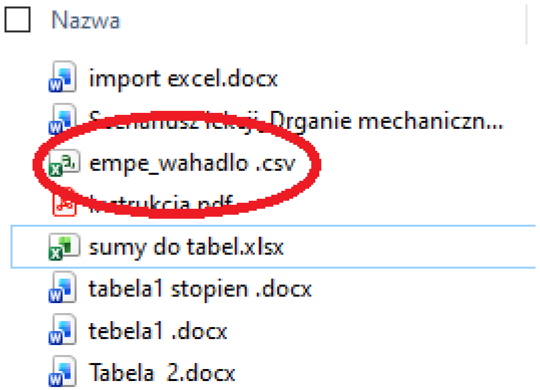
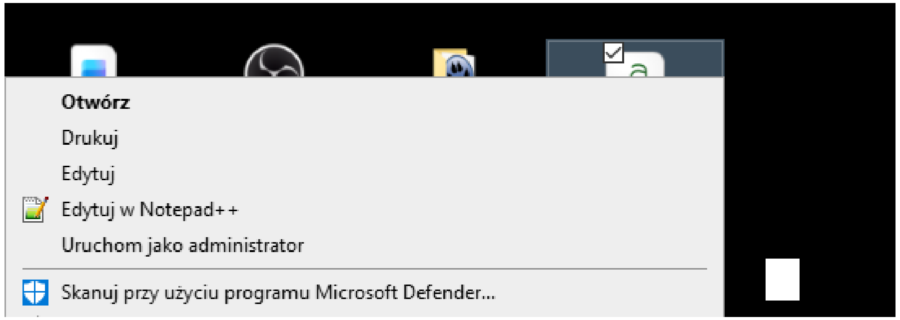
Projekt współfinansowany w ramach programu Unii Europejskiej Erasmus+

Instructions for importing data into an MS Excel spreadsheet

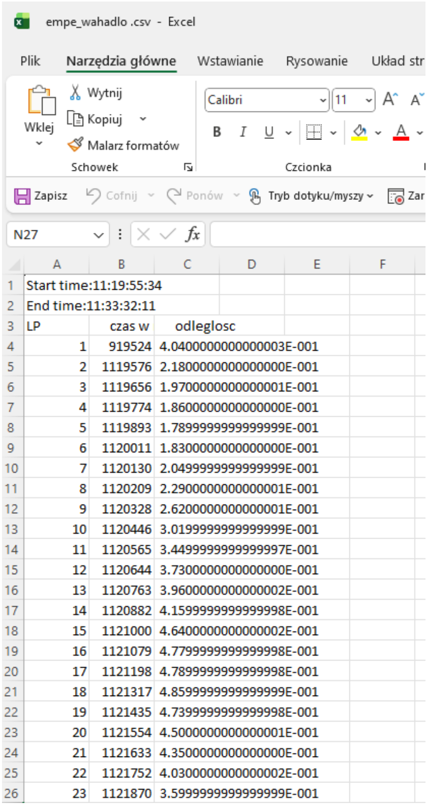


Open the CSV file and launch Excel, which should import your data:



It may happen that Excel uses a comma instead of a full stop as the decimal separator, in which case we can quickly adjust our data. Use the Excel function to find *the full stop* and replace it with *a comma*.

Below is what the Excel window looks like after importing data with the wrong decimal point format.



	A	B	C
1	Start time:11:19:55:34		
2	End time:11:33:32:11		
3	LP	czas w	odleglosc
4	1	919524	4.0400000000000003E-001
5	2	1119576	2.1800000000000000E-001
6	3	1119656	1.9700000000000001E-001
7	4	1119774	1.8600000000000000E-001
8	5	1119893	1.7899999999999999E-001
9	6	1120011	1.8300000000000000E-001
10	7	1120130	2.0499999999999999E-001
11	8	1120209	2.2900000000000001E-001
12	9	1120328	2.6200000000000001E-001
13	10	1120446	3.0199999999999999E-001
14	11	1120565	3.4499999999999997E-001
15	12	1120644	3.7300000000000000E-001
16	13	1120763	3.9600000000000002E-001
17	14	1120882	4.1599999999999998E-001
18	15	1121000	4.6400000000000002E-001
19	16	1121079	4.7799999999999998E-001
20	17	1121198	4.7899999999999998E-001
21	18	1121317	4.8599999999999999E-001
22	19	1121435	4.7399999999999998E-001
23	20	1121554	4.5000000000000001E-001
24	21	1121633	4.3500000000000000E-001
25	22	1121752	4.0300000000000002E-001
26	23	1121870	3.5999999999999999E-001

We find the Excel function **find and replace**:

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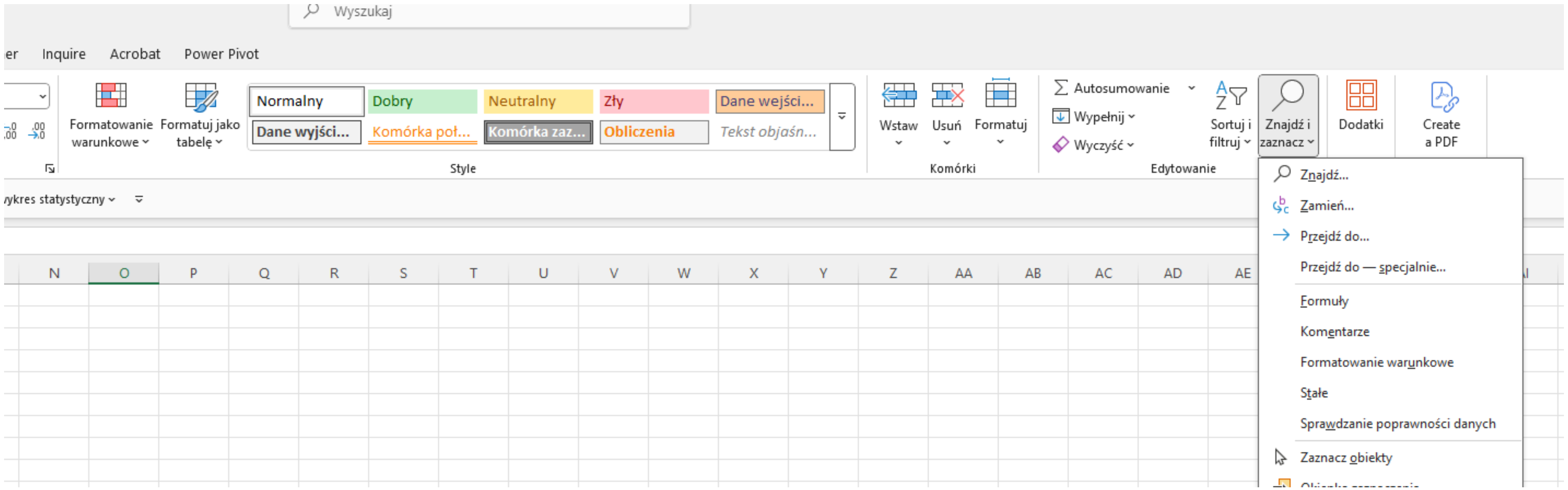
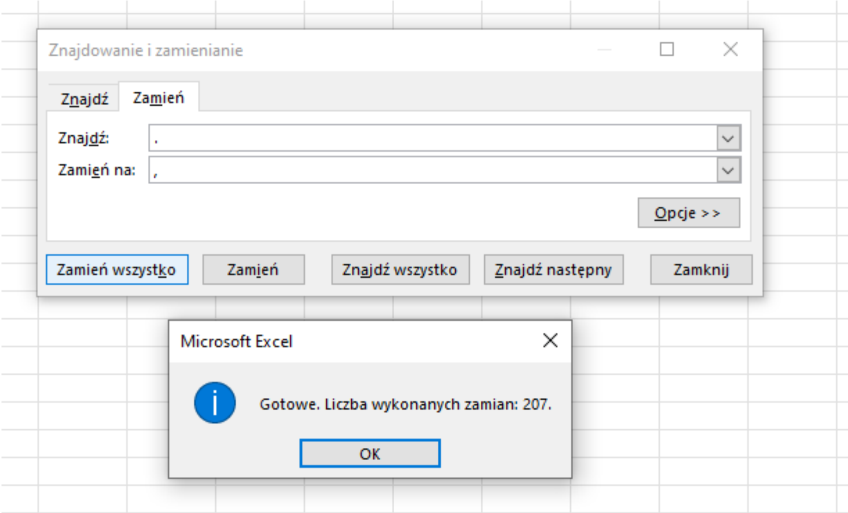
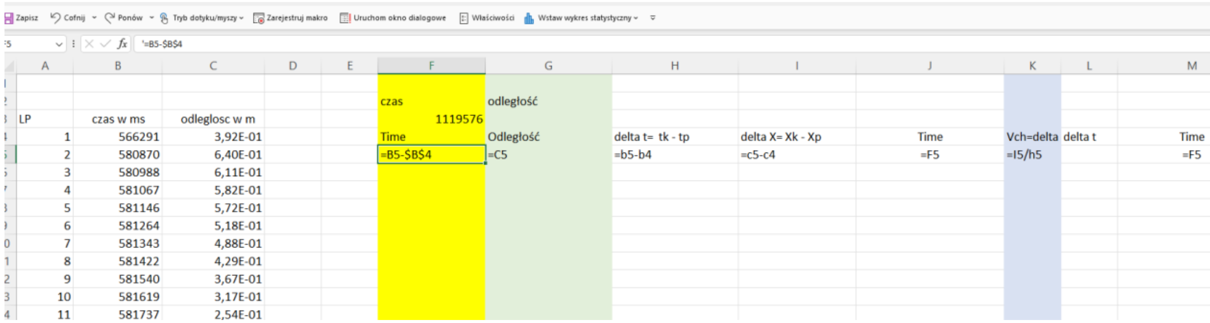


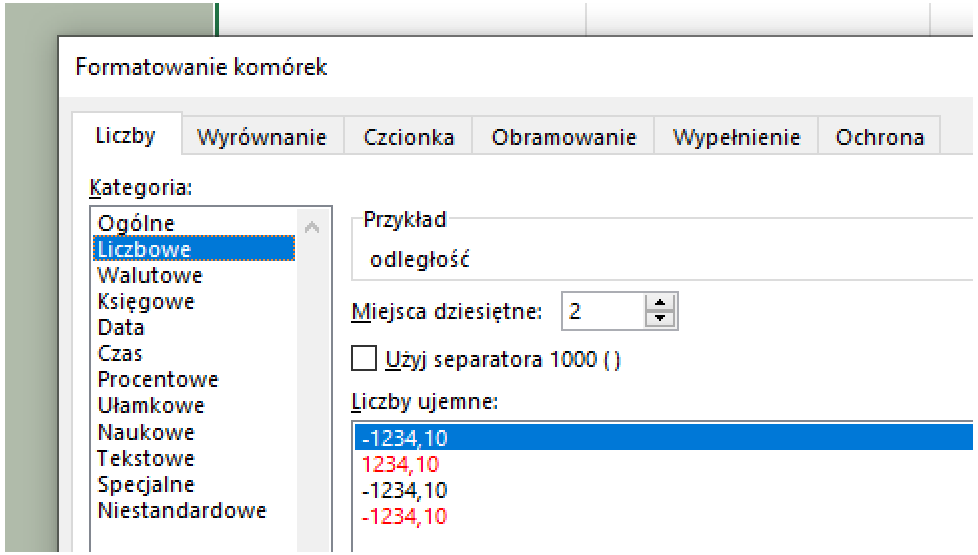
We indicate that we want to replace every decimal point with a comma.


Znajdowanie i zamienianie
Znajdź
Zamień
Znajdź: .
Zamień na: ,
Opcje >>
Zamień wszystko
Zamień
Znajdź wszystko
Znajdź następny
Zamknij
Microsoft Excel
Gotowe. Liczba wykonanych zamian: 207.
OK


=B5-B4
LP
czas w ms
odleglosc w m
czas
1119576
odległość
Time
Odległość
delta t= tk - tp
delta X= Xk - Xp
Time
Vch=delta delta t
Time
1 566291 3,92E-01
2 580870 6,40E-01
=B5-B4
=C5
=b5-b4
=c5-c4
=F5
=I5/h5
=F5
3 580988 6,11E-01
4 581067 5,82E-01
5 581146 5,72E-01
6 581264 5,18E-01
7 581343 4,88E-01
8 581422 4,29E-01
9 581540 3,67E-01
10 581619 3,17E-01
11 581737 2,54E-01

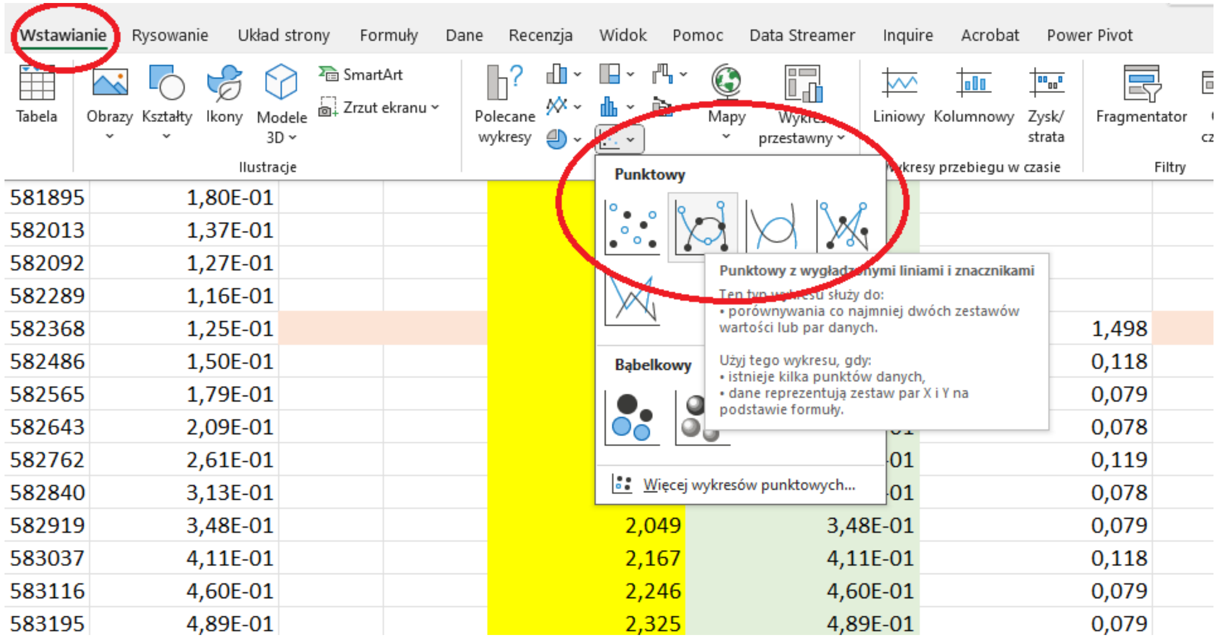
We obtain data in the format 1) No., 2) Time_from_the_start_of_the_sensor_operation, 3) measured_distance.

1. The first step we take is to change the time values so that they start from 0. To do this, we subtract the time from position 1 from each subsequent measurement time. We do this using the formula shown in cell F5, we write =B5-b$4 (we subtract the value from position B4 from each cell in column B)

2. We change the format of the displayed distance in G5 by writing: =C5 and set the general number format for the entire column 

3. We calculate delta t as the end time – start time, taking into account two consecutive measurements.
Where the end time is time_n+1 and the start time is time_n, and **n** is the consecutive ordinal numbers of column A

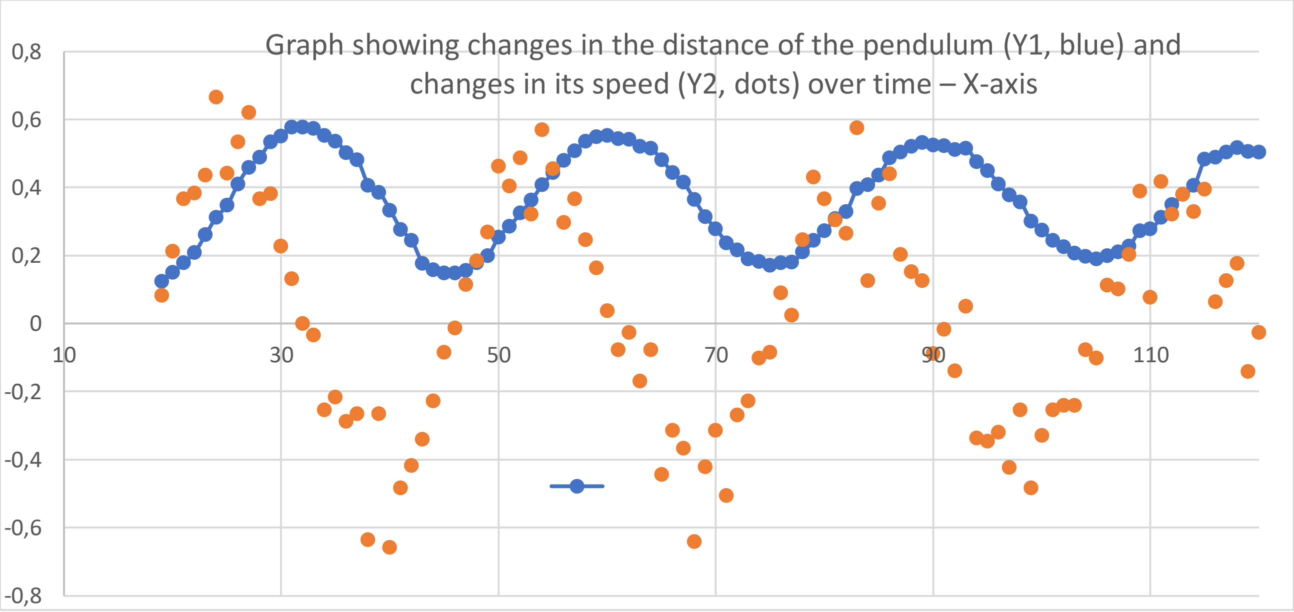
4. In a similar way, we calculate delta_X where: delta_X = X_n+1 – X_n, where n is the consecutive values of column A
5. First, we draw a graph of distance changes over a dozen or so seconds. To do this, we select the same number of rows in the time and distance columns and choose the insert graph option



6. To draw a series of data contained in columns located in different places, select them by holding down the CTRL key.

7. We create a graph of the position and speed of the pendulum so that they have a common time axis. An example graph for a random series of measurements for the EMPE suitcase as a pendulum is presented below:

Graph of the relationship between the velocity coordinate and time:



After creating the graphs, we begin a discussion with the students.

Questions for students that we answer during the discussion based on the prepared graphs:

1. Why is the graph of the changes in the distance between the pendulum and the sensor shifted => "raised" and the resting position point is not on the X-axis?

2. Discuss and indicate where the following are located on the graphs:

   - the resting position (equilibrium)

   - the point of maximum amplitude of deviation from the equilibrium position / the point of maximum deflection from the equilibrium position

   - how do you read the period and frequency of the pendulum's oscillations from the graph? How do you define them? / How do you define these physical quantities?

   - Can such a pendulum be considered a mathematical pendulum? Justify your answer.

   - Can the value of Earth's acceleration / gravitational constant be determined using such a set?

3. Discuss the position of the pendulum when its velocity is zero.

4. Based on the graph, discuss the position of the pendulum when its velocity is at its maximum.

5. How does the speed change as the pendulum moves from its equilibrium position towards the point of maximum deflection?

6. Based on the graphs, discuss how the speed of the pendulum changes as it moves from the point of maximum deviation towards the point of equilibrium.

7. Draw a graph of the pendulum's acceleration / a graph of the relationship between the value (or coordinate) of acceleration and time.

8. Discuss at which point the acceleration of the pendulum is maximum / Discuss at which position of the pendulum the acceleration of the pendulum is maximum.

9. Discuss at which points the acceleration of the pendulum is zero. Discuss at which position of the pendulum its acceleration is zero.

10. Discuss in which area the acceleration values are greater than zero. Discuss in which area the acceleration coordinates are positive.
    In the case of such a command, it is still necessary to specify the axis and the direction of the axis.

11. How to determine the resistance to motion? What are damped vibrations? What resistance to motion occurs when the position of the pendulum changes?

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Experiment.
Determining gravitational acceleration using a mathematical pendulum.

Introduction:

Do you think it is possible to determine the value of gravitational acceleration using a mathematical pendulum?
Below, we present the possibility of using an EMPE case (by changing its mass, e.g. by adding additional weight inside) as a pendulum.

Teacher:

If the period of oscillation of a mathematical pendulum (T) moving within a small angle range is:

$$T = 2\pi\sqrt{\frac{l}{g}}$$

then, using the above formula and knowing that, approximately, for small amplitudes of oscillation, the period of oscillation does not depend on the mass of the pendulum or the amplitude of its oscillations, but only on its length and the value of gravitational acceleration.

Therefore, when the length of the pendulum and its period of oscillation are known, it can be used as a tool to determine the value of the acceleration due to gravity.

Transforming the above formula, we obtain:

$$g = \left(\frac{2\pi}{T}\right)^2 \cdot l$$

We discuss with the students the most optimal way of measuring and preparing the pendulum in order to obtain the most accurate result possible.

We discuss how the length of the pendulum will affect the accuracy of the results obtained, and whether a greater mass of the pendulum will affect the accuracy of the results obtained. Students perform several measurements for different values of mass and length, checking how they affect the accuracy of the results obtained.

Students can use the table below or export data directly from the EMPE programme to a spreadsheet.

Discuss how the length and mass of the pendulum affect the accuracy of the results obtained.

Teacher:

- Use a series of measurements and different pendulum lengths and masses to determine the value of the acceleration due to gravity.
- Determine the influence of other factors on the measurement result obtained.
- How can you determine the resistance to motion?
- What are damped vibrations? What resistance to motion occurs during the motion of a pendulum?
- What is the centre of mass and how can its position be determined?
- Does the method of determining the position of the centre of mass affect the accuracy of the results obtained?
- Sample table for measurements and calculations:

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Lp.	L [m]	h [m]	r [m]	l [m]	$10 \cdot T$ [s]	$10 \cdot T_{średnie}$ [s]	$T_{średnie}$ [s]	$T_{średnie}^2$ [s^2]	g [$\frac{m}{s^2}$]
1									
2									