1 Acceleration measurements

Links to all relevant python scripts can be found in the section: GitHub Links

A RPi pico accelerometer (RP2040-LCD-1.28) was used to measure the accelerations from the shaker. This accelerometer was programmed to output peak accelerations in x,y,z directions as well as the average accelerations in the x,y,z directions. The peak acceleration value (in x,y,z respectively) corresponds to a peak-to-peak acceleration measured by the accelerometer. The accelerometer was securely mounted to the shaker plate via a custom 3D printed mount. Acceleration data outputted by the accelerometer was read via a serial line connection to the PC. This experiment was only concerned with the peak z acceleration value, which was extracted from the data outputted by the accelerometer. In order to calibrate the accelerometer with the duty cycles from the shaker controller, a series of calibration cycles were performed. These involved running the shaker from a low duty cycle to a high duty cycle in small steps and recording both the peak z acceleration and the respective duty cycle. Sufficient length pauses were added between the increases in duty cycle to allow for the acceleration measurement from the accelerometer to stabilise. Acceleration data was averaged over multiple runs and the standard deviation on the peak acceleration measurements were calculated.

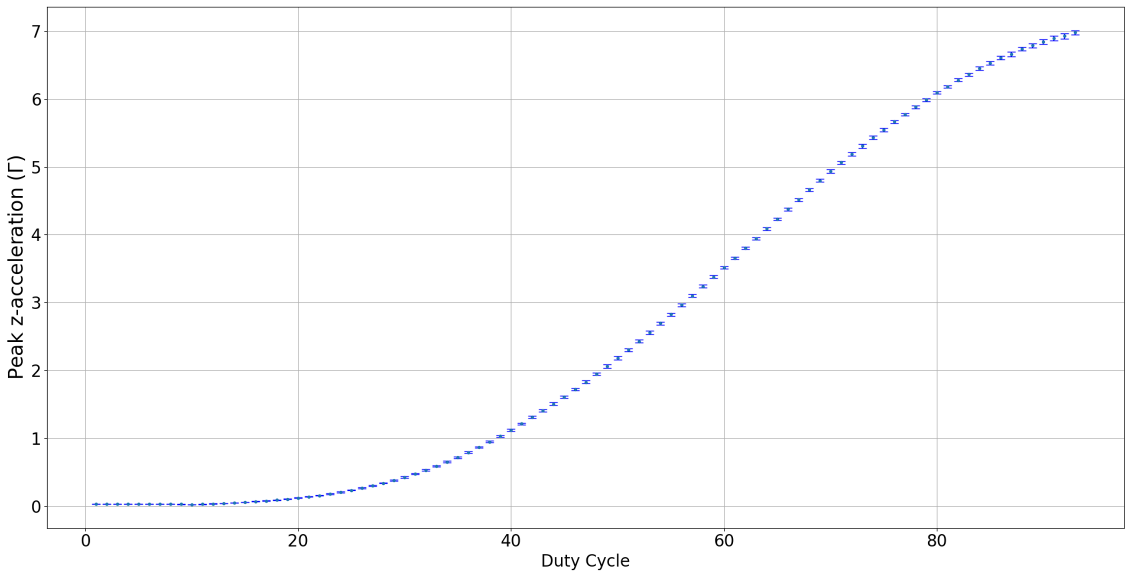

Figure 1: Calibration curve taken using RPi pico accelerometer. Shaker was ramped from a duty cycle of 0.0% to 94.0% in steps of 1%. Data is averaged over 5 individual calibration cycles, with error bars showing standard deviation of data.

2 Comparison to James's Thesis

In the Methods chapter of James's Thesis he plots a calibration curve which was obtained in the same way as described above. A few approximate data points were taken from this plot in James's thesis and plotted alongside the acceleration data taken by the RPi Pico accelerometer. The two sets of data appear consistent with each other when James's thesis data is multiplied by a factor of $\sqrt{2}$, as shown in Figure 2.

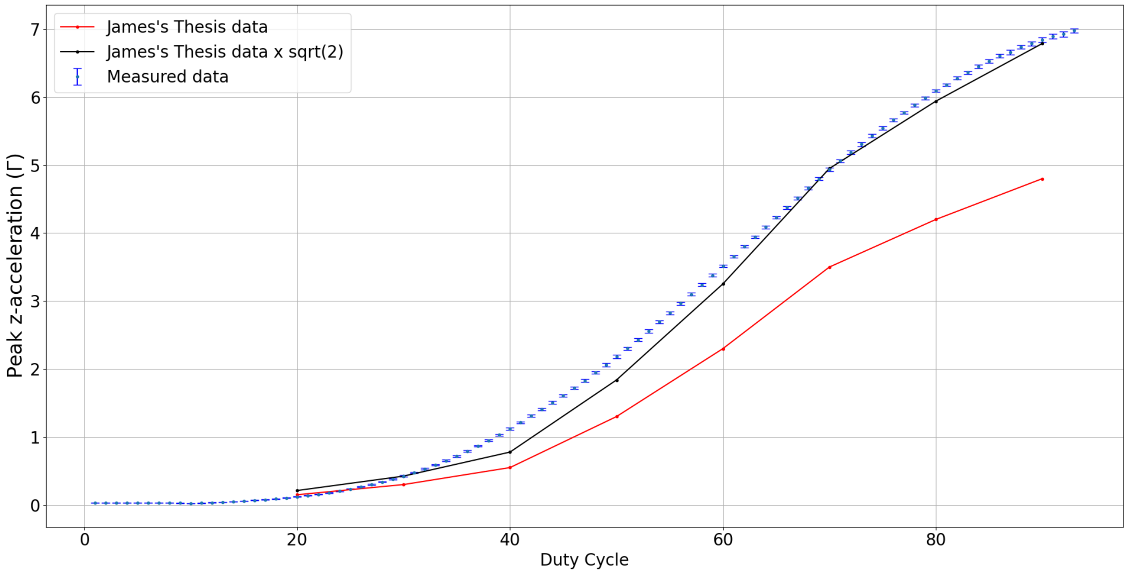

Figure 2: A comparison of the calibration curve above (blue) and the calibration curve from James's thesis (red).

To ensure that the data taken by the RPi pico accelerometer mounted to the shaker was accurate and was not the source of error, another independent measurement of the acceleration was performed. In order to do this a displacement transducer was used to measure the amplitude of oscillation of the shaker plate for a variety of duty cycles in a range 30% to 80%. From the amplitude of oscillation of the shaker plate, the dimensionless acceleration (Γ) can be calculated using:

$$\Gamma = \frac{A(2\pi f)^2}{g} \tag{1}$$

where A is the amplitude of oscillations, f is the frequency of vibrations and g is the acceleration due to gravity.
This transducer was screwed into a bolt on the shaker plate ensuring secure attachment in order to produce accurate data. The output of the displacement transducer was connected to an oscilloscope and the output signal was displayed. The amplitude of the signal was measured using an inbuilt function of the oscilloscope. The frequency of oscillation generated by the shaker was observed to be constant over the tests, this was measured to be 50Hz. The amplitude data was converted from a voltage signal (V) to an amplitude (mm) by calibrating the displacement transducer using a vernier microscope. This was done by securing the transducer onto the vernier microscope and slowly extending the rod on the transducer and measuring the voltage change. A conversion factor to convert from the oscilloscope signal (V) to an amplitude (mm) was obtained from a plot of displacement against change in voltage. The dimensionless acceleration values were then calculated using equation (1). The acceleration values obtained via both independent methods (RPi pico accelerometer and displacement transducer) were plotted against duty cycle. These sets of data were consistent with one another within reasonable experimental error, suggesting confidence in the output of the RPi pico accelerometer mounted to the shaker plate.

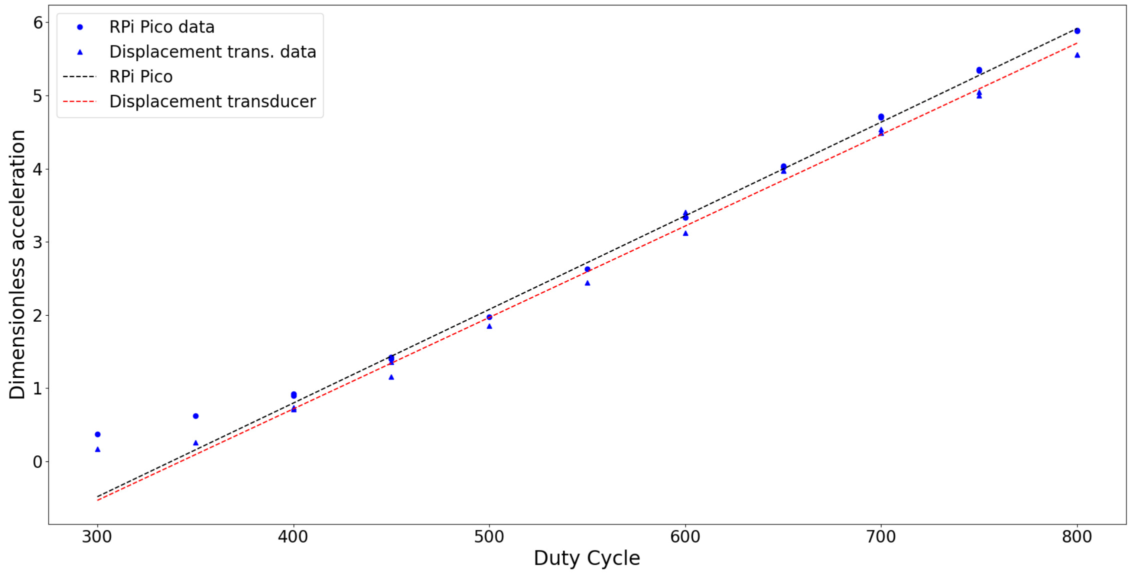

Figure 3: A comparison of the acceleration measured by the RPi pico accelerometer and the displacement transducer. Least-squares fit was performed on the linear region of the data(duty cycle > 400).

3 GitHub Links

Code that deals with serial commands/extracting acceleration data: [Code]
Code that runs the calibration cycle: [Code]
Code that analyses calibration cycle data: [Code]