

Rotational inertia and Newton's second law

AP Physics 1 (algebra-based) · Lab

Name: _____ Date: _____ Class: _____

How can you measure how hard a wheel is to spin? In this lab a falling mass pulls a string wound on a spool and spins a bicycle wheel. From the fall time you calculate the angular acceleration, the torque and the rotational inertia, then test what two extra masses do to it.

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

Aim

To measure the rotational inertia of a wheel from the motion of a falling mass, and to test whether adding two masses at a known distance increases I by the amount $2mr^2$.

Equipment

- Bicycle wheel (or similar) mounted horizontally on a low-friction axle with a small spool
- String, 0.500 kg hanging mass and a mass hanger
- Two clamp masses of 0.200 kg each
- Metre rule, stopwatch, kitchen scale

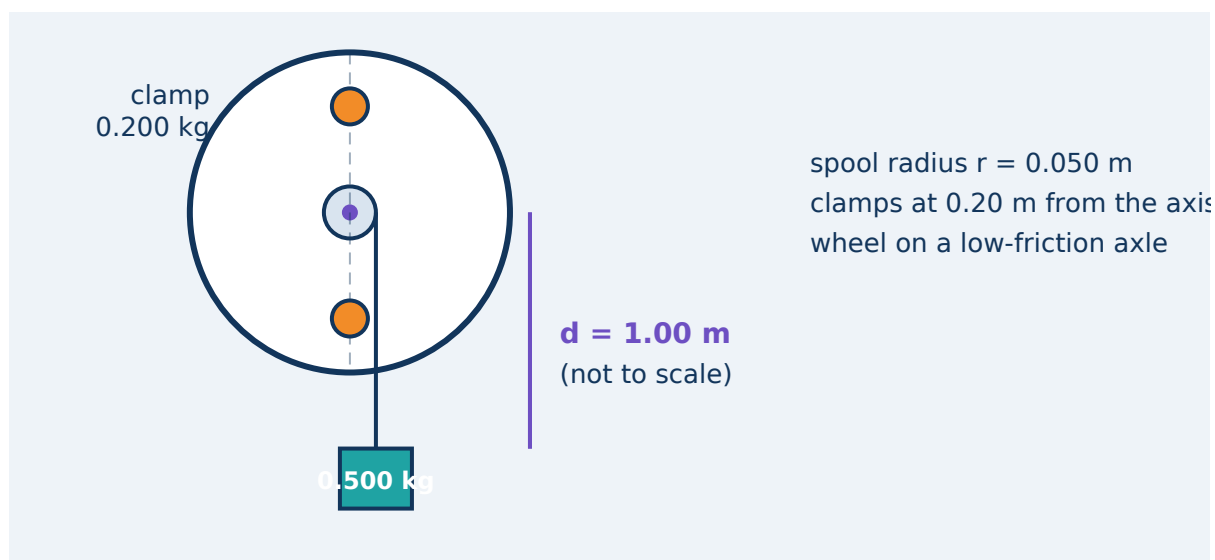
Safety

Safety

Make sure the axle stand is firmly clamped so the wheel cannot tip. Keep fingers and hair away from the spinning wheel and spokes, and keep feet clear of the falling mass.

Method

1. Wind the string around the spool and attach the 0.500 kg mass. Measure the spool radius r with a ruler or thread.
2. Raise the mass by 1.00 m. Release it from rest and time its fall to the floor. Do five trials and calculate the mean time t .
3. Fix the two clamp masses on opposite spokes, each 0.20 m from the axis.
4. Repeat the five timed trials with the clamps in place.
5. Calculate $a = 2d/t^2$ for each run, then the rotational inertia from the motion.



Set-up: the hanging mass falls 1.00 m while the wheel spins; the time is measured with a stopwatch.

Results

Sample data: $d = 1.00$ m, $r = 0.050$ m, hanging mass 0.500 kg.

Trial	Wheel only, t (s)	Wheel with clamps, t (s)
1	4.08	4.38
2	4.03	4.35
3	4.10	4.40
4	4.05	4.36
5	4.06	4.37
Mean	4.06	4.37

Analysis questions

Question 1 Acceleration of the mass

Calculate the acceleration of the falling mass for the wheel without clamps, using $a = 2d/t^2$ with the mean time.

Question 2 Tension and angular acceleration

Calculate the angular acceleration of the wheel and the tension in the string. State whether the tension equals the weight of the mass.

Question 3 Rotational inertia of the wheel

Use $\tau = Tr$ and $\tau = I\alpha$ to calculate the rotational inertia of the wheel alone.

Question 4 Rotational inertia with the clamps

Repeat the calculation for the run with the clamps in place.

Question 5 Testing the prediction

Calculate the increase in I predicted by $2mr^2$ for the two clamps and compare it with the measured increase.

Question 6 Size of the correction

Calculate the percentage difference between T and the weight mg for the wheel-only run, and say whether ignoring it would matter.

Question 7 Uncertainty

Estimate the percentage uncertainty in the mean time for the wheel-only run from half the range, and state the resulting uncertainty in a .

Question 8 Improvements

Suggest two sources of systematic error, including friction in the axle, and one improvement for each.