

Simple harmonic motion and the physical pendulum

AP Physics C (Mechanics and E&M, calculus-based) · Lab

Name: _____ Date: _____ Class: _____

A metre stick can swing from any hole drilled along its length, and the swing time changes with the hole chosen. This lab measures the period for several pivot distances and tests the physical pendulum equation, then uses a straight-line graph to extract g and the radius of gyration of the stick.

Level: AP Physics C (Mechanics and E&M, calculus-based) · **Curriculum:** AP PC:M Unit 7

Aim

To measure the period of a metre stick swinging about different pivot holes and use the physical pendulum equation to find g and the radius of gyration of the stick.

Equipment

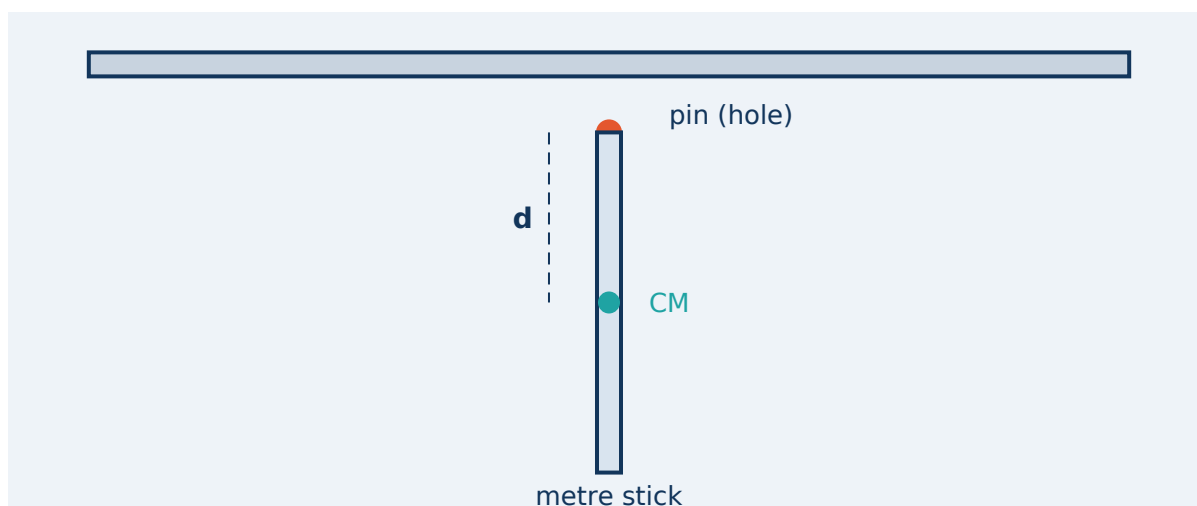
- A metre stick drilled with small holes at 10, 20, 30, 40 and 45 cm from the centre
- A clamp and a horizontal steel pin or nail
- A stopwatch or phone timer
- A protractor to check the starting angle

Safety

Safety

Clamp the pin firmly to the bench edge and keep faces and hands clear of the swinging stick. Wear closed shoes and stand to the side.

Method



Set-up: a metre stick with drilled holes swings from a horizontal pin; d is measured from the pin to the centre (50 cm mark).

1. Hang the stick from the pin through the hole at $d = 0.10$ m.
2. Pull it aside by about 8° (less than 10°) and release it without pushing.
3. Time 10 complete swings and divide by ten to get T .
4. Repeat for each hole.
5. For each hole calculate T^2d and d^2 . Theory predicts $T^2d = (4\pi^2/g)(k^2 + d^2)$, where $k^2 = L^2/12$ is the square of the radius of gyration.

Results

Sample measurements for a stick of length $L = 1.00$ m:

d (m)	Time for 10 swings (s)	T (s)	T^2d (s ² m)	d^2 (m ²)
0.10	19.4	1.94	0.376	0.0100
0.20	15.8	1.58	0.499	0.0400
0.30	15.3	1.53	0.702	0.0900
0.40	15.7	1.57	0.986	0.1600
0.45	16.0	1.60	1.152	0.2025

Analysis questions

Question 1 Check the table

Check the values of T and T^2d for $d = 0.30$ m and $d = 0.45$ m.

Question 2 Straight-line graph

Explain why a graph of T^2d against d^2 should be a straight line, and state its gradient and intercept in terms of g and k .

Question 3 Find g

Take the outer two rows of the table, work out the slope of T^2d against d^2 , then deduce a value for the gravitational field strength.

Question 4 Radius of gyration

Use the intercept to find k^2 and compare it with $L^2/12$.

Question 5 Timing uncertainty

The reaction-time error in starting and stopping the timer is about ± 0.2 s. Calculate the uncertainty in T and its percentage for $d = 0.20$ m.

Question 6 Shape of the data

Explain why T is larger at $d = 0.10$ m than at $d = 0.30$ m, and why it rises again towards $d = 0.45$ m.

Question 7 Amplitude check

Explain why the starting angle must be below about 10° , and estimate the error in T for 40° .