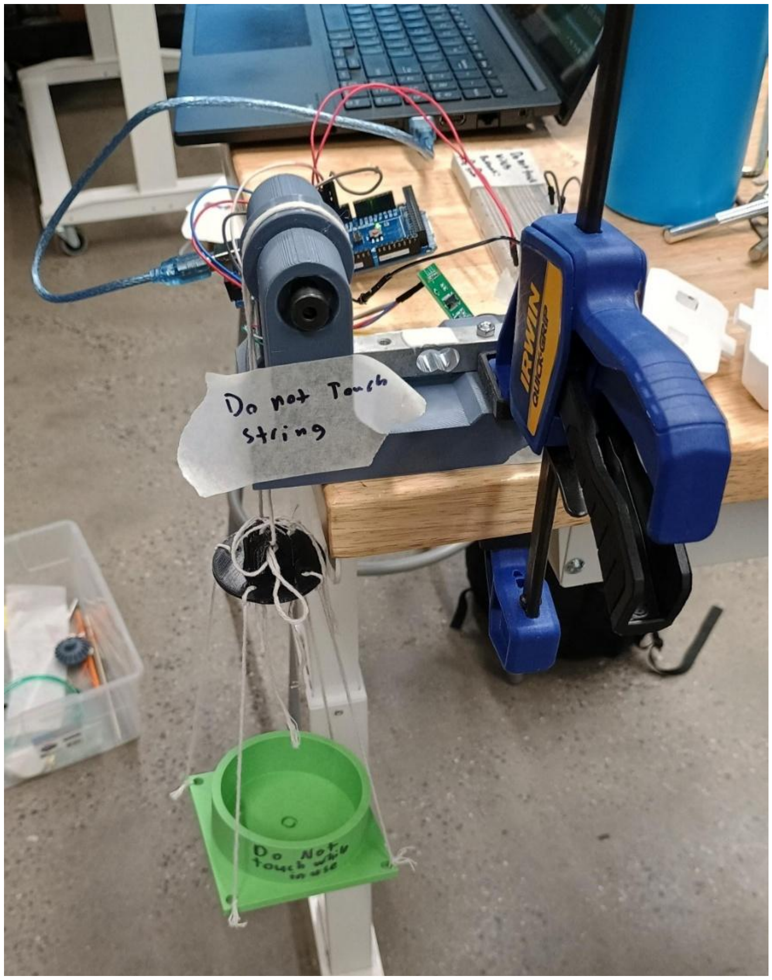
ME 104 Final Project (Mass Scale) Report



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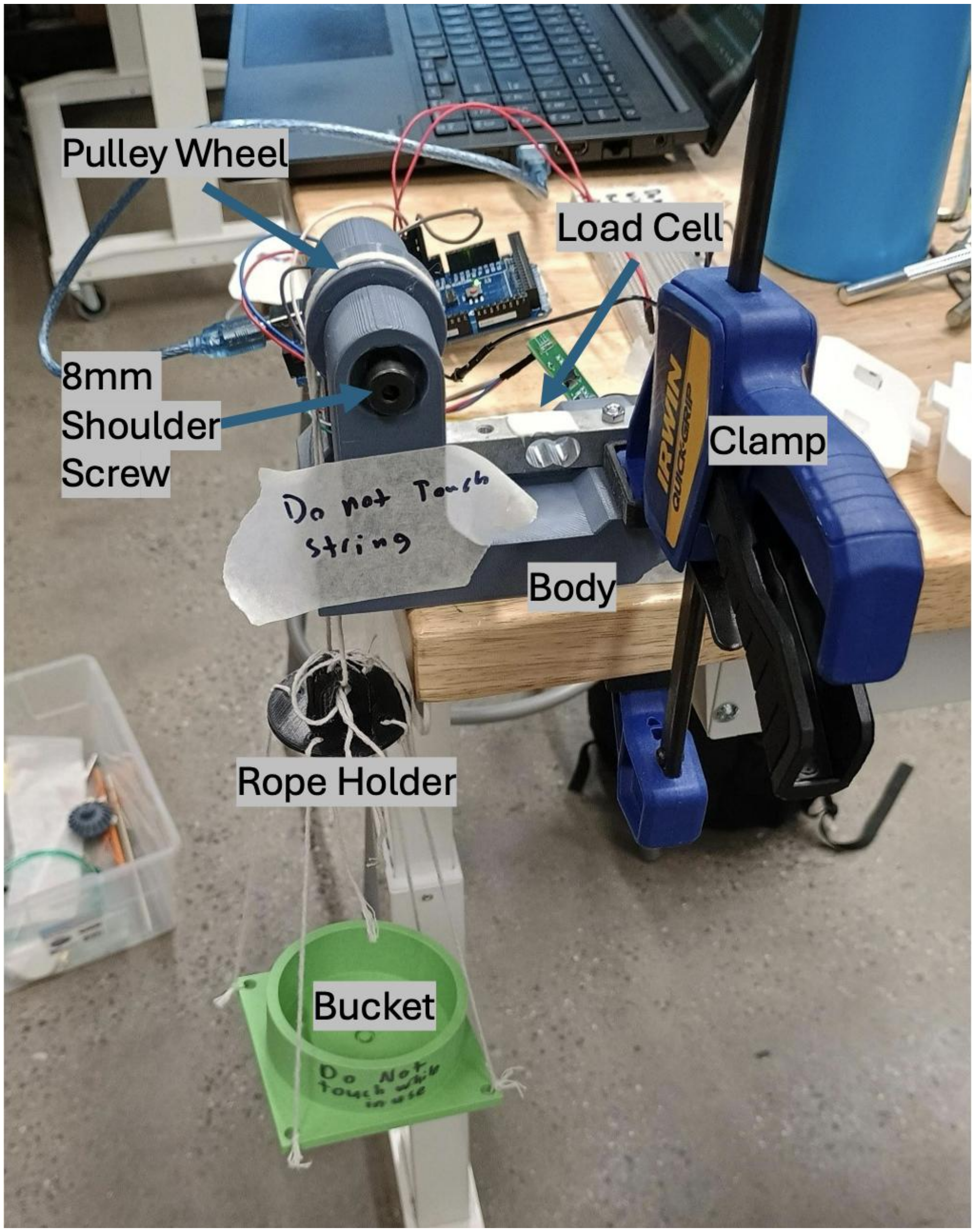
Introduction:

The objective of the scale project was to create a scale on a budget of $30 USD which could accurately measure a mass that the authors experimentally determined. The scale was to have at least two buttons, one of which was “TARE,” which cleared the weight on the scale, while the other switched the display units of the weight between grams(g) and ounces(oz).

It was determined that the measurement must be free from influences from external forces other than gravity acting on the weight that was to be weighed. Based on the knowledge of constraints from statics, the authors came up with three initial solutions: one where the weight was placed onto a plate which slid on a linear rail normal to the measuring plane of a load cell; one where the weight instead of sliding on a linear rail, was attached to a long, hinged arm and rested on the load cell; and one where the weight was dangled from a pulley and the rope holding the weight looped around the pulley and down to a load cell. The design with the pulley was chosen because it was the simplest and required the least parts, while fully freeing the load cell from any forces that were not normal to its plane of measurement. A variation, consisting of a load cell with one end attached to the weight and the other end attached to the weight was considered but rejected as any irregularities in the angle of the table relative to gravity could impact the results.

Mechanical Design:

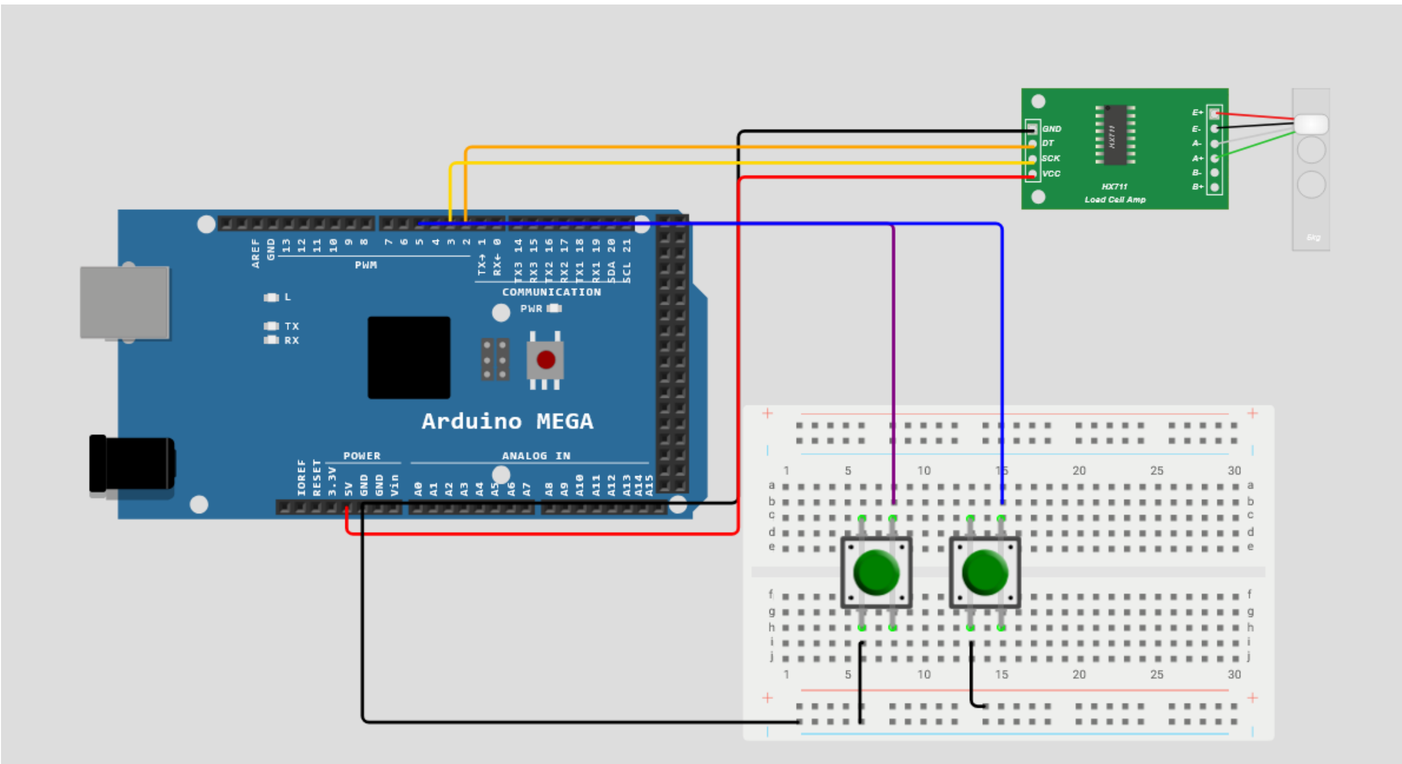


The body of the scale centered around using a 10kg load cell to get accurate readings which could then be turned into grams or ounces (depending on which mode the scale is in). Utilizing the screw holes on one end of the load cell, a part was designed with an elevated platform which matching screw holes. This would allow for the load cell to be kept in place while also allowing for the other end of the load cell to hang off the platform, which would be necessary for data collection.

Now that the load cell was properly attached to the body, the pulley system was constructed through use of a 3D printed wheel which attached fit onto an 8mm shoulder screw. A string was then tied to the load cell, over the pulley and connected to another 3D printed part with the rope holder. This was a part with one hole at the top to connect to the pulley and 4 holes at the bottom, to be connected to the final part of the scale, which was the basket. The main features of the basket were a circular outer wall to stop the weight from possibly sliding off and the 4 holes in the bottom. 4 holes were chosen (1 at each corner) to provide the most stabilization for the bucket and to ensure that it did not tip in any direction should a mass not be perfectly centered. The last step in setting up the scale was to use a clamp to stop the scale from potentially tipping over and ensuring that all the load was being measured by the load cell which was tied to the pulley.

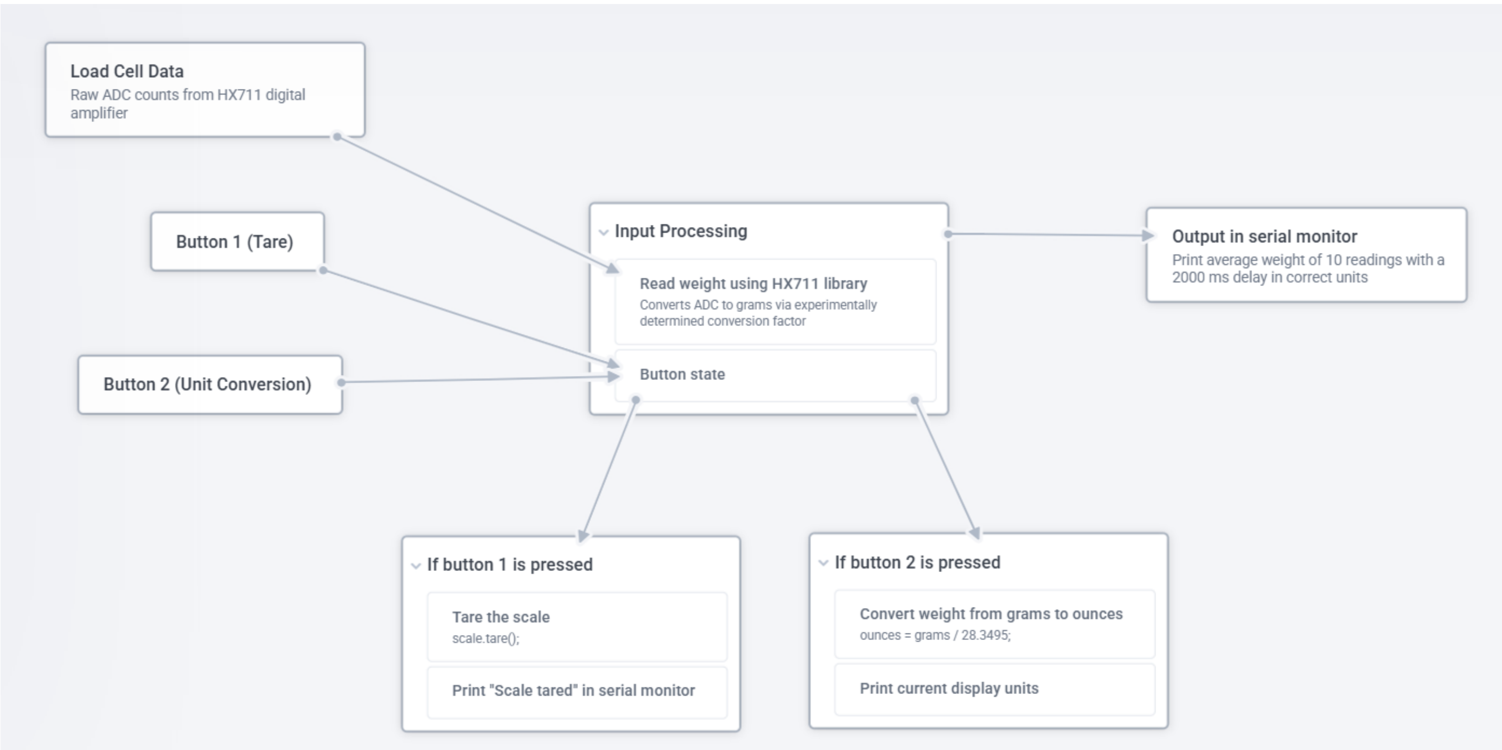
Electrical Design:

The load cell wires were soldered directly to the HX711 amplifier board, while jumper wires connected the HX711 to the Arduino. The button circuitry was assembled on a breadboard using jumper wires.



Algorithm design:

The functional block diagram illustrates a weight measurement system that uses an HX711 load cell and two buttons (tare and unit conversion) to process input data, calculate weight in grams or ounces, and display the result on the serial monitor.



Data Analysis

Max weight:

The max weight was determined by the size of the mass basket is 2 kg, the 2kg calibration mass was determined to be the largest that could fit in the basket.

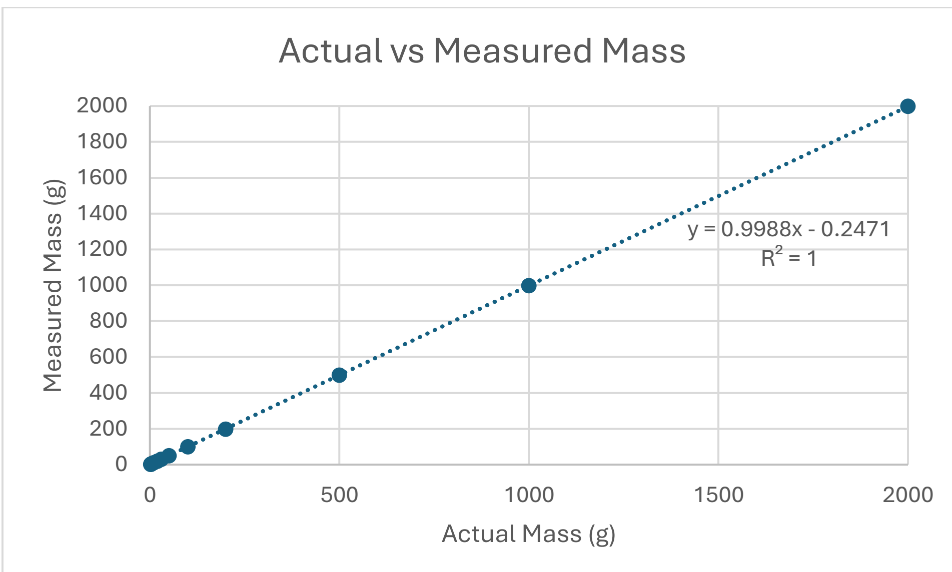
Percent error of full scale:

$$\frac{|2000 - 1997.92|}{2000} \times 100 = 0.104\%$$

The mass scale recorded a measurement of 1997.92 g, while the actual mass was 2000 g.

Linearity:

The following plot was obtained by measuring a range of masses from 2 g to 2000 g. The 300 g mass was not measured because it was missing from the set.



The plot of actual vs measured mass shows a strong linear relationship, with a slope of 0.9988, indicating that the measured mass is very closely equal to the actual mass. Additionally, a R^2 value of 1 shows a perfect linear correlation between the measured and actual masses.

Standard deviation

A standard deviation of 0.2614 was calculated after repeatedly weighing a 100 g mass 44 times, with a 2000 ms interval between each measurement.

Sources cited:

[1] ShangHJ, “J 4 Sets Digital Load Cell Weight Sensor + HX711 ADC Module Weighing Sensor for Arduino DIY Portable Electronic Kitchen Scale Kit (10kg) .” 2025

[2] M. Giglia, “7 - Amplifier,” in *ME103B*, Mar. 25, 2025

[3] M. Giglia, “10a - Final Project Introduction,” in *ME103B*, Apr. 9, 2025

Acknowledgements:

- The authors would like to thank Prof. Sidebotham for attending the measurements lab classes and teaching statics so the scale could be designed with the correct statics principles.
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