In many high-speed devices (such as jet engines and tube charges), minimizing vibrations is critical. As excess vibrations can lead to poor efficiency and part fatigue.

One source of vibration comes when the center of mass of an object is not coincident with the center of rotation. As the off-set mass swings around, it exerts forces causing the object to vibrate. By attaching the object to a swing, we can constrain the forces to only act in a single direction (approximately), causing the swing to rock back and forth.

How can we correct this imbalance?

1. An accelerometer measures the periodic swinging motion given off by the spinning object.
2. An optical distance sensor records the time when the motor/object pass through the origin (0 deg)
3. A sin wave is fit to the acceleration data
4. The amplitude of the accelerations along with the phase shift between the rotation and acceleration in extracted, provide us with a vector representing the state of imbalance in the system

How can we use vectors to balance the object?

1. We start by measuring the initial background vibration
2. We add a small test mass somewhere on the object and take a second measurement. The new measurement is the sum of the background vibration, and the vibration induces by the test mass
3. We would like to know B (the independent effect of the added mass) but we cannot measure this quantity directly. Luckily simple math shows that B = A+B – A which are quantities we *can* measure.
4. In order to balance the wheel, we need to calculates B’ such that such that A + B’ = 0. This can be done using vector algebra.
5. The change in magnitude between B and B’ tells us how much heavier of lighter our test mass needs to be.
6. The angle between B and B’ tells us how much we need to adjust the placement of the mass.
7. Repeat the process until the desired vibration threshold has been reached

Does it work?

1. At high vibration magnitude, the machine is able to make state measurements precisely with a standard deviation of only 1 deg.
2. At low vibrations, the acceleration data is lost in the sensor noise, which limits the ultimate accuracy of the device.
3. In testing, the machine was able to decrease the vibrations in the unbalanced test-wheel by 80%.