Cavendish

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Pre-Lab:

1 **Setup.**

- 1.1 Measure mass and diameter: M, M', m, m'
- 1.2 Measure mass and length of extra boom (not the one in the experiment)
- 1.3 measure window thickness
- 1.4 (TA!) Align boom: Without M, M', m, m', raise the boom to near vertical center. When the boom is oscillating in a steady damped wave, adjust the rotary so that the boom oscillates about about the desired 0 position.
- 1.5 Angle Calibration: align the laser so that it will reflect off the boom mirror onto the far wall. When the boom is in damped oscillation, record both the computer angle (θ_{comp}) and mark on the wall (or a horizontally aligned paper) where the laser hits at each turning point. Save this data and plot laser vs θ_{comp} to get angle calibration. Use the period of oscillation found to get the moment of inertia for the boom alone (without masses).
- 1.6 Background "noise": observe (record?) the boom with no masses at equilibrium

2 **Static Measurement of G.** When the boom is pulled towards M and M' it is displaced from its equilibrium position. When the boom is displaced from its equilibrium position, the twisted tungsten wire exerts a restoring force on the boom. This relationship causes the boom to oscillate about a displaced equilibrium angle. The displaced equilibrium angle is what is needed to find G.

- 2.1 Lower the boom and carefully place m and m' on the ends.
- 2.2 Place M and M' onto the carriage rotate the carriage so that it is perpendicular to the glass wall (the lead balls will be as far away from the window as they can be)
- 2.3 Allow the boom with attached m and m' settle (can use RE magnet to speed this process along)
- 2.4 When oscillations angle < 5 mRad, start collecting data. Record data continuously for the rest of this step.
  - 2.4.1 Record the time. rotate M/M' carriage until the M and M' gently touch the glass window. Record a few cycles
  - 2.4.2 record the time. rotate M/M' carriage so that M and M' are now gently touching the opposite side of their glass walls. Record a few more cycles.
  - 2.4.3 repeat this set several more times for an appropriate statistical measurement of the static displacement. stop recording. The difference between the two equilibrium angles in a set of measurements is equal to $2\theta_D$.

3 **Driven (resonant) Measurement of G.** The boom is driven into an oscillating state after which it is allowed to die off in the damped system. The equilibrium angle and the damping coefficient are then used to calculate θ_D, which is then used to calculate G.

- 3.1 Set M,M' to center position (far away from glass walls)

3.2 Wait for boom oscillation < 1 mR amplitude.

3.3 Alternately swing the M/M' carriage to gently touch opposite sides of the glass walls in order to increase the amplitude of boom oscillation. This is done by positioning M/M' so that the boom is always approaching it. When the boom reaches a turning point and starts to move away from M/M', swing M/M' around to the opposite side so that the m/m' are again moving toward M/M'.

3.4 After the boom amplitude appears to approach some asymptotic value (about 6 or 7 cycles), move M/M' to center position and record boom oscillation's natural decay (about 10 cycles).