Static Equilibrium of a Rigid Body

Objective: To examine the conditions of force and torque on a body in static equilibrium.

Theory: If the beam (meter stick) is in static equilibrium, then the net force (along each axis) is zero and the net torque on the beam is zero, too.

Equipment and Procedure :

A loaded meter stick, pivoted at one end, is held at an angle by a string. The string passes over a pulley and is attached to a spring scale (dynamometer).

1. Take one of the drilled meter sticks with attached hinge. Determine the mass of the stick itself as follows:
   Measure the mass of your meter stick, with its hinge attached, on the balance provided. Then subtract the mass of a hinge that your teacher will give you to get the stick's mass. Please do not take the hinge off the meter stick.
2. Set up the apparatus as demonstrated by your teacher, similar to the diagram.
3. Adjust the vertical location of the pulley, or that of the short rod holding the spring scale, so that the meter stick stays at some angle, not horizontal but not more than about 40 degrees. *Calibrate 0-reading of spring for vertical-up measurements and adjust the set so that the string tension is between about 1.5 and 4 Newton*, since we know our spring scales are not very accurate outside that range.
4. Determine the position (marking) of the hinge on your drilled meters tick.
5. Measure/record the following data:
   - Distances d_1 , d_2, and d_{string} Notice that all these d's must be the distances *from the hinge*.
   - Masses m_1 and m_2 [You may take these masses as stamped, without measuring them.]
   - The two angles (between meter stick and horizontal, and between string and stick.)
   - The tension in the string, as measured by the spring scale.
6. Determine the position of the stick's CG (center of gravity) from the hinge. (Yes, you can assume that the CG is at the 50-cm *mark*, but where is that from the *hinge*?)

Analysis of the data:

1. Use the symbols in the previous section, record all values you measured in a table.
2. Draw the large, clearly labeled isolation diagram of the beam (meterstick).
3. Taking all measurements as "known" except the tension, use the equilibrium conditions (net **F** and net torque eq'ns) to calculate T_{th} , the theoretical value of the tension in the string, showing all steps as you would do in a class problem.
4. Calculate the difference (subtraction) between the theoretical tension and the measured (experimental) tension Tmeas, and express this difference as a percentage of the theoretical value.
5. Use the translational equilibrium conditions to calculate the horizontal and vertical components of the force by the hinge on the beam. Call them $\mathbf{F_H}$ and $\mathbf{F_V}$.

Conclusion:

In this section, neatly restate the three theoretical values (F_H, F_V and T_{th}), the measured T_{meas}, the percent difference, and give a very short comment on the comparison of theoretical and measured T.

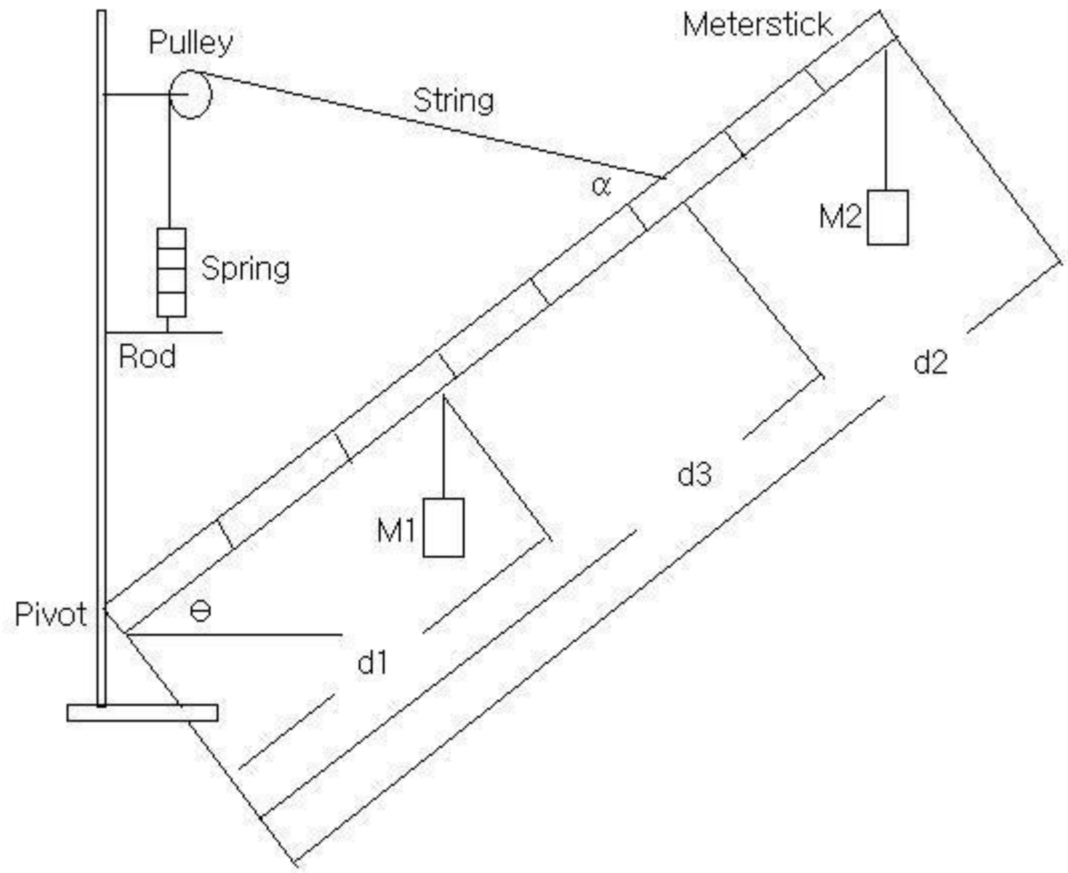
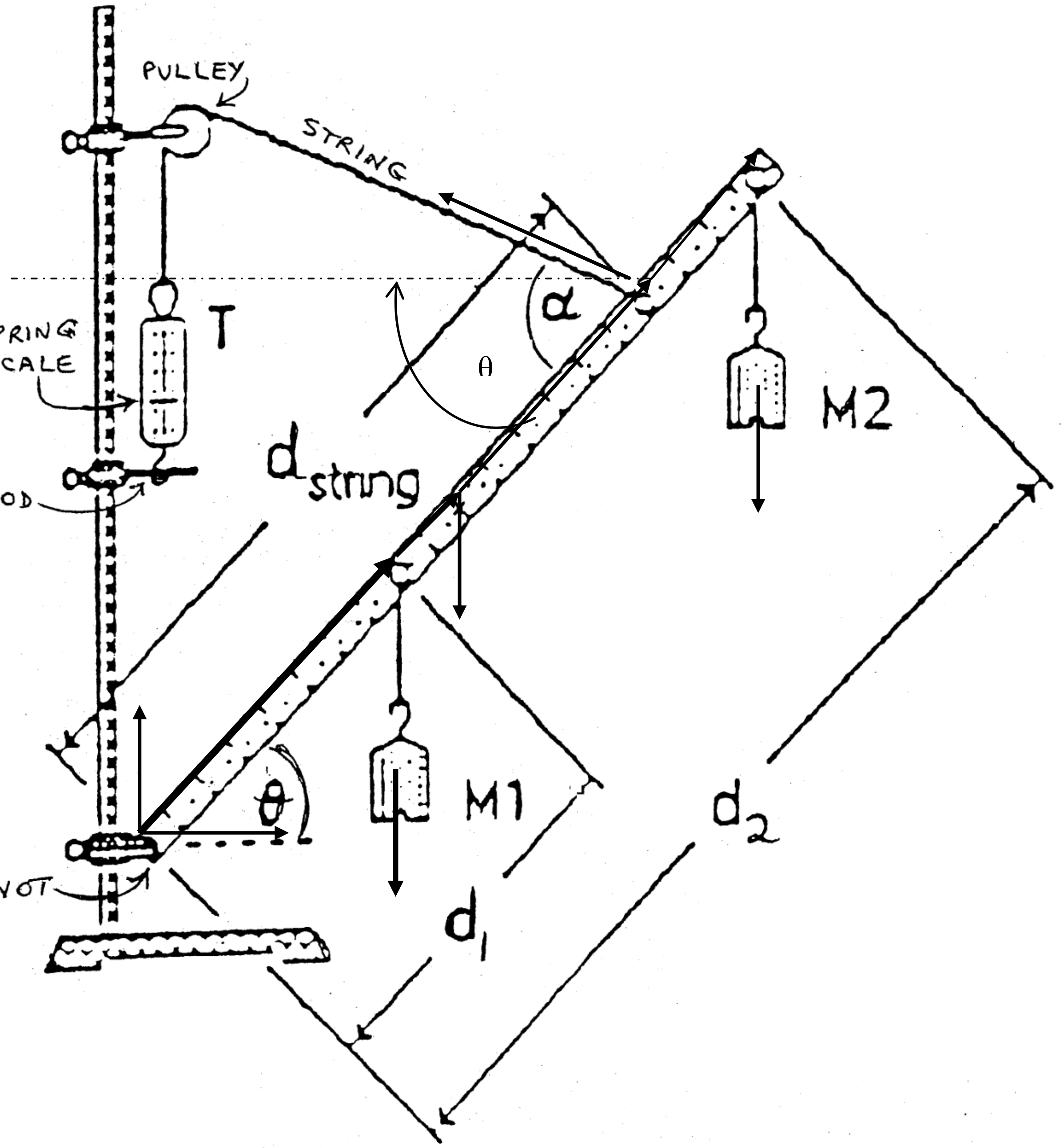


Diagram for Static Equilibrium



PULLEY
STRING
SPRING SCALE
T
ROD
PIVOT
α
θ
θ
M2
M1
d_{string}
d_1
d_2