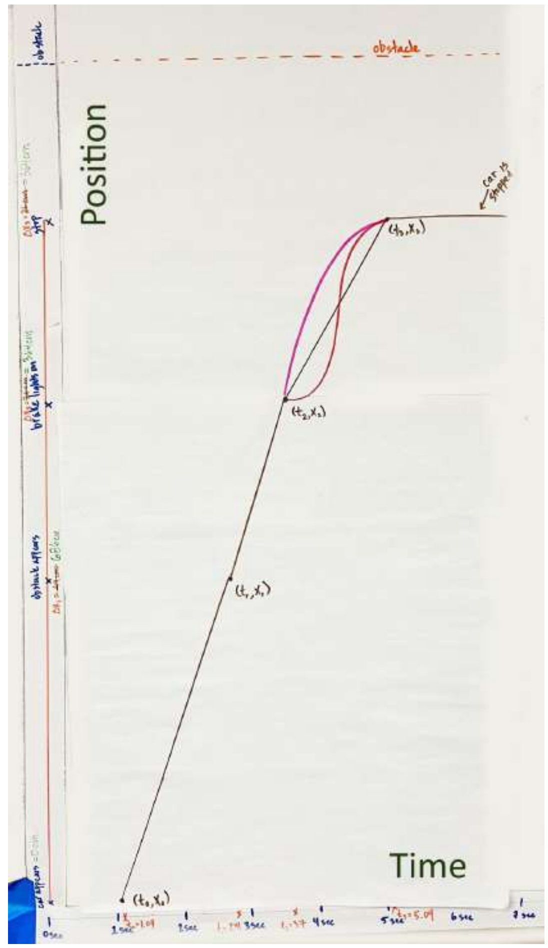
Making a Position-Time Graph

Undistracted Driving Video: https://youtu.be/Z11esq-Zs2E?si=j5gSUw7dRqIqxSsL
Distracted Driving Video: https://youtu.be/D2-2L_e3bLU?si=2jZ57RdNLrrzgr4u

The goal of this activity is to collect data from two videos of a car being driven (linked at the top of this document) and then use the data to create a large position-time graph. At the end of the activity, you should have a graph for undistracted driving similar to the one shown here, along with a similar graph for distracted driving plotted on the same axes (or on a different sheet if you prefer). The details of this activity in the *Teacher Guide* are summarized here for quick reference.



Step 1. Watch the videos and identify differences. Present **slide B.** Project the two videos and ask students what differences they noticed between the clips.

Step 2. Create a position-line for the non-distracted driver. Present **slide C**. Tape a strip of receipt paper to the screen or whiteboard so the video is projected over it. Extend the paper across the frame at the height of the car's bumper. (If using a monitor, tape the paper to the edges and turn up the brightness to see the video through it.) Use a meterstick to create a line on the paper.

Step 3. Identify and label important positions. Elicit ideas about what positions are "important." Use probing questions to help students see clues like brake lights and rotation of the tire. Mark the following:

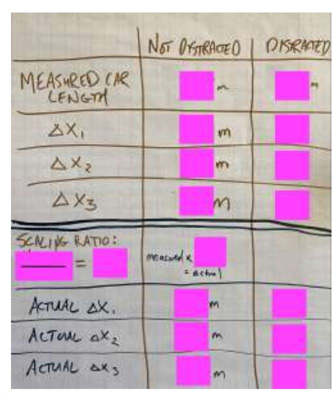
- Position 0: The car appears.
- Position 1: The obstacle appears.
- Position 2: The brake lights go on.
- Position 3: The car comes to a complete stop.

Step 4. Introduce *reaction distance* and *braking distance* and add to Personal Glossary. Point to the interval between the appearance of the obstacle and the brake lights, and ask, *What happens to the car during this interval?* Listen for students to say that the driver sees the obstacle, or reacts. Say, *Yes, this is the interval where the driver reacts. So let's call it the reaction distance.* Do the same thing for the braking distance.

Step 5. Measure and record the distances from point to point. Use a meterstick to measure the distances between the consecutive marked points on the line, starting where the car first appeared (X_0). These will likely be great enough that you won't need to use decimal places beyond the centimeter measurement. If students do want to use fractions of a centimeter, ask them to consider the error introduced by measurement. Record these distances on the timeline.

Step 6: Elicit ideas about how to calculate the real-life distances. Present **slide D**. Have students share their ideas about using scale to determine the distances. Say, *We need a way to keep track of measurements that we make using what we see on the screen, as well as the actual distances they correspond to in real life. You can write values on a handout, and I'll keep track of them for the class.* Listen for ideas about wanting to know the real length of something in the video. Then ask about finding the ratio of the actual car to the measured distance (scaling ratio). Present **slide E**. Distribute *Creating Position-Lines* to each student. Say, *I looked up the length of this kind of car. It is 4.5 meters long.*

Step 7: Calculate ΔX1, ΔX2, and ΔX3 and add to the position-line. Have students write the measured values in the table on the handout (in the "Undistracted" column), then calculate "actual" values using the scaling ratio. Add these actual values to the position-line.



Step 8: Repeat the procedure for the distracted driver. Use the toy car to elicit predictions on what will be different when the driver is distracted. Then complete steps 3-7 for the second video, recording values on the handout and position-line. Compare the two position-lines side by side, and ask how they are different and why. Present **slide H** and briefly discuss.

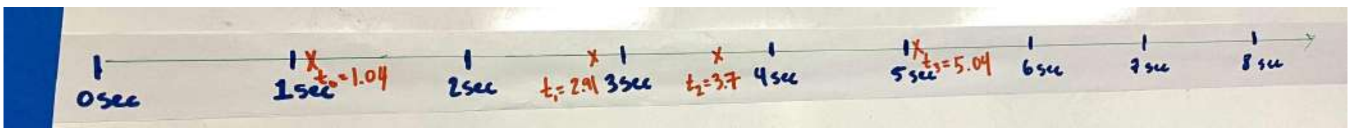
Step 9. Motivate analysis of timing. Use the toy car to "drive" along the line to re-create the distracted driver scenario. Present **slide I** and discuss. Then present **slide J** and assign the home learning.

Break between Day 1 and Day 2

Step 10: Add reaction time to Personal Glossary. Optional: Ask, *How could we test to see whether being distracted impacts our reaction time?* Have students use https://www.justpark.com/creative/reaction-time-test/ to test their reaction times normally and when another student is distracting them, and notice that being distracted does make a difference. See the alternate callout in the Teacher Guide.

Step 11: Create a timeline for the undistracted driver. Present **slide M**. Use a new strip of receipt paper for this timeline. It should be on the same scale as the position-line, as these will eventually be combined as the axes of a graph (see the image at the top of this document). Select seconds as the relevant unit. The videos are 6 seconds and 7 seconds long, respectively, so your line should go to about 7 seconds.

Use the time code from the video to figure out the times associated with each important position identified previously. Then determine the lengths of each time interval, add them to the timeline as shown, and label this timeline “Undistracted”.

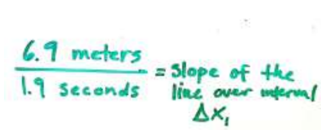


Step 12: Motivate comparing our variables on a graph. Present **slide N**. Say, *We have two different ways to look at the events in the video: as time passes, and as the position of the car changes. What could we do to visualize what’s happening here in both dimensions, time and position, and look for a relationship between these?* Have students consider how to visualize what’s happening here in both dimensions, time and position, and look for a relationship between these.

Step 13: Create the *y-axis* by repositioning the position-line. Move the paper position-line up and sideways to be the *y-axis* for the *x-axis* timeline as shown in the image, joining their origins at the bottom left corner. You may choose to move through the next several steps without projecting slides, to focus attention on the graphing, or use **slide P** to articulate the task.

Step 14: Determine the lines between points. Ask, *How do we represent the moment the car appeared, in both time and position, on this graph?* Help students see that we can graph this point, and use a meterstick to plot each point: (t0, x0), (t1, x1), (t2, x2), (t3, x3).

Step 15: Calculate the speed of the car before braking. Write 6.9 meters/1.9 seconds on the board. Say, *In math terms, we call this the slope of the line, or how much the y-axis changes every time the x-axis changes.* Label the fraction as “slope of the line over interval Δx_1”. Then say, *Let’s take a closer look at what this slope is telling us.*



Go through the calculations as a class. You should find that the car was moving at about 3.6 meters per second. (Optionally, type this into Google to convert, or do the calculations with the class to figure out what this means in MPH; 1 m/s is 2.2 MPH.) Then repeat these calculations for the second time interval. You should find that the car was moving at about 4.6 meters per second after the obstacle appeared but before braking.