Kinematics
Motion in 1-Dimension
Graphing Kinematic Quantities

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Jan 15, 2020

Last time

- 1-D kinematics
- quantities of motion
- graphing position against time

Overview

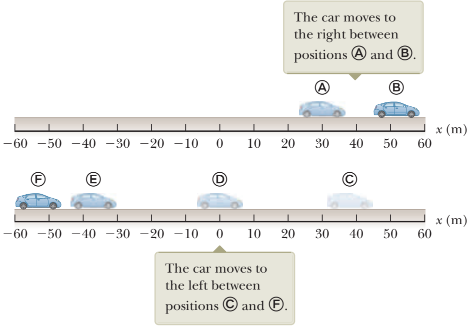
- graphing velocity and acceleration against time
- more about graphs of kinematic quantities vs time

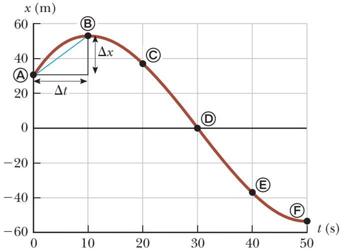
Graphing Kinematic Quantities

One very convenient way of representing motion is with graphs that show the variation of these kinematic quantities with time.

Time is written along the horizontal axis – we are representing time passing with a direction in space (the horizontal direction).

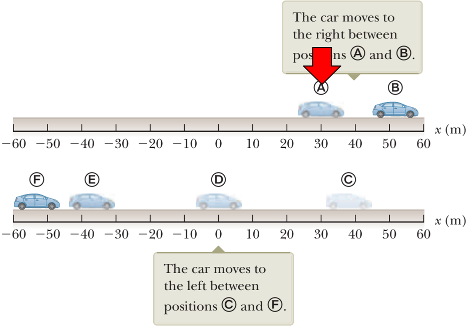
Position vs Time Graphs

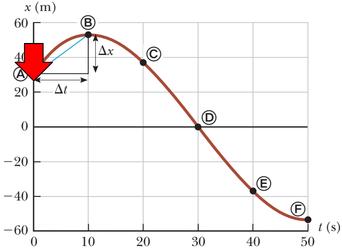




[1] Figures from Serway & Jewett

Position vs Time Graphs





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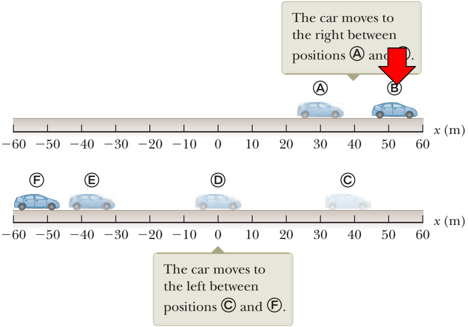

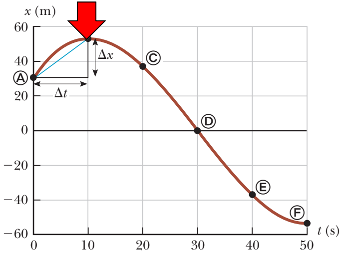

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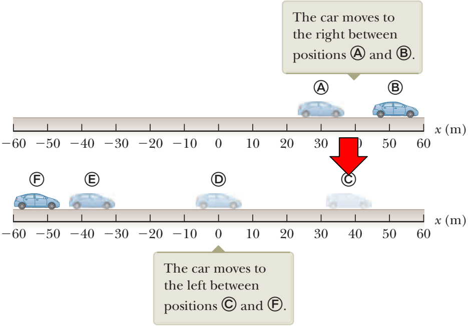

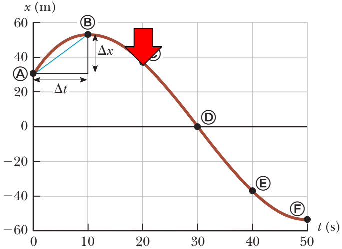

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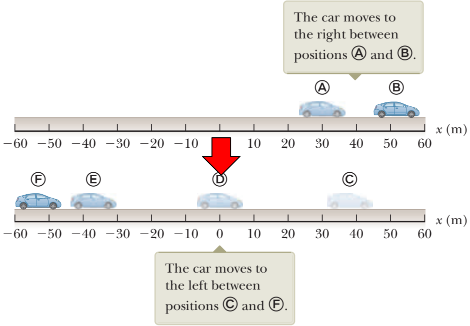
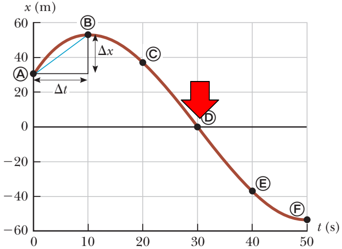
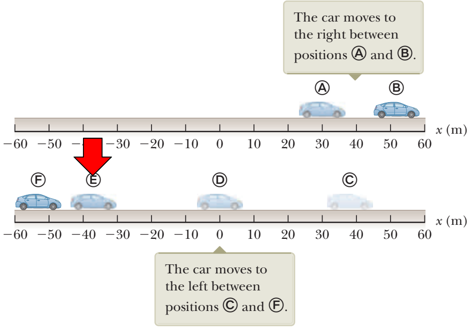
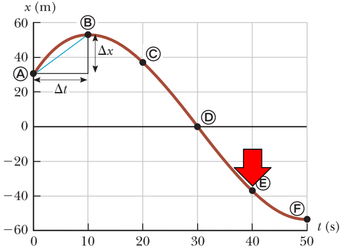




Figures from Serway & Jewett[1]

Position vs Time Graphs





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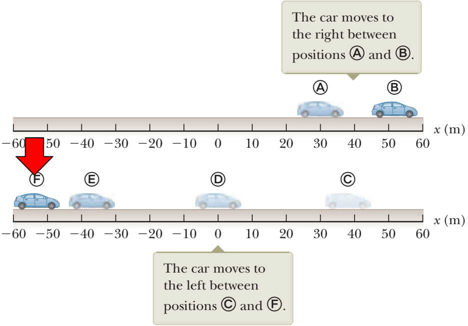

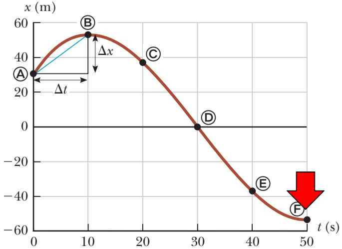

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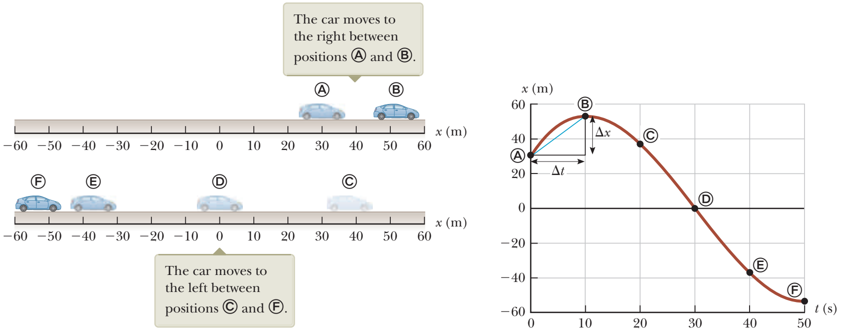
Position vs Time Graphs

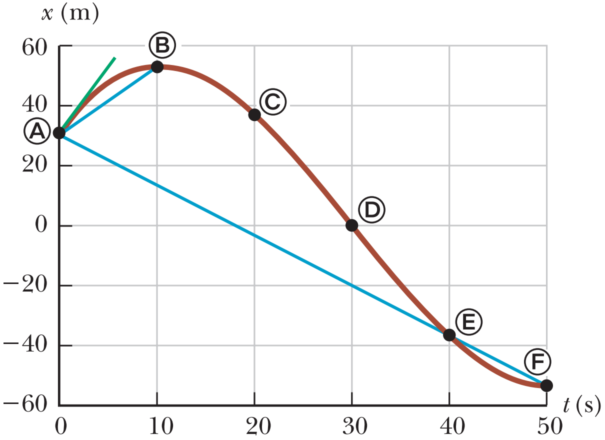


The average velocity in the interval A→B is the slope of the blue line connecting the points A and B. $\overrightarrow{\mathbf{v}_{\text{avg}}} = \frac{\overrightarrow{\Delta x}}{\Delta t}$

[1]Figures from Serway & Jewett

Average Velocity in Position vs Time Graphs

A→B: $\overrightarrow{\mathbf{v}_{\text{avg}}} = \frac{\overrightarrow{\Delta x}}{\Delta t} = 2 \text{ m/s } \hat{\mathbf{i}}$

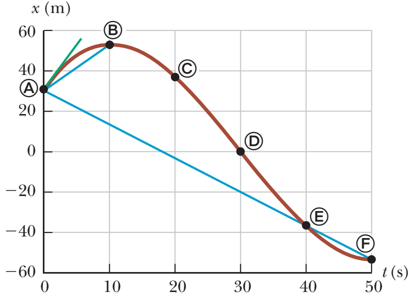


A→F: $\overrightarrow{\mathbf{v}_{\text{avg}}} = \frac{\overrightarrow{\Delta x}}{\Delta t} = -1.8 \text{ m/s } \hat{\mathbf{i}}$

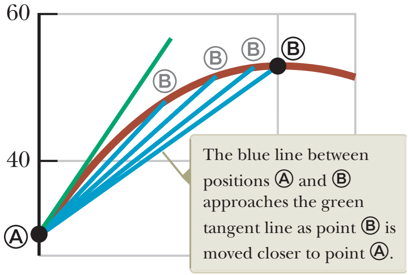
Velocity in Position vs Time Graphs

The (instantaneous) velocity is the **rate of change of displacement** ⇒ the **slope** of a velocity-time graph.

Pos.-time graph for car



zoomed in



The green line is the tangent line, gives the slope of the curve at $t = 0$.

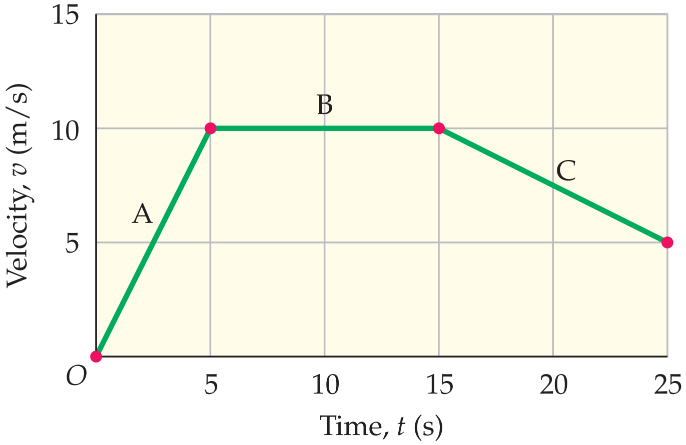
$$\vec{\mathbf{v}} = \lim_{\Delta t \to 0} \frac{\overrightarrow{\Delta \boldsymbol{x}}}{\Delta t}$$

Velocity vs Time Graphs

We can plot the *slope* of a position-time curve against time as well.

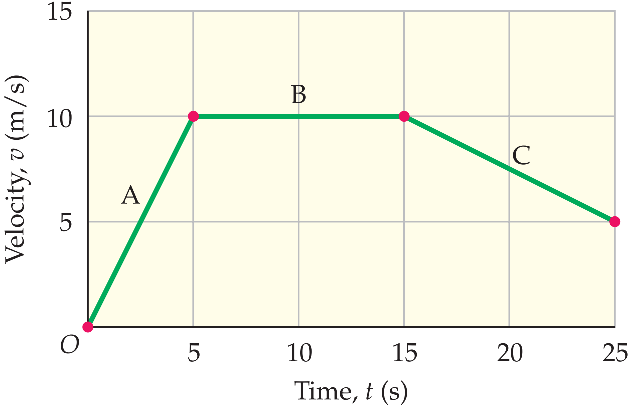
This is plotting the **velocity** of an object at each point in time.

Velocity vs Time Graphs



Velocity vs Time Graphs

The area under a velocity-time graph has a special interpretation: it is the **displacement** of the object over the time interval considered.



$$\overrightarrow{\Delta x} = ?$$

Velocity vs Time Graphs

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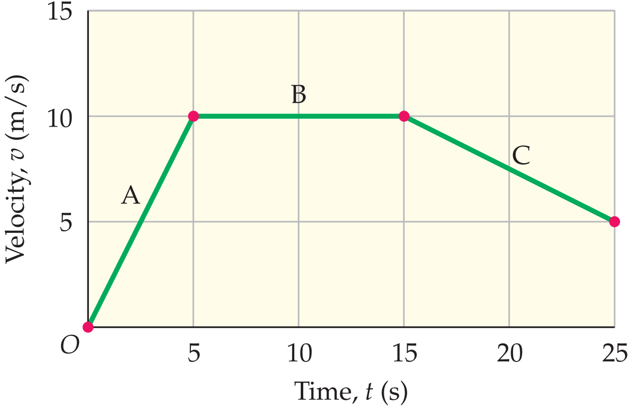
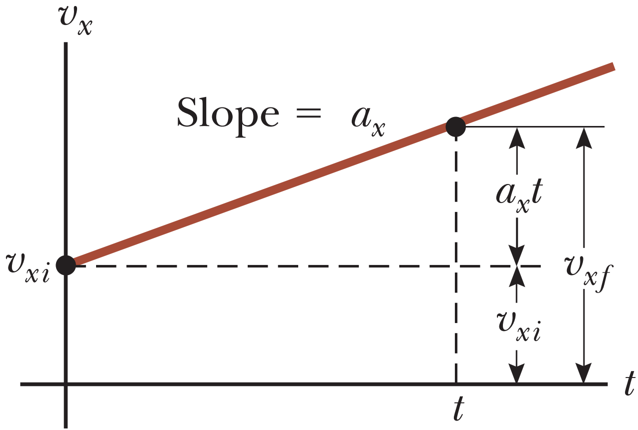
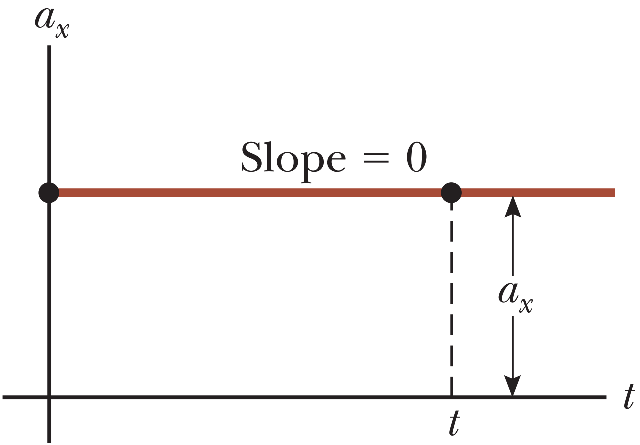


$$\overrightarrow{\Delta x} = (\underbrace{25 \text{ m}}_{A} + \underbrace{100 \text{ m}}_{B} + \underbrace{75 \text{ m}}_{C})\hat{\mathbf{i}} = 200 \text{ m } \hat{\mathbf{i}}$$

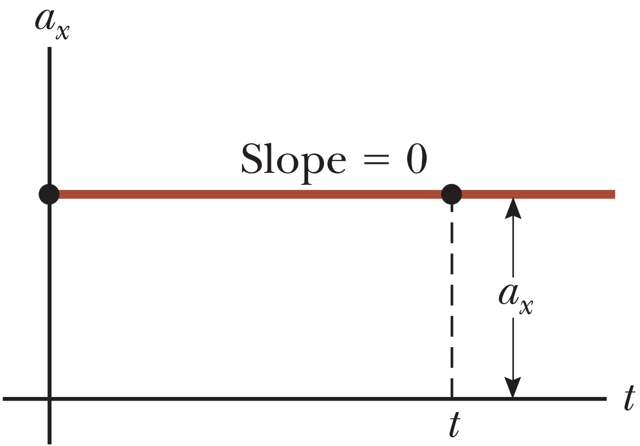
Acceleration in Velocity vs Time Graphs



Acceleration vs Time Graphs



Acceleration vs Time Graphs



The area under an acceleration-time graph is the **change in velocity** over that time interval.

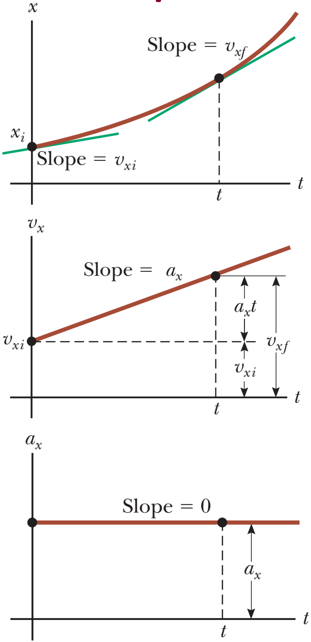
Relating Position, Velocity, Acceleration graphs

For a single moving object, the graphs of its position, velocity, and acceleration are not independent!

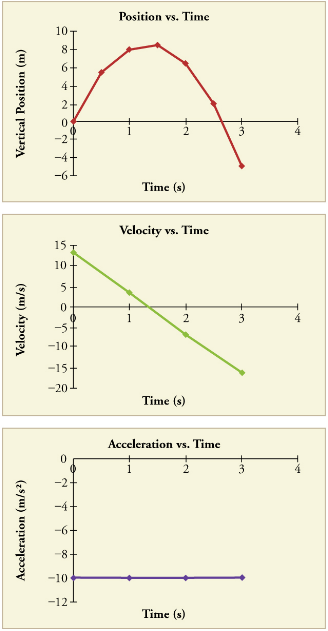
The slope of the position-time graph is the velocity.

The slope of the velocity-time graph is the acceleration.

Constant Acceleration Graphs



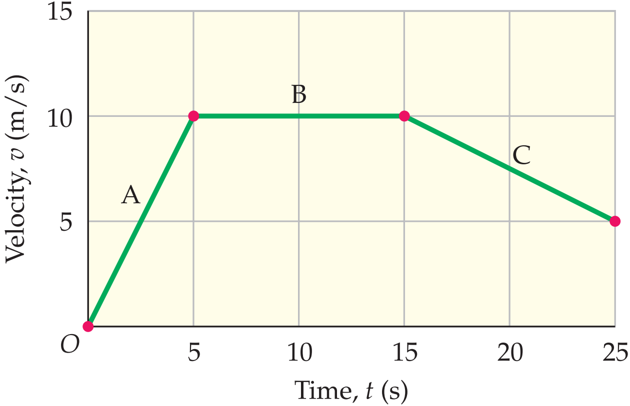
Falling Objects



[1] OpenStax Physics

Relating Graphs

What would the position-time graph be for this motion, assuming $x(t=0)=0$? What would the acceleration-time graph be?



$$\overrightarrow{\Delta \boldsymbol{x}} = (25 \text{ m} + 100 \text{ m} + 75 \text{ m})\hat{\mathbf{i}} = 200 \text{ m } \hat{\mathbf{i}}$$

Summary

- graphing kinematic quantities

Homework Walker Physics:

- Ch 1, onward from page 14. Probs: 53, 55 (reading a graph)
- Ch 2, onward from page 47. Probs: 21, 23