

Angular motion, torque and balance

AP Physics 1 (algebra-based) · Lab

Name: _____ Date: _____ Class: _____

How does the turning effect of a load change with its distance from a pivot? You balance a fixed 0.200 kg load against a lighter 0.100 kg mass on a metre rule pivoted at its centre, change the position of the load, and test whether the torques balance each time.

Level: AP Physics 1 (algebra-based) · **Curriculum:** AP P1 Unit 5

Aim

To test that a rule balances when the clockwise and anticlockwise torques about the pivot are equal, and to find how the balancing distance depends on the load distance.

Equipment

- Metre rule with a knife-edge pivot or a ruler resting on a pencil at the 50.0 cm mark
- Load of 0.200 kg and a counterweight of 0.100 kg, each on a loop of thread
- Tape to hold the threads in place

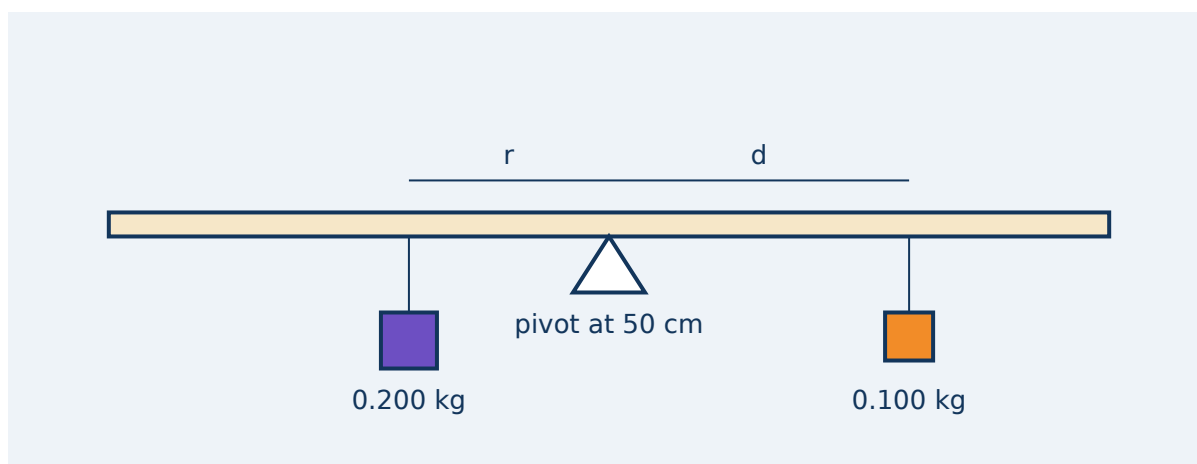
Safety

Safety

Work over a table, not near the edge, so falling masses cannot hit your feet. Keep the masses small and stand clear while the rule is adjusted.

Method

1. Balance the unloaded rule on the pivot and check that it stays horizontal.
2. Hang the 0.200 kg load at $r = 0.050$ m from the pivot on the left.
3. Slide the 0.100 kg mass along the right side until the rule balances. Record its distance d from the pivot.
4. Repeat for $r = 0.100, 0.150, 0.200$ and 0.250 m.
5. Calculate the torque on each side using $\tau = m g \times \text{distance}$.



The load and the counterweight hang on opposite sides of the pivot at the centre of the rule.

Results

Sample measurements. Complete the two torque columns using $g = 9.81 \text{ N/kg}$.

r (m)	d (m)	Left torque (N m)	Right torque (N m)
0.050	0.101		
0.100	0.199		
0.150	0.305		
0.200	0.398		
0.250	0.503		

Analysis questions

Question 1 Left and right torques

Complete the table by calculating the torque of the load (0.200 kg at r) and of the counterweight (0.100 kg at d) for each trial.

Question 2 Percentage difference

Calculate the percentage difference between the two torques for the first and last trials and state whether the rule is in equilibrium within experimental error.

Question 3 Graph of d against r

Describe the graph of d against r. Calculate the gradient using the first and last points and compare it with the ratio of the masses.

Question 4 Reading uncertainty

The distances are read to $\pm 0.002 \text{ m}$. Calculate the percentage uncertainty in the torque of

the load for $r = 0.050$ m.

Question 5 Why the pivot is at the centre

Explain why the pivot is placed at the centre of the rule and what would happen if it were not.

Question 6 Predict a new balance

Predict the distance d needed to balance the 0.200 kg load placed at $r = 0.180$ m.

Question 7 Improving the method

Propose two changes that would reduce the uncertainty in the balance distances.