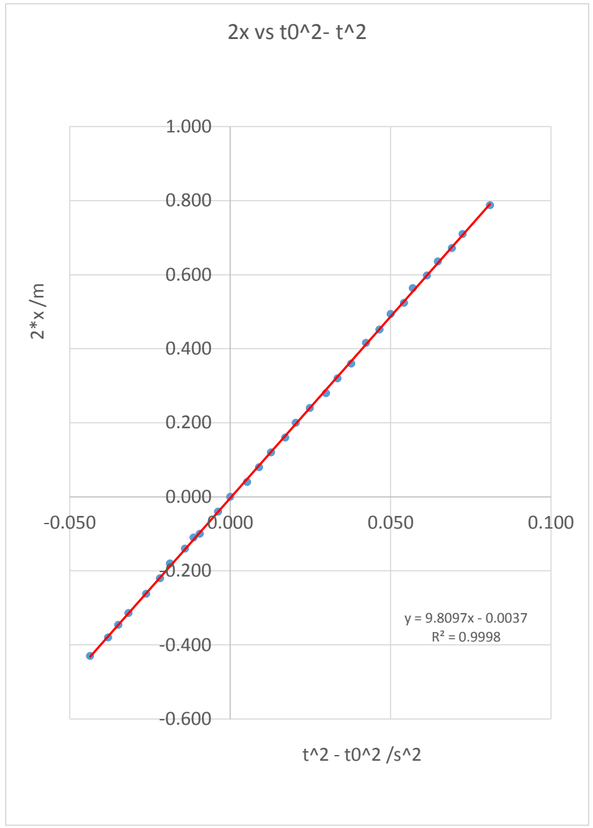
Measuring the strength of gravity using vertical ball bearing drop with magnetic release timing system **x error +/- 0.1 cm**

Dr Andrew French. 5/9/2020. Winchester College lab P5.

							Y	X	X^2	Y^2	XY	(Y-Yfit)^2
x /cm	t1/s	t2/s	t3/s	t /s	t error /s		2(x-x0) /m	t0^2 - t^2 /s^2				
42.0	0.566	0.567	0.567	0.567	0.0006		0.000	0.000	0.0000	0.0000	0.0000	1.3799E-05
40.0	0.570	0.570	0.570	0.570	0.0000		-0.040	-0.004	0.0000	0.0016	0.0002	7.7888E-07
36.5	0.576	0.577	0.577	0.577	0.0006		-0.110	-0.011	0.0001	0.0121	0.0013	3.4484E-05
20.5	0.604	0.604	0.604	0.604	0.0000		-0.430	-0.044	0.0019	0.1849	0.0188	5.9861E-06
23.0	0.599	0.600	0.599	0.599	0.0006		-0.380	-0.038	0.0015	0.1444	0.0145	6.9711E-06
24.7	0.596	0.598	0.596	0.597	0.0012		-0.346	-0.035	0.0012	0.1197	0.0121	5.3742E-09
26.3	0.594	0.595	0.593	0.594	0.0010		-0.314	-0.032	0.0010	0.0986	0.0100	8.5824E-07
28.9	0.589	0.590	0.589	0.589	0.0006		-0.262	-0.026	0.0007	0.0686	0.0069	1.5499E-06
31.0	0.586	0.586	0.585	0.586	0.0006		-0.220	-0.022	0.0005	0.0484	0.0048	2.2753E-06
33.0	0.583	0.583	0.583	0.583	0.0000		-0.180	-0.019	0.0004	0.0324	0.0034	6.2729E-05
35.0	0.580	0.578	0.579	0.579	0.0010		-0.140	-0.014	0.0002	0.0196	0.0020	5.4042E-06
37.0	0.576	0.575	0.574	0.575	0.0010		-0.100	-0.010	0.0001	0.0100	0.0010	8.7433E-06
44.0	0.561	0.562	0.563	0.562	0.0010		0.040	0.005	0.0000	0.0016	0.0002	6.3268E-05
46.0	0.558	0.559	0.559	0.559	0.0006		0.080	0.009	0.0001	0.0064	0.0007	2.1149E-05
48.0	0.556	0.555	0.555	0.555	0.0006		0.120	0.013	0.0002	0.0144	0.0015	1.0517E-06
50.0	0.551	0.551	0.552	0.551	0.0006		0.160	0.017	0.0003	0.0256	0.0027	1.9801E-05
52.0	0.548	0.548	0.549	0.548	0.0006		0.200	0.020	0.0004	0.0400	0.0041	1.0163E-05
54.0	0.545	0.544	0.544	0.544	0.0006		0.240	0.025	0.0006	0.0576	0.0060	9.7994E-08
56.0	0.539	0.540	0.540	0.540	0.0006		0.280	0.030	0.0009	0.0784	0.0084	8.6694E-05
58.0	0.536	0.537	0.536	0.536	0.0006		0.320	0.033	0.0011	0.1024	0.0107	2.0206E-05
60.0	0.532	0.532	0.533	0.532	0.0006		0.360	0.038	0.0014	0.1296	0.0136	4.1323E-05
62.8	0.528	0.528	0.528	0.528	0.0000		0.416	0.042	0.0018	0.1731	0.0176	2.0234E-05
64.6	0.524	0.525	0.523	0.524	0.0010		0.452	0.047	0.0022	0.2043	0.0210	6.0990E-07
66.7	0.521	0.521	0.520	0.521	0.0006		0.494	0.050	0.0025	0.2440	0.0247	4.9836E-05
68.2	0.517	0.516	0.517	0.517	0.0006		0.524	0.054	0.0029	0.2746	0.0284	1.3281E-05
70.2	0.514	0.513	0.515	0.514	0.0010		0.564	0.057	0.0032	0.3181	0.0321	8.8253E-05
71.9	0.510	0.509	0.510	0.510	0.0006		0.598	0.061	0.0038	0.3576	0.0367	1.4505E-08
73.8	0.506	0.506	0.507	0.506	0.0006		0.636	0.065	0.0042	0.4045	0.0412	2.1691E-05
75.6	0.501	0.503	0.502	0.502	0.0010		0.672	0.069	0.0048	0.4516	0.0464	4.8646E-06
77.5	0.499	0.498	0.499	0.499	0.0006		0.710	0.072	0.0052	0.5041	0.0514	9.4471E-06
81.4	0.490	0.489	0.491	0.490	0.0010		0.788	0.081	0.0066	0.6209	0.0638	8.8821E-06



$$H - x = \tfrac{1}{2} g t^2$$

$$H - x_0 = \tfrac{1}{2} g t_0^2$$

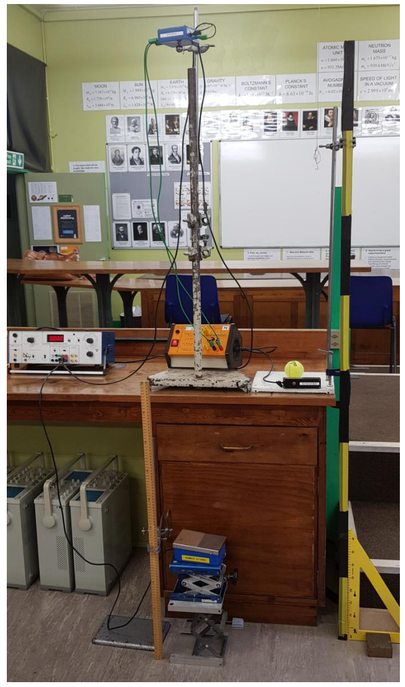
$$\therefore \tfrac{1}{2} g \left(t_0^2 - t^2 \right) = x - x_0$$

$$\therefore \underbrace{2\left(x - x_0\right)}_{Y} = g \underbrace{\left(t_0^2 - t^2\right)}_{X}$$

$$Y = gX$$

H is total d to ground.

x is height target fron



Xbar	0.0173
Ybar	0.1655
N	31

X^2 bar	0.0016
Y^2 bar	0.1532
Xybar	0.0157

V[X]	0.0013
V[Y]	0.1258
cov[X,Y]	0.0128
r	0.9999
r^2	0.9998
s	0.0046

g	9.810
g error	0.023

c	-0.004
cerror	0.001

$$g = \left(9.81 \pm 0.02\right) \mathrm{ms}^{-2}$$

LINE OF BEST FIT RECIPE

$$\overline{x} = \frac{1}{N}\sum_{i=1}^{N} x_i, \quad y = \frac{1}{N}\sum_{i=1}^{N} y_i, \quad \overline{x^2} = \frac{1}{N}\sum_{i=1}^{N} x_i^2, \quad \overline{y^2} = \frac{1}{N}\sum_{i=1}^{N} y_i^2, \quad \overline{xy} = \frac{1}{N}\sum_{i=1}^{N} x_i y_i$$

$$V[x] = \overline{x^2} - \overline{x}^2, \quad V[y] = \overline{y^2} - \overline{y}^2, \quad \mathrm{cov}[x,y] = \overline{xy} - \overline{x} \times \overline{y}$$

$$m = \frac{\overline{xy} - \overline{y}\overline{x}}{\overline{x^2} - \overline{x}^2} = \frac{\mathrm{cov}[x,y]}{V[x]}, \qquad c = \overline{y} - m\overline{x}$$

$$r = \frac{\mathrm{cov}[x,y]}{\sqrt{V[x]V[y]}}$$

$$\Delta m = \frac{s}{\sqrt{N}} \frac{1}{\sqrt{V[x]}}, \qquad \Delta c = \frac{s}{\sqrt{N}} \sqrt{1 + \frac{\overline{x}^2}{V[x]}}$$

$$s = \sqrt{\frac{1}{N-2}\sum_{i=1}^{N} \left(y_i - m x_i - c\right)^2}$$