how a sheet of metal will be folded into the shape of the clip. The view is from the front of the sheet as it is folded.
Figure 3: Cutting out clips. After the sheet metal has been folded, it will be cut into 0.5cm long clips. The clips will be deburred after cutting to remove sharp edges.

The sleeve nut design was integrated into the plunger claw. This simple device is merely a cylindrical nut, tapped to fit the lead screw, and welded to steel bars. The nut will move the claw up and down the lead screw, while the claw “grips” the syringe plunger. Due to changes in components, and a lack of foresight in previous designs, the steps taken during loading had to be rethought. This was done in the lab by all members of the team. The drawings of this claw component, and the actions taken by it during the new syringe loading process, are shown in Appendix I.

To determine how the syringe cartridge would be constructed, a model of it was made using cardboard. The model was the same size as the expected prototype, which will be made out of aluminum. The construction includes bending two sheets of aluminum to form the cartridge halves. These halves will then be welded together. Using this model, a plan for the cartridge construction was developed, and is shown in figures 4 and 5. Once aluminum welding training has taken place, these parts can be built.

Figure 4: The drawing below shows the sequence of bends to be taken in the construction of the cartridge halves. Each bend is numbered to show the order of operations.
Figure 5: The drawing shows the joining of the two halves, and points out the locations of the welds.

Since the materials to make these components were ordered later, the other components that would have been ordered with them, (including digital and mechanical potentiometers, stepper motors, and servos) were ordered later as well. By looking around some more, these other components were found at much lower prices. In fact, the group saved over $300 over previous budget estimates.

Lastly, the “double check circuit” designed to monitor the progress of the syringe plunger had to be reconfigured to make sure it worked with the new microprocessor. Using PSpice, the circuit was checked, and was successful.

Future Work:

First and foremost, the cartridge, clips, and motor assembly will begin construction. These components should not require too much time, though accuracy will be important. The start date will also have to depend on the availability of further training in aluminum tungsten inert gas (TIG) welding. Once parts are available for testing, the “double-check-circuit” will undergo its final stages of design. While the layout of the necessary components is understood, the final values of variables still need to be configured. This cannot happen yet, because the tolerances of the potentiometers and the rate of increase of their resistances vary depending upon the individual piece. A range has been supplied by the manufacturer, but accuracy requires further investigation. Also next week, programming of components will begin. The components to be programmed are the microprocessor, the display, and the digital potentiometer.
**Project Review:**

By ordering the parts after the shop training, the team set itself up to be behind schedule. According to the team’s Project outline:

- the motor and mechanical potentiometer should already be linked in the motor assembly,
- the stepper motor should have been tested, and calculations for its programming should be done,
- the “double-check-circuits” should be built,
- the bottle holder should be built,
- the case layout should be in planning,
- the cartridge should be built and linked with the motor,
- and quite a bit of programming should be under way.

Right now, the team has none of the above complete. While this may seem horrifying, the team is not necessarily worried. So far, everything that has been accomplished has been so at a quick rate, and future steps are expected to follow in a similar manner. Once all of the components come in the mail, there isn’t anything that should keep the team from achieving a working prototype by deadline.

**Hours Worked:**

Daniel Littleton has worked for approximately 25 hours on the syringe loading device. These times include hours spent researching components, brainstorming with the team, planning action steps, calculating necessary variable in circuit schematics, testing circuits in PSpice, drawing diagrams in Microsoft Visio®, building models, speaking with experts, and ordering parts.
**Appendix I:** The action steps taken by the plunger claw during loading.

**Step 1:** The cartridge rotates to place a syringe in range of the plunger claw.

**Step 2:** The claw rises to meet the syringe. Here, the claw also pushes the plunger to expel any air.

**Step 3:** The motor assembly is moved towards the syringe. The claw then “Grabs” the plunger.

**Step 4 and 5:** The claw pulls the plunger down to meet the volume specified. Once filling is complete, the claw returns to its starting position.