

Rotational energy, rolling and angular momentum

AP Physics 1 (algebra-based) · Lab

Name: _____ Date: _____ Class: _____

Can you change how fast you spin without anyone pushing you? In this lab you sit on a swivel chair holding two weights, time your turns with arms out and arms in, and use the results to test conservation of angular momentum and to find the rotational inertia of you and the chair.

Level: AP Physics 1 (algebra-based) · **Curriculum:** AP P1 Unit 6

Aim

To test conservation of angular momentum by timing a student on a swivel chair with arms out and arms in, and to use the results to find the rotational inertia of the student and chair.

Equipment

- Swivel chair or rotating stool with a low-friction bearing
- Two 1.5 kg weights (dumbbells or bags of sand)
- Phone camera on a stand, or a helper with a stopwatch
- Metre rule, marker tape for the floor

Safety

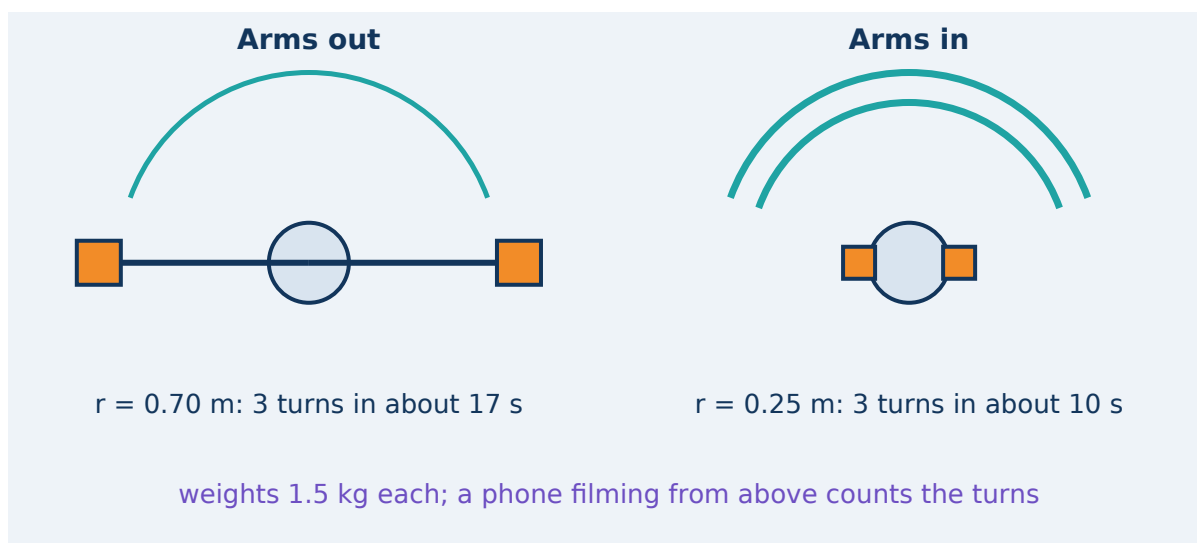
Safety

Clear a wide space around the chair. A helper stands close, ready to steady the chair. Spin slowly, keep feet raised, and stop at once if you feel dizzy. Never let go of the weights while spinning.

Method

1. Measure the distance from the axis of the chair to the weights with arms stretched out (r_{out}) and arms pulled in (r_{in}).
2. Sit with feet raised and weights held out. A helper gives a gentle push to start slow steady turning.
3. Time three complete turns with arms out, then pull the weights close to the chest without touching the floor and time three turns again.
4. Repeat three times. Calculate the mean times and the angular speeds $\omega = 2\pi \times 3 \div t$.

5. Use conservation of angular momentum to find I_0 , the rotational inertia of the student and chair without the weights.



Set-up: the student is given a push, then stretches out the weights, and later pulls them in without any further push.

Results

Sample data: $r_{\text{out}} = 0.70 \text{ m}$, $r_{\text{in}} = 0.25 \text{ m}$, two weights of 1.5 kg.

Trial	Time for 3 turns, arms out (s)	Time for 3 turns, arms in (s)
1	17.4	10.2
2	17.0	9.9
3	17.2	9.9
Mean	17.2	10.0

Analysis questions

Question 1 Angular speeds

Calculate the mean angular speed with arms out and with arms in, using $\omega = 2\pi \times 3 \div t$.

Question 2 Rotational inertia of the weights

Calculate the rotational inertia contributed by the two weights in each position, treating them as point masses.

Question 3 Rotational inertia of student and chair

Use $I_{\text{out}}\omega_{\text{out}} = I_{\text{in}}\omega_{\text{in}}$, where $I = I_0 + \text{the weights' contribution}$, to find I_0 .

Question 4 Checking the conservation law

Using your value of I_0 (rounded to 1.6 kg m^2), calculate the angular momentum in each position and the percentage difference.

Question 5 Kinetic energy change

Calculate the kinetic energy with arms out and with arms in, and explain the difference.

Question 6 Uncertainty

Estimate the percentage uncertainty in the mean time with arms out using half the range, and say how it affects ω .

Question 7 Friction and other errors

Explain how friction in the bearing and the mass of the arms would affect the results.

Question 8 Making the test fairer

Describe two changes to the swivel-chair procedure that would make the angular momentum comparison more convincing.