Quality of Measurement

Aim:
For my experiment I am going to be investigating gravity by freefall by dropping a ball bearing onto a micro switch (pressure pad) from different heights and recording the time taken for it to land.

Plan:
I have chosen to measure gravity by freefall using a range of apparatus. I decided to use timing electronics linked to a micro switch pad with a ball bearing release mechanism to provide the most accurate results possible.

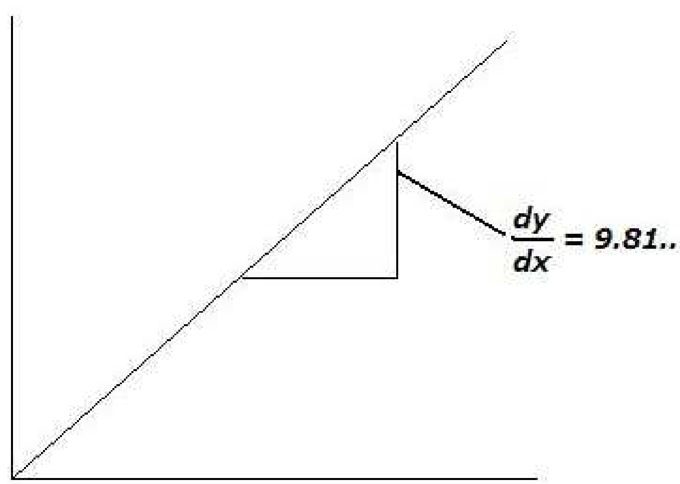
I am going to achieve my aim by having a ball bearing in between two metal plates and when the potential difference is lost between the two plates (when ball is dropped) the timer will begin until the pressure pad is hit.

Accuracy is key in getting the correct results, I need to be working towards proving that g = 9.81… metres per second. I am going to give room for error by taking +/- 0.1cm for the dropping height as well as maintaining the time to 3dp.

I am going to drop my ball bearing from heights ranging from 100cm – 10cm in increments of 10cm +/- 0.1cm and I will be doing this 3 times to increase the reliability of my results by taking an average of the three.

The equation I'm going to use to plot as the x-axis against the distance fallen will be ($S = ut + \frac{1}{2} at^2$) which will relate to:
($y = mx + c$)
where $ut = c$ so that can be excluded as $ut = 0$
and $mx = \frac{1}{2}at^2$ therefore $x = \frac{1}{2}t^2$ and $m = a$ so the x-axis will be plotted to $\frac{1}{2}t^2$ where t is the time

I predict that there will be a constant gradient of around $9.81ms^{-2}$ between the height being dropped and $\frac{1}{2}t^2$ helping me prove "g" by freefall. I also predict that the graph should show a trend in the distance fallen +/- 0.1cm to $\frac{1}{2}t^2$ due to the gradient remaining a constant.



My predicted graph for my result

Prior to my main experiment I did a preliminary experiment to see how many final test proved in the accuracy of "g" by freefall, as well as giving me an idea of what to expect for my results and help me in deciding what apparatus to use.

Apparatus:

- Stopwatch
- Ticker Timer
- Ruler
- Clamp
- Boss
- Retort Stand

As it's a very simple experiment the set up of the circuit will be very simple too the ticker timer will be placed on a clamp attached to a retort stand and the ticker timer will have a weight attacked to a 5cm strip of paper and the ticket timer will punch holes in the paper every 0.02s as it falls, so all there is to do is count the dots for each height and times it by 0.02.

Results

Height (cm) +/- 0.1cm	No. of dots on tape	Time Taken (s)
100cm	22	22 x 0.02 = 0.44s
90cm	19	19 x 0.02 = 0.38s
80cm	17	17 x 0.02 = 0.34s
70cm	15	15 x 0.02 = 0.30s
60cm	13	13 x 0.02 = 0.26s
50cm	11	11 x 0.02 = 0.22s
40cm	8	8 x 0.02 = 0.16s
30cm	6	6 x 0.02 = 0.12s
20cm	5	5 x 0.02 = 0.10s
10cm	3	3 x 0.02 = 0.06s

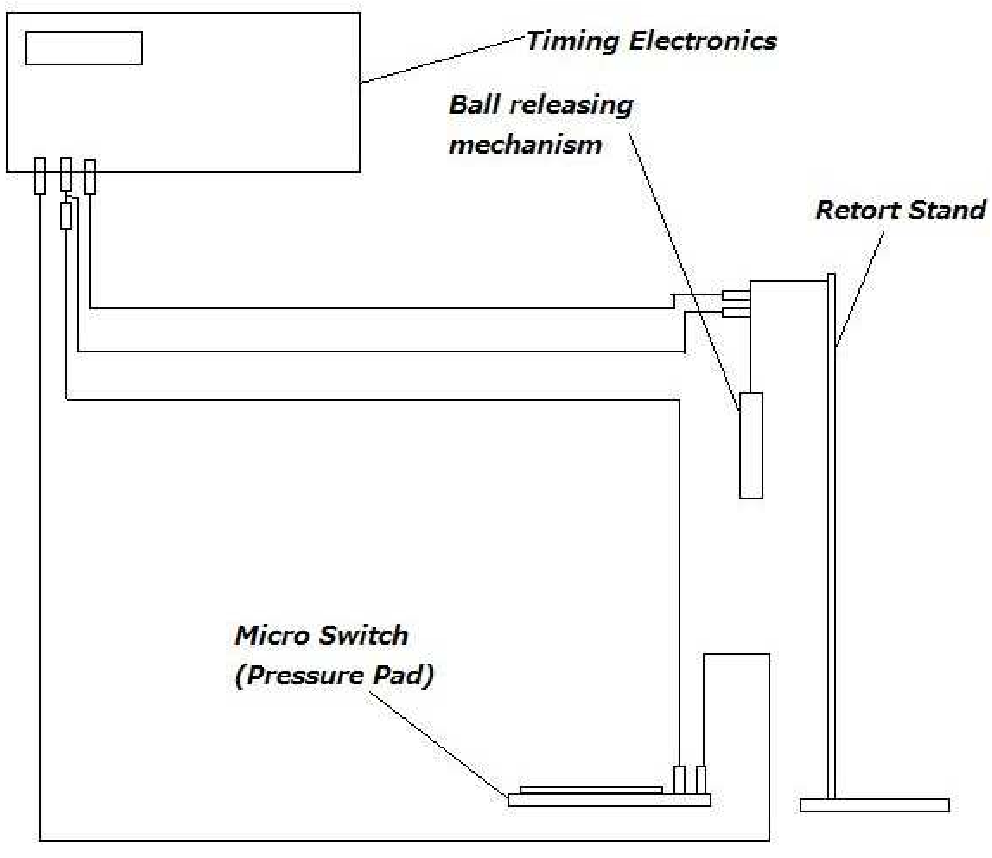
Height (cm) +/- 0.1cm	Time Taken (s)	$\frac{1}{2}t^2$
100cm	0.44s	0.097
90cm	0.38s	0.072
80cm	0.34s	0.058
70cm	0.30s	0.045
60cm	0.26s	0.034
50cm	0.22s	0.024
40cm	0.16s	0.013
30cm	0.12s	0.007
20cm	0.10s	0.005
10cm	0.06s	0.002

Here are the averages of the results I got for the ticker tape experiment after I had all the data there I still had some work to do yet which was working out “g”

Apparatus:

- Retort Stand
- Timing Electronics
- Wires
- Boss
- Clamp
- Ball Release Mechanism
- Micro switch (Pressure Pad)

Diagram:



Method:

1. Set up apparatus as show above so the ball releasing mechanism is directly above the micro switch and test the circuit to check that it works correctly
2. Pull the micro switch up to reset it and then insert the ball bearing into the release mechanism.

3. Set the height of the release mechanism to desired distance
4. Release the ball bearing so that it strikes the pressure pad and record the time take to fall
5. Repeat step 4 until you have a three similar results for that distance
6. Then repeat step 3 onwards until all the heights have been completed and recorded

Height (cm) +/- 0.1cm	**Average +/- 0.0005s**	**½t^2**
100cm	**0.442 s**	**0.0975**
90cm	**0.421 s**	**0.0885**
80cm	**0.390 s**	**0.0760**
70cm	**0.360 s**	**0.0640**
60cm	**0.336 s**	**0.0564**
50cm	**0.310 s**	**0.0480**
40cm	**0.276 s**	**0.0380**

30cm	**0.231 s**	**0.0267**
20cm	**0.192 s**	**0.0184**
10cm	**0.135 s**	**0.0091**

Safety:

I believe there is very little risk to this experiment as nothing is potentially a real danger for the user. The only main problem is the miss use of electrical equipment but as the voltage being used is quite minimal there's very little chance of any sort of serious injury. So as long as the experiment is carried out properly and safely then nothing should be a problem.

Results:

Height (cm) +/- 0.1cm	Attempt 1	Attempt 2	Attempt 3	Average +/- 0.0005 s
100cm	**0.442 s**	**0.441 s**	**0.443 s**	**0.442 s**
90cm	**0.416 s**	**0.426 s**	**0.421 s**	**0.421 s**
80cm	**0.391 s**	**0.389 s**	**0.390 s**	**0.390 s**
70cm	**0.359 s**	**0.361 s**	**0.361 s**	**0.360 s**
60cm	**0.339 s**	**0.334 s**	**0.336 s**	**0.336 s**
50cm	**0.313 s**	**0.312 s**	**0.306 s**	**0.310 s**
40cm	**0.274 s**	**0.277 s**	**0.276 s**	**0.276 s**
30cm	**0.244 s**	**0.236 s**	**0.234 s**	**0.231 s**
20cm	**0.190 s**	**0.192 s**	**0.193 s**	**0.192 s**
10cm	**0.137 s**	**0.136 s**	**0.133 s**	**0.135 s**

Here are my results I got from the experiment, as you can see all three attempts have been averaged so that they can be used for the next stage of my results.

As I predicted there is a good correlation between the data $\frac{1}{2}t^2$ taking into account room for air resistance and measuring error.

Analysis of results:

Firstly, the main conclusion I can make from looking over my results and graph is that there are slight factors effecting the results such as the uncertainty of +/- 0.1cm of the distance fallen as well as a slight effective of air resistance coming into play; although that's so small it can be excluded for the time being.

As you can see from the graph I measured my gradient for 0.0483 on the x-axis and 47.5cm on the y axis giving me an answer of:

47.5

$G = 0.0483 = 9.83ms^{-2}$

Although you also have to take into account the +/- 0.1cm distance fallen you can clearly see the range of error for “g” is:

$$G = \frac{47.4}{0.0483} \leftrightarrow \frac{47.5}{0.0483}$$

Having g range from

$$G = 9.813 \leftrightarrow 9.855$$

As you can see taking into account +/- 0.1cm makes a real difference to the results helping you get a more clear view of what the possibilities so it is clear whether the test has had anomalies along the way.

Fitness For Purpose

As you can see from the analysis I was able to accurate plot “g” by freefall even more this proved that the system I used to find “g” in my experiment was well suited for the task in hand. I also thought that the task used relates well to everyday surroundings as gravity takes a big part.

From the experiments I did you can clearly see that the system I finally used to plot my analysis is well suited to the degree of accuracy needed for something like this. With a difference in the experiments using the ticker time and having “g” = and in my experiment involving the timing electronics where “g” = $9.83ms^{-2}$