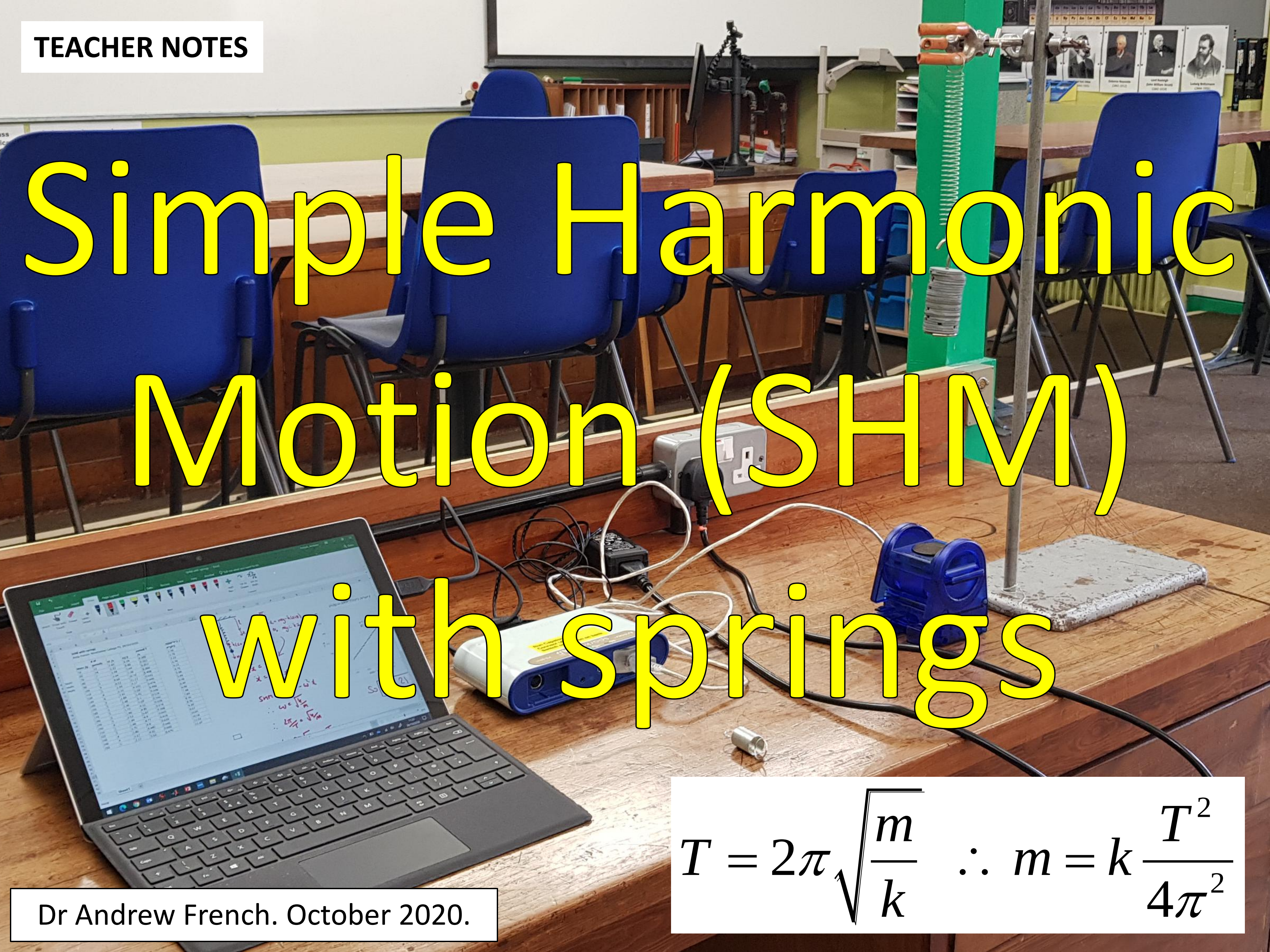
TEACHER NOTES

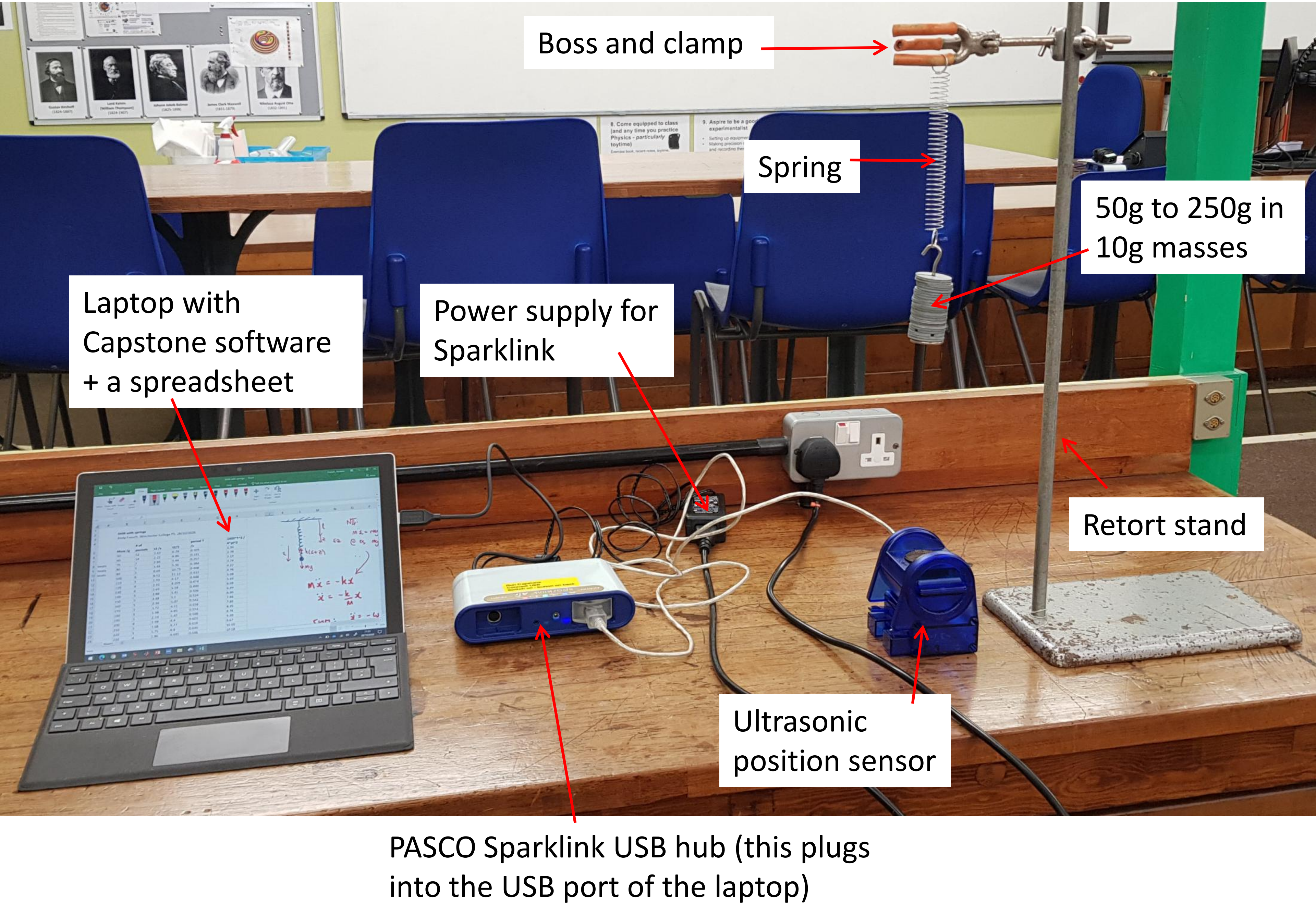
Simple Harmonic Motion (SHM) with springs

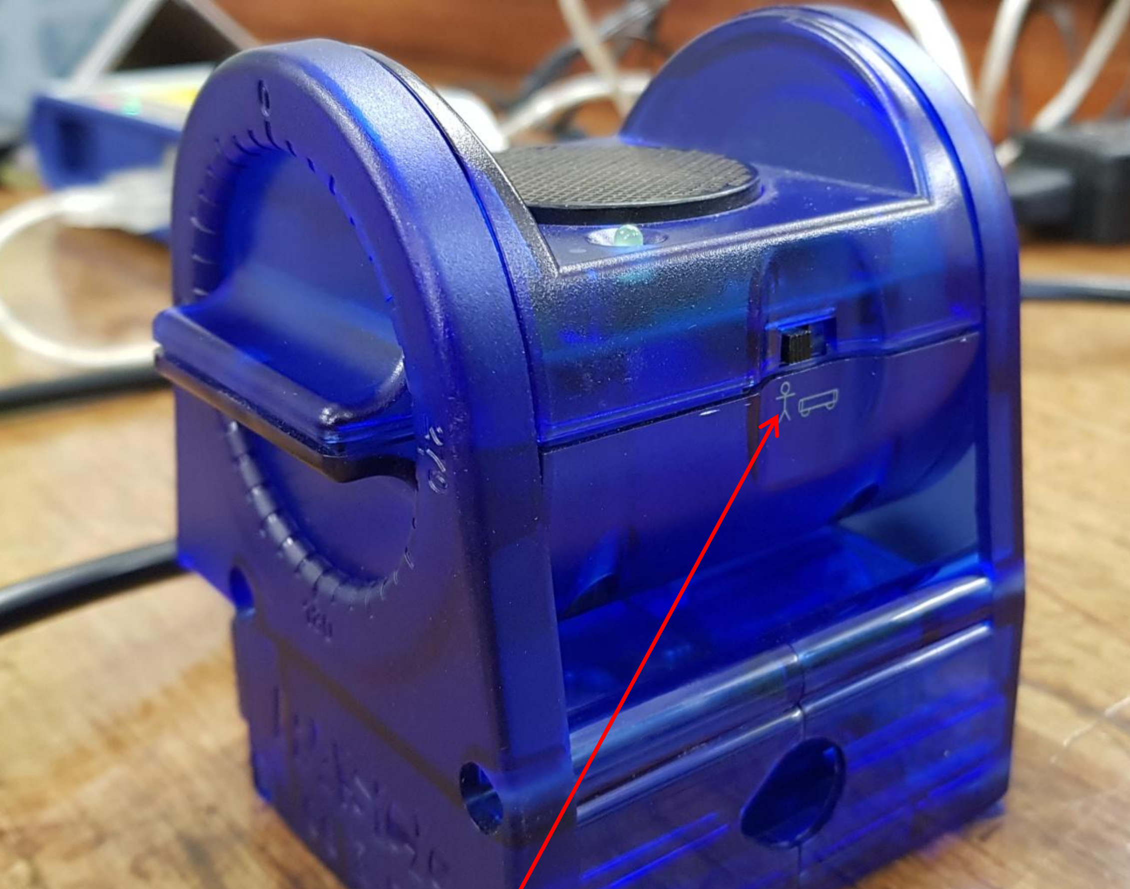


$$T = 2\pi\sqrt{\frac{m}{k}} \quad \therefore \; m = k\frac{T^2}{4\pi^2}$$

Dr Andrew French. October 2020.

Equipment setup



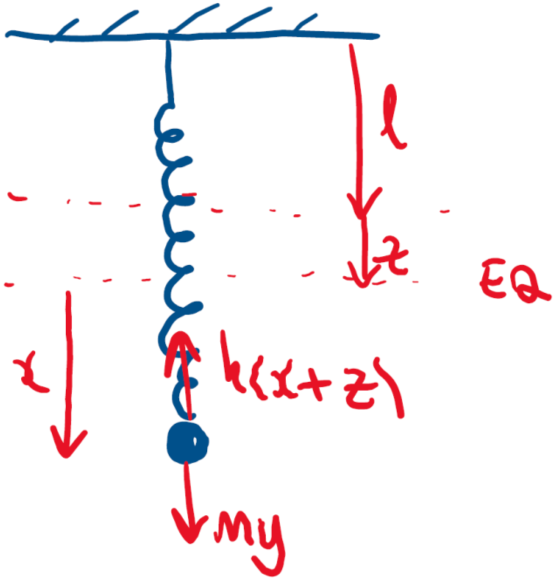


Record at 100Hz

Set ultrasonic position sensor in ‘**person**’ mode. The beam is slightly wider, and will mean smooth sinuoidal measurements will be obtained even if the mass jerks around sideways a little.

The 10g mass hook is also 10g.

Simple Harmonic Motion (SHM)



NII:

$$m\ddot{x} = mg - k(x+z)$$

@ eq $mg = kz$

$$\therefore \quad m\ddot{x} = -kx$$

$$\ddot{x} = -\frac{k}{m}x$$

$$x = A\cos\left(\frac{2\pi t}{T}\right)$$

$$\dot{x} = -A\frac{2\pi}{T}\sin\left(\frac{2\pi t}{T}\right)$$

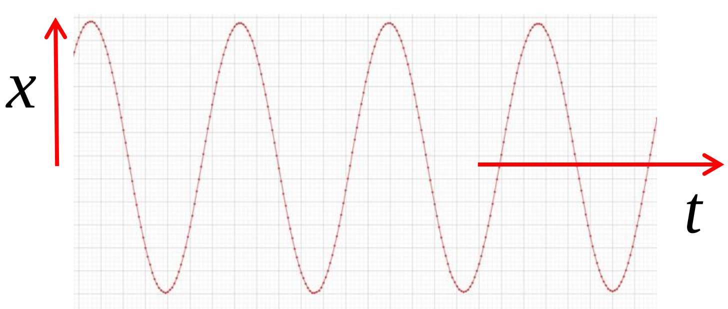
$$\ddot{x} = -A\frac{4\pi^2}{T^2}\cos\left(\frac{2\pi t}{T}\right)$$

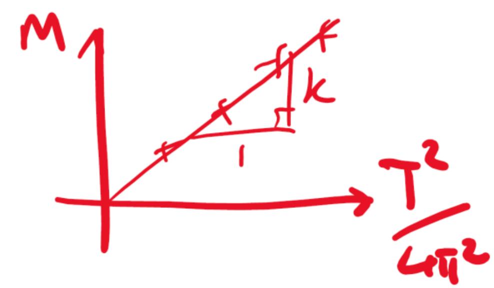
$$\ddot{x} = -\frac{4\pi^2}{T^2}x$$

$$\therefore \quad \frac{4\pi^2}{T^2} = \frac{k}{m}$$

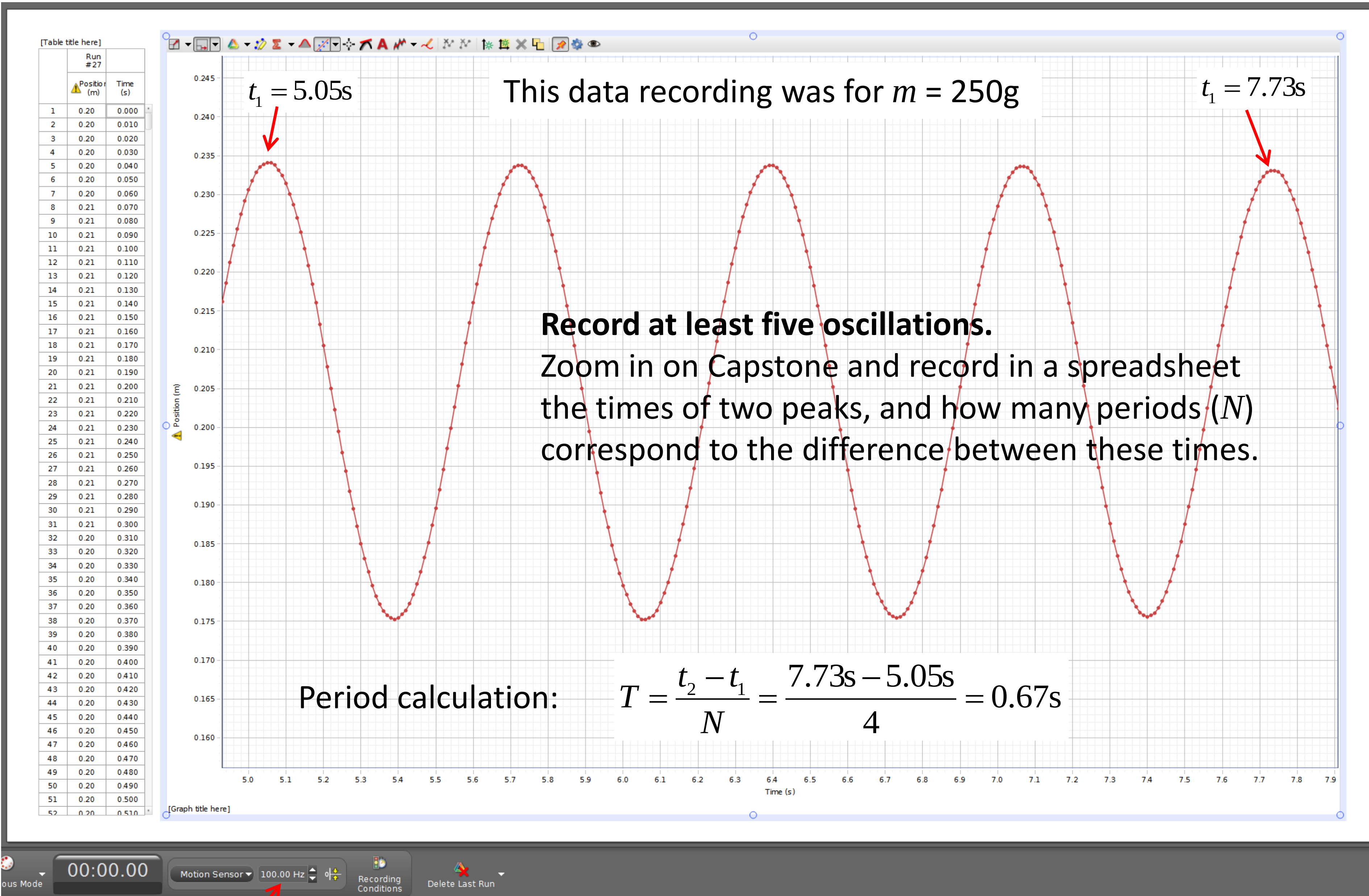
$$\therefore \quad \boxed{m = k\frac{T^2}{4\pi^2}}$$

$$x = A\cos\left(\frac{2\pi t}{T}\right)$$





plot M vs $T^2/4\pi^2$



	Run #27 Position (m)	Run #27 Time (s)
1	0.20	0.000
2	0.20	0.010
3	0.20	0.020
4	0.20	0.030
5	0.20	0.040
6	0.20	0.050
7	0.20	0.060
8	0.21	0.070
9	0.21	0.080
10	0.21	0.090
11	0.21	0.100
12	0.21	0.110
13	0.21	0.120
14	0.21	0.130
15	0.21	0.140
16	0.21	0.150
17	0.21	0.160
18	0.21	0.170
19	0.21	0.180
20	0.21	0.190
21	0.21	0.200
22	0.21	0.210
23	0.21	0.220
24	0.21	0.230
25	0.21	0.240
26	0.21	0.250
27	0.21	0.260
28	0.21	0.270
29	0.21	0.280
30	0.21	0.290
31	0.21	0.300
32	0.20	0.310
33	0.20	0.320
34	0.20	0.330
35	0.20	0.340
36	0.20	0.350
37	0.20	0.360
38	0.20	0.370
39	0.20	0.380
40	0.20	0.390
41	0.20	0.400
42	0.20	0.410
43	0.20	0.420
44	0.20	0.430
45	0.20	0.440
46	0.20	0.450
47	0.20	0.460
48	0.20	0.470
49	0.20	0.480
50	0.20	0.490
51	0.20	0.500
52	0.20	0.510

$t_1 = 5.05\text{s}$

This data recording was for m = 250g

$t_1 = 7.73\text{s}$

Record at least five oscillations.
Zoom in on Capstone and record in a spreadsheet the times of two peaks, and how many periods (N) correspond to the difference between these times.

Period calculation: $T = \dfrac{t_2 - t_1}{N} = \dfrac{7.73\text{s} - 5.05\text{s}}{4} = 0.67\text{s}$

Set recording rate at 100Hz

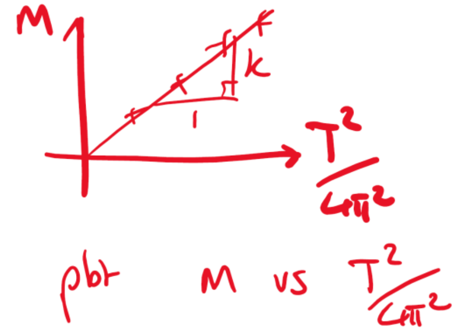
Capstone screenshot

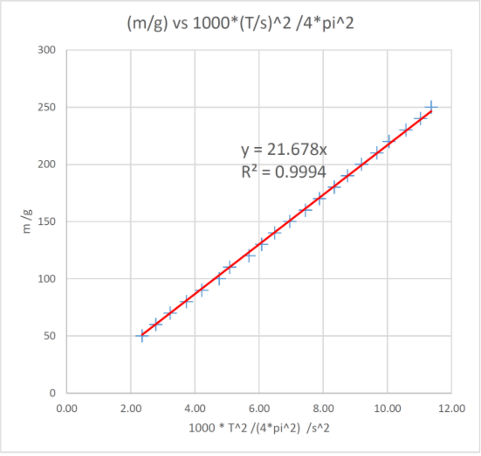
SHM with springs

Andy French. Winchester College P5. 28/10/2020.

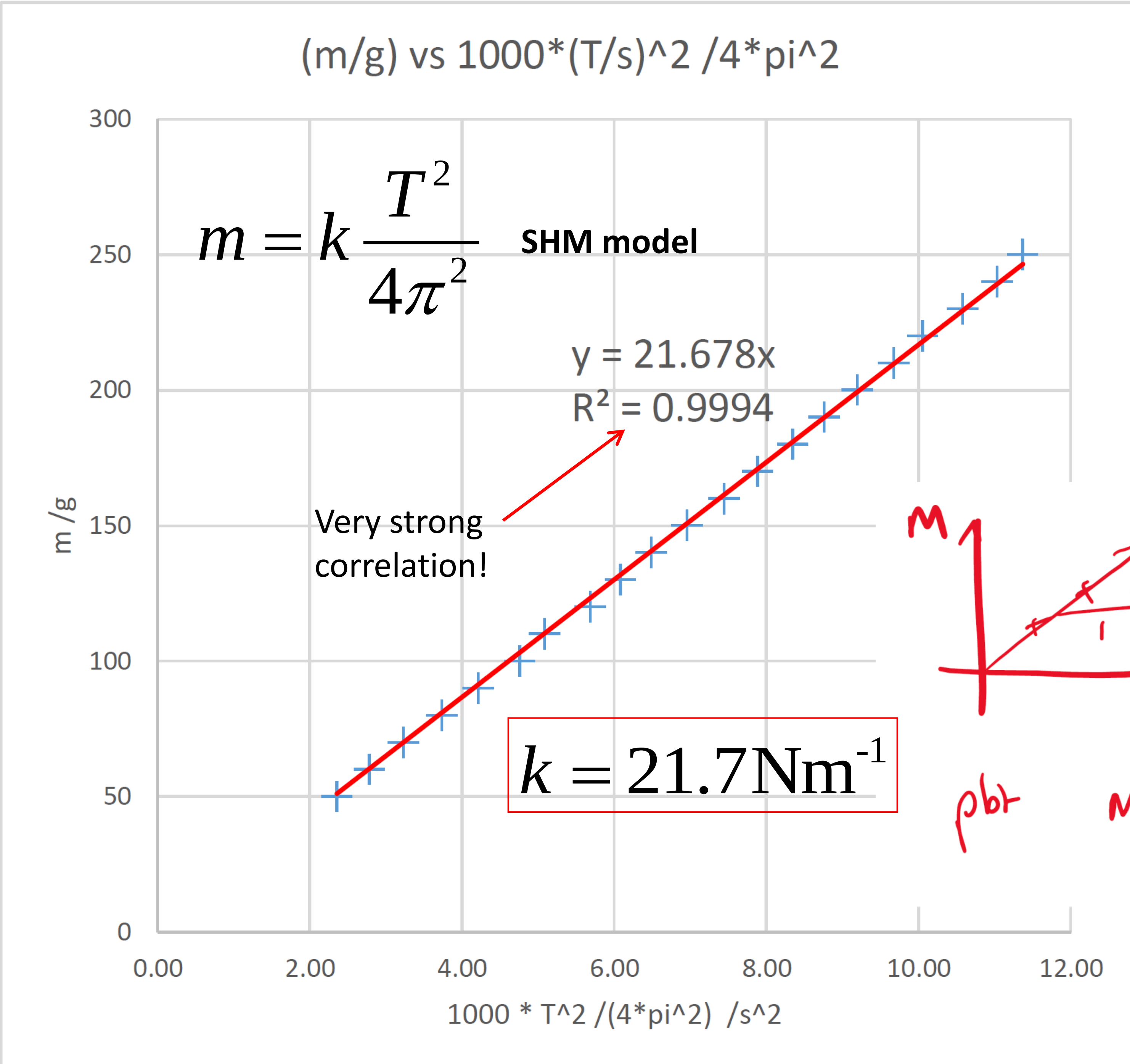
$$m = k\frac{T^2}{4\pi^2}$$

	Mass /g	# of periods	t1 /s	t2/2	period T /s	1000*T^2 / 4*pi^2
	50	12	2.63	6.29	0.305	2.36
	60	14	2.22	6.86	0.331	2.78
beats	70	7	2.94	5.44	0.357	3.23
beats	80	5	3.44	5.36	0.384	3.74
beats	90	5	8.69	10.73	0.408	4.22
	100	6	8.52	11.12	0.433	4.76
	110	5	1.93	4.17	0.448	5.08
	120	4	2.31	4.205	0.474	5.69
	130	6	2.65	5.59	0.490	6.08
	140	5	2.88	5.41	0.506	6.49
	150	5	2.48	5.1	0.524	6.96
	160	5	2.36	5.07	0.542	7.44
	170	5	1.72	4.51	0.558	7.89
	180	5	1.98	4.85	0.574	8.35
	190	5	2.53	5.47	0.588	8.76
	200	4	1.99	4.4	0.603	9.20
	210	5	1.68	4.77	0.618	9.67
	220	5	1.75	4.9	0.630	10.05
	230	4	1.86	4.445	0.646	10.58
	240	4	2.27	4.91	0.660	11.03
	250	5	2.17	5.52	0.670	11.37





So $k = 21.7$ N/m



Plot mass m in g vs $\frac{1000T^2}{4\pi^2}$

The gradient should be the spring constant k in Nm^{-1}.