TORQUES AND EQUILIBRIUM

OBJECTIVES:

Most real, rigid objects cannot be considered point objects, and therefore it's possible for a set of forces to rotate on object even if the net force on it is zero.

The purpose of this experiment is to examine the two conditions of equilibrium:

1. The net force must be zero and
2. The net torques must be zero.

APPARATUS:

Knife Edge Clamps, Balance Support, Meter Stick and Masses.

GENERAL METHOD:

Balance a meter stick that has two masses suspended from it at various points along the stick. Calculate the torques required to keep the system in equilibrium.

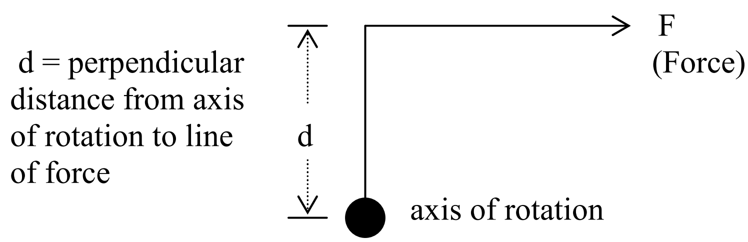
THEORY:

The theory you'll need is a working definition of <u>torque</u>.

Torque is the product of a <u>force</u> times its <u>moment arm</u>, where by the moment arm we mean the perpendicular distance from a point of rotation to the line of action of the force.

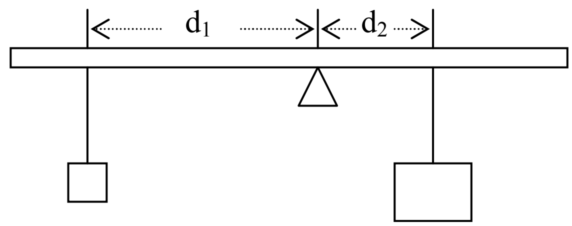
This is complicated to say and easier to illustrate:

Torque = Force × Distance



Torque also has a direction, so it should be considered a vector. We won't worry about the direction of this vector. Instead, you can think of the torque as tendency to twist the rigid body clockwise or counter-clockwise. At equilibrium, nothing is rotating, so <u>the sum of the clockwise torques must equal the counter-clockwise torques.</u>

PROCEDURE:



mass m_1 mass m_2

torque 1 = $m_1 g \times d_1$ torque 2 = $m_2 g \times d_2$

1. First balance the meter stick without any weights on it. You'll find that it should balance with the knife-edge close to the 50 cm mark.

2. Next suspend two masses, 100 grams and 200 grams, on either side of the 50 cm mark. Adjust the distances of each until the system is balanced. Is there more than one pair of distances that allow you to balance the system?

3. Record one of your pairs of distances, d_1 and d_2. Then calculate the torques about the center of mass of the meter stick. Are the clockwise torques approximately equal to the counterclockwise torques? What must the value of the force be that acts upward through the knife-edge at the center of mass?

4. To makes things interesting, add a third mass of 50 grams on the same side as the 200 grams weight and rebalance the system. Calculate the torques again and discuss the conditions for equilibrium.

CHALLENGE QUESTION:

Devise a means of using these same components to measure the weight of the meter stick. To keep things simple just use one mass and of course the knife-edge and meter stick. Do it, explain you method, and compare your answer to the mass measured on a lab balance.

DATA ORGANIZATION SHEET
EXP TORQUES and EQUILIBRIUM

$F_1 = m_1g$ (N)	d_1 (m)	$\tau_1 = F_1d_1$ (Nm)	$F_2 = m_2g$ (N)	d_2 (m)	$\tau_2 = F_2d_2$ (Nm)	Percent difference

$F_1 = m_1g$ (N)	d_1 (m)	$\tau_1 = F_1d_1$ (Nm)	$F_2 = m_2g$ (N)	d_2 (m)	$F_3 = m_3g$ (N)	d_3 (m)	$\tau_2 = F_2d_2 + F_3d_3$ (Nm)	Percent difference