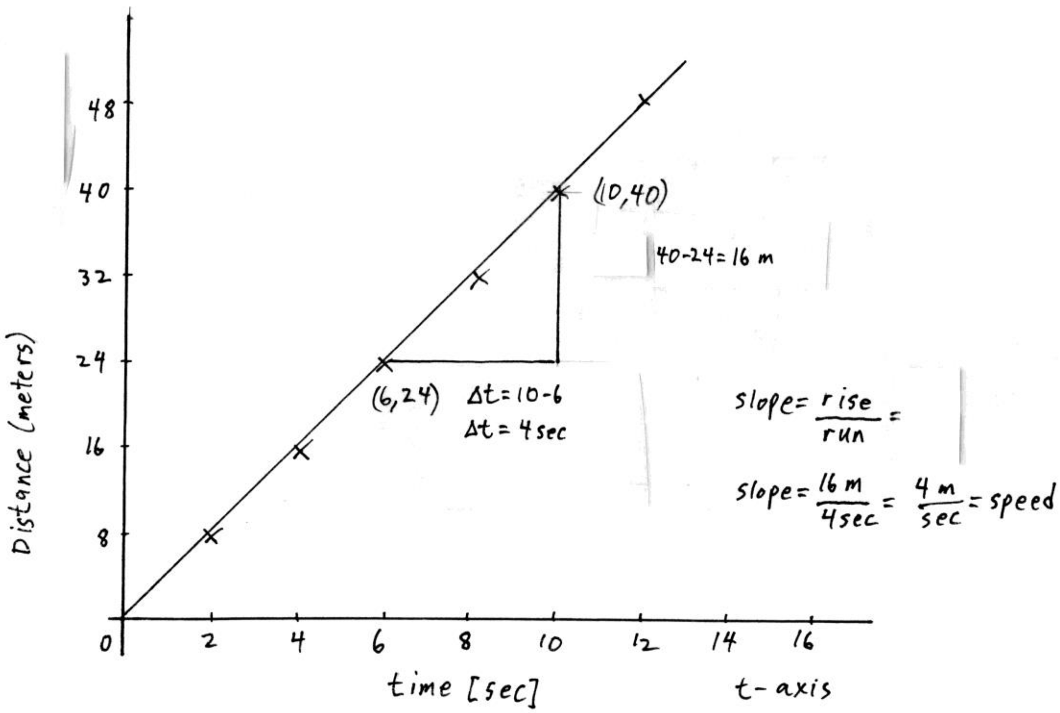
Physics Lecture #2: Position – Time Graphs

If we plot the position of a moving object at increasing time intervals, we get a position – time graph. This is sometimes called a distance – time graph.

Suppose a car is moving east in a straight line. When it passes a tree, we note the position of the car at regular time intervals. Below is a chart showing how far the car is from the tree every two seconds.

Time (seconds)	**0**	**2**	**4**	**6**	**8**	**10**	**12**
Distance (meters)	**0**	**8**	**16**	**24**	**32**	**40**	**48**

If we plot these values with distance on the vertical axis and time on the horizontal axis, we get the graph below.



The graph is a straight line. If we pick two points on the line, we can calculate the slope of the line. I picked points (6,24) and (10,40). The vertical change, or rise, is 40 – 24 = 16 m. The horizontal change, or run, is 10 – 6 = 4 seconds. The slope of a line is rise/run, or 16/4 = 4 m/s. The slope represents the change in position over time, which is the definition of speed.

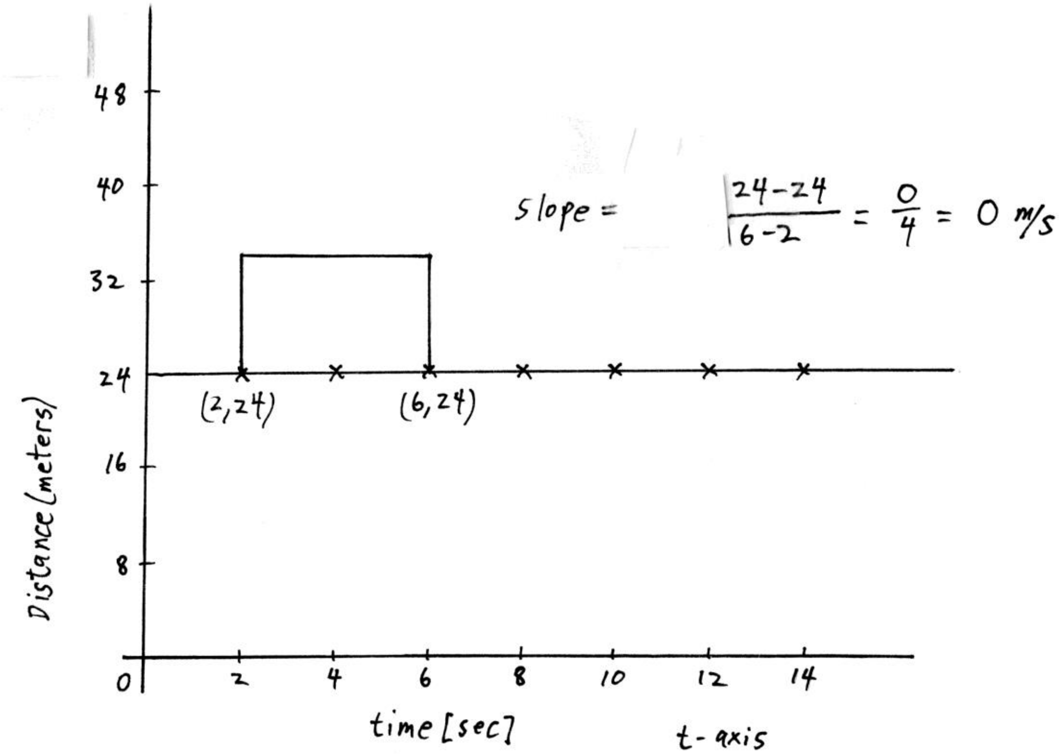
In a position – time graph, the slope of the line is the speed or velocity of the object.

Since the graph above is a straight line, the slope or velocity never changes. Also, since the line moves up from left to right, the object is moving in a positive direction.

Suppose we measure the distance of another car from a tree at two second intervals.

Time (seconds)	**0**	**2**	**4**	**6**	**8**	**10**
Distance (meters)	**24**	**24**	**24**	**24**	**24**	**24**

Plotting the points, we get the graph below.



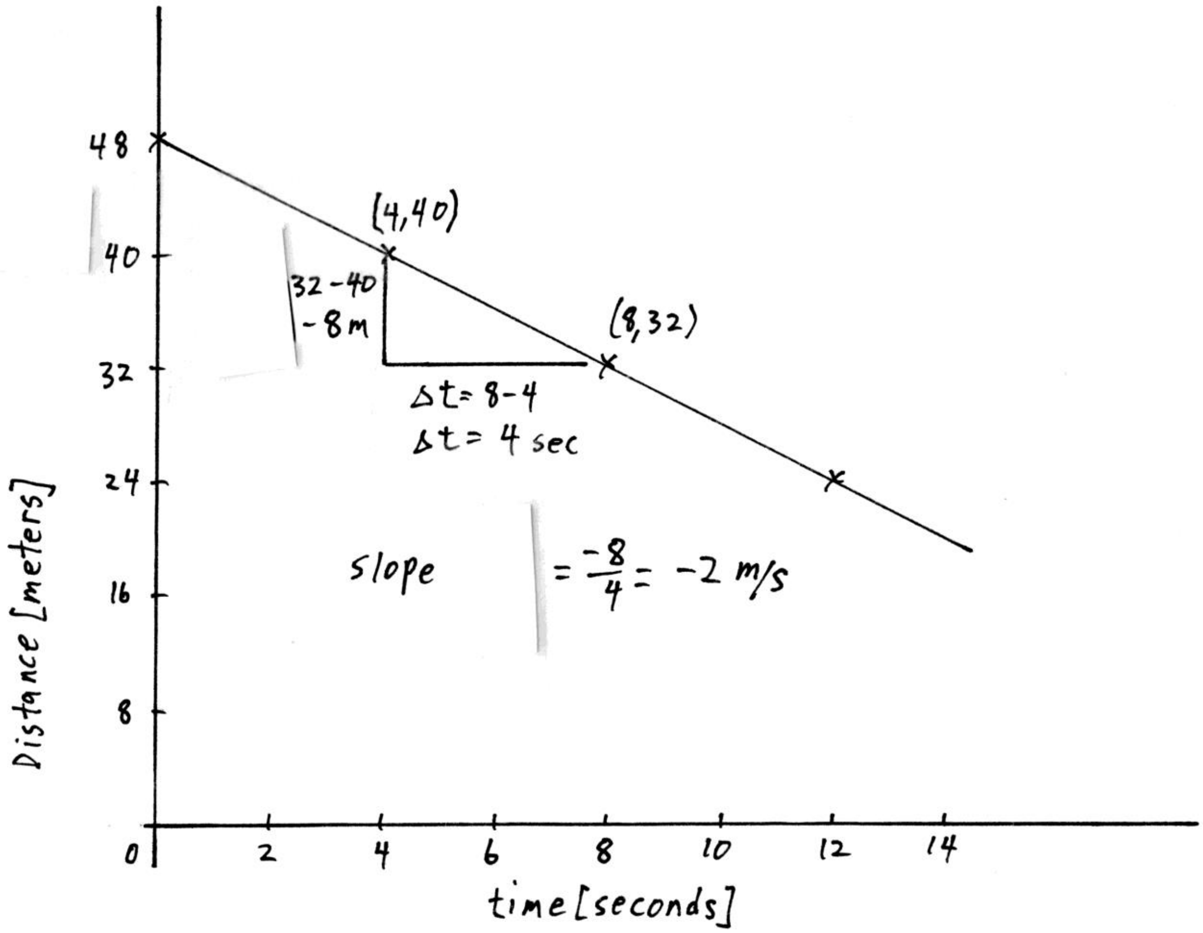
If we pick points (2,24) and (6,24), we compute the slope of the line as (24-24)/(6-2) = 0 m/s. This means that the object is not moving. Notice that when the slope of line is zero, you get a horizontal line.

In a position – time graph, a horizontal line means that the object is not moving.

Suppose we measure the position of another car from a tree at two second intervals.

Time (seconds)	**0**	**2**	**4**	**6**	**8**	**10**	**12**
Distance (meters)	**48**	**44**	**40**	**36**	**32**	**28**	**24**

Plotting the points, we get the graph below.



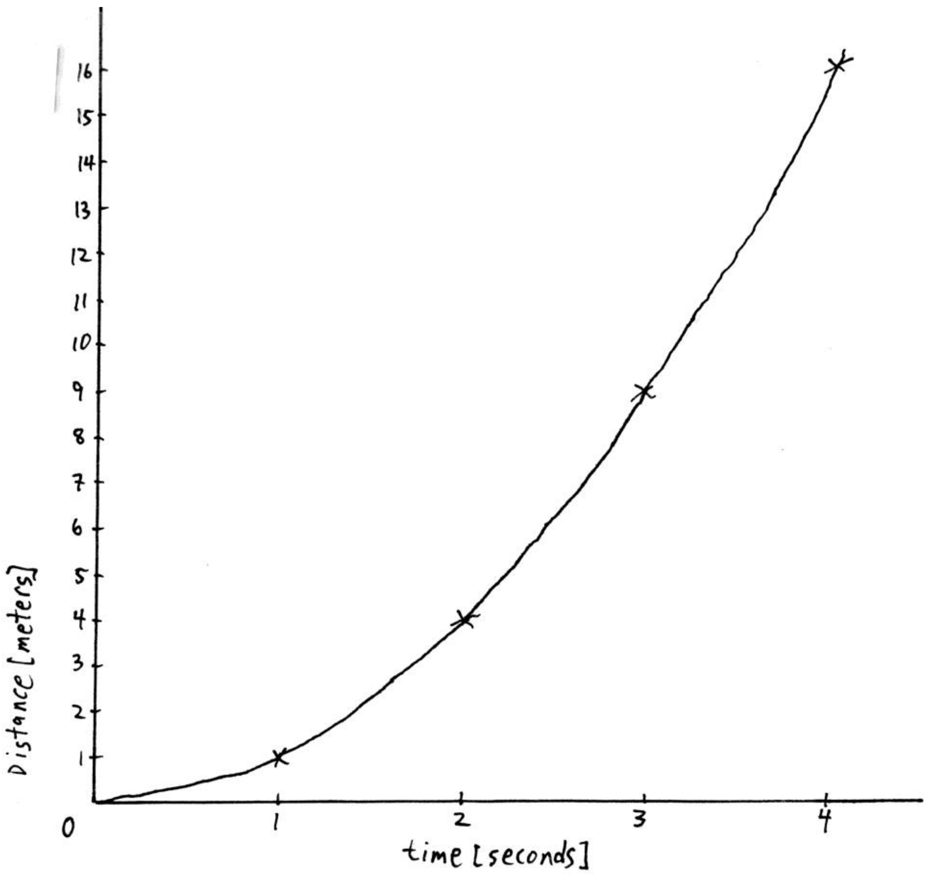
If we pick points (4,40) and (8,32), we compute the slope of the line as (32-40)/(8-4) = -2 m/s. Notice that the slope is negative, and that the line slants downward from left to right. This means that our object is moving at a constant speed in a negative direction. Since the motion of our object is horizontal, the negative sign means that the object is moving right to left, or to the west. If the object was moving vertically, a negative sign means the object is moving down or south.

In a position – time graph, a negative slope means the object is moving backward, or in a negative direction.

Let's measure the position of yet another car at one second intervals as it moves in a straight line away from a tree.

Time (seconds)	**0**	**1**	**2**	**3**	**4**
Distance (meters)	**0**	**1**	**4**	**9**	**16**

Plotting the points, we get the graph below.



Notice that the plot of this graph is a *curved* line, not a straight line. This shows that the object is moving faster and faster as each second passes. From 0 to 1 second, it covers a distance of 1-0 = 1 m. But from 1 to 2 seconds, it covers 4-1 = 3 m. It covers a greater distance in the second time interval, which shows that the velocity is increasing.

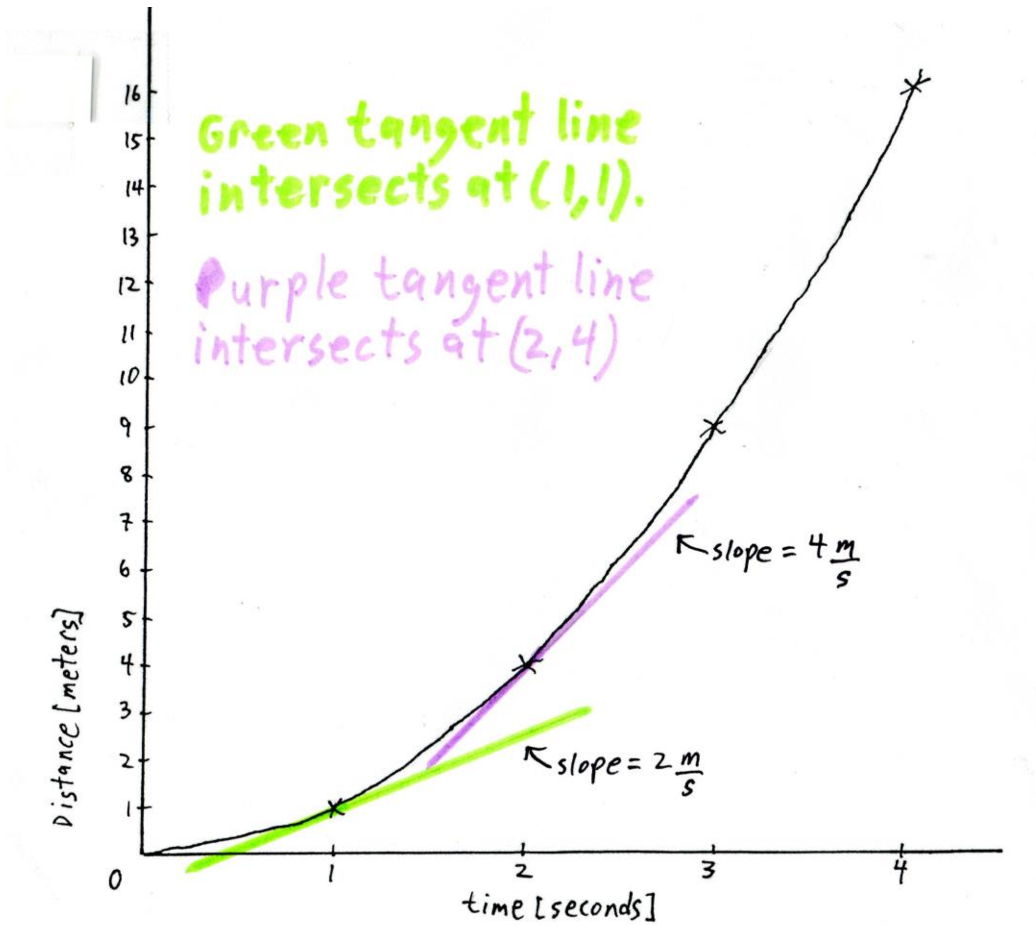
In a position – time graph, if the line curves upward, the object's velocity is increasing.

When the velocity of an object increases or changes, we say the object is accelerating.

If the velocity of the car is constantly increasing, how can we determine the velocity at a particular point in time? One way to do it is to sit in the car and take a picture of the speedometer at one second time intervals. The exact moment you snap the picture would give you the *instantaneous velocity* of the object at that particular point in time.

A safer way to get the instantaneous velocity is to draw a *tangent line* through a point on the graph. A tangent line intersects only one point on the line.

To illustrate, suppose we wanted to know the slope or velocity of the car at 1 second and at 2 seconds. We would draw a tangent line through points (1,1) and another tangent line through point (2,4). In the picture below, the green tangent line intersects the curve only at (1,1), and the purple tangent line intersects the curve only at (2,4).



If you measured the slope of the green line, it would 2. Thus, the instantaneous velocity of the car after 1 second had elapsed would be 2 m/s. If you measured the slope of the purple line, it would be 4. Thus, the instantaneous velocity of the car after 2 seconds is 4 m/s.

The instantaneous velocity of an object is its velocity at an exact moment in time.

In a position – time graph, the slope of a line drawn tangent to a point on the curve gives the instantaneous velocity at that point.

This is how you would find the instantaneous velocity by drawing tangent lines. Later on I'll show you how to calculate the instantaneous velocity using a formula.