Name _____ Date _____ Period _____

ZornScience
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Motion Graphs Virtual Lab

Physics

Open **activities.zornscience.org/physics-graphing-lab/** and stay in **Explore** mode. Follow each step and show your work with units.

Objective

Use a moving cart to find how the **position-time**, **velocity-time** and **acceleration-time** graphs of the same motion are connected.

NGSS alignment: HS-PS2-1. Analyze data to support the claim that Newton's second law describes the relationship among the net force on an object, its mass, and its acceleration (data such as graphs of position or velocity as a function of time).

Practices and concepts: Analyzing and interpreting data; Using mathematics and computational thinking; Patterns; Stability and change.

Meet the simulation

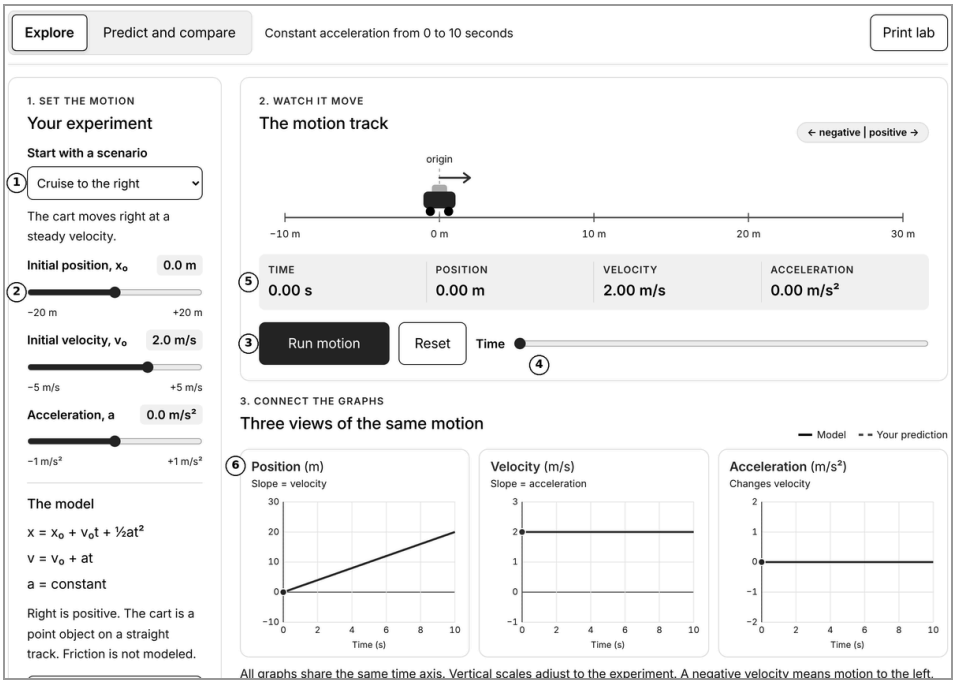


Figure 1. The Physics Graphing Lab in Explore mode.

(1) Scenario menu: loads a ready-made motion.

(2) Sliders: initial position x_0, initial velocity v_0, acceleration a.

(3) Runs the 10 s motion.

(4) Time slider: moves to any time. Click it, then use the arrow keys to step 0.1 s.

(5) Readouts: time, position, velocity, acceleration.

(6) Linked graphs of x, v and a against time.

Right is positive. Changing a setting returns the cart to 0 s.

Pre-lab

1. A cart's velocity is −2 m/s. What does the negative sign tell you about the motion? Does it mean the cart is slowing down?

2. A cart starts at $x_0 = 0$ m with $v_0 = 0$ m/s and $a = 0.6$ m/s^2. Use $v = v_0 + at$ and $x = x_0 + v_0t + \frac{1}{2}at^2$ to predict its velocity and position at $t = 10$ s.

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Part A. Constant velocity

1. Run 1: choose the scenario **Cruise to the right** (x_0 = 0 m, v_0 = 2.0 m/s, a = 0.0 m/s^2).
2. Move the Time slider to each time in the table and record the **position** readout.
3. Run 2: keep a = 0.0 m/s^2. Set x_0 = 10 m and v_0 = −1.5 m/s. Record the position at each time again.

Time (s)	0	2	4	6	8	10
Run 1 position (m)						
Run 2 position (m)						

3. Calculate the slope of the position-time graph for each run. Show your setup with units.

4. Compare each slope with the velocity readout. What does the slope of a position-time graph tell you? What do the velocity-time and acceleration-time graphs look like when velocity is constant?

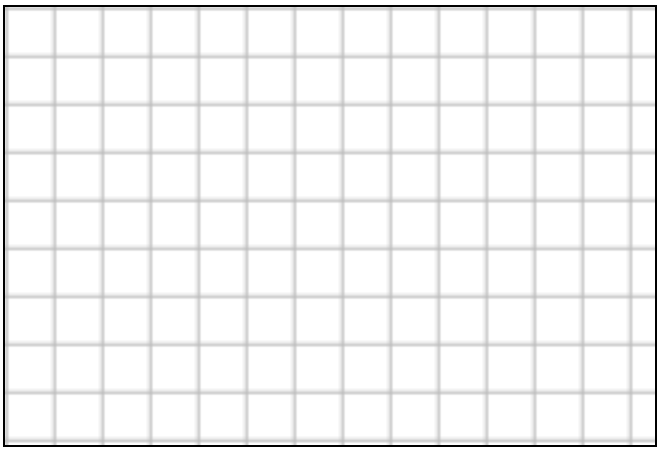
Part B. Speeding up

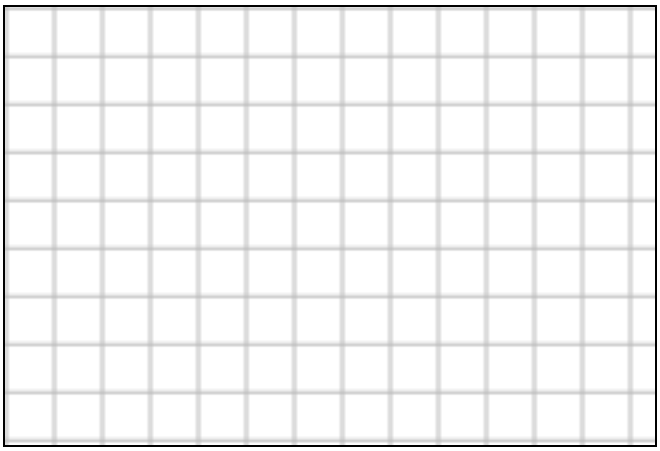
1. Choose the scenario **Speed up to the right** (x_0 = 0 m, v_0 = 0.0 m/s, a = 0.6 m/s^2).
2. Move the Time slider to each time and record the position and velocity readouts.

Time (s)	0	2	4	6	8	10
Position (m)						
Velocity (m/s)						

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5. On the left grid, graph velocity (y-axis) against time (x-axis) and draw a line of best fit. On the right grid, graph position against time and draw a smooth curve. Label both axes with units.





6. Calculate the slope of your velocity-time graph with units. Which readout does it match?

7. Why is the position-time graph curved in Part B but straight in Part A? Use the distance traveled in the first 2 s and the last 2 s as evidence.

8. Compare the values at 10 s with your Pre-lab question 2 prediction. Did the kinematic equations match the simulation?

9. The simulation cart has no friction and a perfectly constant acceleration. In Parts A and B, name one way a real cart on a real track would make the graphs look different.

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Part C. Turning around

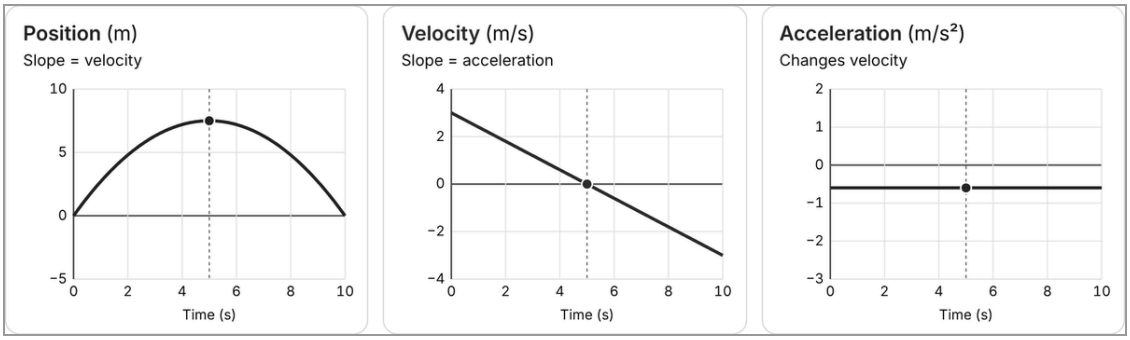


Figure 2. The three graphs for the Turn around scenario with the Time slider at 5 s.

1. Choose the scenario **Turn around** ($x_0 = 0$ m, $v_0 = 3.0$ m/s, $a = -0.6$ m/s^2). Select **Run motion** and watch the cart.
2. Move the Time slider to 5.0 s and record the readouts below.

Time (s)	Position (m)	Velocity (m/s)	Acceleration (m/s^2)
5.0			

10. How does each graph show the moment the cart turns around at 5 s?

11. Is the cart speeding up or slowing down from 0 to 5 s? From 5 to 10 s? Explain using the signs of v and a.

12. A classmate says, "At 5 s the cart is stopped, so its acceleration is zero." Use the readouts to explain why this is wrong.

13. Choose **Slow to a stop** ($x_0 = -10$ m, $v_0 = 4.0$ m/s, $a = -0.4$ m/s^2). Before you check, use $x = x_0 + v_0t + \frac{1}{2}at^2$ to predict the position at 10 s. Then check with the Time slider.

Conclusion

14. Write a claim that answers the objective. Support it with specific numbers from Parts A and B, then explain your reasoning about slopes.

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