PHYS S211: General Physics I
Lab 6: Statics
10/18/22 (due 10/25/22)

Name(s):

Topics:

1. Torque / torque balance
2. Static equilibrium

Introduction:

In this lab you will test the relationships between force, torque, and static equilibrium by performing a series of experiments in which masses are hung from a half-meter stick. Recall that when a system is in equilibrium,

$$\sum F_x = 0$$

$$\sum F_y = 0$$

$$\sum \tau = 0$$

What you should turn in:

You may submit a group report. Submit the report as a single document separate from this hand-out, and clearly indicate if you are submitting it as a group report.

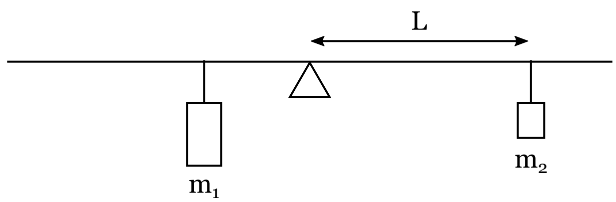
- Part 1: Graph of position vs. 1/weight and best-fit line through the data. [3 pts]
- Part 1: Theoretical relationship between position and weight, and discussion of how it compares to your observations. [3 pts]
- Part 2a: Calculation of the mass of the meter stick, including derivation that shows how you made the calculation. [3 pts]
- Part 2b: Comparison of distance in unequal arm balance to theoretical values, including derivation. [3 pts]
- Part 3: Determination of mass of the hanging sphere by using the tension protractors. [3 pts]
- Part 3: Calculation of initial angular acceleration and response to questions. [3 pts]

Equipment:

- Bar balances
- Masses
- Tension protractors and stands
- Heavy metal sphere

PART 1: EQUILIBRIUM AROUND CENTER OF MASS

Balance a half-meter stick by placing the fulcrum near its center. Place mass $m_1 = 100$ g on the 20 cm mark and do not move that mass. Make the stick balance by placing another mass, m_2, at a different location. Use five different masses for m_2 and for each one find the distance L shown in the figure below.



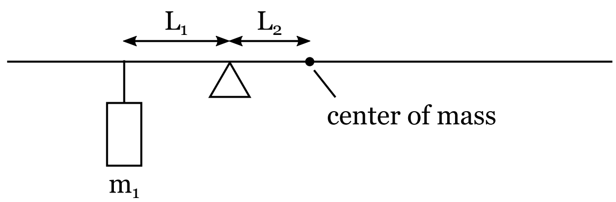
Make a graph of position (y-axis) versus 1/weight (x-axis) of m_2 and find a best-fit relationship between position and weight. **Note that you need to account for the mass of the brackets when calculating weights.** Explain your results and compare with what you expected to find. What is the meaning of the slope? What about the y-intercept? Include the graph in your lab report. Be sure to use proper units and to label the axes.

	mass, m_2	weight, $(F_g)_2$	distance, L
Trial 1			
Trial 2			
Trial 3			
Trial 4			
Trial 5			

Use Newton's Laws to find a theoretical relationship between the distance L and the weight (F_g) of m_2. In other words, set $\sum \tau = 0$ and solve for L. How does this relationship compare to your graph?

PART 2: MASS OF THE HALF-METER STICK

(a) Gravitational forces can be treated as acting at the center of the mass of an object. Using this concept, you will compute the mass of the meter stick by solving a static equilibrium problem. Set up an arrangement of parallel (vertical) forces by placing the fulcrum anywhere other than the center of mass of the half-meter stick. By placing appropriate masses as shown in the diagram, make the half-meter stick balance. What is the mass of the half-meter stick?

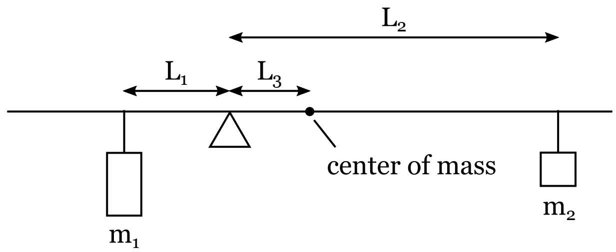


Repeat the experiment with different values of m_1, L_1, and L_2 to confirm the value of the half-meter stick's mass that you found.

mass, m_1	L_1	L_2	half-meter stick mass

Be sure to demonstrate how you calculated the mass of the meter stick. Use a scale to measure the mass of the half-meter stick to compare to your calculations.

(b) With an unequal arm balance, such as shown in the diagram below, hang a mass on each side of the half-meter stick in such a way to make it balance. (That is, using a rotation point that is not at the center of mass of the half-meter stick, use two masses and find the balance points.) Record the masses and distances and compare them to a calculation of the situation you have created.



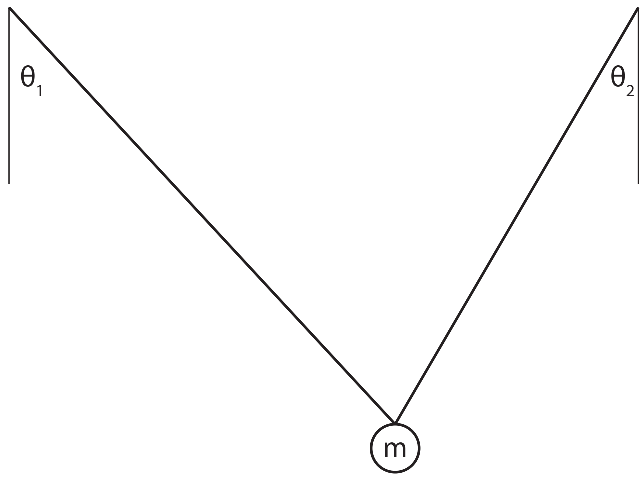
m_1	m_2	L_1	L_2	L_3

One way to compare your measurements to theory is to solve for L_2 using $\sum \tau = 0$. Show how you do this and compare the theoretical values of L_2 to what you measured.

How much would your theoretical values of L_2 have differed from the experimental values if you had neglected to account for the mass of the meter stick in your derivation?

PART 3: MASS OF HANGING SPHERE

Hang the metal sphere from two strings that are connected to the tension protractors. The strings should not be vertical.



Determine the mass of the sphere by measuring the forces and angles from the tension protractors and applying Newton's Laws.

What would the initial angular acceleration be if one of the strings was cut? The moment of inertia of a sphere rotating around some point axis is $I = m\left(d^2 + \frac{2}{5}r^2\right)$, where r is the radius of the sphere and d is the distance from the center of the sphere to the axis of rotation. How much different would your answer be if you assumed that the sphere was a point mass, in which case the moment of inertia would be $I = md^2$?