33 Weighing an Elephant

Purpose

To determine the relationship between masses and distances from the fulcrum for a balanced seesaw.

Required Equipment/Supplies

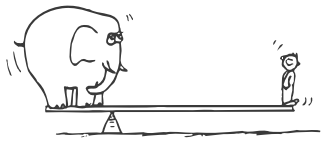
meterstick
wedge or knife-edge
2 50-g mass hangers
slotted masses or set of hook masses
knife-edge level clamps

Discussion

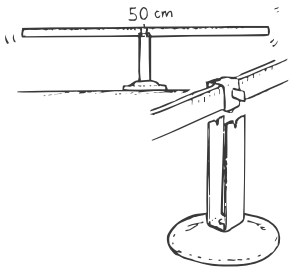
An object at rest is in equilibrium (review Section 4.7 of the text). The sum of the forces exerted on it is zero. The resting object also shows another aspect of equilibrium. Because the object has no rotation, the sum of the torques exerted on it is zero. When a force causes an object to start turning or rotating (or changes its rotation), a nonzero net torque is present.

The seesaw is a simple mechanical device that rotates about a pivot or fulcrum. It is a type of lever. Although the work done by a device can never be more than the work or energy invested in it, levers make work *easier* to accomplish for a variety of tasks.

Suppose you are an animal trainer at the circus. You have a very strong, very light, wooden plank. You want to balance a 600-kg baby elephant on a seesaw using only your own body weight. Suppose your body has a mass of 50 kg. The elephant is to stand 2 m from the fulcrum. How far from the fulcrum must you stand on the other side in order for you to balance the elephant?



Laboratories do not have elephants or masses of that size. They do have a variety of smaller masses, metersticks, and fulcrums that enable you to discover how levers work, describe their forces and torques mathematically, and finally solve the elephant problem.



Procedure

Step 1: Carefully balance a meterstick horizontally on a wedge or knife-edge. Suspend a 200-g mass 10 cm from the fulcrum. Suspend a 100-g mass on the opposite side of the fulcrum at the point that balances the meterstick. Record the masses and distances from the fulcrum in Data Table A.

1. Can a heavier mass be balanced by a lighter one? Explain how.

Step 2: Make more trials to fill in Data Table A. You can do this by using the masses of Step 1 and changing their positions. For instance, you can move the heavier mass to a new location 5 cm farther away, and then rebalance the meterstick with the lighter mass.

You can also change the magnitudes of the masses. Replace the heavier mass with another mass and rebalance the lever by moving the lighter mass. Record the masses and distances from the fulcrum in Data Table A. Be sure to take into account the mass of any hanger or clamp.

TRIAL	SMALL MASS (g)	DISTANCE FROM FULCRUM (cm)	LARGE MASS (g)	DISTANCE FROM FULCRUM (cm)

Data Table A

Analyze data for pattern.

Step 3: Use any method you can devise to discover a pattern in the data of Data Table A. You can try graphing the large mass vs. its distance from the fulcrum, the small mass vs. its distance from the fulcrum, or another pair of variables. You can also try forming ratios or products.

Step 4: After you have convinced yourself and your laboratory partners that you have discovered a pattern, convert this pattern into a word statement.

Express pattern as statement.

Step 5: Now convert this word statement into a mathematical equation. Be sure to explain what each symbol stands for.

Convert statement into equation.

Step 6: With the help of your partners or your teacher, use your equation to find the distance a 50-kg person should stand from the fulcrum in order to balance the 600-kg elephant. Show your work (neglect the mass of the supporting board).

Solve for unknown distance.

$d =$ _____ m

Analysis

2. Why must the mass of the hangers and clamps be taken into account in this experiment?

3. If you are playing seesaw with your younger sister (who weighs much less than you), what can you do to balance the seesaw? Mention at least two things.

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4. Taking account of the fact that the board holding up the elephant and the trainer (see sketch in the Discussion section) has weight, would the actual position of the trainer be farther from or closer to the fulcrum than calculated in Step 6?

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