Projekt współfinansowany w ramach programu Unii Europejskiej Erasmus+

Mathematics
Cycle I Upper primary school
Understanding graphs and relationships

Topic 1	**We create and interpret graphs describing motion**
Duration	3 lessons (135 minutes)
Class/Age	The teaching cycle is aimed at pupils in the final years of primary school who are not familiar with the concept of functions, and we do not explicitly introduce this concept during the cycle (grade 7-8).
Objective	*The aim of this module is to develop an **intuitive** understanding of types of relationships and their graphs.* 1) Creating and interpreting graphs in the context of motion analysis at the intuitive level 2) Developing an understanding of graphs 3) Developing an intuitive understanding of unambiguous relationships between variables 4) Developing covariational reasoning
Description	Students create and examine graphs describing changes in distance over time using embodied experiments. During the lesson, students use the EMPE sensor together with the EMPE software. The sensor measures the distance to the nearest obstacle, and the software shows a real-time graph of changes in this distance over time. Students are involved in embodiment experiments by walking with the sensor and analysing the graphical interpretation of their movement. They have the opportunity to create and observe multiple graphs of different shapes, and they also perform reverse activities – they move in such a way as to reflect the movement shown in the graphs provided, and they interpret and analyse different movement graphs.
Teaching aids	- EMPE sensor with software - desktop computer or laptop with a web browser - projector screen - projector - work sheets for students

This material is provided by the EMPE Team, responsible institution: University of the National Education Commission in Krakow.

During the lesson, the teacher and students use the EMPE sensor with EMPE software developed as part of the EMPE project. Instructions for using the sensor can be found on the project website (https://empe.uken.krakow.pl).

TOPIC 1. We create and interpret graphs describing motion

LESSON PLAN

PRE-TEST

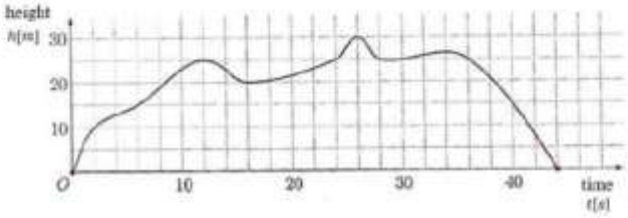
At the beginning of the lesson cycle, we can ask students to individually and in writing complete a two-task PRETEST. Its purpose is to test their intuitive understanding of graphs.

The Pretest tasks are as follows:

PRETEST

Name and surname.....**Class**.....

Task 1. The graph shows changes in the height of a flying drone above the ground during its flight. Answer the following questions.



a) How long did the flight last? .....

b) What was the maximum height reached by the drone? .....

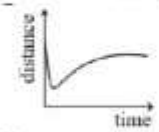
c) Does the graph show the drone's flight path (trail)? ○YES ○NO,

because.....

Task 2. Which of the drawings could represent the distance of the ball from the goal at a certain point in time during the game?

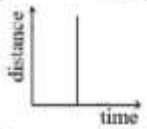
○YES ○NO , because:

.....



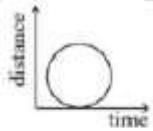
○YES ○NO , because:

.....



○YES ○NO , because:

.....



○YES ○NO , because:

.....

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The teacher collects the Pretest and will refer to it in the subsequent stages of the lesson cycle.

Activity 1. Drama and experiment

1a) Drama. Formulating hypotheses

The teacher reads the movement scenario described in Worksheet 1:

> *At first, I stand still for a moment.*
>
> *Then I walk at a steady, moderate pace towards the wall, and then at the same pace away from the wall. I stand still for a moment. Then I walk at a steady, fast pace towards the wall, and then at the same pace away from the wall.*
>
> *I stand still for a moment.*
>
> *Finally, I walk at a steady, slow pace towards the wall, and then at the same pace, I move away from the wall.*
>
> *At the end, I stand still for a moment.*

Then, the movement described above is performed by a selected student or teacher.

It is worth starting the walk from the back of the room and moving towards the board, because in this arrangement, when the pupil walks from the back of the room to the front, we will elicit typical mistakes (see Figure 2 on the left) and it will be possible to work on them later in the lesson.

After completing the movement (performing the drama), the teacher distributes Worksheets 1 (Fig. 1) to the pupils.

The students' task is to make their first attempt at sketching the shape of a graph showing the changes in distance from the wall during this movement.

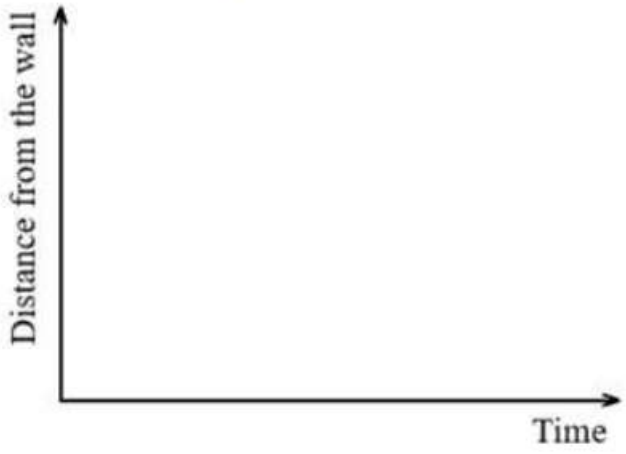
Name and surname ..... class.....

WORKSHEET 1

Activity 1. Sketch what the graph of my distance from the wall will look like, taking into account all stages of my movement:

I begin by standing still for a short moment. Then I walk toward the wall at a steady, moderate pace, and after reaching a point near the wall, I walk away from it at the same pace. Again, I stop and stand still for a moment. Next, I walk toward the wall at a steady, fast pace, and then walk away from the wall at the same fast pace. I pause and stand still again. Finally, I walk toward the wall at a steady, slow pace, and then walk away from it at the same slow pace. At the end, I stand still for a moment once more.

Your graph – first attempt:



1 , Worksheet 1, Activity 1

1b) Discovering how the sensor works

We proceed to manipulate the sensor. The teacher shows the sensor, opens the software and the graph, displays it on the projector and starts the measurement. They direct the sensor in different directions. The pupils observe how the graph is created in the application at this time.

The teacher asks the question:

- What can you say about this graph? (What are the descriptions of the coordinate axes? What is being measured?)

We wait for the pupils' answers, which will be:

- the sensor measures the distance to the nearest obstacle it encounters,

- the graph shows changes in the distance of the sensor from the nearest obstacle over time.

1c) Performing the experiment with the sensor. Verifying hypotheses

We perform the experiment described at the beginning of the lesson, this time using the sensor. The selected student performs the described movement independently.

Comment. Students should be instructed to hold the sensor in the same position (e.g. close to their body) and not to move it, especially in the front-back directions. It is worth repeating the experiment several times with different students.

A correctly constructed graph should have significantly different slopes of the straight lines:

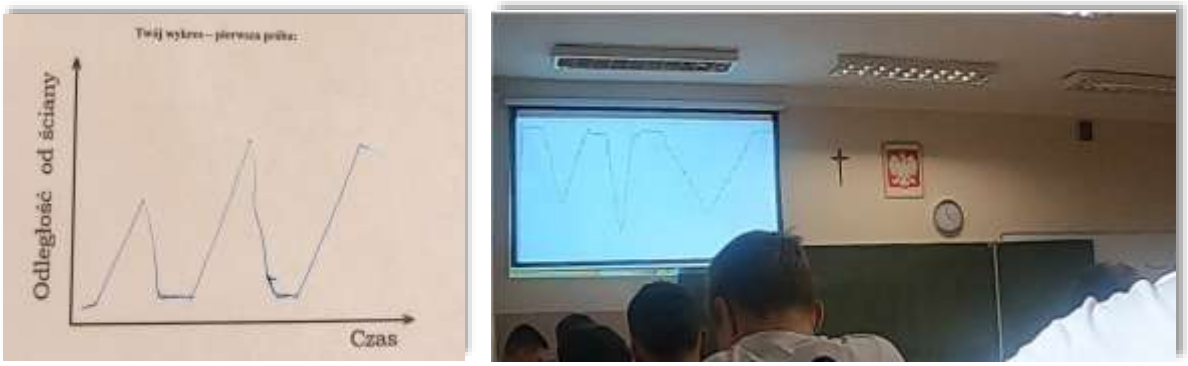


Figure2 . On the left – a typical incorrect prediction by a student. On the right – a graph produced by the sensor.

The students redraw the correct graph.

Students answer the question below the graph on their own: *What do you notice?*

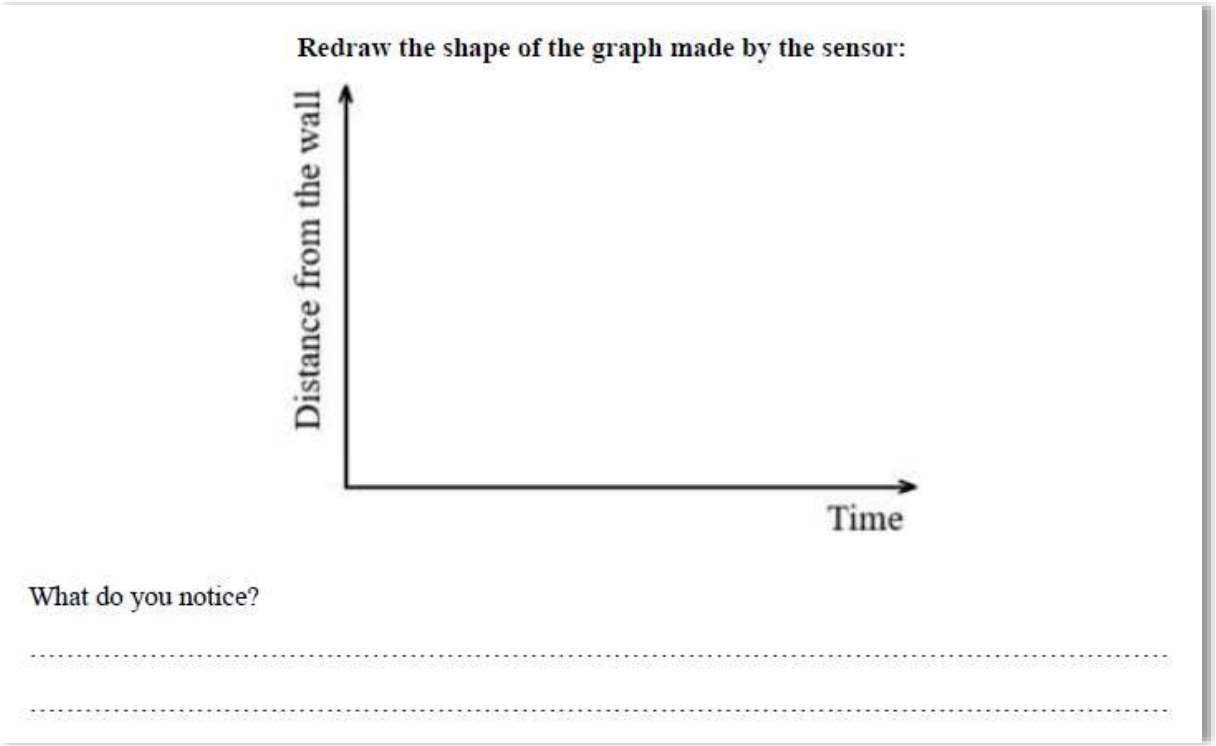


Figure3 . Worksheet 1, Activity 1 (cont.).

1d) Analysis of the graph

Please read the students' statements.

> *Comment: A typical mistake is to draw the graph following the trajectory of movement to the board, as in Fig. 2 (left). We refer to this mistake in the discussion and analyse it with the pupils, explaining why such a graph is drawn incorrectly.*

The teacher then asks the students questions to facilitate the analysis of the entire graph, for example:

- Why is the graph horizontal at the beginning? (we are standing, so the distance is the same)

- How does the distance between the sensor and the wall change during movement towards the wall? (the distance decreases)

- How does the distance between the sensor and the wall change when moving away from the wall? (the distance increases)

- How can we tell from the graph when we were walking fast? (greater slope of the line – more vertical segments of the line, distance covered in a short time)

- How can we tell from the graph when we were walking slowly? (smaller slope of the line – more horizontal segments of the line, distance covered in a long time)

- Was the break in movement the same length each time?

- Was the break in movement the same distance from the board each time?

- Why are there different slopes on the graph? (because we walk at different speeds)

- If we walk very fast, will the graph be vertical?

- If we walk very slowly, will the graph be horizontal? (as the pace increases, the graph becomes more and more vertical)

Comment: It is worth paying attention to distractors and imperfections in the graph. For example, in Fig. 4, you can see how the person holding the sensor stumbled while moving slowly towards the board, which is marked in red in the photograph.

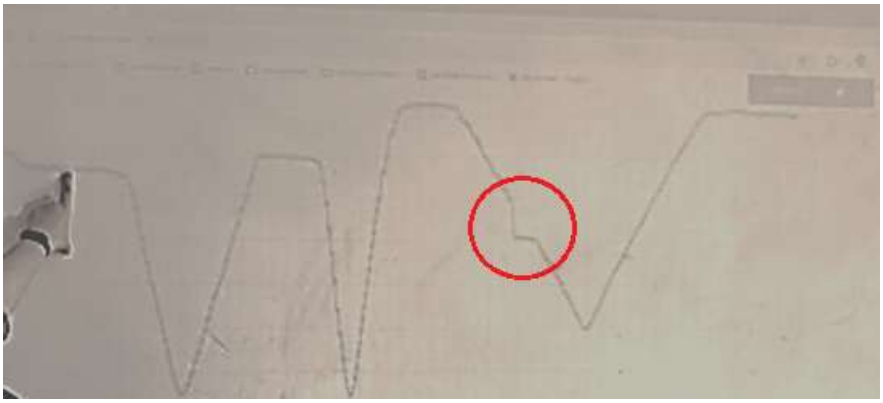


Figure4 . Analysis of distractors on the graph.

Activity 2. Slowly – quickly at a steady pace TOWARDS the wall

Independent work by students. Students complete the Worksheet (p. 2):

Two people walk TOWARDS the wall, starting at the same distance from the wall, both walking at the same pace but one slowly and the other quickly. Sketch in one coordinate system what the graphs of both movements will look like.

Person 1 walks towards the wall slowly – line named s

Person 2 walks towards the wall quickly – line named q

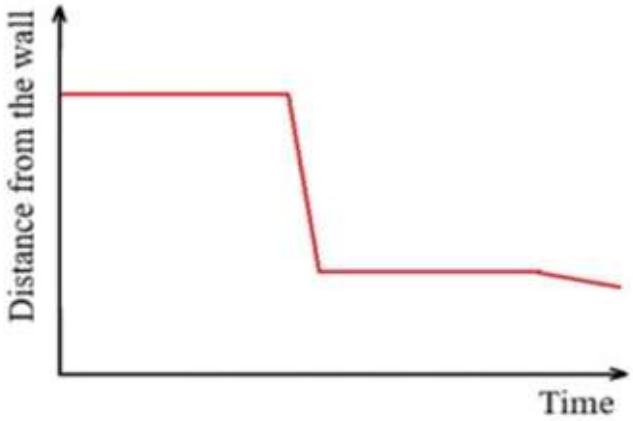
In your own words, how can you tell from the chart when the movement towards the wall was slow and when it was fast?

Selected pupils read out their statements.

Activity 3. Interpretation and description of the graph

The pupils are asked to perform the reverse activity, which consists of describing in words the possible movement shown in the graph:

Activity 3. The graph shows what my other movement looked like:



Describe in words what this movement might have looked like:

.....

.....

.....

.....

5 . Worksheet 1, Activity 3.

Activity 4. Slowly – quickly at a steady pace AWAY FROM the wall

Independent work by students. Students complete Worksheet 2 (p. 3):

Two people walk FROM the wall, starting at the wall and ending the movement at the same distance from the wall, both walking at the same pace but one slowly and the other quickly. Sketch in one coordinate system what the graphs of both movements will look like.

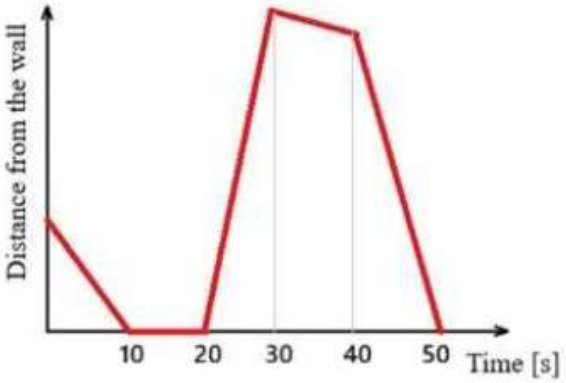
Person 1 walks slowly away from the wall – line named s
Person 2 walks quickly away from the wall – line named q

In your own words, how can you tell from the graph when the movement towards the wall was slow and when it was fast?

Activity 5. Summary – Graph analysis

Students fill in the table by interpreting the movement chart:

Activity 5. Based on the graph describing the movement, complete the table (write a word or tick ✓).



Time interval	0-10 [s]	10-20 [s]	20-30 [s]	30-40 [s]	40-50 [s]
Slow/ Fast /Moderate					
TOWARDS / FROM wall					
Fastest					
Does not change distance					

How do you know when the movement was fastest?

.....

.....

Figure6 . Worksheet 2, Activity 5.