



University  
of Idaho

# Mass Property Measurement Device



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## Background:

SEL designs and manufactures many digital products ranging from transmission protection to control systems around the globe. To better understand the failure modes of the products, a series of mechanical analysis is performed by SEL. Computer-Aided Design (CAD) models lack detailed information about component density, which leads to inaccurate measurement of the Center of Gravity (CG) of the product. By building a device, which measures the CG of the product automatically, using mass sensors will help to solve the issue of incorrect CG measurement of SEL products.

## Objective:

- A device to measure CG in 3 axes.
- CG location is an important point for failure analysis.
- Current methods of determining CG are inadequate.
- Simplify workflow for SEL employees.

## Requirements:

- Automated
- Calculates 3D center of gravity for complex objects
- Accuracy of within 1% or .1 inches
- Static load of 50 lbf
- 20in cube maximum specimen size
- Operate 1-year maintenance free
- Standard 120V AC outlet
- \$5000 budget

## Concept Development:

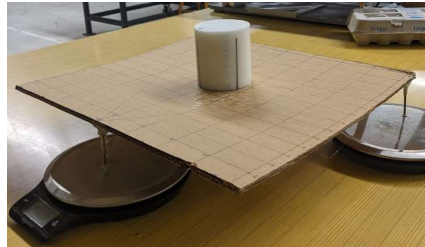
Center of gravity can be determined by acquiring the forces' due to gravity at three locations in two orientations, one flat to measure X and Y-coordinates then remeasure at an incline to calculate Z-coordinate.

$$X = \frac{(F_2 + F_3) * L}{W} \quad X' = \frac{L * \cos(\theta) (F_2' + F_3')}{W}$$

$$Y = \frac{(F_3 + F_2) * D}{2W} \quad \alpha = \tan^{-1}(\cot(\theta) - \left(\frac{X'}{X \sin(\theta)}\right))$$

$$Z = R \sin(\alpha)$$

## Prototypes:

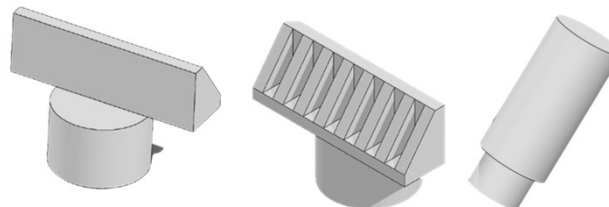


Flat Orientation Testing

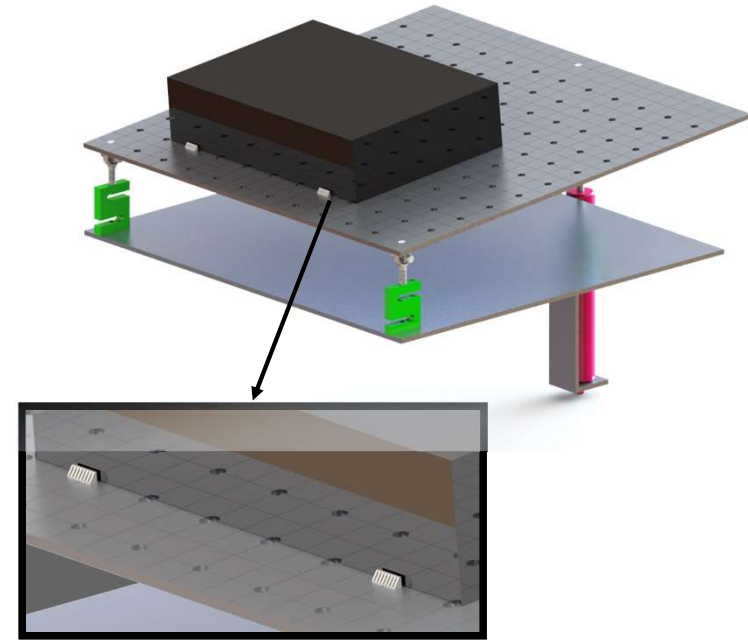


Inclined Orientation Testing

## Table-Top Design:



Pegs made to fit into the tables surface and configurable to a variety of shapes.



## Testing:

Total Tests: 265

With initial prototype, less than 10% of data out of 0.1in error bounds in X and Y

With initial prototype, Z-coordinate error close to within bounds using new method

## Future Design Considerations:

- Load cells moved underneath table lifting mechanism
- Use off the shelf locating pins instead of designing custom pegs

## Acknowledgements:

- Jonathan Richards, Mechanical Engineer Manager, SEL
- Dr. Michael Maughan, Advisor Professor
- Maxwell Johnson, Graduate Student Mentor