



# Helmet Testing Platform

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## Introduction

- Galvion LTD is a protective armor and head system manufacturing company focused on military personnel with all stages from design, R&D, and manufacturing done within the company.
- By making a helmet testing platform to measure the center of pressure (CoP) and moments on the neck vertebrae and muscles using tactical headborne equipment, Galvion can improve and make safer, more comfortable equipment.

## The Testing Apparatus

### Assembling the platform

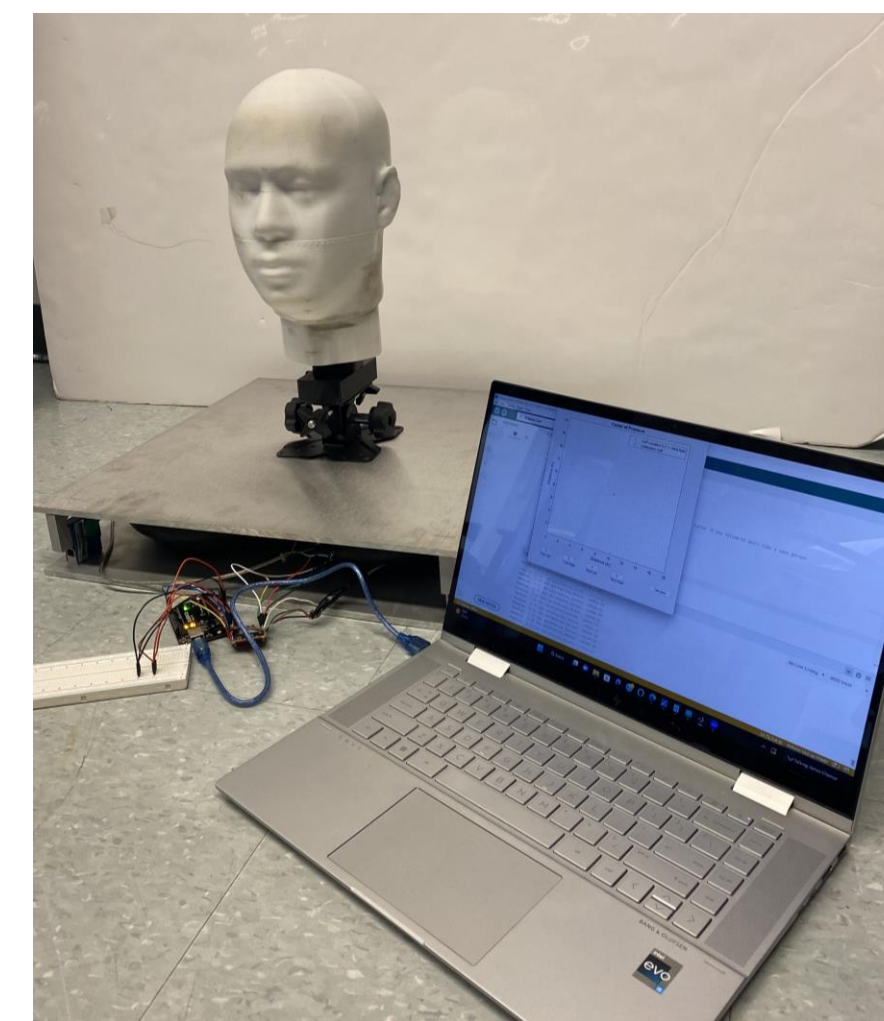


Image 1: Testing the model during assembly.

### Circuit Diagram

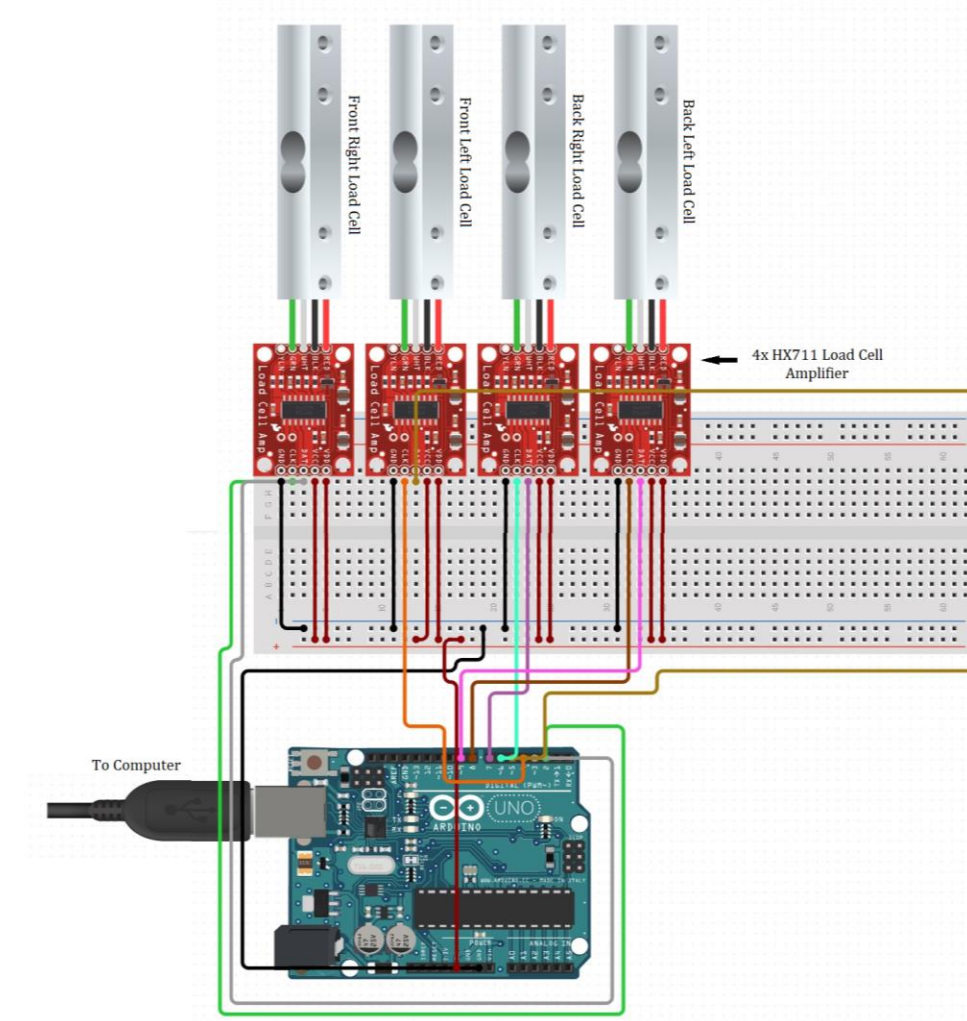


Image 2: Electronic Wiring Diagram using 4 HX711 amplifiers, 4 25lb S type load cells and an Arduino Uno R3.

## Equations and Validation

The following equations were derived from basic static moment and force equations for a 2D plate being supported at 4 corners :

$$y_f = \frac{F_1 + F_2 - F_3 - F_4}{\Sigma F} \cdot \frac{H}{2}$$

$$x_f = \frac{F_2 + F_4 - F_1 - F_3}{\Sigma F} \cdot \frac{L}{2}$$

Where F1, 2, 3, and 4 correspond to the top left, top right, bottom left, and bottom right sensor readings respectively, H referring to plate height, L referring to plate length, and Yf and Xf being the x and y location of the CoP with respect to the center of the plate

With the 4 force outputs from the sensors, and the length and width of the plate, the x and y location of the CoP projection on the plate is calculated.

## Design Requirements

- Accurately measure load-induced shifts in CoP of a head model with different helmet designs and loadout.
- Include a neck model with at least an anatomical range of motion capable of incremental adjustment along sagittal and frontal axes.
- Allows for quasi-static measurements with continuous rotation along range of motion preferred.
- Expedite testing process with easily swappable head forms.

## COP Results Presentation

### CoP Equation Validation

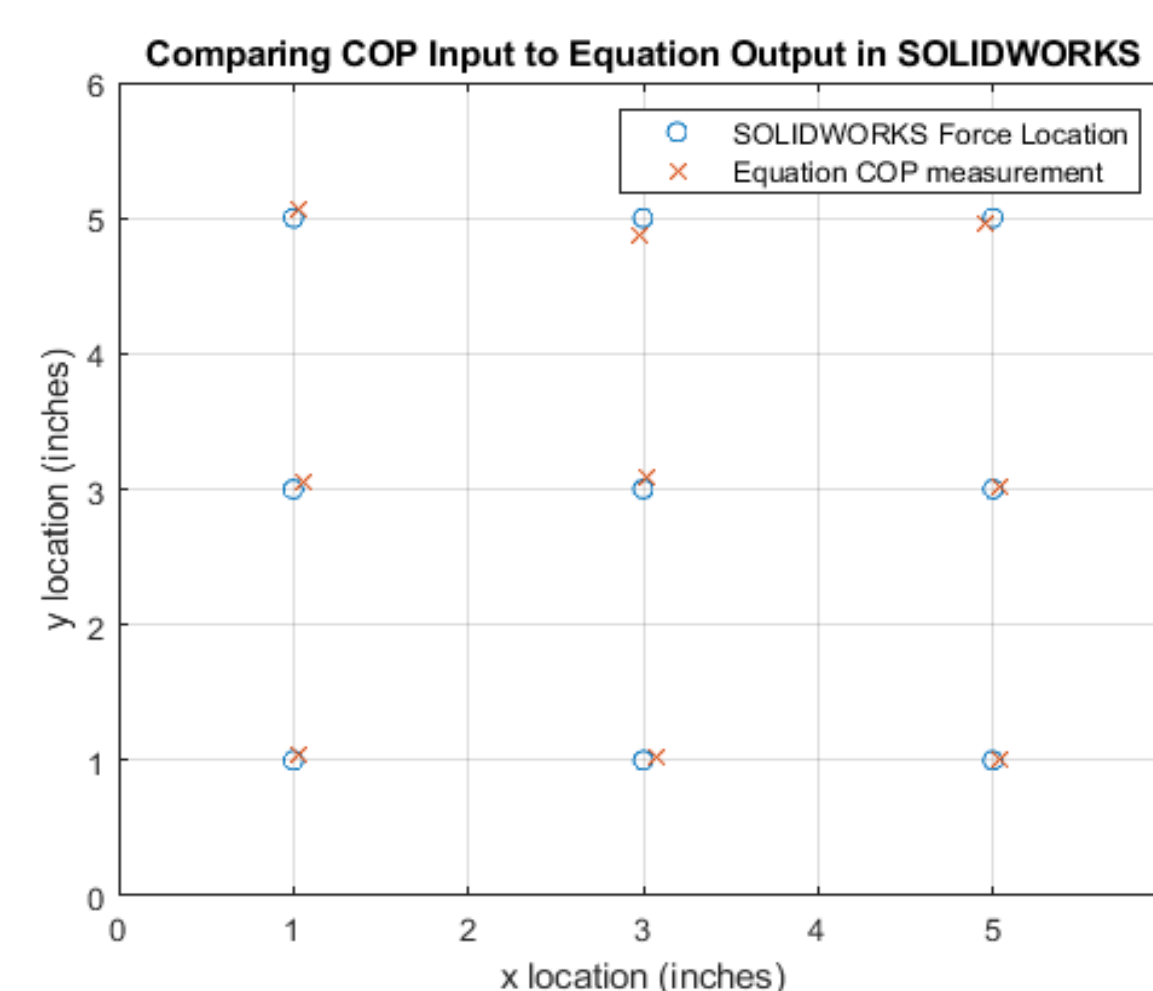


Image 3: Plot from testing COP location calculated with shown equations compared to SolidWorks simulated COP location.

### Graphical User Interface

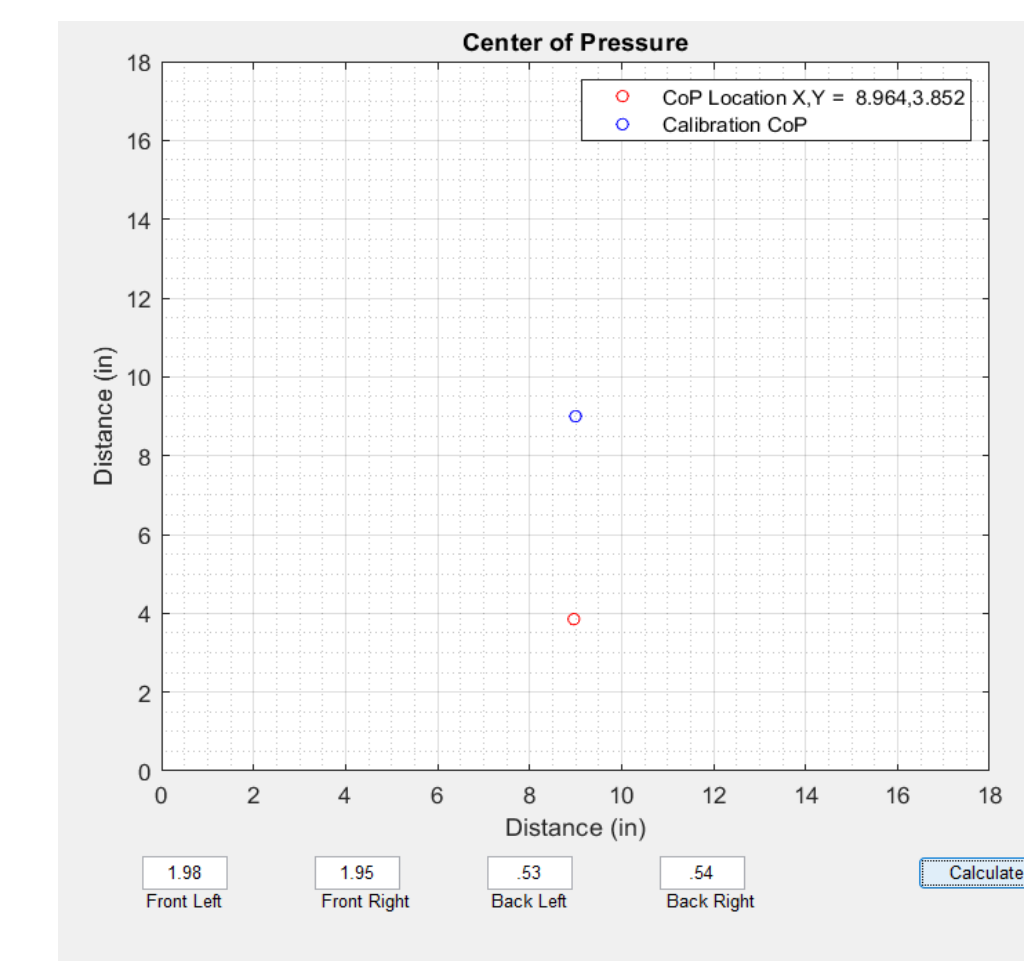


Image 4: MATLAB GUI that allows for 4 inputs, based on obtained force values from circuit, to easily calculate CoP.

## Future Steps

- Maximize range of motion for mounting platform.
- Compare Arduino measurements to LabView DAQ measurements.
- Test and modify final design and code respectively to make CoP accuracy comparable to rated accuracy of load cells ( $\pm 0.08$  oz.).
- Conceal wiring and customize to off-the-shelf quality for Galvion's needs.
- Obtain device (digital level) to measure the pitch and roll of the neck mount.

## Methodology

- Design plate with load sensors, head model, and model neck with pitch and roll capability.
- Develop moment-equations that can be used to find the CoP on a plate supported at its corners.
- Fabricate testing platform fitted with Arduino Uno R3 and create code for retrieving sensor measurements.
- Calibrate voltage output from HX711 amplifier and perform CoP evaluation with GUI.
- Test and refine calculations to approximate stress and moment about chosen vertebra.

## Mounting the Head Form to the Plate

### Head Form Mount (to the neck)

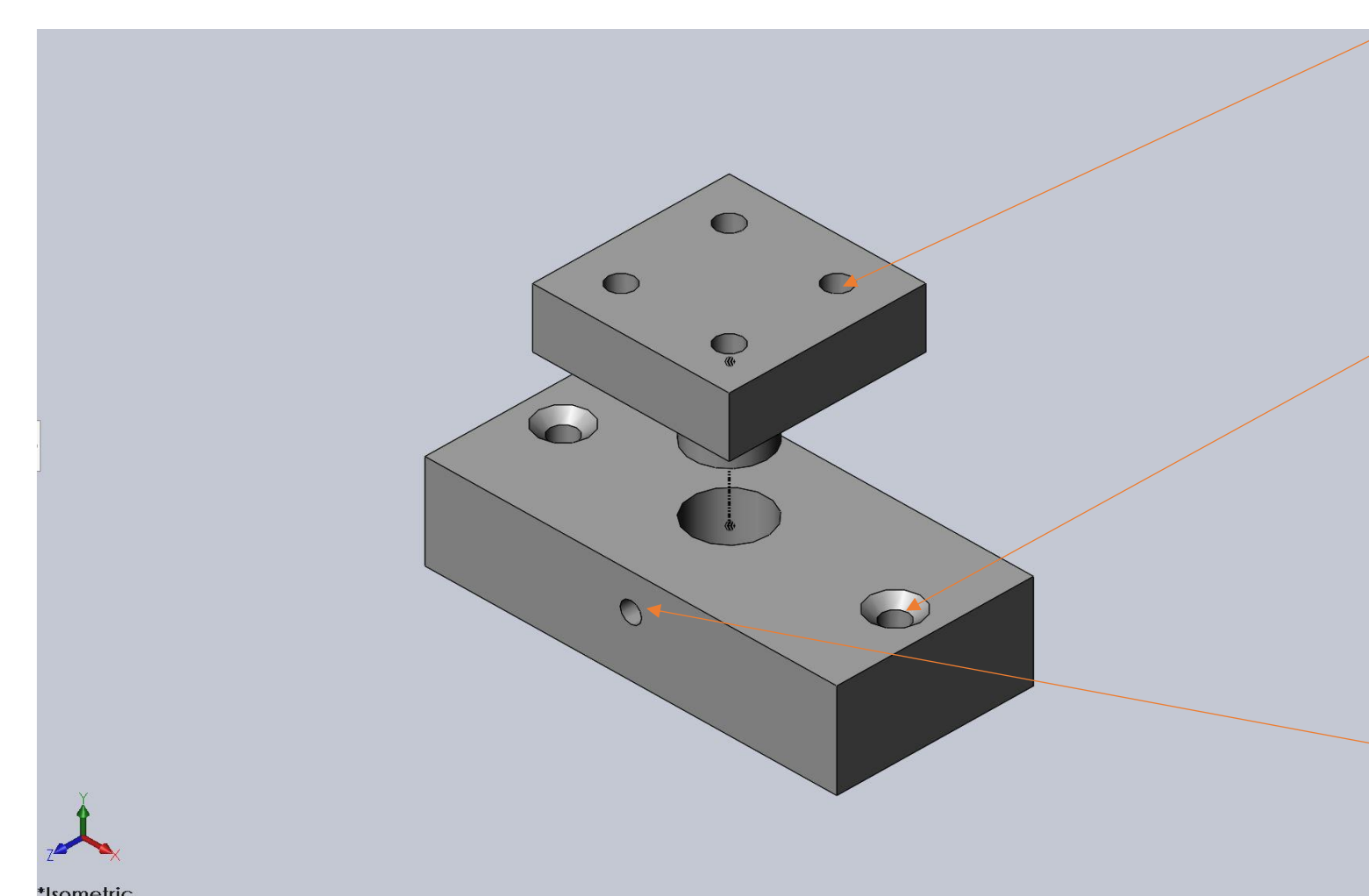


Image 5: Custom 3D printed PLA plastic mount. Allows for easy removal of head models and facilitates 360 degrees of yaw with the use of a set screw.

### Pivoting Neck Mount

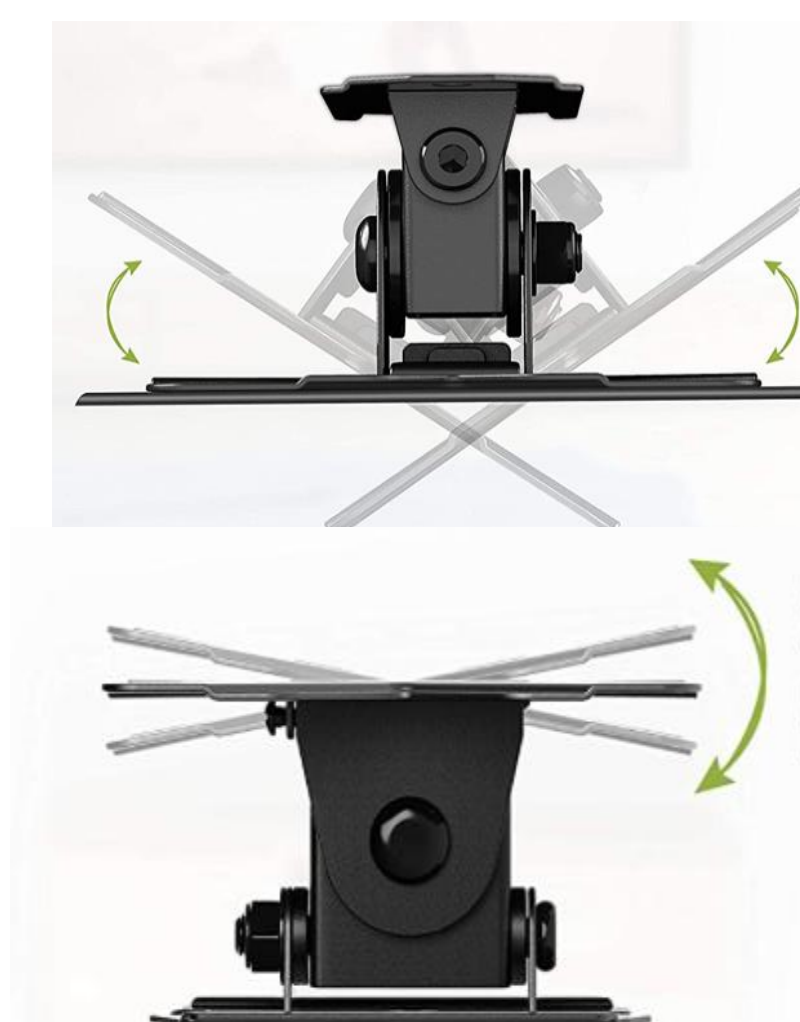


Image 6: Commercial off the shelf neck mount allowing for pitch and roll of the head form.

## Acknowledgements

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## References

- [1] S. Al-Mutlaq, "Load Cell amplifier HX711 breakout hookup guide," *Load Cell Amplifier HX711 Breakout Hookup Guide - SparkFun Learn*. [Online]. Available: <https://learn.sparkfun.com/tutorials/load-cell-amplifier-hx711-breakout-hookup-guide>. [Accessed: 13-Apr-2023].