

Physics: Torque Challenge Lab

To be completed in your lab notebook but graded as an assessment

Pre Lab:

1. If a stick was made of homogenous wood and 100 cm long, describe where the Center of Mass of the stick would be. Why must this be the case?
2. If a balanced stick is in equilibrium, it is completely horizontal. Describe the torques acting on it, including their directions.
3. The Force of Friction acts at the bottom of an object where it comes in contact with the surface its sitting on. Where does the Force of Gravity of an object act?

Materials:

A wooden stick of heterogeneous weight (not evenly distributed)

Metal hangers that fit onto the stick

Assorted hanging masses

Ring stand & horizontal support

$$\sum T = T_{Left} + T_{Right} = m\alpha$$

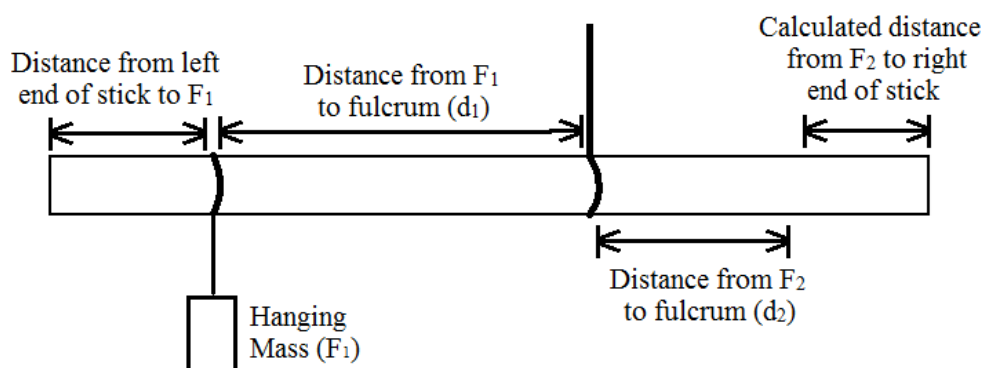
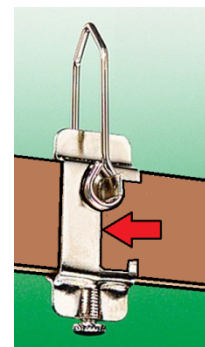
$$\sum T = 0Nm \text{ and then } -T_{Left} = T_{Right}$$

$$\text{Therefore } F_1d_1 = F_2d_2$$

Procedure:

1. Measure the total length of your stick in centimeters (to the nearest 0.1 cm) and record it in your lab notebook.
2. Glue your data table into your lab notebook.
3. Put the two metal hangers on the stick (one pointing up and another down) and **weigh** the stick by hanging it from one of the metal hangers using a Force scale. Try to hang the stick as vertically as possible while weighing it. **Record** this value (to the nearest 0.01 N) in your lab notebook as F_2 .
4. One of the metal hangers should have the loop up, this will be the one you hang the whole stick from and is called the *fulcrum*. The other metal hanger should have the loop facing down, this will be the one you hang additional masses from.
5. Notice that your stick has three points marked on it, point A, B and C. Move the metal hanger that has the loop up (the fulcrum) to the “A” position and hang it from the ring stand. *It will not be balanced at first.*
6. Calculate the Force of Gravity of a 100 gram mass (to the nearest 0.01 N) and record it in your data table as F_1 .
7. Move the other metal hanger, with its loop facing down, on the other side of the stick and hang the 100 gram mass from it.
8. Move this second metal hanger with the 100 gram mass along the stick until it is balanced. The stick *is not balanced* until it is **completely level** and does not torque (spin).
9. Measure these distances (to the nearest 0.1 cm) and record in your data table:
 - a. From the left side of your stick to this metal hanger.
 - b. Between the two metal hangers and record this as d_1 in your data table. This is the distance between where F_1 is being applied and the fulcrum where the whole stick is balanced.
10. In order for the stick to be balanced there must be an equivalent torque on the other side of the meter stick. You have already found the size of this force (the Force of Gravity of the stick itself) and recorded it as F_2 . *This force will remain the same throughout the lab.* You will calculate the position of this force in a little bit.

11. Move the fulcrum from position “A” to position “B” and make the stick balance again. You may use 100 grams again or a different sized hanging mass. *If you change the hanging mass you must recalculate F_1 and enter it in the data table.*
12. Repeat step #8 and 9.
13. Repeat steps #11 with your final fulcrum position “C.”
14. Now remove the additional hanging mass so that the only thing on the stick is the metal hanger. Move this fulcrum until the stick is hanging level. Measure the distance from the middle of the metal hanger (the arrow points to it at the right) to the two ends of the meter stick.
15. For your three trials the torque created by the hanging mass ($T_1 = F_1 d_1$) must equal the torque on the other side caused by the Force of Gravity of the stick itself ($T_2 = F_2 d_2$). Use Torque formulas to **calculate** d_2 (distance from the F_2 to the fulcrum) for Trial A, B and C and record in your data table.
16. For each trial you measured two distances and you just calculated the third:



17. Use simple addition to calculate the last column of your data table, the calculated distance from F_2 to the end of the stick, and fill in your table. If you were to add up all four distances in a horizontal row for one trial they *should* equal the total length of your stick you measured in your first step.

Analyzing Questions:

🔧 In your lab notebook, write “Analyzing” and you will answer the questions below in complete sentences. Don’t forget to number your answers!

4. Find the average calculated position of the F_2 in reference to the end of the stick (last column of your data table) for the three trials and record it below your data table. Compare this experimental location of F_2 (the location of the stick’s center of mass) to the actual location you found by balancing the stick with no other weight on it.
5. You may have found that your data may not be perfect. List at least three possible sources of error in complete sentences. “Human error” and “calculator error” are not acceptable sources of error; be specific.

Applying Questions:

🔧 In your lab notebook, write “Applying” and you will answer the questions below in complete sentences. Don’t forget to number your answers!

You probably noticed that your stick had mass added to one side and removed from the other. If even more mass was added to this same side:

6. What would have changed about the location of its Force of Gravity (F_2)?

7. What would have changed about the location of the hanging mass (F_1) on the opposite side of the fulcrum?