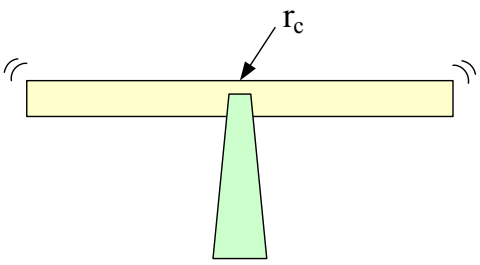
# Equilibrium of Torques

Name_____TA_____

Partners_____

Section#_____Date_____

## 1. Preparation




**Find the center of mass of a meter stick.**

Get the balance of meter stick without hanging mass.

Reading of the center of gravity $r_c$ = _____

**Weigh the meter stick with a balance.**

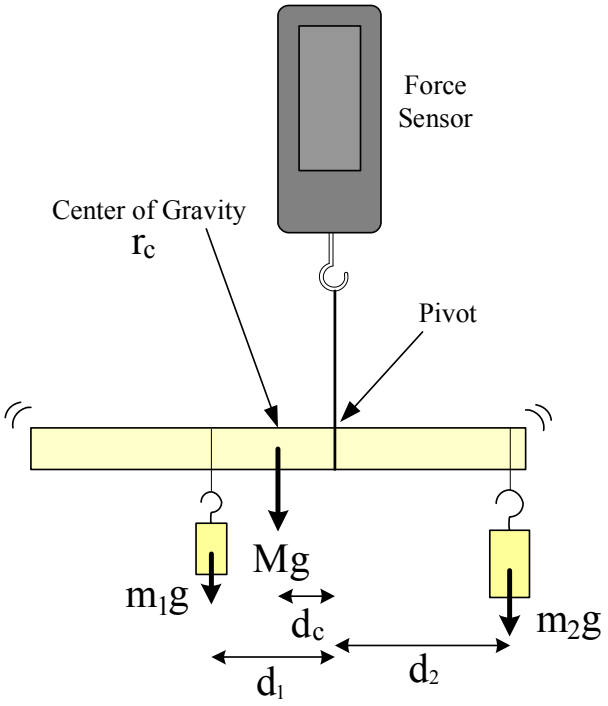
Before you do this, take off the metal apparatus from the meter stick. (You can measure the mass with a balance anytime.)

Mass of meter stick (by weighing with a balance): _____ **(1)**

(Do not forget the units.)

## 2. Conditions of Equilibrium

Use the force sensor, and set up as shown.




- The net external force

$\sum F = -m_1 g - Mg - m_2 g + \text{tension (in force sensor)} =$ (calculation)

_____ (N)

- The net external torque

$\sum \tau = \tau_{\text{pivot}} + \tau_{\text{gravity}} + \tau_{m_1} + \tau_{m_2}$

$= 0 + Mgd_c + m_1 gd_1 - m_2 gd_2 =$ (calculation)

_____(Nm)

**3. Application of the balance of torques** (*Use different hanging masses.*)

**Follow the procedure:**

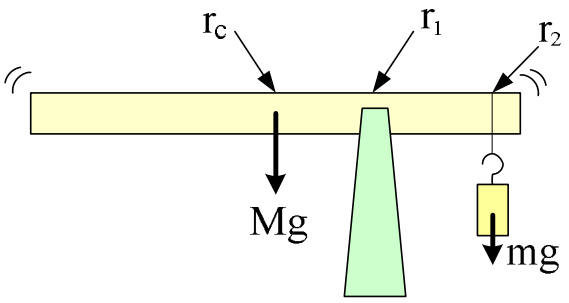
Important Tips:
- Use SI units. (meters, and kilograms)
- The range of $r_1$ should be from 0.25m to 0.75m. (If you want to challenge, go for it.)
- At equilibrium, the meter stick **must be horizontal**.
- Please try to read 4 digits for the meter stick calibration.

**Try six different $r_1$'s.**

Change the positions of fulcrum six times. Also change the hanging mass for each trial.

**Calculate $M = \frac{|r_1 - r_2|}{|r_C - r_1|} m$ for each case, and the average; then, obtain the standard deviation.**

$r_1$, $r_2$, and $r_c$ are just reading from the meter stick.




| $m$ (hanging mass) | $r_1$ | $r_2$ | $\lvert r_1 - r_2 \rvert$ | $\lvert r_c - r_1 \rvert$ | $M = \frac{\lvert r_1 - r_2 \rvert}{\lvert r_c - r_1 \rvert} m$ |
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Average and standard deviation: $M =$ (  ±  ) [  ]⇐ unit

**Question 1**

**How does this compare with the mass obtained by weighing (1) the meter stick?**

The mass obtained by equilibrium of torques is equal to the mass by weighing with a balance. If your results are off, discuss the causes of error.

**Question 2**

**Deduce whether accuracy is improved by choosing large or small value of m, $|\mathbf{r_1}-\mathbf{r_2}|$ or $|\mathbf{r_c}-\mathbf{r_1}|$.**

Comparing the agreement of individual measurements with the average and with the result of weighing the meter stick, deduce whether accuracy is improved by choosing large or small value of $m$, $|r_1 - r_2|$ or $|r_c - r_1|$.

**Question 3**

**What is the mass of your laboratory table?**

What is the mass of your laboratory table? Provide a diagram and description of your method for determining the weight of a laboratory table without doing the experiment.