Activity worksheet: motion graphs

Name	Group	Date

What you will learn

With the Motion Graphs simulation you will watch a car or a person move along a straight track and, at the same time, see their position–time (x-t), velocity–time (v-t) and acceleration–time (a-t) graphs being drawn. You will learn to read a motion graph, to build one and to tell constant-velocity motion from constant-acceleration motion.

How to work. Each activity has three steps:

1. **Predict.** Before looking at the simulation, write down what you think will happen and why.
2. **Observe.** Set up the simulation, watch what happens and note down the data.
3. **Explain.** Compare what happened with your prediction and explain why.

If your prediction turns out to be wrong, don't rub it out: getting it wrong and understanding why is the best way to learn.

Each activity has a link that opens the simulation already set up. If you have the worksheet on paper, go to **simulaciencia.es/en/simulations/cinematica** and set it up as described under “Set up the simulation”.

How to read the data. The track is a ruler from −20 to 100 m; the positive direction is to the right (“x +”). The three graphs share the time axis and a dashed cursor: the point on each graph belongs to the object at that instant. The “Time” slider moves the cursor to any moment. The drop-down “Data at the cursor time” gives the time (t, in s), the position (x, in m), the velocity (v, in m/s), the acceleration (a, in m/s²), the distance travelled and the displacement.

Before you start

What do you think now? Write T (true) or F (false). You will come back to this table at the end.

Statement	T or F
a) The x-t graph is a drawing of the path the object follows.	
b) If the x-t graph goes down, the object is going downhill or slowing down.	
c) If the x-t graph is a horizontal line, the object is moving at constant velocity.	
d) If the velocity is negative, the object is slowing down.	
e) When an object stops for an instant to turn round, its acceleration is zero.	

Activity 1. Walking and running

Set up the simulation: Explore mode, example **Person walking (1.5 m/s)**, with marks every second and the previous graph kept in grey. Open the simulation ready to use

Predict. Sketch what you think the x-t graph of a person walking at a steady pace will look like. And for a person running?

My sketch

Observe. Press "Start". When it finishes, choose the example "Person running (4 m/s)" and press "Start" again: the walking graph stays in grey.

Question	Walking	Running
What shape is the x-t graph?		
How are the marks for each second spaced on the track?		
Position at 20 s (m)		
How many metres does it move each second?		

Explain. What does it mean when one x-t graph is steeper than another? Is the graph the path the person follows?

My explanation

Activity 2. Stop at the newsstand

Set up the simulation: Challenges mode, challenge **3. Stop at the newsstand**. Open the simulation ready to use

Predict. Look at the yellow challenge graph. What do you think the object is doing during the horizontal stage?

My prediction

Observe. Read the graph stage by stage and fill in the table. Then build the stages in the panel ("+ Add stage") and press "▶ Check".

Stage	From t = … to t = … (s)	From x = … to x = … (m)	Velocity (m/s)
1			
2			
3			

Explain. What does the v-t graph of this motion look like? What does a horizontal stage mean on the x-t graph, and what does it mean on the v-t graph?

My explanation

Activity 3. Heading back to the origin

Set up the simulation: Explore mode, example **Person walking back towards the origin.** Open the simulation ready to use

Predict. The person starts at x = 60 m and walks towards the origin. Will the x-t graph go up or down? Will the velocity be positive or negative?

My prediction

Observe. Press “Start” and watch the track, the graphs and the green velocity arrow.

Question	What I observe
Does the x-t graph go up or down?	
Where is the v-t graph: above or below the axis? What value does it show?	
Which way does the green arrow point?	
Position at 20 s (m)	

Explain. What does the minus sign of the velocity mean? Write the equation $x = x_0 + v \cdot t$ for this motion.

My explanation

Activity 4. There and back

Set up the simulation: Challenges mode, **Free** option, with two stages already built: 10 s at 4 m/s and 10 s at −4 m/s. Open the simulation ready to use

Predict. You walk to a friend's house 40 m away and come back. At the end, how many metres have you walked? How much has your position changed?

My prediction

Observe. Press “Start”. At the end, open “Data at the cursor time”.

Quantity	Value
Final position (m)	
Distance travelled (m)	
Displacement (m)	
Average velocity = displacement / time (m/s)	
Average speed = distance travelled / time (m/s)	

Explain. Why are the distance travelled and the displacement different? When would they be the same?

My explanation

Activity 5. The car pulls away

Set up the simulation: Explore mode, **Constant acceleration**, example **Car pulling away slowly**, with marks every second. Open the simulation ready to use

Predict. The car starts at rest and speeds up. How will the marks for each second be spaced on the track? What shape will the x-t and v-t graphs have?

My prediction

Observe. Press “Start”. Then use “Time” or the “Table of values” to fill in the table.

t (s)	0	2	4	6
v (m/s)				

Explain. By how much does the velocity increase each second? What is that quantity called? Describe the shape of the three graphs.

My explanation

Activity 6. Braking at the lights (ESO 4)

Set up the simulation: Explore mode, example **Car braking at traffic lights** (v_0 = 10 m/s, a = −2 m/s², stops when it reaches v = 0), with the area under v-t. Open the simulation ready to use

Predict. Work out how long the car takes to stop and how many metres it travels before stopping.

My prediction and calculations

Observe. Press “Start” and move the cursor to the instant it stops.

Question	What I observe
At what instant does it stop?	
What is the area under the v-t graph up to that instant?	
At what position does it stop?	
What signs do v and a have while it brakes?	

Explain. How is the area under the v-t graph related to the distance it travels? How do you know it is slowing down?

My explanation

Activity 7. Forward, stop and back (ESO 4)

Set up the simulation: Explore mode, example **Slows down, stops and comes back** (v_0 = 7 m/s, a = −1 m/s²), with pauses at key moments. Open the simulation ready to use

Predict. At the instant the car stops to turn round, what is its velocity? And its acceleration?

My prediction

Observe. Press “Start”. The simulation pauses by itself at the key moment; press “Resume” to carry on.

Question	What I observe
At what instant and position does it change direction?	
v and a at that instant	
After turning round, does it go faster and faster or slower and slower? Why?	
What shape is the x-t graph? Is the car climbing a mountain?	

Explain. Why is the acceleration not zero when the velocity is? When does an object slow down and when does it go faster and faster?

My explanation

The challenges

Open **Challenges** mode. Open the challenges Each challenge shows a graph that you have to recreate by building the motion in stages. Read the story, build the stages and press “▶ Check”. If it doesn't work, read the message: it tells you where and why the graphs move apart. Challenges 1 to 5 are constant velocity; 6 to 10 are constant acceleration (ESO 4).

Challenge	Stages you used (duration and value)	Attempts	Completed?
1. A walk			
2. There and back			
3. Stop at the newsstand			
4. Heading home			
5. From velocity to position			
6. The car pulls away			
7. Braking at the lights			

Challenge	Stages you used (duration and value)	Attempts	Completed?
8. The mountain			
9. Speed up and slow down			
10. Reversing			

Apply what you have learnt

Solve without the simulation. Write the formula, the calculation with its units and the result.

1. A cyclist passes x = 5 m at t = 0 and x = 35 m at t = 10 s, at constant velocity. Calculate their velocity, write their position equation and say where they will be at t = 20 s.
2. A car travels at 72 km/h along a straight road. How long does it take to cover 500 m?
3. An object goes from x = 0 to x = 20 m between t = 0 and t = 10 s (stage A), stays at x = 20 m until t = 15 s (stage B) and comes back to x = 0 between t = 15 and t = 20 s (stage C). Calculate the velocity in each stage and draw its v-t graph.
4. (ESO 4) A car at 20 m/s brakes with constant acceleration and stops in 4 s. Calculate the acceleration and the distance it travels before stopping.
5. (ESO 4) A motorbike starts from rest with a = 3 m/s². Calculate its velocity and the distance travelled after 6 s.

Problem	Calculation and result
1	
2	
3	
4	
5	

Review your ideas

Go back to the “Before you start” table. Would you change any answer? Write which one and explain why, using something you saw in the simulation.

What has changed in my ideas

Going further (ESO 4)

1. Open challenge 8 “The mountain” and check your solution. Turn on “Slope of x-t (velocity)” and read the slope at t = 0, t = 8 s and t = 12 s. Open the simulation ready to use
2. In challenge 9 “Speed up and slow down”, turn on “Area under v-t (displacement)”. Work out the area of each stage of the v-t graph and add them up. Does it match the train's final position?
3. In challenge 10 “Reversing”, what signs do v and a have between t = 8 s and t = 12 s? Is the car speeding up or slowing down? Why?

My answers

Self-assessment

Put an X to show how confident you feel at the end.

I can...	Yes	Nearly	Not yet
Explain that a motion graph is not the object's path			
Read the velocity from an x-t graph (slope) and from a v-t graph			
Interpret a horizontal stage and a downward stage on an x-t graph			
Tell distance travelled from displacement			
Recognise the graphs of constant-velocity and constant-acceleration motion			
Tell whether an object is slowing down or speeding up from the signs of v and a			
Use a prediction and an observation to change an idea I had			

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