Tests with single two-wire pendulum – part two

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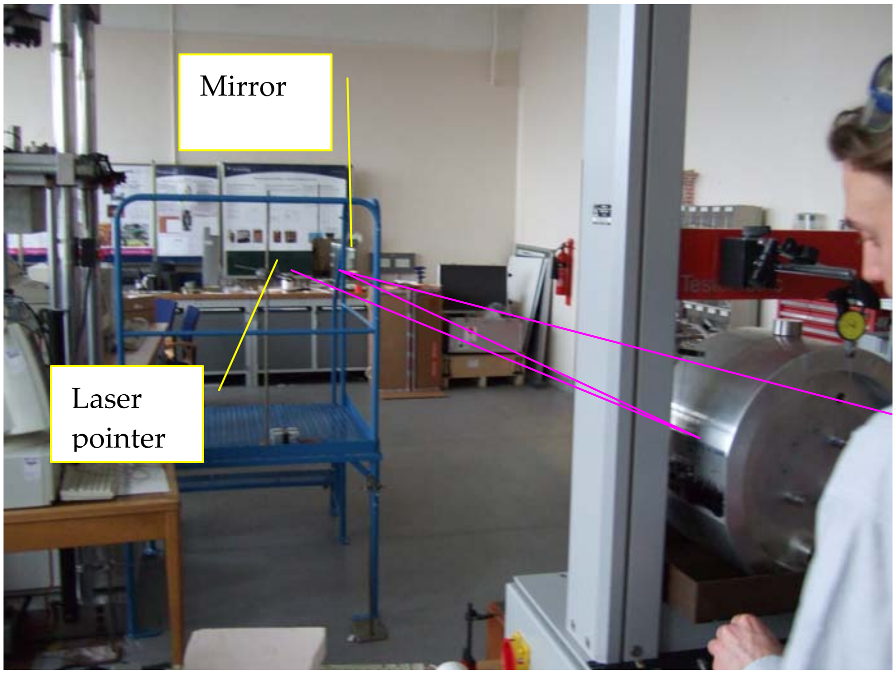
1. APPARATUS

We set up a 40.2kg test mass from two wires in the mouth of a test machine (to provide a convenient way to raise/lower the mass). Under the mass was a shallow tray of water for damping. The mass was suspended from two wires, and a laser with an optical lever of 7.8*2+2 = 17.6m including a mirror (figures). The spot size of the optical lever was about 20mm (figure) but it had features which enabled it's location to be determined to ~1mm.



General view of apparatus. The path of the optical lever is shown in pink. The screen onto which the pointer finally shines is not visible in this view.

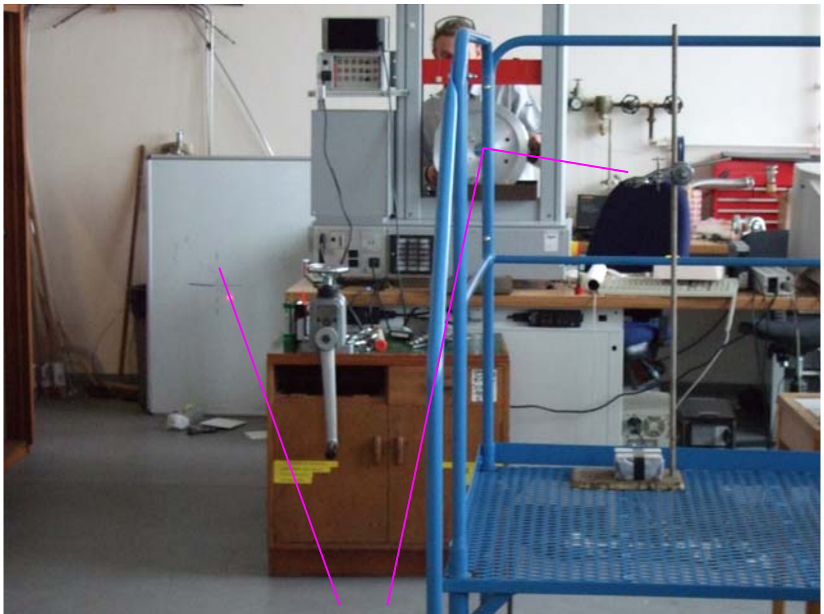


Figure 2 – general view of apparatus. The path of the laser pointer is shown in pink.

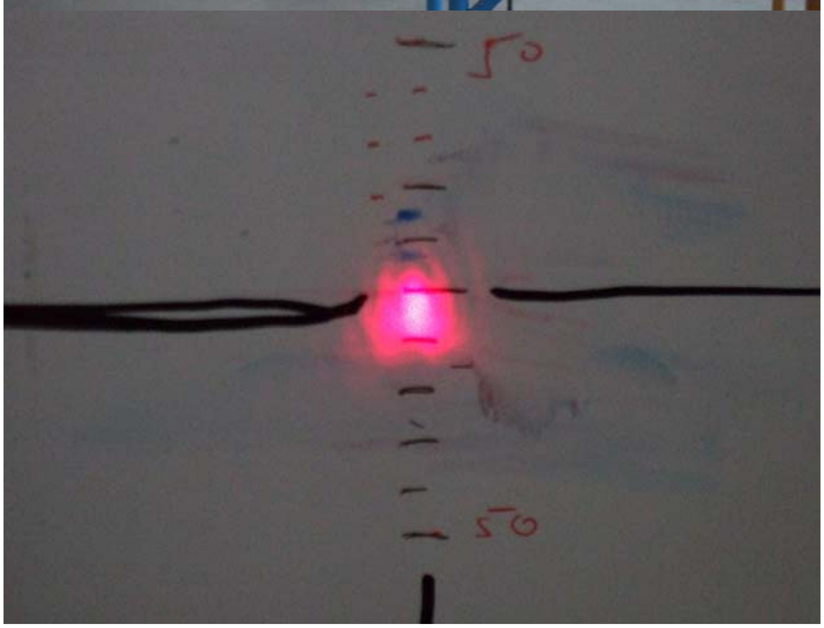


Figure 3. The shape of the laser pointer during test 1. The Marks on the board are at ~10mm intervals (used to assess the magnitude of the input tilt).

With the mass sitting on the base of the test machine, the spot motion was about 1mm.

We therefore conclude that the limit of resolution of the measurements is about 1mm, corresponding to a test mass motion of (1/17.6/2 = 0.03mRad).

With new clamps and wire we raised the mass and attempted to hand the mass while keeping the laser spot at the same height – in this way we avoided tipping the mass. The object was to avoid damaging the clamps. The maximum excursion we saw during the lift was between about -250 + 150mm (-7 to +4 mRad). We ended up at about +150 (+4mRad) compared to the rest position. We moved the far mirror to bring the laser spot back to zero. The wires had a diameter of 0.71mm (nominal).

2. METHOD, RESULTS

The basic method was to tilt the mass using one of a pair of dial gauges as pushers, and to gently release the mass to allow it come back to the nominal zero position with minimal overshoot.

2.1 Test 1 – standard wires, plain clamps

With the mass suspended we looked first to see if we could see hysteresis at small levels of displacement, the idea being to increase the size of input motion until found something. We recorded the zero point. We then made an accidental motion of +/- ~200mm (6mRad) and the zero point moved down by about 2mm.
The tests then started as noted below.

input		output		
mm	mRad	mm	mRad	
+/- 10	+/- 0.3	+/- 1	+/- 0.03	
1	0.03		0.00	
-250	-7.10		0.00	
150	4.26		0.00	
200	5.68		0.00	
-100	-2.84	-5	-0.14	
same	#VALUE!	-14	-0.40	
100	2.84	-10	-0.28	
-100	-2.84	-12	-0.34	
100	2.84		0.00	accidental excursion +/- 300
300	8.52	-1	-0.03	
-300	-8.52	-14	-0.40	followed by a pause
300	8.52	-7	-0.20	
-300	-8.52	-17	-0.48	
300	8.52	-9	-0.26	
-300	-8.52	-19	-0.54	
			0.00	

For an input motion of ~17mRad we saw an output range of ~0.25mRad or about 1.5%, with a sensitivity of (0.06/17) ~0.4%.

2.2 Test 2 – standard wires, brazed clamps.

The shape of the laser spot had changed and it no longer had small features. Therefore the accuracy of our measurements went down a little – although it was still possible to claim movements of order 1mm and they have been faithfully noted, it would be hard to justify a repeatability better than 2-3mm.

The clamps had been brazed as shown in the photo

input		output		
mm	**mRad**	**mm**	**mRad**	
+/- 10	**+/- 0.3**	**+/- 2**	**+/- 0.06**	
100	2.84	1	0.03	
-100	-2.84	0	0.00	
200	5.68	5	0.14	
-200	-5.68	-1	-0.03	
300	8.52	5	0.14	
-300	-8.52	-5	-0.14	
300	8.52	3	0.09	
-300	-8.52	-5	-0.14	
300	8.52	4	0.11	
-300	-8.52	-5	-0.14	
300	8.52	3	0.09	

For an input motion range of 17mRad, we saw an output range of ~0.25mRad or around 1.5% with a sensitivity of (0.12/17) ~0.7%.

2.3 Test 3 – standard wires, brazed clamps, oscillated

For this test the disturbing force was suddenly removed. The decay limits for the first few cycles were approximately 300 270 250 210 190 mm.

input		output		
mm	**mRad**	**mm**	**mRad**	
+/- 10	**+/- 0.3**	**+/- 2**	**+/- 0.06**	
-300	-8.52	0	0.00	oscillated
300	8.52	0	0.00	oscillated

So allowing the oscillation removed the offset effect.

2.4 Test 4 – standard wires, oscillation test

With new wires and clamps, we tried first a slow release (to see that the offset effect was still present) and then an oscillated release.

input		**output**		
mm	**mRad**	**mm**	**mRad**	
+/- 10	**+/- 0.3**	**+/- 2**	**+/- 0.06**	
300	8.52	5	0.14	new wires
-300	-8.52	-4	-0.11	
300	8.52	3	0.09	oscillation from ~200
-300	-8.52	3	0.09	oscillation

Again we see that allowing the oscillation has removed the offset effect.

2.5 Test 5 – thicker wires

The wires were switched for 1.1mm diameter, using a groove designed for, and previously used with, 0.71mm wire.

The frequency was 2.5Hz; the effect we measured with 0.71mm wires (T080033) when the pendulum had a similar frequency was 2%.

input		**output**		
mm	**mRad**	**mm**	**mRad**	
+/- 10	**+/- 0.3**	**+/- 2**	**+/- 0.06**	
-200	-5.68	0	0.00	1.1mm wire
200	5.68	0	0.00	
-400	-11.36	-5	-0.14	input hard to judge; - 400 to -500
400	11.36	0	0.00	
-400	-11.36	-5	-0.14	overshoot to ~-450

The magnitude we see is about (0.14/22) or 0.7%. It would be good to bias the mass to give the same frequency (hence d) as with the small wires, and try again.