Patrycja Saran, class 1A

Goal of my project was to determinate dependence of the angle of inclination on the speed of air bubble.

First, I had to obtain necessary equipment, which was:

- Ruler;
- Timer;
- Spirit level;
- marker;
- Tube with the air bubble;
- Object which would help stabilize the tube (wall, furniture, etc.).

Obtaining:

I had a ruler already at home, same with something to lay the tube on. Both, timer and spirit level, I have installed on my cellphone. I borrowed the tube from my teacher. I've made marks with marker on tube about 5 centimeter each.

Measurments:

I measured path using ruler with 0,2 centimeter measurments uncertainty, which was due to the resolution of measuring instrument (both ends of measured section).

Time was measured by timer, time of each angle was measured three times, then from those three I calculated arithmetic mean. From arithmetic mean I was adding and deducting 0,21 seconds (Timer had 0,01 second measurment uncertainty due to the resolution of measuring instrument. 0,2 seconds is average human reaction time) from each to have minimum time and maximum.

Angle of inclination was measured with mobile app named: "Poziomica". To use it properly I had to first stabilize it on lying tube, to save such position as 0.0 degrees. Measurment error of the spirit level was 0.1 degree, due to resolution of measuring instrument. Although I'm aware of it's existence I haven't placed it on any diagram or in any table, because I believe it's small enough to not affect results of the project.

After stabilizing I was placing the tube on different object, to reach bigger angles. First I tried using 15 centimetres high box, it turned up to be too high, so I used books and stacked on each other they did pretty well until 30 degrees. Then I reached out for box once more, and then box on top of books, it worked till 50 degrees. Later on I used tall speaker to stabilize tube and the speaker did it's job fantastic.

Calculating velocity:

Velocity used in diagram was the average velocity, so things such as maximum velocity at angle of inclination equal 55 degrees could be an error due to the fact that diagram doesn't include velocity's uncertainty. All of the average measurments (information used to make the graph) are in a table:

Ta[s]	Sa[cm]	Va[cm/s]	Angle[degrees]
17,95	5	0,28	5
6,93	5	0,72	10
4,55	5	1,10	15
3,7	5	1,35	20

2,88	5	1,74	25
2,32	5	2,16	30
2,06	5	2,43	35
2	5	2,50	40
1,98	5	2,53	45
1,89	5	2,65	50
1,73	5	2,89	55
2,01	5	2,49	60
2,06	5	2,43	65
2,24	5	2,23	70
2,81	5	1,78	75
2,99	5	1,67	80
3,9	5	1,28	85
4,1	5	1,22	90

I was calculating maximum and minimum velocity from those schemes:

$$V_{max} = S_{max} : t_{min}$$

$$V_{min} = S_{min} : t_{max}$$

Velocity's uncertainty was calculated with the least positive case method, from following scheme[2]:

$$V_u = 0,5(V_{max} - V_{min})$$

Where Vu stands for velocity's uncertainty, Vmax is for maximum velocity, Vmin is for minimum velocity. Below, you can see a table of my results:

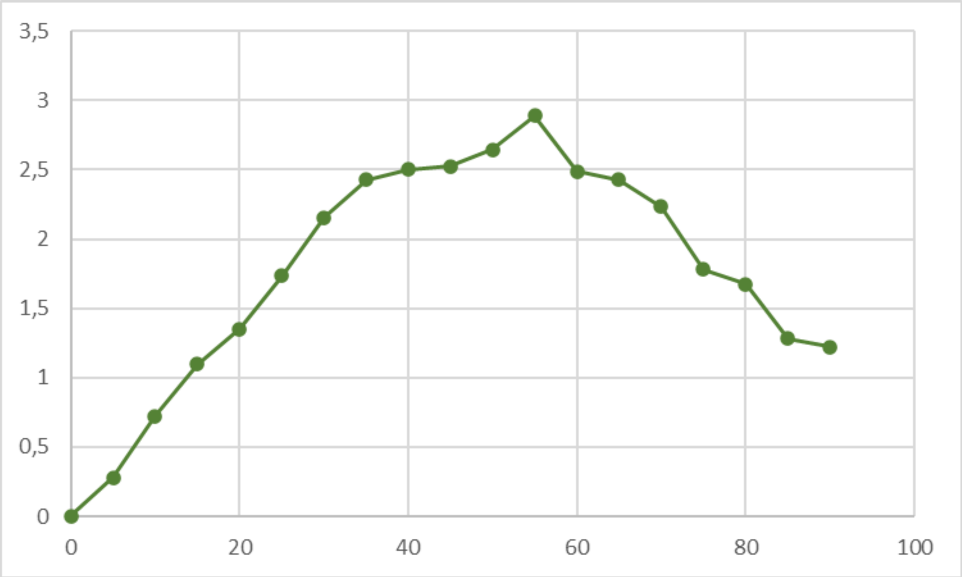
Angle[degrees]	Tmin[s]	Tmax[s]	Smax[cm]	Smin[cm]	Vmax[cm/s]	Vmin[cm/s]	Vu[cm/s]
5	17,74	18,16	5,2	4,8	0,29	0,26	0,01
10	6,72	7,14	5,2	4,8	0,77	0,67	0,05
15	4,34	4,76	5,2	4,8	1,20	1,01	0,09
20	3,49	3,91	5,2	4,8	1,49	1,23	0,13
25	2,67	3,09	5,2	4,8	1,95	1,55	0,20
30	2,11	2,53	5,2	4,8	2,46	1,90	0,28
35	1,85	2,27	5,2	4,8	2,81	2,11	0,35
40	1,79	2,21	5,2	4,8	2,91	2,17	0,37
45	1,77	2,19	5,2	4,8	2,94	2,19	0,37
50	1,68	2,1	5,2	4,8	3,10	2,29	0,40
55	1,52	1,94	5,2	4,8	3,42	2,47	0,47
60	1,8	2,22	5,2	4,8	2,89	2,16	0,36
65	1,85	2,27	5,2	4,8	2,81	2,11	0,35
70	2,03	2,45	5,2	4,8	2,56	1,96	0,30
75	2,6	3,02	5,2	4,8	2,00	1,59	0,21
80	2,78	3,2	5,2	4,8	1,87	1,50	0,19
85	3,69	4,11	5,2	4,8	1,41	1,17	0,12
90	3,89	4,31	5,2	4,8	1,34	1,11	0,11

Diagram of the velocity dependence on the angle of inclination of the tube:

As I mentioned before, graph doesn't include uncertainty, so while it can provide information such as how does the velocity changes depending on angle of inclination of tube, it's not a good idea to read things like: „On what angle the bubble had the greatest speed", because four highest speeds also have huge measurment uncertainty.

The „x" axis shows angle of inclination of the tube with air bubble in degrees. The „y" axis shows average speed of the bubble inside of the tube, in centimeter per second.

Graph of the velocity dependence on the angle of inclination of the tube:



Conclusions made from graph:

Speed of the bubble is a curve. Speed reaches maximum around 45 degrees, because of measurment uncertainty, I can't say on which angle exactly. Velocity after reaching around 55 degrees, rapidly drops after 65 degrees, until it stops at 90 degrees with speed between 1,11-1,33 centimetres per second.

Summary of project:

Practical part of the project is very simple and fast, that's the best part of it,. Measuring alone went quiet fast and smooth. Calculating was also pretty painless with help of excel. From all, I didn't enjoy making the graph. Measurment errors are really troublesome when it comes to making conclusions from diagram (if graph is poorly made), so in case of recreating it, I suppose a paper would be a better place for drawing the diagram or some sort of a professional programme. Unfortunately, I my graph doesn't show the exact shape of the curve too well.

Bibliography (also link to picture from presentation):

1.https://humanbenchmark.com/tests/reactiontime ;

2. Barbara Sagnowska, Maria Fiałkowska, Jadwiga Salach:" Fizyka. Podręcznik. Klasa 1. Zakres rozszerzony. Reforma 2019".Wydanie III, Warszawa 2019, Wydawnictwa Szkolne i Pedagogiczne Spółka Akcyjna.

Picture in slide nr 4 from presetation:https://www.dw.com/en/europeans-turn-back-clocks-for-daylight-saving-perhaps-for-last-time/a-55389492