FROM TRAILS TO GRAPHS

STUDENTS RECORD THEIR MOVEMENTS AND PREPARE GRAPHICAL REPRESENTATIONS OF THEIR MOTION

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SUITABLE FOR AGE(S)	SUBJECT(S)	KEY FOCUS
12-18 years	Science, Physics, Mathematics	Visualization Interpreting graphs

INTRODUCTION

Describing motion with graphs is an effective but abstract process. Many students struggle to accurately draw graphical representations of motion, and it is even more challenging for them to extract data about the motion from a graph.

The ability to quickly interpret or communicate data in graphical form is essential for general literacy. Graphs are used extensively in science, physics, and mathematics classes; however, the transfer of knowledge about graphs across these subjects is often weak. This task helps students bridge the gap between physical experience and the abstract mathematical description of motion. It develops their ability to visualise, record, describe, and ultimately graph different forms of motion.

This task proposes a hands-on approach: students record trails of their own simple movements, describe both the motion and the resulting trails in words, and then transform these trails into simple graphs. To complete the learning cycle, the task is inverted: motion represented by simple graphs is described in words.

TASK DESCRIPTION

Students begin by observing and discussing familiar trails (e.g. footprints, ski trails, plane trails), then create their own motion trails using simple equipment. Finally, they transform these trails into graphs and practice reading graphs to describe motion. The task offers students the opportunity to engage deeply with a chosen phenomenon and collaborate to refine their questioning and inquiry skills.

Activities presented in this task enable students to visualise the trail left by their moving body (specifically their hand) and experience how different modes of motion influence the trail. A time component is then added to transform the trail into a simple graph. Students should have some preliminary knowledge about:

- Coordinate systems
- The presentation of independent (time) and dependent (position) variables in graphs
- The concepts of speed and direction
- Spatial orientation (left, right, from, to) and uniform motion.

TASK PREPARATION

The teacher prepares materials for recording motion trails and provides guiding questions to help students reflect on the connection between trails and graphs.

Materials needed:

- Soft pencils, markers, or similar — important that a small force enables drawing (use at least two different colours)
- Sheets of paper (A4 or A3; continuous roll paper is even better)
- Flat surface (large tables for two or more students) for recording motion trails.

TASK IMPLEMENTATION

Introduction — Observing Trails

The teacher begins by asking students whether they have recently noticed any trails and what data about the motion or object in motion they could extract from them. Common examples include:

- Animal or human footprints in snow, mud, or on a wet floor
- Plane trails
- Ski or sled trails or
- Prints left by Wet bicycle or car tire tracks

The teacher leads a discussion about what data can be deduced from such prints (for example, which animal made them, in which direction it moved, and sometimes also its speed and how long ago the prints were made). And how some of this data is similar to what is shown in graphs of motion.

Making Trails

Students work in pairs. One student holds the paper at the left edge and slowly drags it to the left. The second student positions the marker at the left side of the paper and holds the marker still so that it leaves a trail on the paper. Students should have some time to master the procedure and switch roles. It is essential that the movement of the paper is slow and uniform, maintaining a consistent speed. The hand holding the marker should rest in the same position.

Step 1: Body at Rest

When students master the procedure, the teacher asks them to use markers of different colours to record trails of the hand.

- One with the marker held close to them
- One with the marker held far from them

Resulting horizontal lines will appear at different distances from the bottom edge of the sheet.

Students switch roles and repeat the procedure, drawing on a new sheet of paper. Resulting trails should be marked "hand at rest" or similar.

Discussion follows:

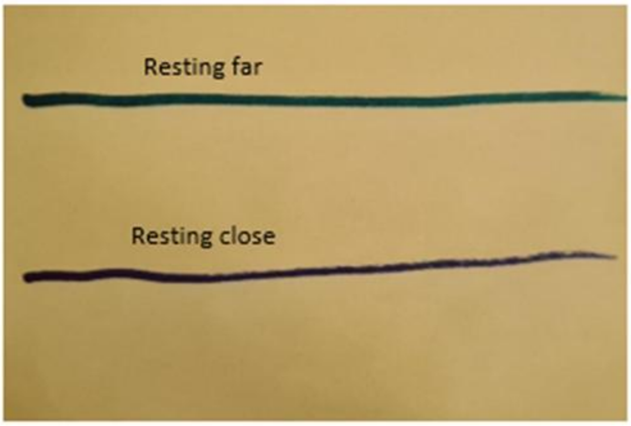
The teacher asks whether the distance of the hand position from the paper edge can be determined, and students usually suggest measuring it along the vertical edge of the sheet. A further question concerns time: which part of the trail was made first and which at the end of the movement? Again, students observe that the left part of the trail was created before the right one, or that the further to the right they follow the trail, the more time has passed since the start of the movement. Both observations are important for converting trails into graphs, as will be discussed later.

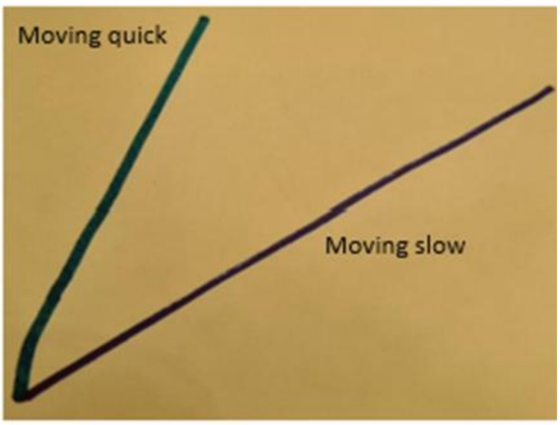
Step 2: Uniform Motion at Different Speeds

Students repeat the process, but this time the marker moves away from the student as the paper slides left- First at a slow speed, then again at a faster speed (using a different colour marker).This generates trails of different slopes.

Discussion focuses on how to interpret:

- Speed from the trail (steepness)
- Direction of motion.





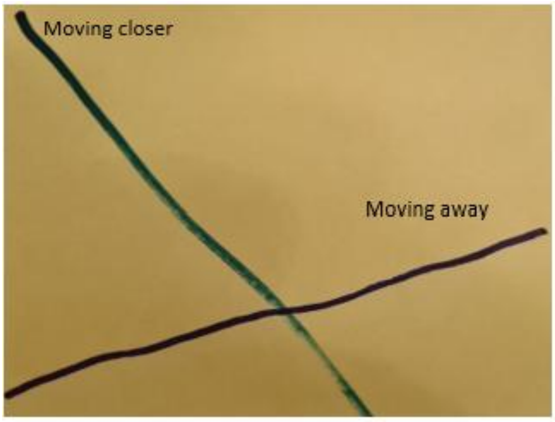
New sheets of paper are used, and students have similar roles: one pulls the paper to the left while holding it at the edge, and the other positions the marker at the lower left corner. The student then slowly moves the marker away from themselves as the paper slides underneath, ensuring the marker only moves outward from the student, not sideways.

Afterwards, the paper is returned to its original position, and a different coloured marker records a second movement starting from the same point and in the same direction, but at a higher speed. Students then switch roles, repeating the process with trails recorded on a new sheet of paper. A brief description of the movement is added to each sheet.

Step 3: Uniform Motion in Different Directions

Students now explore movement directions: First, the marker is moved away from the student. Then, starting at the top left corner, the marker is slowly moved towards the student. Pairs switch roles and repeat the process.

New sheets of paper are used; students prepare as they did previously. The first trial follows a similar pattern: the marker is placed at the bottom left corner and gradually moved away from the student. Then, a marker of a different colour is used; it begins at the top left corner and is slowly moved towards the student. Roles are switched, a new sheet of paper is used, and the task is repeated. A brief description of the movements is written on the paper.



Different trails may vary in more than one property; this presents a great opportunity to “read” the trails for all available data. The trails in the picture above were created while markers moved in different directions and at different speeds, with the green marker moving faster than the blue one.

Step 4: Free Movements

Students are encouraged to experiment with different combinations of movement modes mentioned above, drawing trails on the paper and sliding the marker below it. The resulting trails become more complex, and students are encouraged to describe the recorded movements orally or in writing. Finally, groups exchange their drawings and discuss what data about the movement they can infer from the trails; the teacher should ask them to describe how and when the hand with the marker moved (“First it rested close, then it slowly moved even closer and then quickly away, and at the end …”). The authors of the drawings confirm or correct the descriptions of their peers.

Step 5: From Trails to Graphs

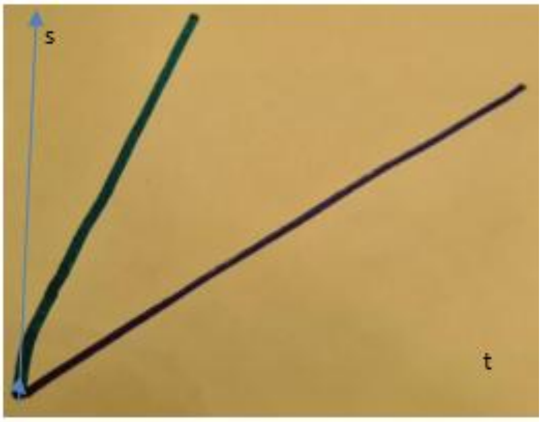
Now, students transform their trails into graphs:

The teacher reminds students that parts on the right side of the trail were made later than those on the left; moving from the left to the right means a change in time. Zero seconds ("0 s") time is usually assigned to the beginning of the movement (and the trail). The teacher leads a discussion on how to determine which part of the trail originated 1s (or any suitable time interval) after the start and whether it is the same on all drawings.

Students should recognise that the speed at which the paper moves is crucial for the time scale. If we measure how far the paper has moved in 1 second, we know how far to the right the trail was made 1 second after the start.

We draw a horizontal axis along the bottom edge of the paper and use it to read the time (t) data about the movements (marking the position of 1 s). The second axis is drawn vertically along the left edge of the paper and is used to read the distance (s) data, where the scale is simple: 1 cm on the graph corresponds to 1 cm travelled.

Students then read distance-time graphs from their trails.



The information about the speed and direction of movement is conveyed through the inclination of the graph; teachers should ask appropriate questions to help students learn how to interpret it. As a result of the activities, students should be able to draw and read graphs representing distance travelled versus time for uniform motion. Problems might occur if students are unable to move the paper and/or their hand as described. In such cases, teachers or more experienced students might assist with this.

Additional information: The simplest movement taught in physics is linear uniform motion, and the simplest graphs are on distance travelled vs. time. Besides data on distance, the velocity can be compared (and even calculated) from the steepness of the curve in the graph: the steeper the curve, the bigger the velocity. Additionally, the direction of the movement can also be deduced from the inclination of the curve: an ascending curve indicates an increase in distance, while a descending curve indicates a decrease in distance.

KEY LEARNINGS

This task was carried out with future teachers, who found it very helpful. One participant noted that although they are adults, these activities helped clarify the purpose of motion graphs.

This task gives students hands-on experience of:

- How motion translates into a graph
- How to interpret the graph's features (slope, direction, changes over time)

This supports the transfer of learning from physical experience to abstract mathematical representation.

Co-funded by the
Erasmus+ Programme
of the European Union

CONCLUSION

Graphs are powerful tools for communicating data. The ability to read and communicate data in graphical form is an essential part of scientific and mathematical literacy. While the concepts involved are taught in different subjects, transferring this knowledge between contexts is challenging for students. This task provides them with rich opportunities to experience, discuss, and master the topic, not just through talking and drawing, but through physical engagement with the concepts.

REFERENCES

Additional activities on the topics, including velocity and acceleration graphs are offered by COACH software (developed at University of Amsterdam). These activities use computers and ultrasound trackers.