**BACKGROUND:**

Chris Hewatt of Denver, CO developed a theoretical concept for a novel propulsion device. This device utilizes the principals of centrifugal force and conservation of angular momentum to create forward thrust. Potential applications for this device would most likely be boats and wheeled typed vehicles.

The device would utilize an electric motor or combustion engine to power a shaft mounted vertically on a vehicle. Attached to this rotating shaft is a rigid horizontal arm at the tip of which is an independent vertical axis. This axis supports an independent body which maintains its orientation relative to the vehicle regardless of the supporting arm orientation.

The theory behind this novel device is a forward thrust force is generated when the independent body becomes rigidly affixed to the rotating arm. The purpose of this project is to mathematically calculate the thrust potential of the device. The device will be kept to its most basic form and will not take into account the workings of the device. A basic overview of the conceptual device can be viewed in Figure 1.0 along with its corresponding coordinate system.

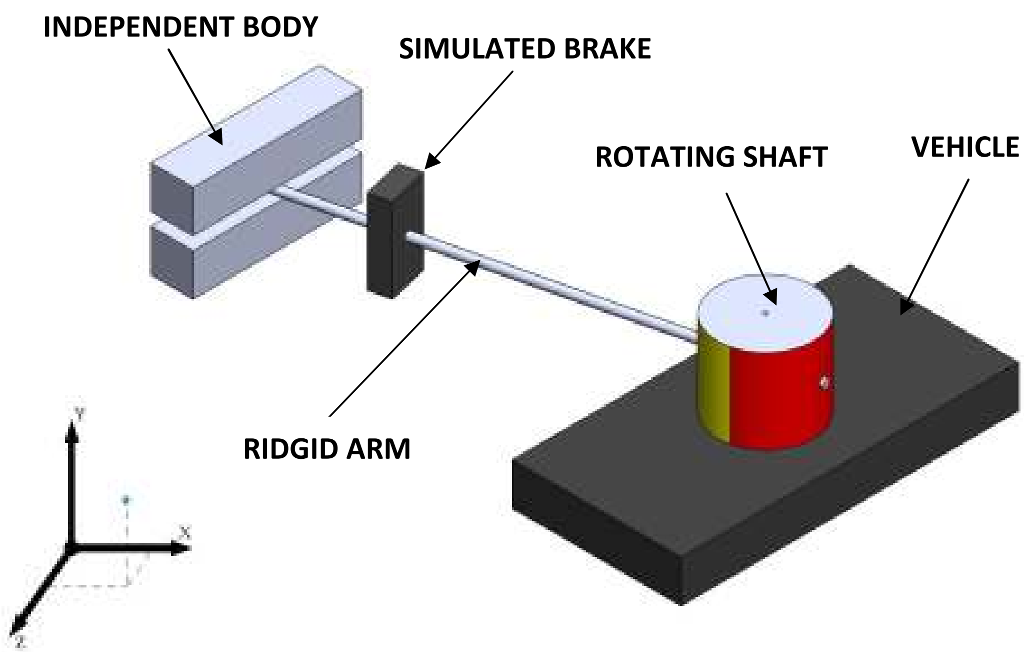


Figure 1.0 Experimental Propulsion Device

**OBJECTIVES:**

The primary object of this project phase is review two key system properties to determine their effect on the overall thrust potential of the vehicle.

1. Mass of Independent Body relative to mass of rotating shaft.
2. Rotational speed of rotating shaft and rigid arm relative to independent body

**METHODS:**

The primary tool utilized will be a 3D kinetic body simulation utilizing SolidWorks CAD software combined with the SolidWorks Motion simulation package. This package is a very powerful tool to assist in visualization the forces and actions taking place in a complex kinetic body. The first step was creating a simple kinematic model that accurately represented the intentions of the design. Figure 2.0 represents a top view of this model.

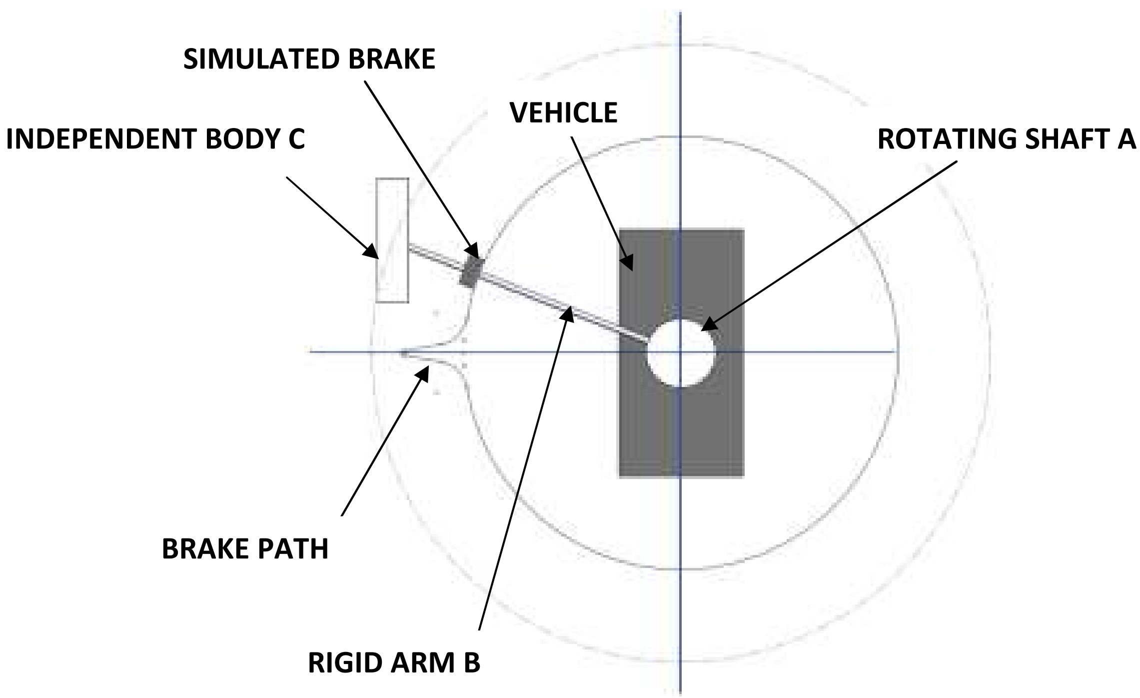


**Figure 2.0 Layout View of SW Kinetic Model**

The solid body volume of the rotating shaft and independent body were set to 1.0 cubic inch such that the assigned density of the part would be equal to the desired weight of the body. The vehicle, rigid arm and simulated brake were all assigned an extremely low density to give them a negligible weight relative to the whole system.

Once the model was created a constant velocity motor feature was attached to the rotating shaft, a contact feature with a Coefficient of Friction value of 1.0 was created between the brake and independent body, and a z direction reaction force measurement was assigned along the rotational axis of the primary shaft.

**CONFIGURATION ONE:**

The model was subsequently run with three different load cases with a rotational speed of 10 and 20 RPM run for each load case.

- Load Case 1: Rotating Shaft A to be 75% of the total mass of the entire device with Independent Body C to be 25% of the total mass. For this exercise a value of 75 lbm and 25 lbm were subsequently used.
- Load Case 2: Rotating Shaft A to be 50% of the total mass of the entire device with Independent Body C to be 50% of the total mass. For this exercise a value of 50 lbm and 50 lbm were subsequently used.
- Load Case 3: Rotating Shaft A to be 25% of the total mass of the entire device with Independent Body C to be 75% of the total mass. For this exercise a value of 25 lbm and 75 lbm were subsequently used.

**CONFIGURATION ONE RESULTS:**

Upon reviewing the results it was discovered a thrust force does indeed occur when the brake engages independent axis C at the desired location. The issue with this design however is the eccentric (vibration) forces generated are far greater in magnitude than the thrust forces generated when the brake is applied. The eccentric forces are sinusoidal in nature and occur in both the x and z directions. You can reference the included data tables, charts, and video files to gain a greater understanding of the results.

When viewing the charts you will see momentary spikes in the thrust force value which coincide with the force generated when the brake is applied to Independent Body C. In order to obtain a straight-line force the duration and orientation of this impulse brake has to be strategically applied and released. Future work could be done in this area to further understand this relationship in regards to thrust forces.

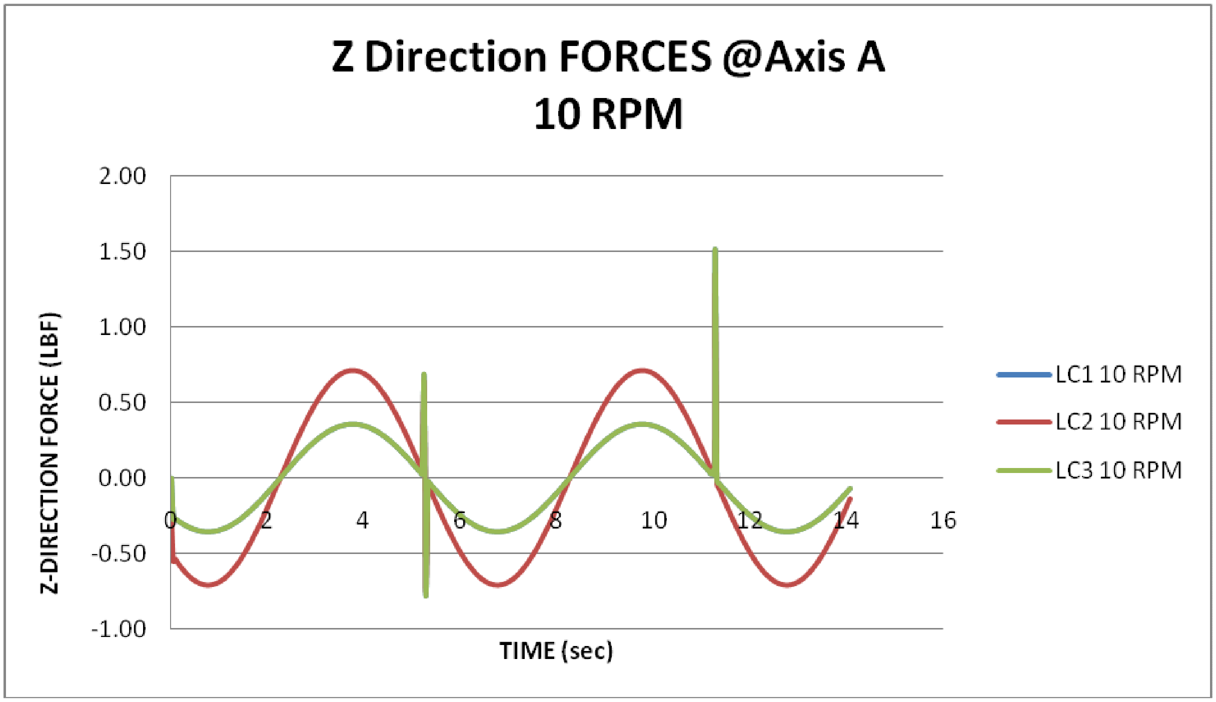


**Figure 3 Z-Direction Forces @ Axis A at 10 RPM**

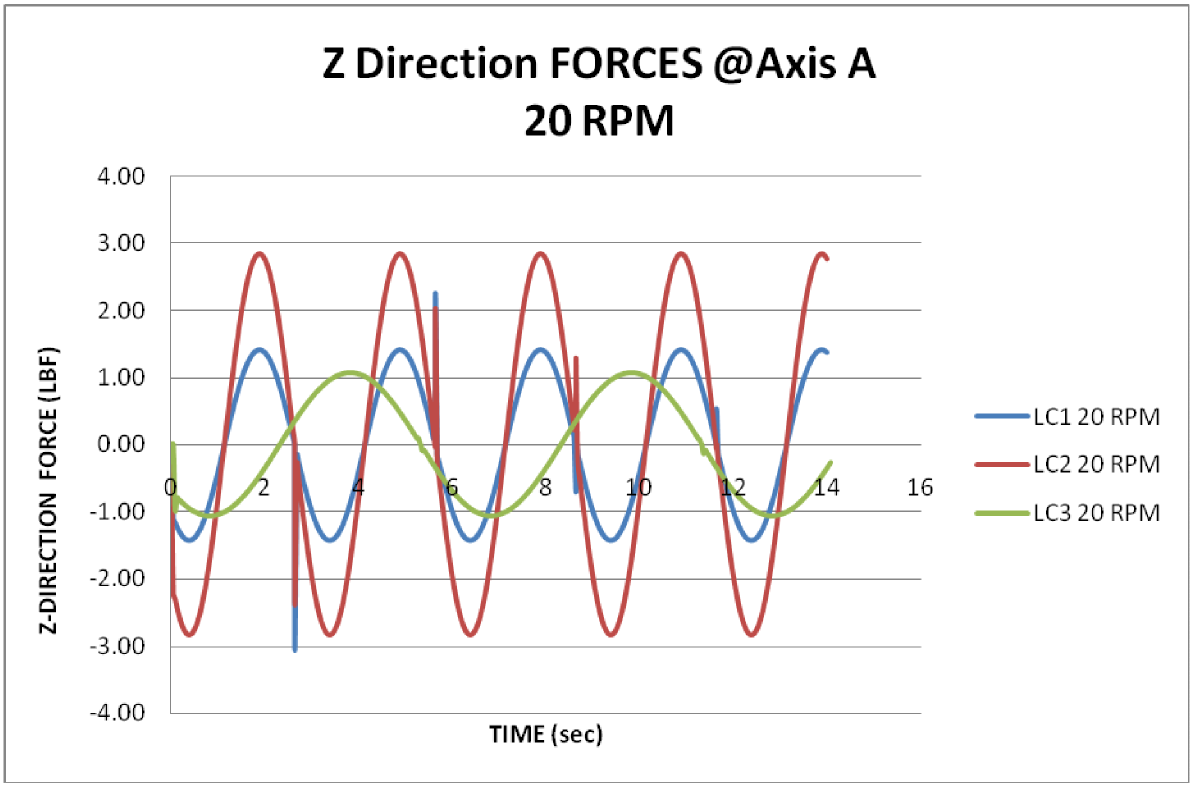


Figure 4 Z-Direction Forces @ Axis A at 20 RPM

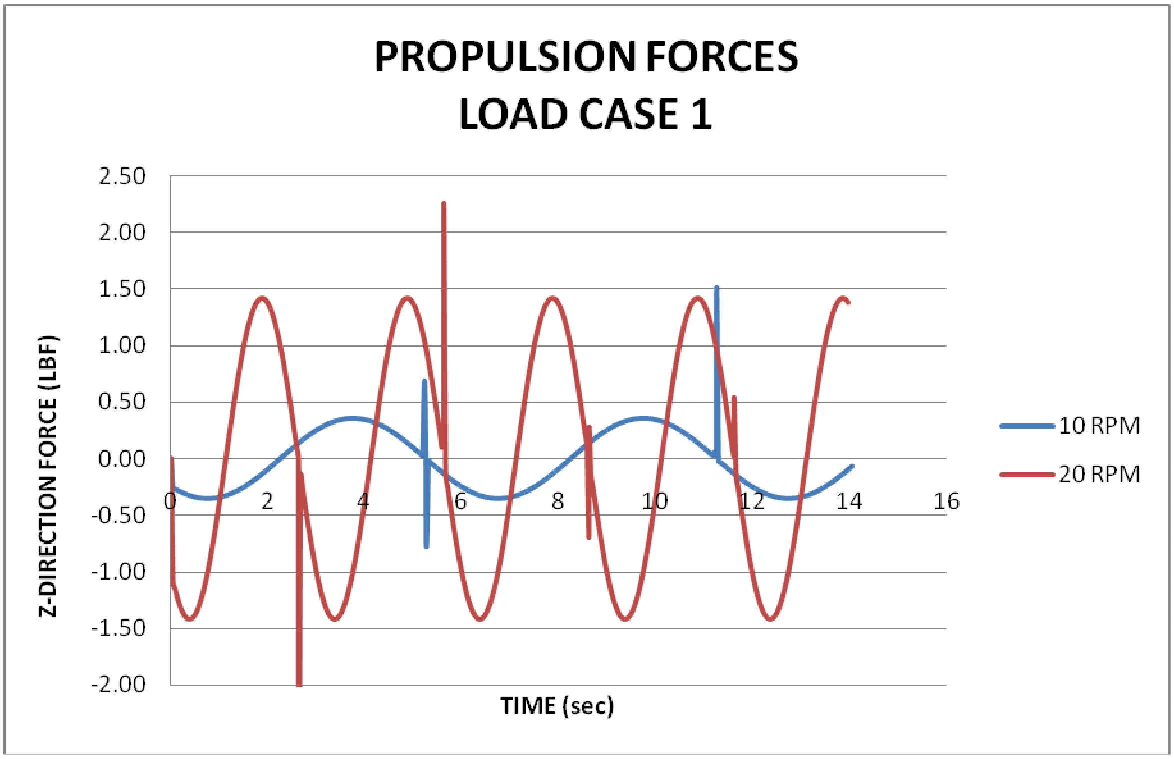


**Figure 5 Z-Direction Forces @ Axis A with Load Case 1**

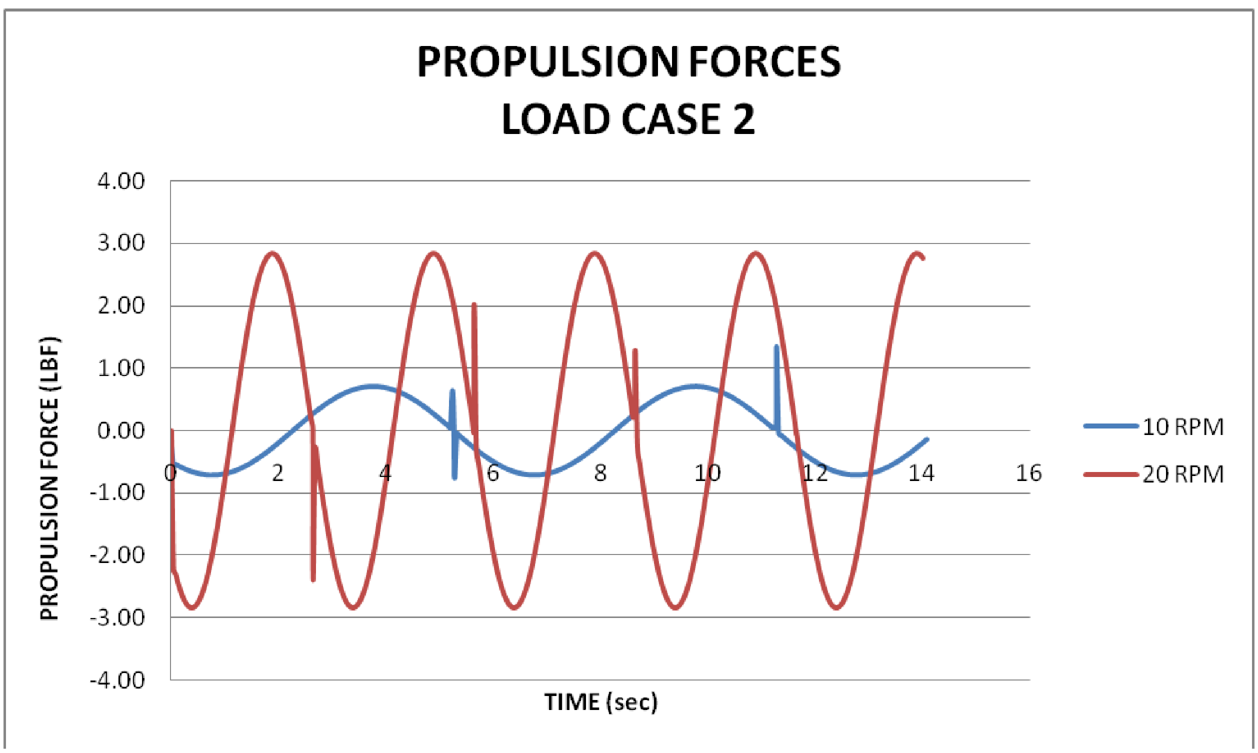


**Figure 6 Z- Direction Forces @ Axis A with Load Case 2**

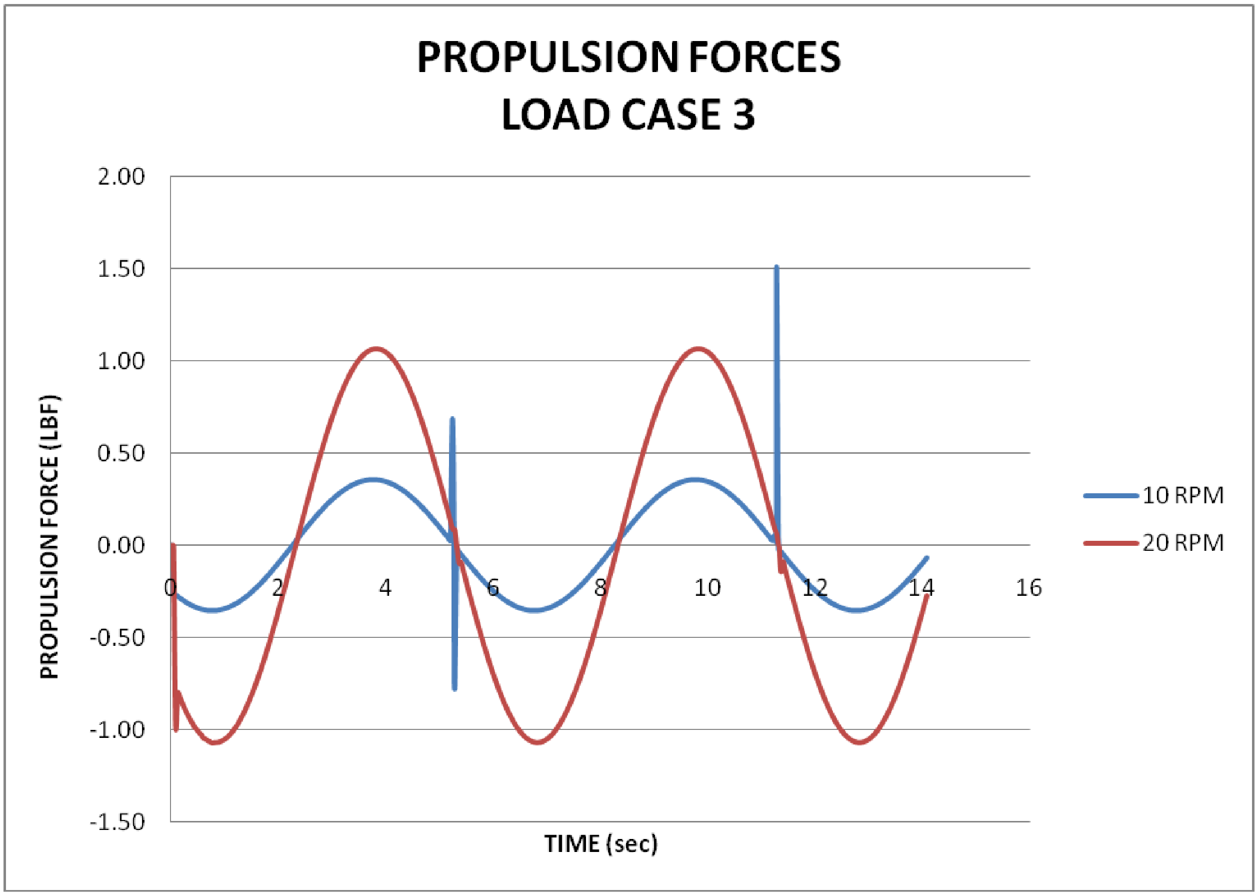


Figure 7 Z- Direction Forces @ Axis A with Load Case 3

**CONFIGURATION TWO:**

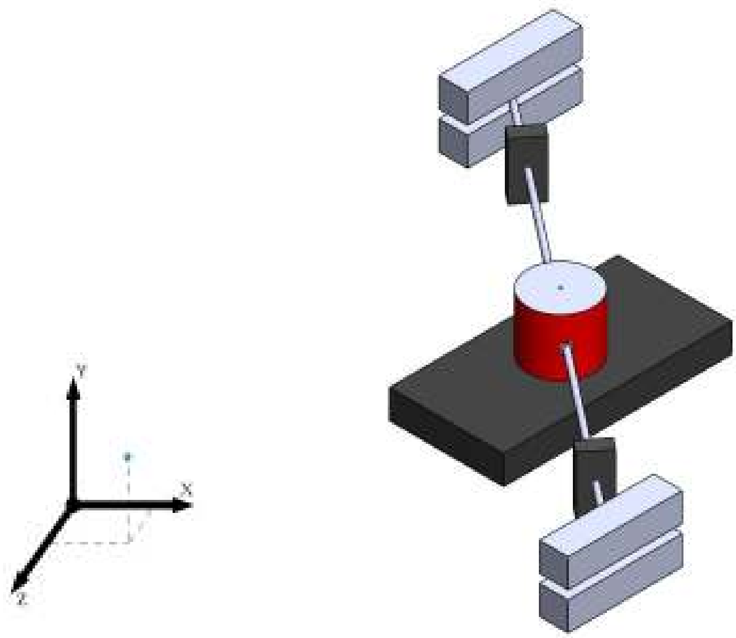


**Figure 8.0 Configuration Two Isometric**

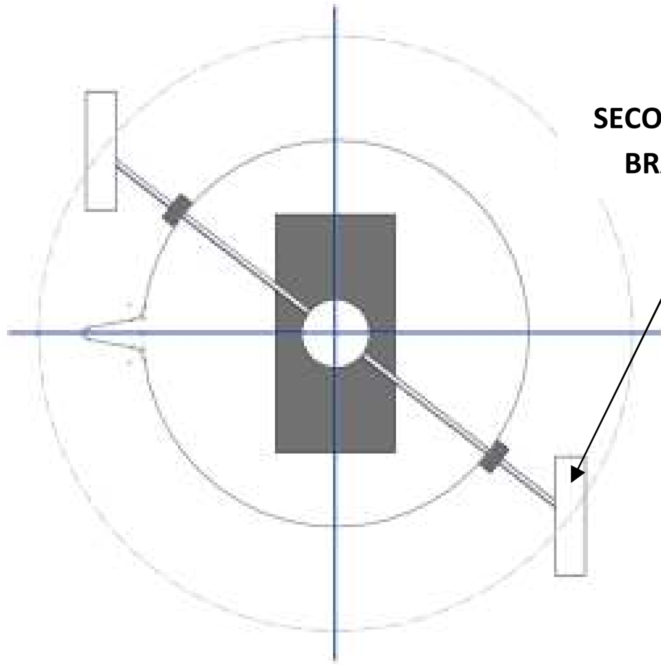


Figure 9.0 Configuration Two Top View

**CONFIGURATION TWO RESULTS:**

Configuration two is a first attempt at dynamically balancing the assembly. The theory was the vibration noise being generated by the eccentric loading could be filtered out leaving only the thrust forces. A second goal was to great more efficient system in that two thrust pulses per revolution would be generated. From the results as depicted in Figure 10 you will see a short load spike at start up and three spikes at roughly 2, 6, and 8 seconds. These spikes represent the thrust force generated when the brake engages independent mass C.

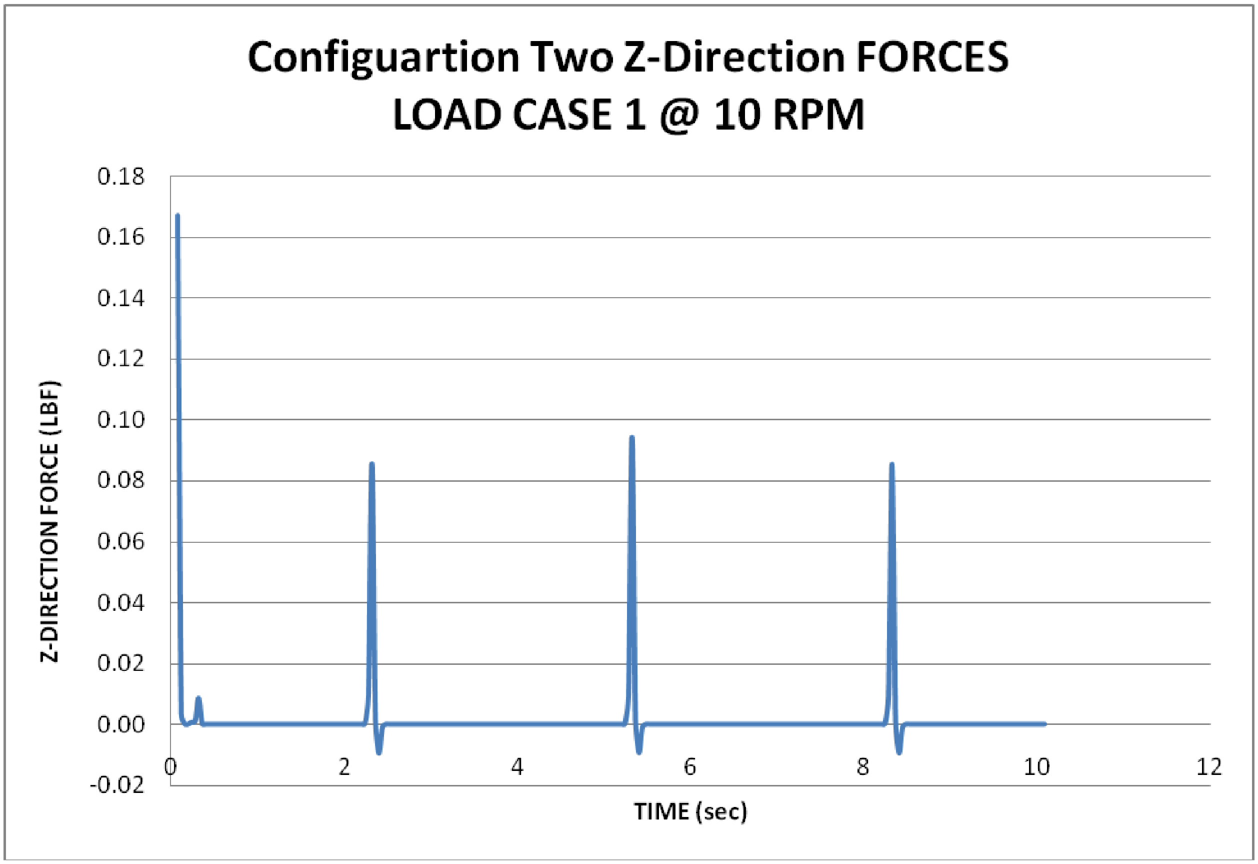


Figure 10 Configuration Two Z- Direction Forces @ Axis A

**CONFIGURATION THREE:**

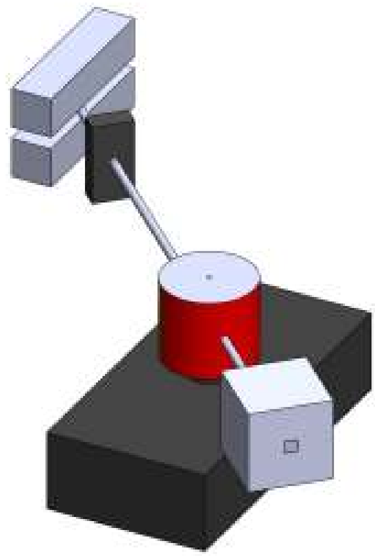

Figure 11 Configuration Three Isometric View

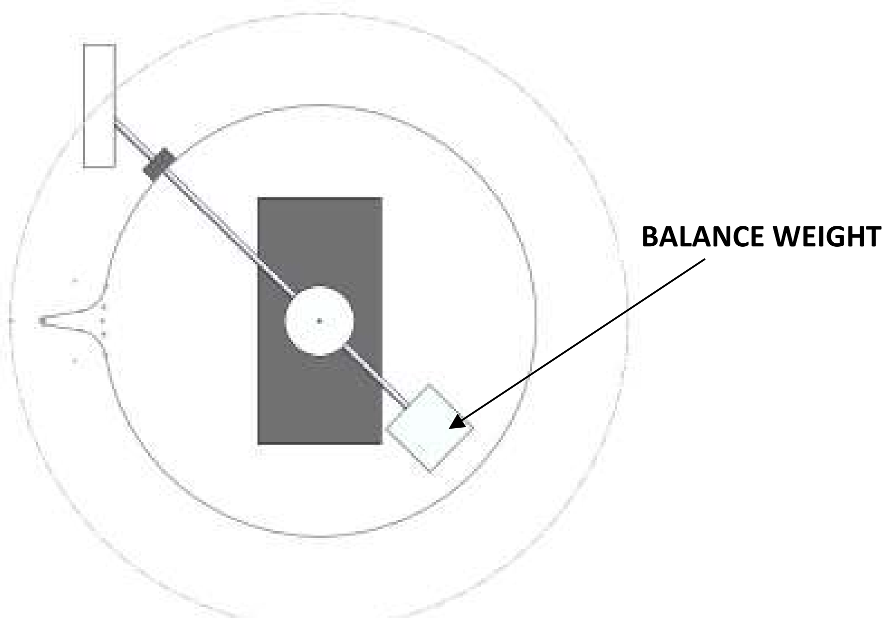


Figure 12 Configuration Three Top View

**CONFIGURATION THREE RESULTS:**

Configuration three was created to show only those forces generated by a single independent mass being engaged and disengaged. This was accomplished by adding a counterbalance weight to dynamically balance the assembly. The results are very similar to those seen in configuration two. You will notice a short spike created during startup along with two thrust pulses coinciding with the brake being engaged over two revolutions.

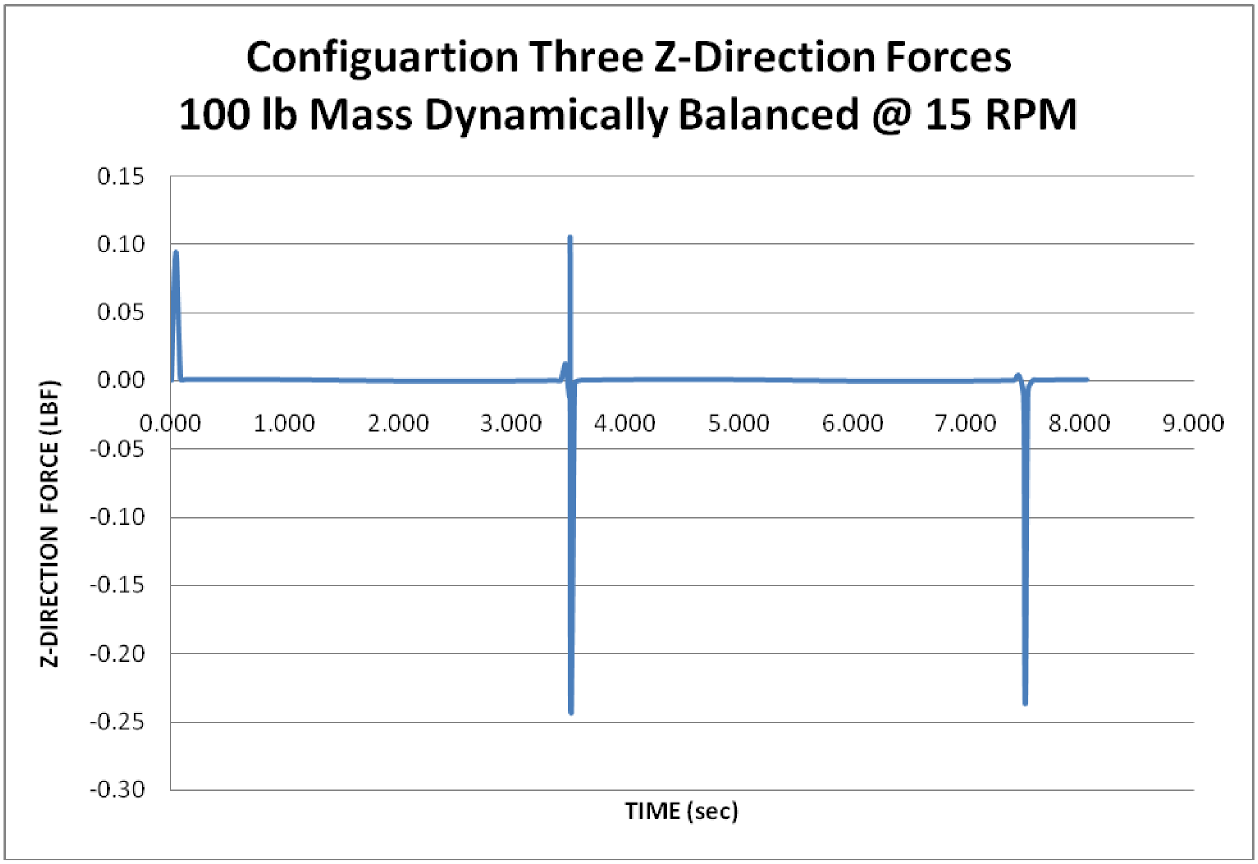


Figure 13 Configuration Three Z- Direction Forces @ Axis A

**SUMMARY:**

Upon a review of the results one can conclude the locking and unlocking of independent mass C creates a thrust force parallel in direction to the mass's direction of travel. This thrust force can be canceled out as a result of forces generated by eccentric or unbalanced loading. To prevent this force cancelation the rotating assembly needs to be in some way dynamically balanced. This can be accomplished with a counterweight or second identical brake and mass system located 180 degrees from the first mass and brake assembly.

The thrust force or impulse force generated with this method is maximized when generated over a very short period of time. For this reason the design of the brake or clutch system will be a very critical to the success of this propulsion system.

I believe future work should be focused on fine tuning the simulation of the brake engaging and disengaging. I also believe additional work should be placed on more accurately simulating the effects of the gyroscope on the independent mass. The results of this work will lead to a greater understanding of the variables surrounding the performance of this novel propulsion device.