

# *MND Physics*

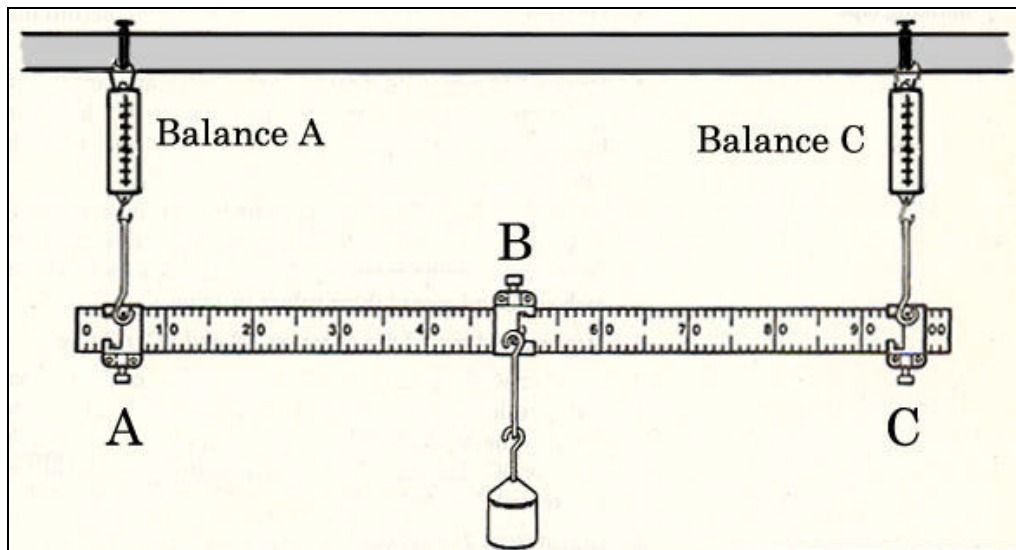
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## Investigating Torque



There is a good reason for attaching a doorknob as far as possible from the hinges of the door. When you open a door, you must apply a force. Where you apply that force and in what direction you push or pull determines how hard or easy it is to open or close the door. Forces not only produce motion in a straight line, they also produce rotation for objects that have a fixed axis of rotation.

In this experiment, two parallel upward forces (the two spring scales) will balance the downward force of the hanging weight. The two upward forces will tend to cause rotation of the system because each is exerted over a distance (the lever arm) from the third force, the downward acting weight. The fixed point B is the axis of rotation.



The force at point A acts over distance AB and produces a clockwise torque.

The force at point C acts over distance BC and produces a counter-clockwise torque.

Since the system is in equilibrium (not rotating), the clockwise torque must equal the counter-clockwise torque.

**EQUIPMENT:**

Table H- rack system with clamps, meter stick, 3 hangers with bails, 2 spring scales, mass set.

## PROCEDURE:

### Part 1:

1. Set up the apparatus as shown without a hanging mass.
2. IMPORTANT: Zero the hanging scales!
3. For trial 1, position one upright clamp at the 5 cm mark, one upside-down clamp at the 50 cm mark, and one upright clamp at the 95 cm mark.
4. With no mass hanging from clamp B, observe the readings of both scales. To insure good readings, lightly tap or bump the meter stick to remove any frictional influences on the scales.
5. Record the scale values (Newtons) in your data table as "initial force".
6. Hang a 500g mass from the center clamp at the 50 cm mark.
7. Record the scale values (Newtons) in your data table as "final force".
8. The "net force" is the final minus initial reading.
9. Record the distances AB and BC in meters.
10. Calculate the clockwise and counter-clockwise torque:

$$t_{CW} = F_{\text{Scale C net reading}} \times d_{BC}$$

$$t_{CCW} = F_{\text{Scale A net reading}} \times d_{AB}$$

### PART 2:

11. Move clamp A to a new position, somewhere between the 15 cm and 25 cm mark. Record this new value. Clamps B and C remain in their original positions.
12. Repeat steps 4 – 10.

### PART 3:

13. Move clamp A to a new position, somewhere between the 25 cm and 35 cm mark. Record this new value. Clamps B and C remain in their original positions.
14. Repeat steps 4 – 10

### FINAL PROCEDURE:

15. Remove and weigh the meter stick (keep the 3 brackets and hardware attached).

**DATA:**

FORCE DATA:

	Spring Scale A			Spring Scale C		
Trial	Initial Force (N)	Final Force (N)	Net Force (N)	Initial Force (N)	Final Force (N)	Net Force (N)
Part 1						
Part 2						
Part 3						

TORQUE DATA:

Trial	Net Force Scale A (N)	Lever Arm Distance AB (m)	$t_{ccw}$ Counter Clockwise Torque (Nm)	Net Force Scale C (N)	Lever Arm Distance BC (m)	$t_{cw}$ Clockwise Torque (Nm)
Part 1						
Part 2						
Part 3						

## ANALYSIS:

- Since the system is in equilibrium, the clockwise torque should equal the counter-clockwise torque. Perform an error calculation as follows:

$$\% \text{ difference} = \frac{|\text{counter-clockwise torque} - \text{clockwise torque}|}{\text{counter-clockwise torque}} \times 100\%$$

- Since the system is in equilibrium, prove that all forces upward equal all forces downward. Discuss any anomalies.
- Discuss all possible sources of error.

## QUESTIONS:

1. Two children, a boy and a girl, are sitting on a balanced teeter-tauter. The child on the left hand side is 3.00 m from the pivot point and has a mass of 40.0 kg. The child on the right hand side is 5.91 m from the first child. What is the child's mass on the right hand side? The boy is heavier than the girl. Which side is the girl on, left or right?
2. The technique for measuring forces and torques in this lab can be used to determine the forces exerted by the piers of a bridge. Calculate the forces exerted by each pier (left hand and right hand pier) supporting a 5.00 m long foot-bridge. The 100.0 kg foot-bridge is supporting a 55.0 kg person standing on the bridge 2.00 m from the left hand edge.