PHYS 0XX-0X Experiment 6: Rotation and Torque

Names
@XXXXXXXXX

Calculations and Results

Calculations

Part 1 – measure 5 (p_1, p_2, p_3, p_4, p_5)

avg $(P_1 + P_2 + P_3 + P_4 + P_5)/(5)$ position

$(49.7 + 49.8 + 49.7 + 49.7 + 49.6)/5 = \boxed{49.7\text{ cm}}$

P_1 example

$G = 49.7$ cm

$F_1 = 33.8$ cm

$M_s = 12.4$ cm

$SO_{g x_2} = 21.4$ cm

Part 2 $G - F = COG_{x_1}$ $F - M = SO_{g}x_2$ $M_{stick} = \frac{M x_2}{X_2} = \frac{SO_g \cdot (F-M)}{G-F}$

1 | $49.7 - 33.8 = 15.9$ $33.8 - 12.4 = 21.4$ $\frac{60 \cdot 21.4}{15.9} = 67.3g$

2 | $49.7 - 33.5 = 16.3$ $33.5 - 12.4 = 21.1$ $50 \cdot 21.1/16.9 = 64.7g$

3 | $49.7 - 33.6 = 16.1$ $33.6 - 12.4 = 21.2$

4 |

5 | etc...

$$\frac{67.3 + 64.7 + 65.8 + 67.3 + 65.5}{5} =$$

Avg $M_{stick} = 66.12g$

Actual Stick $= 97.9g$

$$\% \text{ ERORR} = \frac{|97.9g - 66.12g|}{66.12g} \times 100\% = \boxed{48.1\% \text{ ERROR}}$$

$G_1 = 49.7$ cm $F_1 = 40.1$ cm $COG_{x_1} = 9.6$ cm $M_{75g} = 12.4$ cm $75g x_2 = 27.7$ cm

U position of unknown $= 84$ cm $x_3 + x_1 = 43.9$ cm

$$\text{Mass of Unknown} = \frac{(75g \cdot 27.7\text{cm}) - (66.12g \cdot 9.6\text{cm})}{43.9\text{ cm}} = 32.9 \text{ grams}$$

Avg $M_{unknown} = 32.9 + 32.7 + 33.3 + 32.5 + 33.0/5 = 32.88g$

$$\% \text{ ERROR} = \frac{|15 - 32.88|}{32..88} \times 100\% = \boxed{54.4\% \text{ ERROR}}$$

[PART3]

Conclusions

1. Why was the supporting force exerted on the meter stick by the sharp edge not considered in your calculations?

The calculations did not account for the supporting force applied by the meter stick's sharp edge because it is vertical and has no bearing on the torque estimate.

2. A meter stick that is rotated at the 50 cm mark fails to balance due to material irregularities that cause the stick's center of gravity to deviate from its geometric center. However, equilibrium is achieved when 150 g and 300 g of weights are positioned at the 10 cm and 75 cm markers, respectively. The pivot point is then moved to the 43 cm mark, and

equilibrium is once more achieved by switching the weights. Ascertain the meter stick's mass and center of gravity locations.

In this experiment, the supporting force exerted by the sharp edge on the meter stick was not included in the torque calculations because it is a vertical force. Since torque is only influenced by forces that act perpendicular to the lever arm and contribute to rotational effects, this vertical supporting force did not affect the system's torque balance.

When examining the meter stick's equilibrium before and after moving the pivot point, it was found that material irregularities caused the center of gravity to deviate from the geometric center, which affected its balance. Initially, when 150 g and 300 g masses were placed at the 10 cm and 75 cm markers, respectively, equilibrium was achieved at the 50 cm pivot point. Using torque calculations, the system demonstrated that the clockwise and counterclockwise torques were balanced.

After shifting the pivot point to 43 cm and switching the weights, equilibrium was again restored. By applying the principles of torque equilibrium, we determined the mass of the meter stick and its center of gravity location, confirming the critical role of these factors in maintaining balance in systems like Atwood's machine.

In Part II of the experiment, the percent error for the mass of the meter stick was 48.1%, and in Part III, the percent error for the mass of the unknown weight was 54.4%. The % error for Part II indicates that the experimental technique was free of errors and conflicts. Given that the actual value is less than the anticipated value, this negative percentage error could be a sign of a mistake in the experimental process.

In conclusion, the experiment successfully demonstrated the relationship between torque, mass, and center of gravity, deepening the understanding of how irregularities and external forces influence balance in real-world applications. The findings highlight the importance of accurate torque calculations in predicting and explaining the behavior of objects in equilibrium.

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Procedure:

Part I

1. Determine the center of gravity by balancing the meter stick on a sharp edge. Repeat several times. Use the value that is the average of the measured values.
2. Weigh the weight holders and label them. Use the average of several readings.

Center of Gravity of the Meter Stick

P_1	P_2	P_3	P_4	P_5	Average Position
49.7 cm	49.8 cm	49.7 cm	49.7 cm	49.6 cm	49.7 cm

Part II

1. Balance the stick on a sharp edge when a known mass of 50 g is hung from the stick. Do not use the center of gravity of the stick as the balance point or fulcrum and make sure that the fulcrum is always to the left of the COG, otherwise the equation does not hold. Determine the distance from the center of gravity of the stick to the new fulcrum. Determine the distance from the known mass to the new fulcrum. From the condition of equilibrium for torques, solve for the mass of the meter stick. Repeat at least three times with the 50 g mass hung from different places on the stick. Determine the average and compare it to the value determined by weighing the stick.

	Positions		Distance to	Fulcrum	
	Fulcrum	50 g	COG(x_1)	50 g (x_2)	Mass of Meter Stick
1	33.8 cm	12.4	15.9 cm	21.4 cm	67.3 g
2	33.5 cm	12.4	16.3 cm	21.1 cm	64.7 g
3	33.6 cm	12.4	16.1 cm	21.2 cm	65.8 g
4	33.8 cm	12.4	15.9 cm	21.4 cm	67.3 g
5	33.5 cm	12.4	16.1 cm	21.1 cm	65.5 g

Average mass of meter stick: 66.12 g

Part III

1. Hang a 75 g mass from one hanger and an unknown mass from the second hanger. Balance the meter stick at a position other that the center of gravity and make sure that the fulcrum is always to the left of the COG, otherwise the equation does not hold. Determine the distances from the weight hangers to the fulcrum. Determine the unknown weight using the conditions of equilibrium.

	Positions			Distance	to	Fulcrum	
	Fulcrum	75 g	Unknown	COG (x_1)	75 g (x_2)	Unknown(x_1+x_3)	Mass of Unknown Weight
1	40.1 cm	12.4	84 cm	9.6 cm	27.7 cm	43.9 cm	32.9 g
2	40.1 cm	12.4	84 cm	9.7 cm	27.7 cm	43.9 cm	32.7 g
3	40.2 cm	12.4	84 cm	9.5 cm	27.8 cm	43.8 cm	33.3 g
4	40.0 cm	12.4	84 cm	9.7 cm	27.6 cm	44.0 cm	32.5 g
5	40.1 cm	12.4	84 cm	9.5 cm	27.7 cm	43.9 cm	33.0 g

Average mass of Unknown Weight: 32.88 g