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Period 6
December 11, 2017

I Maintaining Equilibrium Using Torque

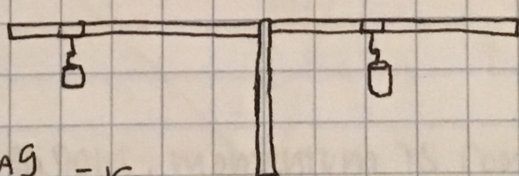
II Purpose

The purpose of this experiment is to use torque to calculate the distance from the axis of rotation required to balance a mass with another mass. The calculated distance will then be compared to the measured distance.

III Background

In this lab, a meterstick was placed on a pivot point, with the center of the meter stick at the pivot point. When the meter stick is balancing on its center of mass, it is in equilibrium, and the sum of torque equals zero. When a force is exerted on one side of the meter stick by a mass, another mass must be placed on the other side of the meterstick in order to maintain equilibrium. In order to calculate this, using the equations below will be necessary. Since the calculated distance from the center required to balance a mass with another mass will be compared with the measured distance, the distance from the center of the meter stick of the second mass will be solved for. Additionally, setting the sum of torque equal to zero will be needed, as explained above.

$$\Sigma\tau = \tau_A - \tau_B = 0$$



$$\tau_A = \tau_B$$

$$\frac{r_A F_A}{F_B} = \frac{r_B \cancel{F_B}}{\cancel{F_B}} \Rightarrow \frac{r_A m_A g}{m_B g} = r_B$$

IV Materials

The following items are required for this lab: a pivot point, a meter stick, and several masses.

V Procedure

(1) A meterstick was placed on a pivot point, with the 50 cm mark lining up with the pivot point.
(2) A 100 g mass was then hung at the 40 cm mark.
(3) A 20 g mass was hung on the other side of the meterstick, and placed at a distance from the center at which the meterstick could maintain equilibrium. This distance along with the distance of the other mass and the masses of the masses were recorded on a data table.
(4) Steps 1-3 were repeated using a different mass for step 3 in each trial.

VI Data

Trial	Mass$_A$ (g)	Distance$_A$ (cm) ±0.1	Mass$_B$ (g)	Distance$_B$ (cm) ±0.1
1	100 g	10 cm	20 g	33 cm
2	↓	↓	50 g	18.2 cm
3	↓	↓	70 g	13.8 cm
4	↓	↓	90 g	11 cm
5	↓	↓	150 g	7.2 cm

VII Analysis

Trial	Calculated Distance$_B$ (m)
1	0.5 m
2	0.2 m
3	0.143 m
4	0.11 m
5	0.067 m

$$r_B = \frac{r_A m_A g}{m_B g}$$

$$= \frac{0.1(0.1)(9.8)}{0.02(9.8)}$$

$$= 0.5$$

<u>Average Measured Distance$_B$</u>

$(33+18.2+13.8+11+7.2)/5 = \boxed{16.64 \text{ cm}}$

<u>Average Calculated Distance$_B$</u>

$(50+20+14+11+6.7)/5 = \boxed{20.34 \text{ cm}}$

Percent Difference (Distance $_B$)

$$\frac{|r_1 - r_2|}{(r_1+r_2)/2} \cdot 100 \Rightarrow \frac{|20.34 - 16.64|}{(20.34+16.64)/2} \cdot 100 \stackrel{?}{=} \frac{3.7}{18.49} \cdot 100 = \boxed{20\%}$$

VIII Conclusion

The goal of this experiment was to use torque to calculate the distance from the axis of rotation required to balance a mass with another mass and compare that value to the measured distance. To do so, my colleagues and I used a meterstick on a pivot point and hung various masses on it. We found that the lighter mass, the farther away it had to be from the pivot point in order to maintain equilibrium. Our percent difference between the measured and calculated distances was 20%, meaning the actual distance needed to maintain equilibrium was very close to the calculated distance. Possible sources of error include the masses not being exactly the distance we intended it to be, and not being precise with reading the distance the second mass was at. To reduce this error, we could use a meterstick of some sort with indents on the measurement marks, so we know that the mass is exactly on the line.