Determinating dependence of the angle of inclination on the speed of air bubble

Preparation for project

Planning of actions

Necessary equipment and how to obtain it

First step in making every project is to collect necessary equipment. List of things I did need to make my measurements, was short and simple:

- ruler;

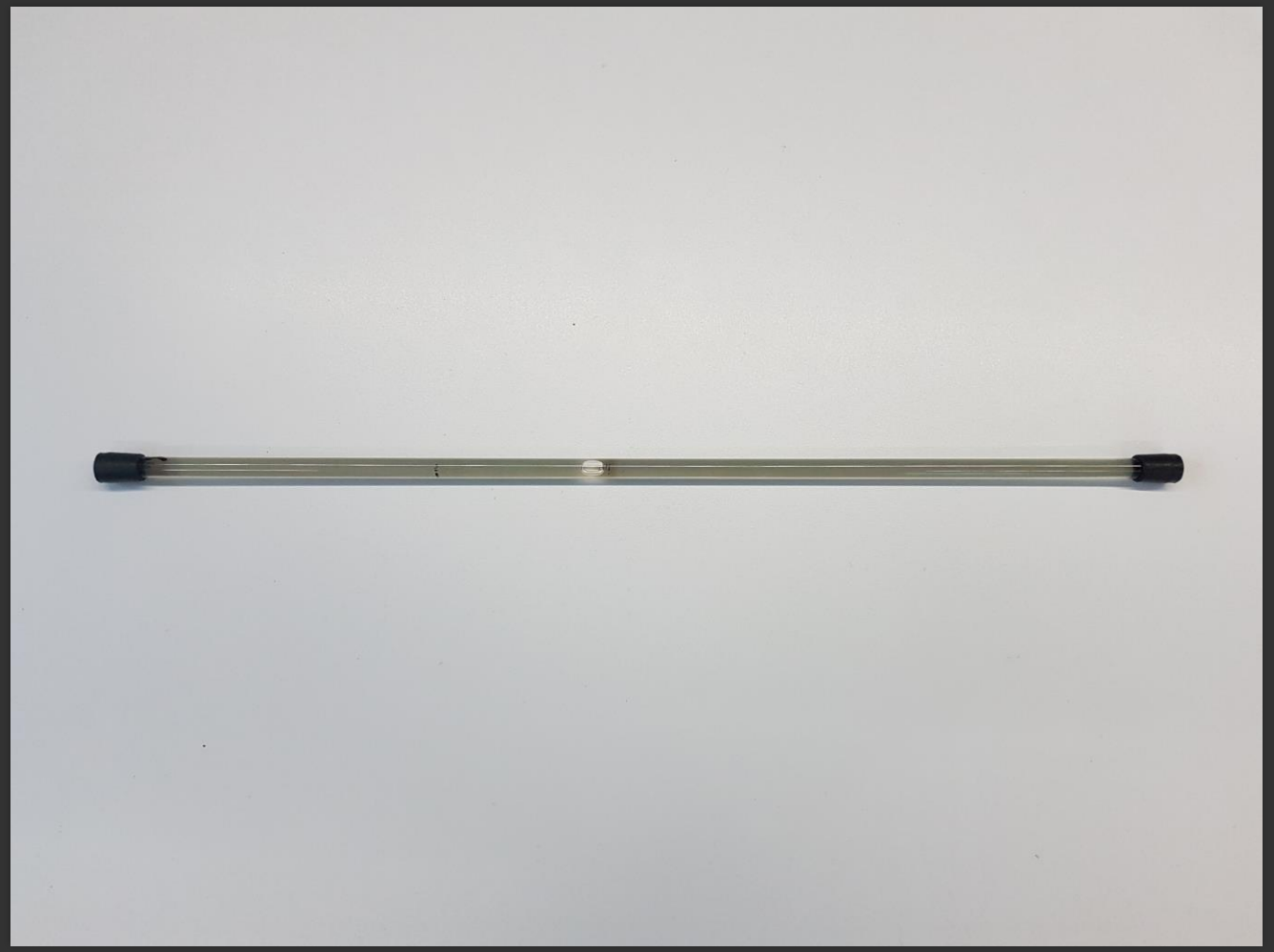
- spirit level;

- timer;

- something to stablize the tube;

- tube with air bubble.

I used timer and spirit level from my cellphone. Last things, the tube is the most difficult to get from all of them, but still quiet easy. I had to borrow it from teacher and return it the next day. To determinate the angle of inclination I placed top of the tube higher and higher, with help of diffrent objects.



How to measure:

Time

Time was the most difficult when it come to measurment uncertainty. I measured the time, three times each angle (I was measuring time on angles: 5,10,15…90). Then I counted arithmetic mean for every measured time. Next, to get maximum and minium time (which I needed to count maxium and minimum velocity) I have added and deducted from every arithmetic mean 0,21 second (0,2s is average time of human reaction1 and 0,01s is due to the resolution of measuring instrument).

Picture:https://www.dw.com/en/europeans-turn-back-clocks-for-daylight-saving-perhaps-for-last-time/a-55389492

Angle of inclination and path.

Angle of inclination, which was measured with mobile app. The spirit level in app had a 0.1 degree measurment uncertainty due to resolution of measuring instrument.

Path was measured with a ruler so it's measurement uncertainty was always the same: 0,2 centimeter (due to the resolution of measuring instrument).

Calculating velocity and making the diagram

After getting all of the materials that I needed, measuring path and time I was finally able to calculate velocity and make diagram.

Velocity

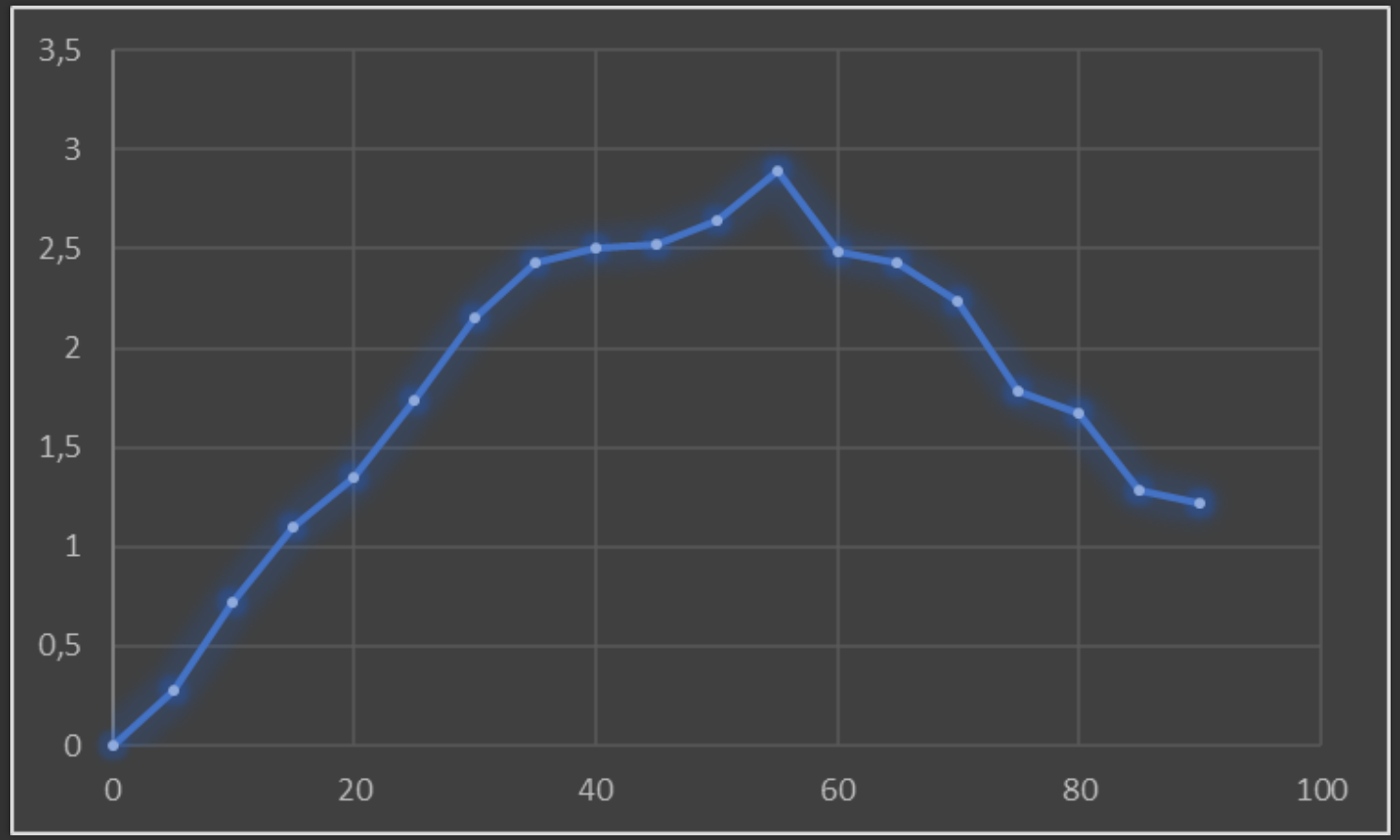
- Velocity is the last thing I had to calculate. It's really important to have correct uncertainty, and remember about it when looking at graph. To calculate velocity's uncertainty I have used the least positive case method. The formula is: „$V_u=0,5(V_{max}-V_{min})$" [2]; where V_u stands for velocity's uncertainty, V_{max} is for maximum velocity, V_{min} is for minimum velocity. I used this method for every made measurment.
- On the side, you can see a table comparing average velocity to maximum and minimum. The table also is featuring measurment uncertainty of average velocity.
- Every column beside „angle" (which is in degrees), is in [cm/s].

Angle	Vmax	Vmin	Vu	Va
0	0	0	0	0
5	0,29	0,26	0,01	0,28
10	0,77	0,67	0,05	0,72
15	1,20	1,01	0,09	1,10
20	1,49	1,23	0,13	1,35
25	1,95	1,55	0,20	1,74
30	2,46	1,90	0,28	2,16
35	2,81	2,11	0,35	2,43
40	2,91	2,17	0,37	2,50
45	2,94	2,19	0,37	2,53
50	3,10	2,29	0,40	2,65
55	3,42	2,47	0,47	2,89
60	2,89	2,16	0,36	2,49
65	2,81	2,11	0,35	2,43
70	2,56	1,96	0,30	2,23
75	2,00	1,59	0,21	1,78
80	1,87	1,50	0,19	1,67
85	1,41	1,17	0,12	1,28
90	1,34	1,11	0,11	1,22

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

The „x" axis shows angle of inclination of the tube with air buble in degrees.

The „y" axis shows average speed of the bubble inside of the tube, in centimeter per second.



Conclusion

- Now, it's obvious that the angle of inclination, of the tube, have effect on air bubble's velocity, on graph three is a curve. It might be suprising that on the angle about 45 degrees is the fastest. It's extremely important to remember measurement uncertainty and fact that my particular diagram couldn't fit in this uncertainty. Speed of the bubble grows fast until about 35 degrees, then it grows slower, and slower. After about 55 degrees it slowly decrease, till 65 degrees. Later on, speed start decresing quiet quick.

Thank You
For Your Attention.

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Bibliography:

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:https://www.dw.com/en/europeans-turn-back-clocks-for-daylight-saving-perhaps-for-last-time/a-55389492