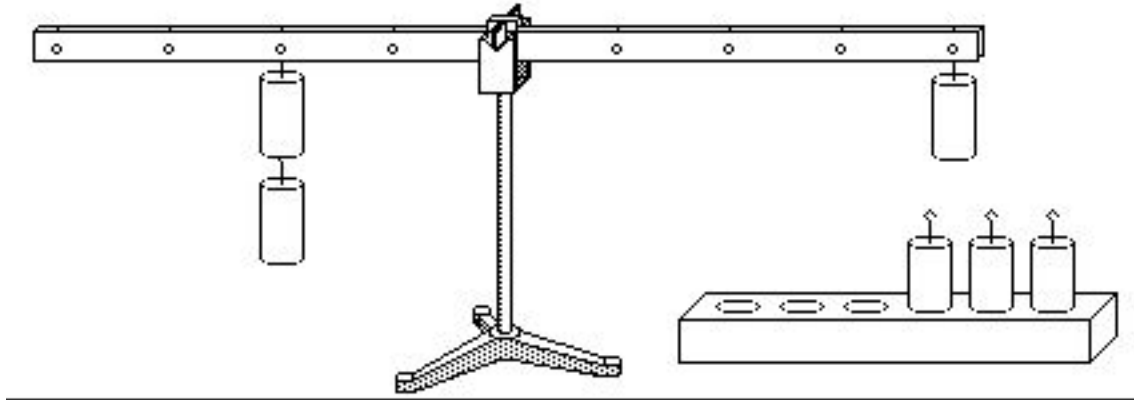


Lab 7: Center of Mass and Torque

Equipment: Fulcrum base support, meter stick, hangers, hanging weights, scale for measuring mass of ruler

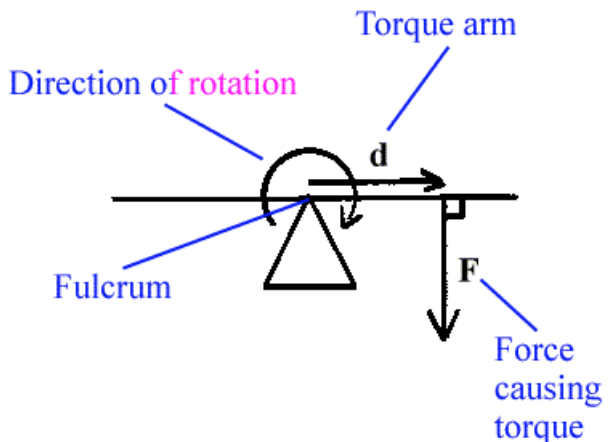


In this experiment, you will calculate the torques exerted by weights hanging from a ruler and predict the location of counterweights to balance the torques on the ruler so that it stands still. Next, we will use torques to experimentally calculate the mass of the ruler and check this using a scale.

The torque due to a force is defined to be:

$$\tau = r \times F$$

where the force and the lever arm (labeled “torque arm” in the diagram) are perpendicular to each other as shown. You can balance a seesaw when the torques are balanced in equilibrium – that is, when the sum of the torques is zero and the torques on one side of the fulcrum are equal and opposite to the torques on the other side. For this activity the force is just the weight of the mass given by $w = mg$.



Procedure

1. Balance the meter stick by itself with the fulcrum. Where does the meter stick balance? That is, where is its center of gravity? Measure the location from the

zero end of the meter stick. Express your answer in cm, and keep 2 decimal places (that is, estimate down to the millimeter).

2. If you place the 200g mass 20 cm to the right of the fulcrum, what is the torque it exerts on the ruler? Show your work in your lab report.
3. How far away from the fulcrum (to the left) would you have to place a 100g mass to balance the above torque? Again, show your work.
4. Place the 200 g mass 20 cm to the right of the fulcrum to test your prediction for the placement of the 100 g mass. Be careful: 20 cm away from the fulcrum may not be at 70cm or 30 cm if your meter stick did not balance at 50 cm! Does the system balance? If not, where does it balance?
5. Now, instead of balancing the torque from the 200g mass with a single 100g mass, say you wanted to balance it with a 100g mass AND a 50g mass. If the 200g mass is 20cm to the left of the fulcrum and the 100g mass is 20cm to the right of the fulcrum, where would you place your extra 50g mass? Sketch the system, and show your work calculating where to hang the 50g mass.
6. Test your prediction from step 5 above. Does the system balance? If not, where does it balance?
7. Next, place the fulcrum exactly on the 85-cm mark. Balance the meter stick using a single mass hung between the 85-cm and 100-cm marks. Record the mass used and its position.
8. Draw a diagram in your lab report of the meter stick showing the fulcrum, the weight, and the lever arms from step 7. Show the force vectors, lever arms, and don't forget the weight of the meter stick!
9. From your diagram and the information gathered in step 7, calculate the mass of the meter stick.
10. Measure the mass of the meter stick using a scale.

Analysis

Calculate the percent error between your predicted and measured locations in steps 3 and 4. Repeat for steps 5 and 6, and the calculated and measured masses of the meter stick. What do you think were your major sources of error or uncertainty? How could you make your results more precise? Summarize your results.