EXPERIMENT 6 TORQUES

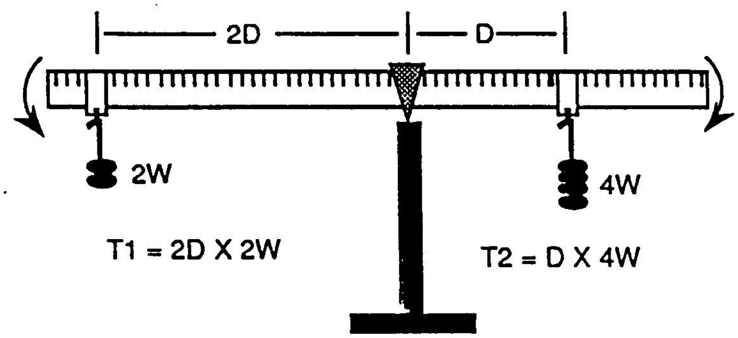


Figure 1

EQUIPMENT

1 meter stick
1 sliding knife-edge clamp
1 balance support
2 sliding mass hangers
2 weight pans
1 set of masses
1 triple beam balance
1 rock
1 rubber band
1 paper clip

INTRODUCTION

The purpose of this experiment is to study the concepts of center of gravity and torque and to apply these concepts to determine the value of an unknown mass.

A *torque* is a product of a force and *lever arm* distance which tends to produce rotation. The lever arm is the perpendicular distance from the axis of rotation to the line along which the force acts.

The *center of gravity* of an object is the average position of its weight. The force of gravity on the entire object can be considered to act at this point. For instance, the center of gravity of a uniform meter stick would be at its midpoint (the 50cm mark).

In this experiment you will observe and calculate the torques produced by objects suspended from a meter stick supported at its center of gravity (see the illustration). The torque produced by each object suspended from the meter stick is found by multiplying its distance from the fulcrum times the force of gravity on that object. In other words:

$$T = D * F$$

where Dis the distance from the fulcrum.

From your observations and calculations, you will determine the value of an unknown mass and explore the concept of a "solitary seesaw".

PROCEDURE

A. Investigation of Torques

1. Hold a meter stick in your hand near the end marked 0 cm.

2. Place a sliding mass hanger on the meter stick and slide it to the 20cm (.2m) mark. Suspend a weight pan from the hanger. Place a 500g (.5kg) mass on the weight pan and attempt to rotate the stick up and down.

3. Slide the mass hanger with the pan and the 500g mass to the 40, 60, 80, and then the 95 cm mark. At each mark attempt to rotate the stick up and down. Notice that the difficulty increases each time you change the position of the mass.

B. Calculation of Torques

1. Slide the gold-colored knife edge clamp onto the meter stick so that the screw adjustment is at the bottom edge of the meter stick (refer to figure 1). Slide the clamp until it is near the 50 cm mark.

2. Place the knife edge clamp and meter stick in the balance support. Notice that the clamp serves as a fulcrum and allows the meter stick to rotate. Carefully adjust the position of the clamp until the

meter stick is balanced in a horizontal position. This is the position of the center of gravity of the meter stick. This is also the position of the fulcrum when the meter stick is balanced with no additional masses on it. Record this position.

3. Slide a mass hanger onto the meter stick and position it 20 cm (.2 m) to the right of the fulcrum. Use the screw to secure the hanger in position. Suspend a weight pan and 500g (.5kg) mass from this hanger.

4. Record the combined mass of the hanger, weight pan, and 500g mass in kilograms. Calculate and record the combined weight.

5. Slide a second mass hanger onto the other end of the meter stick and suspend a pan and a 250g (.25kg) mass from it.

6. Record the combined mass of the hanger, weight pan, and 250g mass in kilograms. Calculate and record the combined weight.

7. Adjust the position of the hanger until the meter stick is balanced in a horizontal position. Record the distance between the position of the hanger and the fulcrum in meters.

8. Use the computer and the torque formula to calculate the two torques acting on the meter stick. Record the results. Ideally you should find that the torques are equal in magnitude.

C. Determination of an Unknown Mass

1. Loop a rubber band tightly around a rock. Bend a paper clip into the shape of an S. Hook one end of the paper clip around the rubber band so that the rock is suspended from the paper clip.

2. Slide a mass hanger onto the meter stick and position it securely 20 cm (.2 m) to the right of the fulcrum. Hook the free end of the paper clip onto the mass hanger.

3. Slide a mass hanger on the other end of the meter stick. From this hanger suspend a weight pan.

4. Place a 100g (.1 kg) mass on the weight pan.

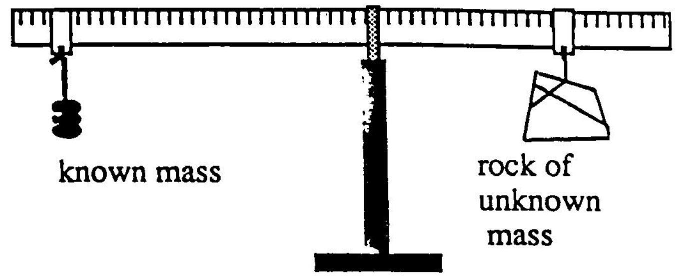


Figure 2

5. Record the combined mass of the hanger, weight pan and 100g mass in kilograms. This is the known mass referred to in figure 2. Calculate and record the weight of this combination.

6. Adjust the position of the hanger until the meter stick is horizontally balanced. At this position, the torque produced by the known mass is equal to the torque produced by the rock and its hanger. Record the distance between the hanger and the fulcrum in meters.

7. Use the computer and the torque formula to find the torque caused by the known mass. Record the result.

8. Write an equation which sets the torque caused by the known mass equal to the torque caused by the rock and its hanger. The equation should look like the one below.

$$\text{torque caused by known mass} = \text{weight of rock and hanger} * .20\,\text{m}$$

From this equation, calculate the weight of the rock with its hanger. Then find the mass of the rock and its hanger. Use the computer for the calculations. From this result, subtract the mass of the hanger. This is the calculated mass of the rock. Record this mass.

9. Use the triple beam balance to find the mass of the rock. Record the result.

10. find the percent error of the calculated mass of the rock as compared to the mass found with the triple beam balance.

D. Investigation of a "Solitary Seesaw"

1. In this part of the experiment, you will construct an equivalent system.

2. Use the triple beam balance to determine the mass of your meter stick. Record this mass in kilograms.

3. Slide the knife edge clamp onto the meter stick and position it near the 90cm mark. Tighten the screw.

4. Place the knife edge clamp and meter stick in the balance support. Notice that the meter stick does not balance with the fulcrum in this position.

5. Slide a mass hanger onto the meter stick and securely position it at the 95cm mark. Suspend a weight pan from the hanger. Place a 200g (.200kg) mass on the pan.

6. Loosen the screw on the knife edge clamp and adjust the position of the fulcrum until the meter stick is horizontally balanced. Record the position of the fulcrum and the distance between the fulcrum and the mass hanger.

CONCLUSIONS

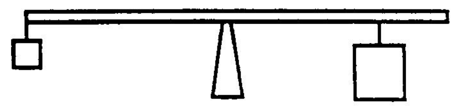
1. Define *torque* and draw a diagram which illustrates the definition.

2. In part A, why did it become more difficult to rotate the meter stick each time you repositioned the mass?

3. After the meter stick was balanced in part B, the system was in *equilibrium*. Define equilibrium. Since forces were acting on the meter stick, explain why the meter stick was in equilibrium.

4. In part D, there was a mass placed on one side of the fulcrum which caused a torque. When the fulcrum was positioned so that the system was in equilibrium, there must have been a second torque to counteract the first. What produced this second torque? At what position along the meter stick did this torque act?

5. A mass of 1 kgm is located at the 0 cm end of the meter stick. If the meter stick is suspended at its center, what mass must be placed at the 75 cm mark to balance the stick?



OVER →

Part B

position of fulcrum = ______ cm mark

combined mass of hanger, pan, and mass (kg)	combined weight (N)	distance from fulcrum (m)	calculated torque (N·m)

Part C

distance from rock and hanger to fulcrum	= ______ m
known mass	= ______ kg
weight of known mass	= ______ N
distance from known mass to fulcrum	= ______ m
calculated torque caused by known mass	= ______ N · m
calculated mass of rock	= ______ kg
mass of rock measured by triple beam balance	= ______ kg
percent error of calculated mass of rock	= ______ %

Part D

mass of meter stick	= ______ kg
final position of fulcrum	= ______ cm mark
distance between fulcrum and mass	= ______ cm