PHYS101 EXPERIMENT 2. VELOCITY AND ACCELERATION

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Data & Results: [20]

Data Point	Time (ms)	Displacement (cm)
1	50	2.3
2	100	4.7
3	150	7
4	200	9.3
5	250	11.5
6	300	13.8
7	350	16.1
8	400	18.4
9	450	20.6
10	500	22.9
11	550	25.2
12	600	27.4
13	650	29.6
14	700	31.9
15	750	34.2

Table 1: Motion with constant velocity

Data Pairs	Δt (ms)	Δx (cm)	v_{av} ($\frac{cm}{ms}$)
1-15	700	31.9	0.0456
2-14	600	27.2	0.0453
3-13	500	22.6	0.0452
4-12	400	18.1	0.0453
5-11	300	13.7	0.0457
6-10	200	9.1	0.0455
7-9	100	4.5	0.0450

Table 2: Average velocity

Instantaneous velocity (from the graph)	Instantaneous velocity (Lagrange`s formula)	% Error
0.0452 cm/ms	0.0448 cm/ms	0.885

Lagrange's formula $\Rightarrow \frac{dx}{dt} = \frac{(1/3)}{\Delta t}\left[\frac{1}{4}x_{-2} - 2x_{-1} + 2x_{1} - \frac{1}{4}x_{2}\right]$

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$= \frac{(1/3)}{50ms}\left[\frac{1}{4}(13.8cm) - 2(16.1cm) + 2(20.6cm) - \frac{1}{4}(22.9cm)\right]$

$= 0.044 cm/ms$

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x(cm)	t(ms)	t^2(ms^2)
0.2	50	25×10^2
0.6	100	1×10^4
1.2	150	225×10^2
2.1	200	4×10^4
3.2	250	625×10^2
4.5	300	9×10^4
6.1	350	1225×10^2
7.9	400	16×10^4
9.9	450	2025×10^2
12.1	500	25×10^4

Table 3: Motion with constant acceleration

$m = 0.48\times10^{-4}$ cm/ms^2 $= \frac{a}{2} \Rightarrow a = 0.96\times10^{-4}$ cm/ms^2 $\Rightarrow 0.96$ m/s$^2 = a \Rightarrow a = g\sin\theta = g\cdot0.1 \Rightarrow g_{exp} = 9.6$ m/s^2

g (theoretical)	g (experimental)	% Error
9.8 m/s^2	9.6 m/s^2	2.04

Questions:

1) **[2.5]** Average velocity and instantaneous velocity are generally different quantities. Can they ever be equal for a specific type of motion? Can the instantaneous velocity of an object ever be greater in magnitude than the average velocity? Can it ever be less?

They can be equal if a motion is a constant velocity motion. Instantaneous velocity can be greater or be less than average velocity. For example consider an object accelerating from the rest to some positive velocity in 10 seconds. Since, the velocity always increasing, the velocity at t=1 will be less than average velocity and the velocity at t=9 will be greater than average velocity if acceleration is constant and positive.

2) **[2.5]** Measurements on a moving particle show that its average velocity is equal to its instantaneous velocity at every instant. What can you say about its acceleration?

Its acceleration is 0 because acceleration is the change in velocity in infinitelly small time intervals and the velocity is not changed in this measurements since $\vec{v}_{av} = \vec{v}_i$

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3) **[2.5]** What are the possible sources of experimental errors in the experimental setup? Is it more appropriate to use a heavy (or light) puck, a small (or large) tilt angle in order to make a better estimate for *g?* Some possible sources of experimental errors are air resistance, surface friction, unwanted angles of air table and the student. Light puck and large tilt angle is more appropriate to use since friction depends on the force that an object applies to the surface, lighting puck will decrease the force by decreasing the weight and larger angles will decrease the force that object applies to the surface. Therefore, the loses energy will be lesser therefore system become more ideal.

4) **[2.5]** Suppose you travel a distance *d*. If you travel at speed v_1 for half the total distance and at speed v_2 for the other half of the total distance, derive an expression for your average speed for the complete trip.

$$d/2 = V_1 t_1 , \quad d/2 = V_2 t_2$$

$$\vec{V}_{av} = \frac{\Delta x}{\Delta t} = \frac{d}{t_1+t_2} = \frac{\vec{V}_1 t_1 + \vec{V}_2 t_2}{t_1+t_2} = \frac{\vec{V}_1 + \vec{V}_2}{}$$

Conclusion: [10]

This experiment was aimed to show the motion with constant velocity and constant acceleration. Particularly the relationships between displacement, velocity and acceleration was considered. $\frac{d\vec{a}}{dt} = \vec{v}$, $\frac{d\vec{v}}{dt} = \vec{x}$. We drew 3 graphs. First was an $\vec{V}_{av} - \Delta t$ graph and it enables us to predict $\vec{V}_{instanterous}$ by predicting $\vec{V}_{av}$ near $\Delta t = 0$. Second graph was $x-t$ graph when the $\vec{a}$ is constant and it shows that under constant acceleration, $x-t$ graph looks like a parabola which means the Δx is always increasing between the same intervals. Final graph was $x-t^2$ graph and shows us that from x and t we can find $\vec{a}$. The error in the first part of the experiment, which is about constant velocity, was 0.885% and it is a result of friction, the student and predicting the instantenous acceleration from the graph. In the second part, I found an error about 2.04% and it is resulted from mostly friction and maybe not proper levelling the air table by using screws.

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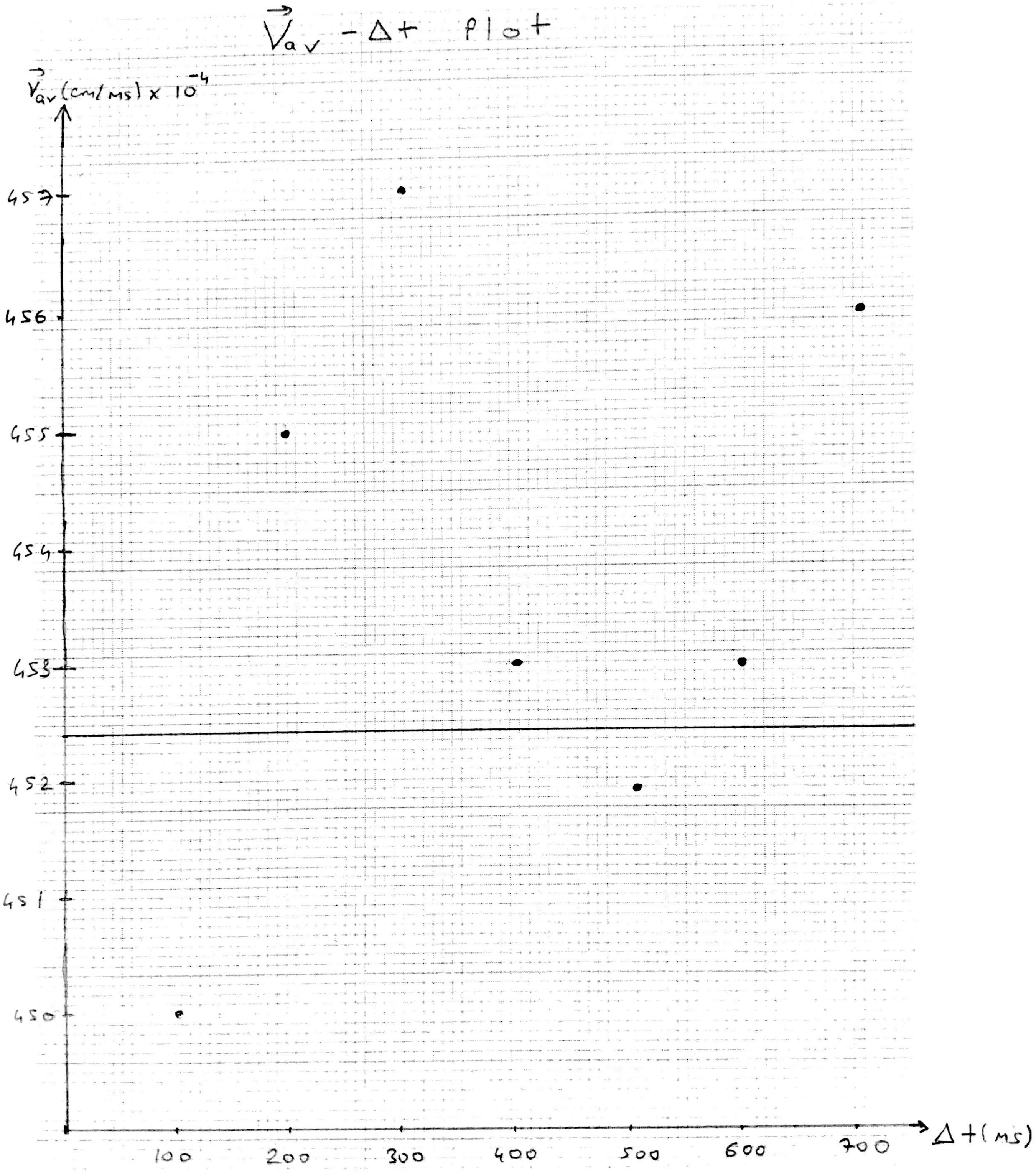
Plot 1 [10]



since these points couldn't make a line, we need to extrapolate the line as where the most points accumulate and draw the line accordingly

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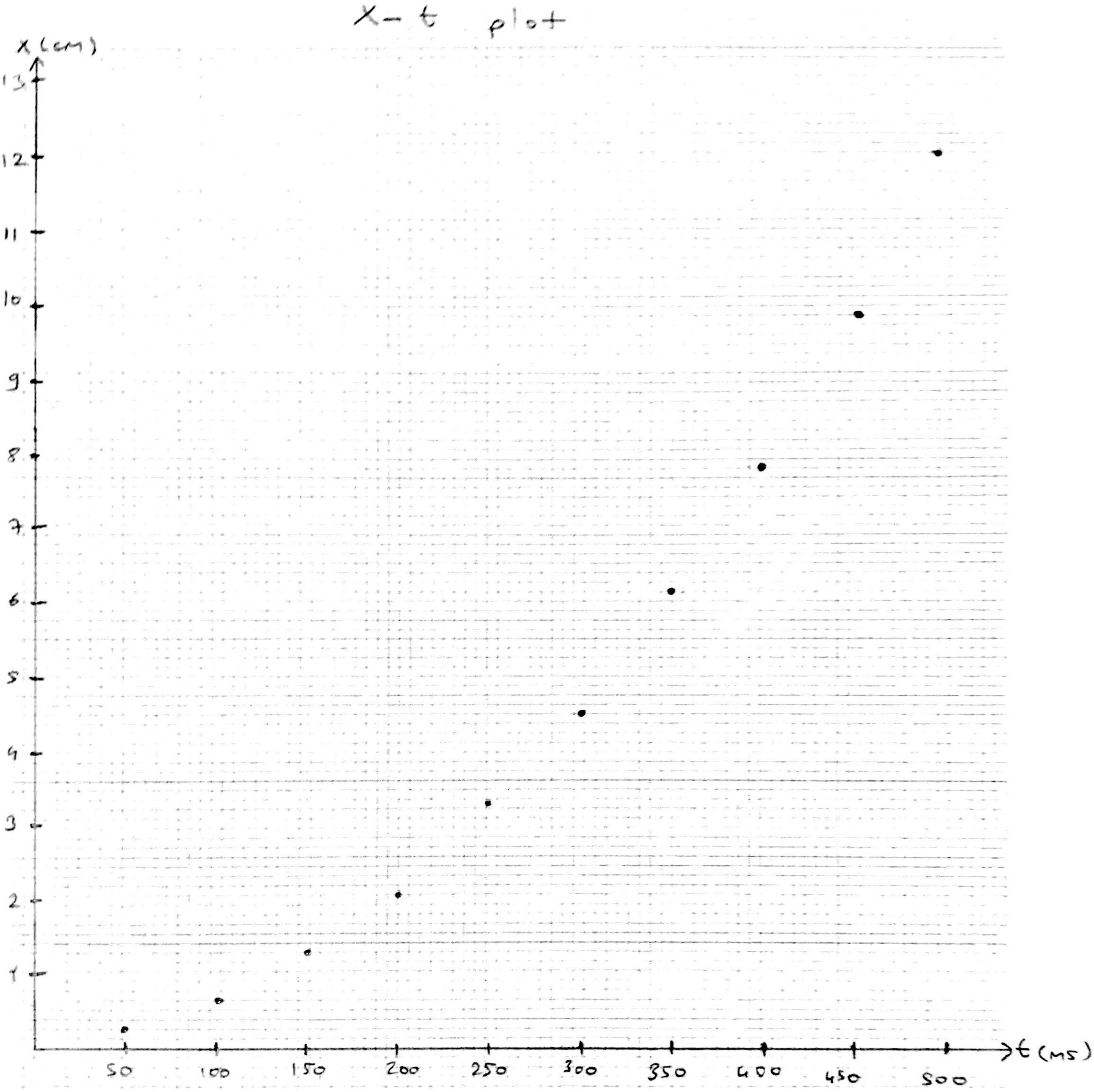
Plot 2 [10]



It is apparent from the plot that x–t is a parabola which intuitively means v is changing therefore, there is acceleration. (Manual and video do not ask to draw the parabola)

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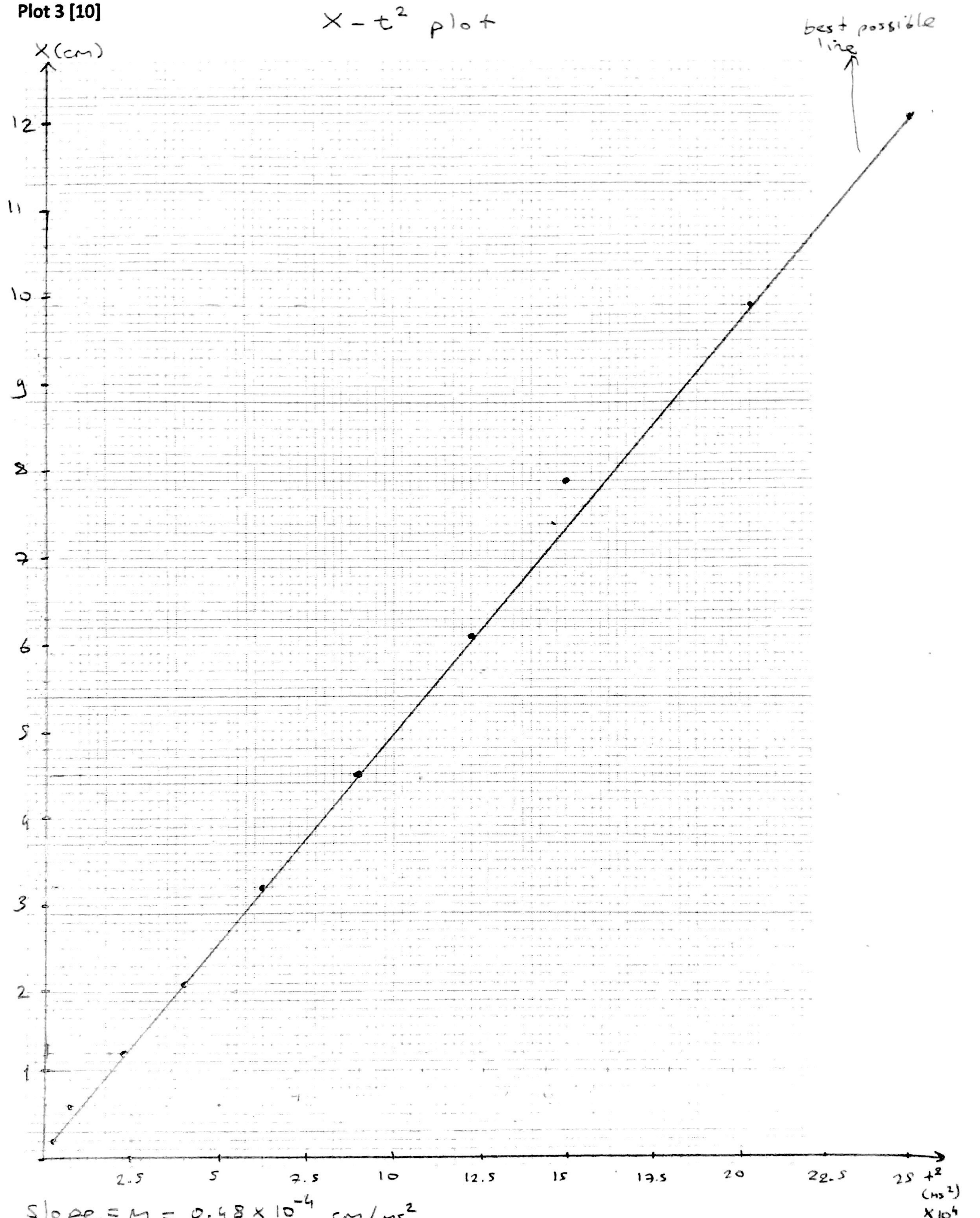
Plot 3 [10]



Slope = m = 0.48 x 10^{-4} cm/ms²