**Experiment 6 and 7: Physical Pendulum Harmonic Oscillations and Waves on Vibrating String**

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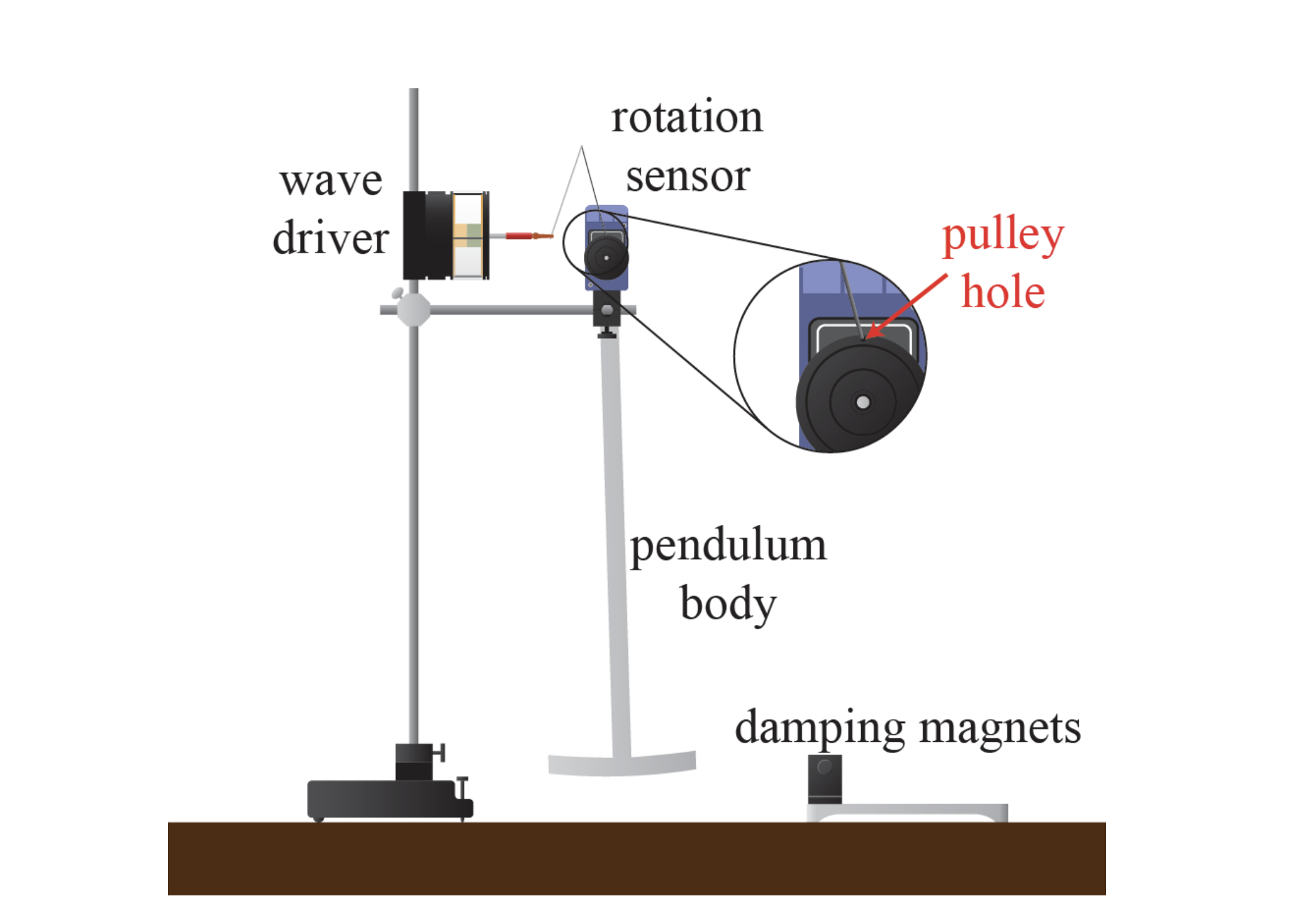
Partner: Shannon Largman

**Abstract**

**Introduction**

**Methods**

*Pendulum*



**Figure X, Physical Pendulum Experiment Apparatus**1**:** This image shows the setup of the equipment that was used for the experiment involving a physical pendulum. For the first part of that experiment, the wave driver was off and disconnected from the rotation sensor. In the second part of the pendulum experiment, the wave driver was used to produce waves in the pendulum. We also included a photogate to record the period of the oscillations at the starting point of the pendulum, but this is not illustrated in the image.

The physical pendulum experiment investigates the damping effect that magnetic field strength has on a swinging pendulum. We investigate the different regimes of damping.

In the first part of this experiment, we look at undriven oscillations. We define the equilibrium point as the point where the pendulum is at rest, pointing vertically downward. We also designated the direction toward the vertical rod as the positive direction and the direction toward the damping magnets as the negative direction. We set our data acquisition system (DAQ) to record the angle from equilibrium in time steps of 0.04 seconds.

For the undamped trial, we move the magnets away from the apparatus to avoid any unintended damping on the system. We placed our photogate next to the vertical rod. We started the edge of the pendulum at the point where it begins to block the photogate sensor. We do this so that we can have a consistent starting point, and also so that we can record the period of the pendulum as it swings. To measure oscillation period, we set up our DAQ so that it records times starting when the photogates goes from blocked to unblocked and finishes timing the oscillation when it goes from unblocked to blocked.

For the damped trial, we place the magnets at the equilibrium point so that the point where the vertical bar meets the horizonal bar in the pendulum sits within the two magnets. To identify the magnet separation at which critical damping occurs, we decrease the separation for every trial, until we reached overdamping. We start at a (50 ± 0.5) mm separation and decrease the distance by about 10 – 12 mm for each trial. We kept the photogate from the undamped trial in the same place so that we have a consistent starting point for each trial. We still record the angle from equilibrium at each time increment with the DAQ.

Next, we look at driven oscillations. For this part of the experiment, we hook up the wave driver to the rotation sensor. We leave the magnet in the same place as they were for the damped undriven oscillation trials (at the equilibrium point). We used a magnet separation of (26.5 ± 0.5) mm for this trial. We used 4 V as our voltage. We turn on the wave driver and determine the resonance frequency by analyzing the Lissajous graphs. We determine the frequency at which the Lissajous plot was horizontal without any tilt.

Also, to determine the amplitude response to frequency of oscillation, we recorded the amplitudes of oscillation for 13 different frequencies. These data points provides us with another method to calculate the Q-factor.

*Waves in a String*



**Figure X, Vibrating String Experiment Setup:** alsdasdf

**Analysis**

*Regimes of Damping*

**Figure X, Title:** This plot shows asdfasfas.

The underdamped data points were produced using a magnet separation of (17.5 ± 0.5) mm. The overdamped oscillation was generated with a magnet separation of (7.5 ± 0.5) mm. The critically damped oscillation used a magnet separation of (13 ± 0.5) mm.

*Resonance*

**Figure X, Undamped Undriven Pendulum Oscillation:** asldkaf

*Q-Factor and Line Widths*

**Figure X, Damped Undriven Pendulum Oscillation:** This plot shows how the angle of the pendulum (in radians) from equilibrium changed as time went on. The magnet separation in this damped trial was (38±0.5) mm.

**Figure X, Title:** At resonance frequency

**Figure X, Title:** asldkfjlas

**Figure X, Title:** asldkfj

For Figures X and X, it would have been better if we had recorded data at frequencies that were further away from the resonance frequency to exaggerate the differences between the plots.

**Figure X, Title:** asldf

**Figure X, title:** This plot shows the Lissajous plots of the two frequencies that generated an amplitude response with magnitude 1/sqrt(2) times the response generated by resonance frequency (rephrase this, ;) alex gang)

**Conclusion**

**Bibliography**