Candidate 6 evidence (Verification of an Equation of Motion)

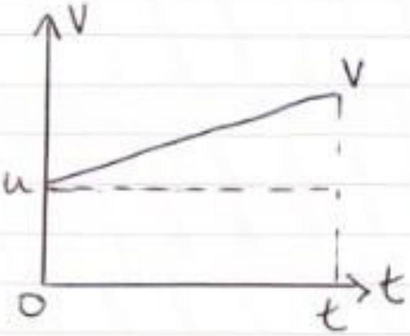
Verification of an Equation of Motion

Aim I'm going to verify the equation $v^2 = u^2 + 2as$

Physics Acceleration is the rate of change of velocity so

$$a = \frac{v-u}{t}$$

A velocity time graph of an object with constant velocity is shown



The area under the graph is the displacement of the object (s).

S = area of rectangle + area of 1/2 triangle

$S = u \times t + \frac{1}{2} \times (v-u) \times t$

but $v = u + at$ so $(v-u) = at$

so $s = ut + \frac{1}{2}at^2$

If you square $v = u + at$

$v^2 = (u + at)^2$

$v^2 = u^2 + 2uat + a^2t^2$

$v^2 = u^2 + 2a(ut + \frac{1}{2}at^2)$

$v^2 = u^2 + 2as$

Method I let a trolley run down a runway from rest and measured the acceleration half way down with a light gate and a TSA module and the speed at the bottom with another light gate and another TSA module.

I measured the length of the runway with a metre stick.

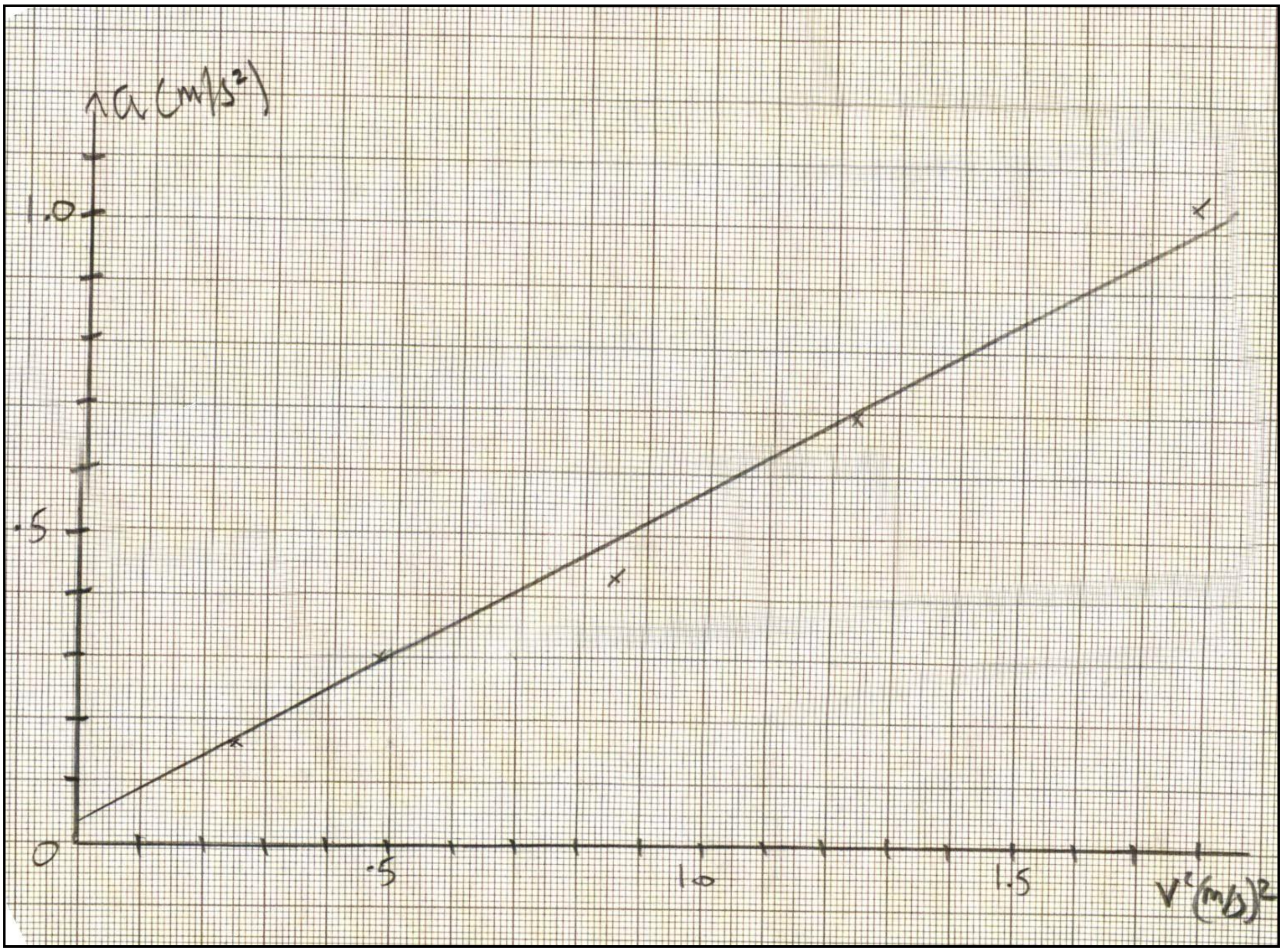
The trolley had a U shaped card on it.

I repeated the experiment two times and changed the height of the runway to take five sets of readings.

TABLE

Acceleration (ms^{-2})				Final speed (ms^{-1})				V^2 (m^2s^{-2})	S (m
1	2	3	average	1	2	3	average		
0.13	0.15	0.19	0.16	0.51	0.53	0.47	0.50	0.25	1
0.29	0.32	0.28	0.30	0.65	0.74	0.69	0.69	0.48	1
0.42	0.48	0.40	0.43	1.01	0.87	0.89	0.92	0.85	1
0.64	0.73	0.69	0.69	1.09	1.14	1.11	1.11	1.23	1
0.98	1.03	1.12	1.04	1.34	1.29	1.35	1.33	1.77	1

GRAPH



(UNCERTAINTIES) The scale reading uncertainty in the TSA module was $\pm 0.001 \, ms^{-1}$ and $\pm 0.001 \, m/s^{-2}$.

The random ~~uncertainties~~ uncertainties a

Acceleration (ms^{-2})	Random uncertainty in acceleration (ms^{-2})	Final speed (ms^{-1})	Random uncertainty final velocity (ms^{-1})
0.16	0.02	0.50	0.002
0.30	0.01	0.69	0.03
0.43	0.03	0.92	0.05
0.69	0.03	1.11	0.02
1.04	0.05	1.33	0.02

ANALYSIS The gradient of the line of best fit is

$$\frac{(0.8 - 0.3)}{(1.4 - 0.5)} = 0.56$$

From the equation $V^2 = 2as$ (because $u=0$)
the gradient is $2s$

So $s = \frac{0.56}{2} = 0.28$ m

This is well away from the 1 metre I ~~ha~~ measured.

CONCLUSION Since my graph is a straight line that goes through the origin (I know it doesn't, but it nearly does), the acceleration of the trolley is proportional to the final speed squared. This is what the equation predicts ($V^2 = 2as$) but the constant is all wrong.

EVALUATIONS The line on the graph did not pass through the origin.
This must have been due to a systematic error in either the measurement in acceleration or the measurement of speed. It could be that the measurement in the size of the card was not exact.

The trolley wheels had some friction, which could have affected the results.
To improve this I could have oiled the area between the ~~wheels~~ wheels and the axles.

The value the graph gave for the length of the runway was not close to the actual length.
This could be because of the friction in the wheels.

REFERENCE https://thestudentroom.co.uk/wiki/revision notes: kinematics: equations of motion for constant acceleration (accessed January 2018)