# M7a: Torque & Equilibrium of a Rigid Body

## Introduction:

Torque is the tendency of a force to rotate a body about some axis. Its magnitude is calculated by multiplying the *force* times the *lever arm*. For this experiment, torques are changed by placing varied masses (thus changing the force) at different positions along a meter stick (varying the lever arm) until the torques on both sides are equal. The meter stick as the rigid body is initially balanced on a support stand. When a mass is placed on one side of the meter stick, the body is no longer at equilibrium and it rotates. A second mass is positioned somewhere on the other side so the torques on both sides are equal and equilibrium is reached once again.

## Apparatus:

- Meter stick
- Support stand
- Clamp to hold the meter stick
- Set of masses
- 2 Mass hangers
- Unknown mass

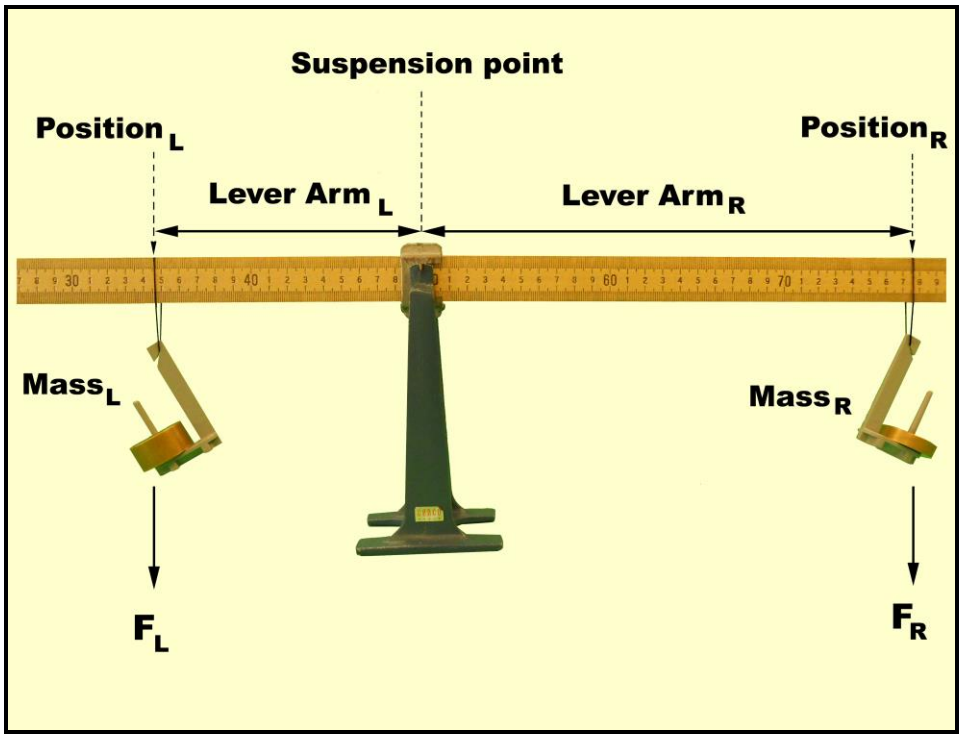


**Figure 1**

## Procedures:

1. Record the position of the point of suspension when the meter stick is balanced and with no mass attached to it. This represents the center of mass of the meter stick, and can be found by looking at the center of the clamp.
2. For each trial measure the total mass placed on each side (combined mass and mass hanger) precise to the hundredth of a gram and convert to kilograms.
3. Place a 100-gram mass on one side of the meter stick by hanging it on the string. Hang a 50-gram mass on the other side of the meter stick, moving it until the meter stick reaches equilibrium and is level. Record the position for each mass.
4. Record the lever arm for each mass. This is the distance from the mass to the point of suspension. Calculate both the force and the torque for each side. Note: at this point, the system has reached equilibrium, therefore each value for torque should be identical, or at least they should be very close.
5. Repeat two more trials using the same masses with different positions.
6. Repeat the same process for trials 4, 5 and 6, using some of the other masses available. Each trial should have different mass combinations.
7. For trials 7, 8, and 9, use a standard mass (which will become your known mass) on one side and the unknown mass provided for the other side. Again position them so equilibrium is reached. Each trial should have a different known mass but the same unknown mass.
8. Complete all the calculations for your known mass.
9. For the mystery mass, record its position and lever arm. Since we are dealing with a mass of unknown quantity, the torque cannot be directly calculated. But since the system is at equilibrium once more, we can assume their torques to be identical. Record the same torque value obtained for the known mass as also being the unknown's torque.
10. Use this torque to calculate the force and the mass of the unknown.

# Experiment M7a: Torque & Equilibrium of a Rigid Body

Student Name_____

*Lab Partner Name*_____

*Lab Partner Name*_____

Physics Course_____

Physics Professor_____

Experiment Start Date_____

| *Lab Assistant Name* | *Date* | *Time In* | *Time Out* |
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Experiment Stamped Completed

## Data Sheet: M7a: Torque & Equilibrium of a Rigid Body

**NAME: _____ DATE: _____**

Location of point of suspension = _____ meters

| | Trial | *left side* | | | | | *right side* | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | mass (kg) | position (m) | lever arm (m) | force (N) | torque (N m) | mass (kg) | position (m) | lever arm (m) | force (N) | torque (N m) |
| *.100 & .050 kg* | 1 | | | | | | | | | | |
| | 2 | | | | | | | | | | |
| | 3 | | | | | | | | | | |
| *assorted masses* | 4 | | | | | | | | | | |
| | 5 | | | | | | | | | | |
| | 6 | | | | | | | | | | |

| | Trial | *known mass* | | | | | *unknown mass* | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | mass (kg) | position (m) | lever arm (m) | force (N) | torque (N m) | position (m) | lever arm (m) | torque (N m) | force (N) | calculated mass (kg) | % Diff. of Calc. and Measured Mass |
| *finding unknown* | 7 | | | | | | | | | | | |
| | 8 | | | | | | | | | | | |
| | 9 | | | | | | | | | | | |

Unknown mass (recorded from lab balance): _____kg