Projekt współfinansowany w ramach programu Unii Europejskiej Erasmus+

INSTRUCTIONS FOR TEACHERS

Analysis of speed and acceleration values IN EXCEL

1. **Data preparation:**

   - record the experimental data, stop the measurement and export the data to a *.csv file in the EMPE programme
   - open the data file in Ms Excel, adjust the data according to the instructions so that it contains a column of measurement times expressed in [ms] and the corresponding measured distances expressed in [m],

- paste the time results in [ms] into column A, replacing the data contained there with your own,
- paste the measured distance values expressed in [m] into column B, replacing the data contained there with your own.

You will automatically receive a graph of speed and acceleration values for the time interval 0 - 500 [ms].
If you want to obtain graphs for any other time intervals, select another interval and draw your own graphs according to the steps described below. The formulas for 2000 measurement points have already been entered according to the algorithm described later in the instructions.

Let us assume:

Row	A (time [ms])	B (distance [m])
2	0	0.500
3	10	0.480
4	20	0.440
5	30	0.390
...	...	...

2. Calculation of instantaneous velocity

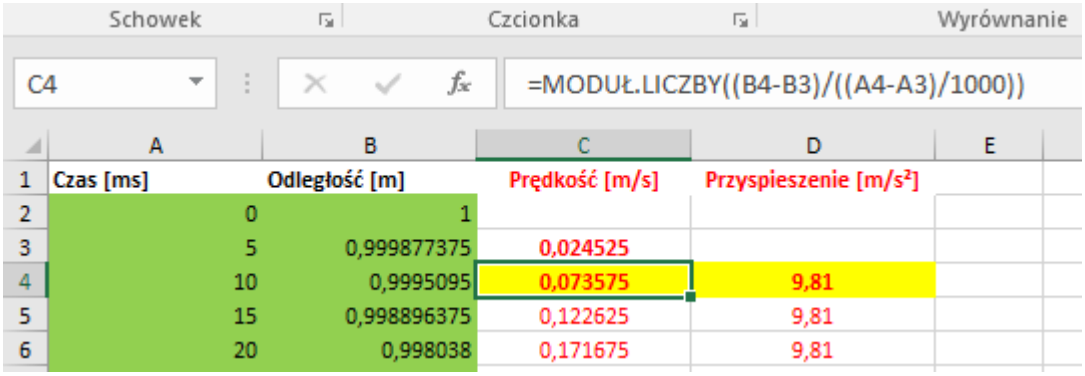
Differential formula:

$$v_i = \frac{\Delta s}{\Delta t}$$

i.e. in Excel:

In column C (e.g. heading: "Speed [m/s]"):

In cell **C3**, enter:



	A	B	C	D	E
1	Czas [ms]	Odległość [m]	Prędkość [m/s]	Przyspieszenie [m/s²]	
2	0	1			
3	5	0,999877375	0,024525		
4	10	0,9995095	0,073575	9,81	
5	15	0,998896375	0,122625	9,81	
6	20	0,998038	0,171675	9,81	

```excel
=(B3 - B2) / ((A3 - A2)/1000)
```

- $B3 - B2$ -change in distance,
- $(A3 - A2)/1000$ - time difference in **seconds** (because A is in milliseconds)

The formula can be copied by "DRAGGING" it downwards.

Note: if the distance **decreases** (because the object is approaching the sensor), the speed will be **negative** – you can take the absolute value:=ABS((B3 - B2) / ((A3 - A2)/1000)) because we only want the value of the speed vector.

In the PL version => module.numbers(number)

3. Calculation of instantaneous acceleration

Formula:

$$a_i = \frac{\Delta v}{\Delta t}$$

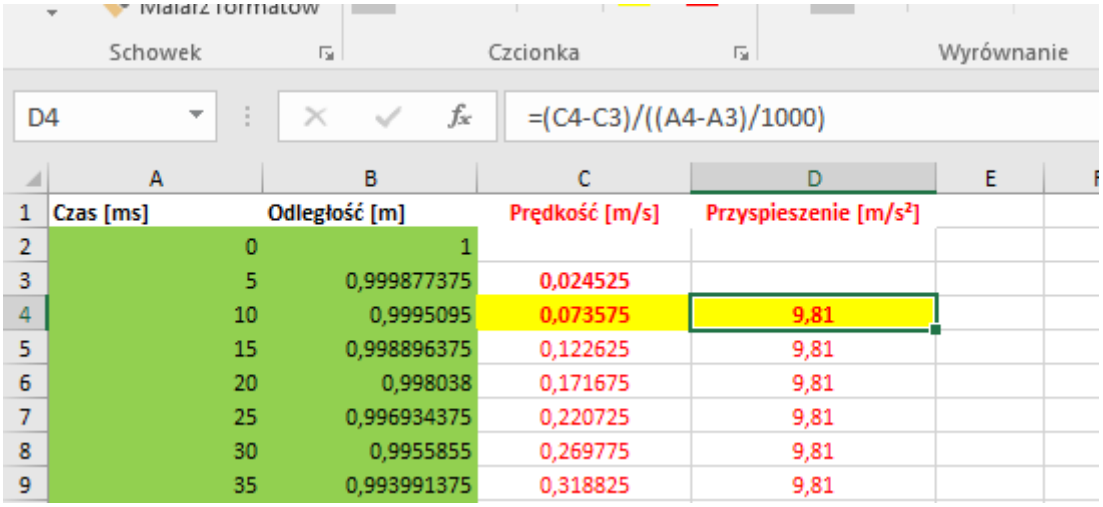
i.e. in Excel:

In column D (e.g. "Acceleration [m/s²]"):

In cell **D4**, enter:

```excel
=(C4 - C3) / ((A4 - A3)/1000)
```

And copy to the other cells by dragging the formula.



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5	15	0,998896375	0,122625	9,81	
6	20	0,998038	0,171675	9,81	
7	25	0,996934375	0,220725	9,81	
8	30	0,9955855	0,269775	9,81	
9	35	0,993991375	0,318825	9,81	

4. Speed and acceleration chart

Select the appropriate number of rows in column **A (time)** and column **C (speed)**. (hold down Ctrl)

Select **Insert → Chart → Scatter (XY) with lines** from the menu.

Title: "Speed as a function of time".
X-axis: "Time [ms]" or "Time [s]",
Y-axis: "Speed value [m/s]".

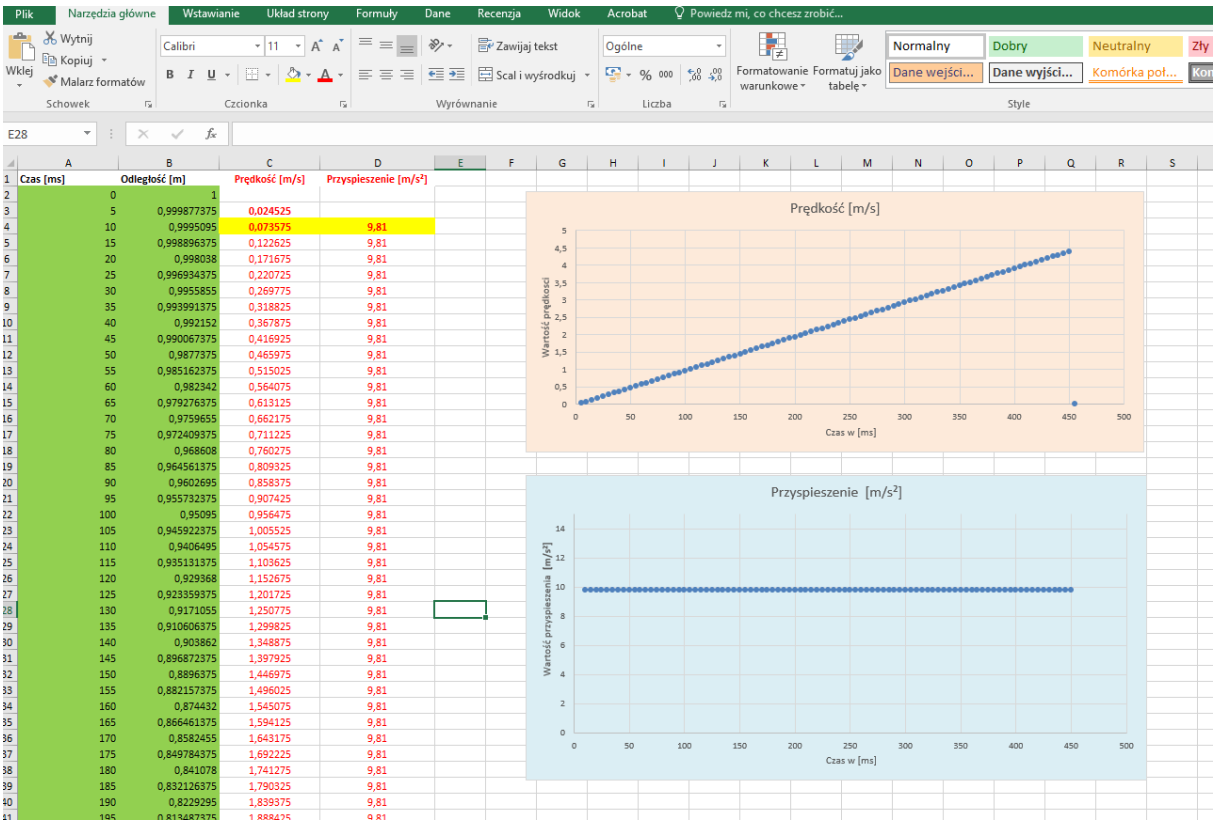
5. Acceleration value – time chart

Select the appropriate number of rows in column **A (time)** and column **D (acceleration)** accordingly. (hold down Ctrl)

Insert **a scatter (XY)** chart as above.

Title: 'Acceleration value as a function of time'.

X-axis: "Time [ms]",
Y-axis: "Acceleration value [m/s^2]".



Czas [ms]	Odległość [m]	Prędkość [m/s]	Przyspieszenie [m/s²]
0	1		
5	0,999877375	0,024525	
10	0,9995095	0,073575	9,81
15	0,998896375	0,122625	9,81
20	0,998038	0,171675	9,81
25	0,996934375	0,220725	9,81
30	0,9955855	0,269775	9,81
35	0,993991375	0,318825	9,81
40	0,992152	0,367875	9,81
45	0,990067375	0,416925	9,81
50	0,9877375	0,465975	9,81
55	0,985162375	0,515025	9,81
60	0,982342	0,564075	9,81
65	0,979276375	0,613125	9,81
70	0,9759655	0,662175	9,81
75	0,972409375	0,711225	9,81
80	0,968608	0,760275	9,81
85	0,964561375	0,809325	9,81
90	0,9602695	0,858375	9,81
95	0,955732375	0,907425	9,81
100	0,95095	0,956475	9,81
105	0,945922375	1,005525	9,81
110	0,9406495	1,054575	9,81
115	0,935131375	1,103625	9,81
120	0,929368	1,152675	9,81
125	0,923359375	1,201725	9,81
130	0,9171055	1,250775	9,81
135	0,910606375	1,299825	9,81
140	0,903862	1,348875	9,81
145	0,896872375	1,397925	9,81
150	0,8896375	1,446975	9,81
155	0,882157375	1,496025	9,81
160	0,874432	1,545075	9,81
165	0,866461375	1,594125	9,81
170	0,8582455	1,643175	9,81
175	0,849784375	1,692225	9,81
180	0,841078	1,741275	9,81
185	0,832126375	1,790325	9,81
190	0,8229295	1,839375	9,81