# Adaptive Mobility Chair

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## Description

This project partnered with Arizona Centers of Comprehensive Education and Life Skills (ACCEL) to create mobility chair that promotes physical development.

**Problem:** Student is unable to properly sit up past a 45 degree angle

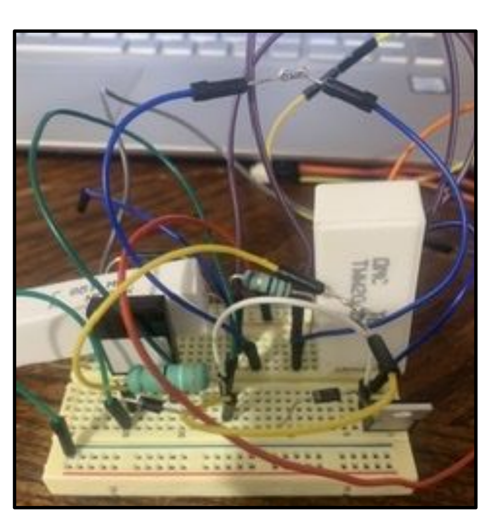
**Solution:** Create a mobility chair capable of variable angle of 45 degrees - 90 degrees

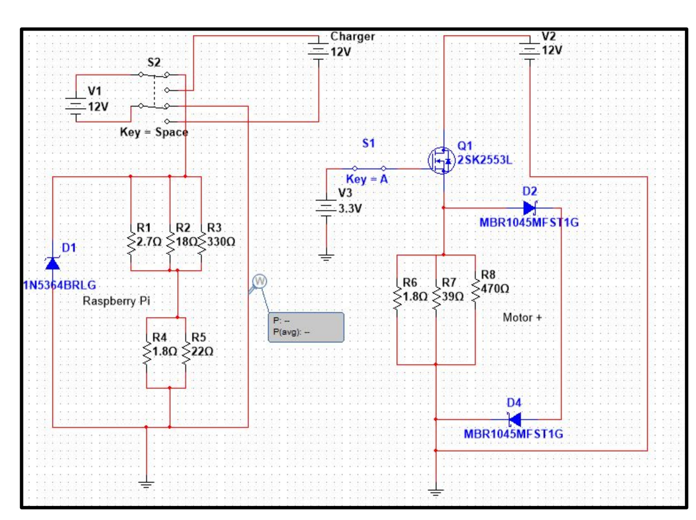
## Justification

Every student with physical or behavioral disabilities is effected in a different way. The current market attempts to lump all disabilities into a broad category, allowing for mass production of mobility chairs. This project is custom-built to a student's specific needs, bringing hope, dignity, and self worth to students who are often overlooked.

## Functional Requirements

1) Enhance Physical and Behavioral Development (Learning to Sit Straight and Respond to Music)
2) Provide Safety Features/Supports
3) Provide Transportation
4) Ease of Use for Caretaker





## Verification and Validation Testing

- Strength Integrity Testing
  - Chair supported weight with safety factor of 2.77 (320 lbs)
- Tipping Test (ISO ISO 7176-5)
  - Chair reclined from the 90 degree angle all the way to the 45 degree without tipping
- Safety Test ( 49 CFR Title 46 Part 57)
  - Unable to be conducted. Expected to prove that a 4-Point harness along with the foam block would restrain the student to the chair, even when stopping abruptly.
- User Interface Testing
  - Unable to be conducted. Expected to show the Raspberry Pi user interface can communicate with tilting system to adjust angle, and speaker to play music.
- Transportation Testing (ADA)
  - Chair pivots 360 degrees and wheels allow static braking on incline.
  - Handles allow for steering at any angle

## Design Specifications and Engineering Standards

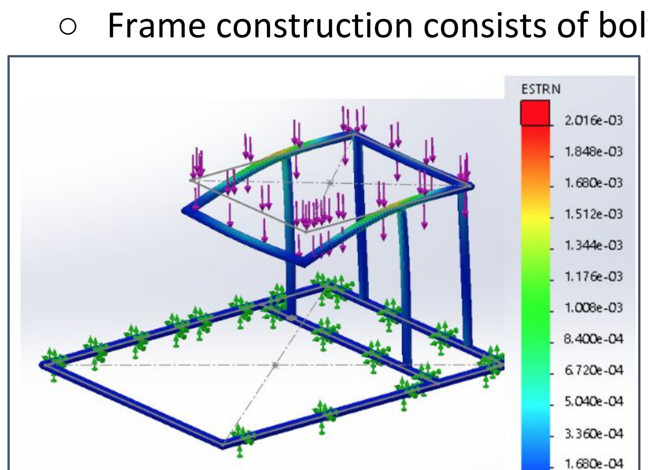
| Design Specification | Corresponding Engineering Standard | Design Specification | Corresponding Engineering Standard | Design Specification | Corresponding Engineering Standard | Design Specification | Corresponding Engineering Standard |
|---|---|---|---|---|---|---|---|
| Chair should provide variable angles between 45 degrees – 90 degrees | *FDA recognizes ISO 7176-5 as a standard for mechanical tilting wheelchairs.* | Audio play Music (30 minutes via customer feedback) | *Approval from the customer must be acquired.* | 4-Point Harness | *Harness must comply by 49 CFR part 57 if being mass produced* | User interface to alter the angle of tilt and music | *IEEE 829-2012 specifies the inspection, analysis, verification, and validation procedures* |
| Backrest, seat, and foot rest should be at a 90/90/90 degree orientation. | *There is no industry standard. However, research says that the natural joint orientation is 90/90/90 (Reed & Lahm, 2009).* | Small sound system capable of playing calming sounds/music | *Customer feedback (approved/not approved)* | Foam block between thighs to prevent slippage | *There is no direct standard, however the block is used to avoid slippage, which is covered by 49 CFR part 57.* | Device wheels can support device and student weight | *Research shows that a safety factor of 2.77 for a wheelchair (Ismail, 2012).* |
| Frame supports the weight of the student and seat (115 pounds). | *Research shows that a safety factor of 2.77 for wheelchair (Ismail, 2012). Frame width less than 32 inches (ADA)* | Shoulder/lateral support prevents student from falling. | *ISO 10542-3 specifies testing requirements for "restraints" used for disabled peoples* | Four all-terrain wheels | *It is recommended that medical-grade caster wheels comply with ANSI ICWM:2012.* | Brakes make chair static at an incline up to 5 degrees | *ISO 7176-1:2014:stability of a mobility chair at a static state. Static brake on wheelchair ramp of 5° (ADA)* |

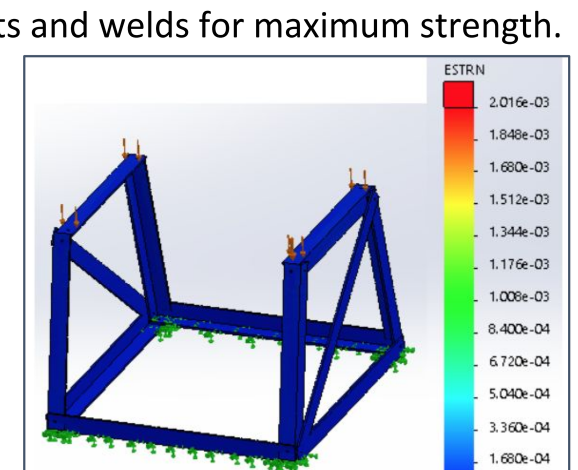
## Design Process

**The overall project is broken down into the following subcategories: Mechanical System, Electrical System, Tilting System, Transportation, and Safety. Specifications regarding the transportation and safety systems were meet by adapting off-the-shelf items to the mobility chair. The Mechanical, Electrical, and Tilting System were designed and built by the Capstone team as shown below.**

### Mechanical System

- Original frame was a simple rectangular design made of round, hollow tubes.
  - Simulation testing showed the strain to be high risk.
- To Mitigate this risk, the following design changes occured:
  - Material changed to 2x2 1:4 angled 6061 T6 aluminum
  - Frame design updated to be trapezoidal with cross supports
  - Frame construction consists of bolts and welds for maximum strength.

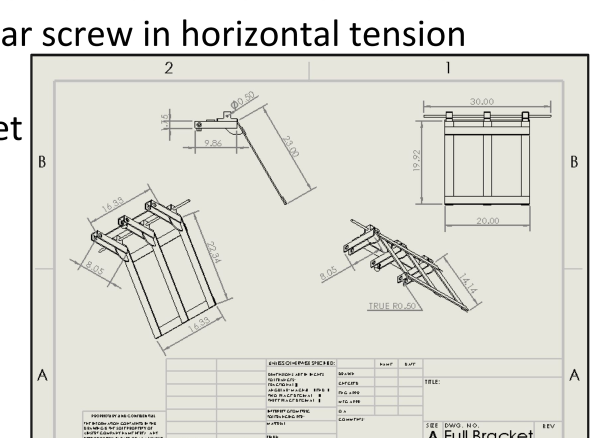




*Strain of original frame design (pictured left) versus strain of updated frame design (pictured right)*

### Titling System

- The original tilting system used a dual-lead screw configuration on the lateral portions of the chair.
  - Industry professionals mentioned risk of binding and motor slippage
- To mitigate risk, the following design changes were made
  - Single 16 inch stroke linear actuator to replace lead screws
  - Orientation of tilting system switched from vertical to horizontal to put the linear screw in horizontal tension (mechanical advantage)
  - A custom pivoting-bracket system to connect the actuator to the chair



*Engineering Drawing of the custom made pivoting bracket*

### Electrical System

- The electrical system is composed of a PCB, Raspberry Pi, and 12V battery.
- The circuit is set up in two parts. There is a voltage divider for the raspberry pi power, and a setup with two transistors and resistors from the battery to the motor.
- Each transistor is activated by one of the tablet outputs, allowing two directional motion with the motor.
- Throughout the design process it was found that the electrical system evolved based upon changes made in the tilting system.

$$R1\ Voltage\ Division = 2.33\Omega = \frac{1}{\left(\frac{1}{2.7}+\frac{1}{18}+\frac{1}{330}\right)}$$

$$R2\ Voltage\ Division = 1.66\Omega = \frac{1}{\left(\frac{1}{1.8}+\frac{1}{22}\right)}$$

$$Motor\ Current\ Control = 1.7143\Omega = \frac{1}{\left(\frac{1}{1.8}+\frac{1}{29}+\frac{1}{470}\right)}$$