

Angular motion, torque and balance

AP Physics 1 (algebra-based) · Lab answers

The answers use the sample data. The torques should match within a few per cent, the graph should be a straight line through the origin with gradient close to the ratio of the masses, and the main errors come from reading the balance point and from friction at the pivot.

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

Question 1 Left and right torques

Left = $0.200 \times 9.81 \times r$; right = $0.100 \times 9.81 \times d$. Values in N m: $r = 0.050$: left 0.098, right 0.099; $r = 0.100$: left 0.196, right 0.195; $r = 0.150$: left 0.294, right 0.299; $r = 0.200$: left 0.392, right 0.390; $r = 0.250$: left 0.491, right 0.493. **Left and right agree closely.**

Question 2 Percentage difference

First trial: $(0.0991 - 0.0981) \div 0.0981 = \mathbf{1.0\%}$. Last trial: $(0.4934 - 0.4905) \div 0.4905 = \mathbf{0.6\%}$. Both are within the reading uncertainty, so the rule is in equilibrium within error.

Question 3 Graph of d against r

The graph is a straight line through the origin. Gradient = $(0.503 - 0.101) \div (0.250 - 0.050) = 0.402 \div 0.200 = \mathbf{2.01}$. The mass ratio is $0.200 \div 0.100 = 2.0$, so they agree.

Question 4 Reading uncertainty

Percentage uncertainty in $r = 0.002 \div 0.050 \times 100 = \mathbf{4\%}$. The masses are known well, so the torque of the load has the same 4 % uncertainty.

Question 5 Why the pivot is at the centre

The weight of a uniform rule acts at its centre. With the pivot there, the rule's weight has a zero lever arm and no torque, so **only the two hung masses matter**. Otherwise the rule's own torque must be included.

Question 6 Predict a new balance

From the gradient 2.0: $d = 2.0 \times 0.180 = \mathbf{0.36\text{ m}}$. Check with torques: $0.200 \times 0.180 = 0.100 \times d$ gives $d = 0.36\text{ m}$.

Question 7 Improving the method

Use a sharper pivot to cut friction, and read the positions from the centre of each thread loop. **Repeat each balance several times and average**, and use a larger range of r to reduce the effect of reading error.