

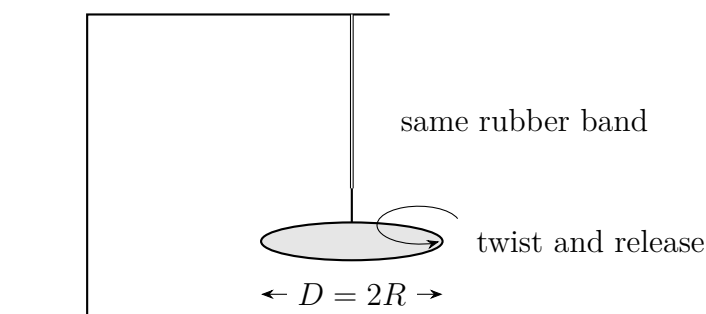
Testing a model with rotational timing

Name: _____ Class: _____ Date: _____

Aim Test a supplied relationship using two rotating mass hangers. Allow 50–60 minutes.

Practical-skills enrichment The rotational theory is beyond AS. You only need the supplied model $T^2 = KmR^2$ and AS measurement skills. Here T is one cycle, m is total mass and R is widest radius. A constant K assumes comparable mass distribution and unchanged band stiffness.

Apparatus Stand, boss and clamp, rubber band, 50 g and 100 g mass hangers, ruler, stopwatch, balance and optional vernier calipers.



Safety Stabilise the stand. Inspect the band for damage and keep the hanger over a tray. Do not stretch or twist the band excessively.

1 Make the comparison fair

1. Measure each hanger's actual mass, including any added load. Measure its widest diameter in two directions and calculate $R = D/2$.
2. Suspend the first hanger from the band. Let it settle. Twist it about half a turn without lifting or pushing it, then release.
3. Use a fixed mark and a fixed direction of crossing. One cycle returns to the same angular position moving in the same direction.
4. Time 10 complete cycles. Repeat three times, resetting the twist angle. Calculate $T = \bar{t}/10$.
5. Repeat with the other hanger using the same band and clamp point. Keep the initial twist angle similar. Recheck the first hanger afterwards to test whether the band has changed.

Before measuring Describe how you will avoid confusing half a cycle with a complete cycle.

2 Record raw and processed data

Resolution: balance _____; ruler/calipers _____; stopwatch _____.

Hanger	m/kg	D_1/m	D_2/m	R/m

Hanger	t_1/s	t_2/s	t_3/s	$\bar{t}/\text{s}$	T/s

Hanger	$mR^2/\text{kg m}^2$	T^2/s^2	$K/\text{s}^2 \text{ kg}^{-1} \text{ m}^{-2}$

Observations Describe any sideways swinging, uneven rotation or damping.

Precision Justify the decimal places of your mass, diameter and timing readings.

3 Compare with uncertainty

Calculate $K = T^2/(mR^2)$ for each hanger. Show one complete calculation with SI units.

For this experiment use an absolute timing uncertainty that includes start/stop judgement and repeat scatter. The stopwatch display alone is not a reaction-time estimate.

$$\frac{\Delta K}{K} \approx 2\frac{\Delta T}{T} + \frac{\Delta m}{m} + 2\frac{\Delta R}{R}, \quad \Delta T = \frac{\Delta \bar{t}}{10}.$$

State and justify $\Delta \bar{t}$, Δm and ΔR for each hanger. If $R = D/2$, then $\Delta R = \Delta D/2$; the fractional uncertainty is unchanged.

Calculate both uncertainty intervals $K - \Delta K$ to $K + \Delta K$. Do they overlap?

Conclusion Are the measurements consistent with a single K ? Explain why overlap is evidence of consistency, not proof of the model, and why two values cannot establish a general relationship.

4 Evaluate and design a stronger test

1. Name two specific limitations and match each to a practical improvement. Explain how the improvement changes the uncertainty or fairness of the comparison.

2. The heavier hanger stretches the band more. Explain why this could change K , even if your timing is excellent.

3. Plan a follow-up using at least six values. Explain how to vary mass while keeping the mass distribution and radius comparable. State the axes of a graph that should be straight if the model holds.

Adding modelling clay changes both the mass and its distribution. A large change in shape is a change to the model, not simply another value of m . Ask the teacher to approve your proposed loads.

Exit check Why does timing 10 cycles reduce fractional timing uncertainty?

Before you leave Return the apparatus, clear the bench and submit your recorded data.