Mechanics
Kinematics in 1 Dimension

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De Anza College

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Last time

- units
- dimensional analysis
- unit conversions
- scientific notation

Overview

- scalars and vectors
- kinematic quantites
- interpreting graphs of kinematic quantities

Unit Conversion Examples

It may be necessary to change units several times to get to the unit you need.

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$$= \frac{60.0 \times 1.609 \times 1000}{60 \times 60}\ \text{m/s}$$

$$= 26.8\ \text{m/s}$$

Kinematics in 1-dimension

We begin by studying motion along a single line.

This will encompass situations like

- cars traveling along straight roads
- objects falling straight down under gravity

Vectors and Scalars

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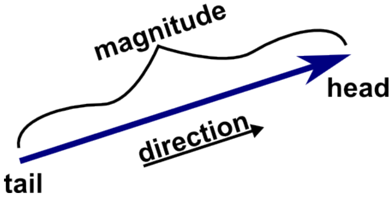
vector

A vector quantity indicates both an amount (magnitude) and a direction. It is represented by a real number for each possible direction, or a real number and (an) angle(s).



Notation for Vectors

In the lecture notes vector variables are represented using **bold** variables.

Example:

k is a scalar

$\mathbf{x}$ is a vector

In the textbook and in writing, vectors are often represented with an over-arrow: $\vec{\mathbf{x}}$

The magnitude of a vector, $\mathbf{x}$ is written:

$$|\mathbf{x}| = x$$

Examples of Scalars and Vectors

Some physical quantities that are **scalars** are

- temperature
- mass
- pressure

Some physical quantities that are **vectors** are

- velocity
- force

Distance vs Displacement

How far are two points from one another?

Distance is the length of a path that connects the two points.

Displacement is the length together with the direction of a straight line that connects the starting position to the final position.

Displacement is a vector.

Position

Quantities

position	$\mathbf{x}$
displacement	$\Delta x = \mathbf{x}_f - \mathbf{x}_i$
distance	d

Position and displacement are *vector* quantities.

Position and displacement can be positive or negative numbers.

Distance is a *scalar*. It is always a positive number.

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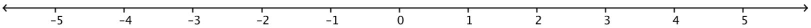

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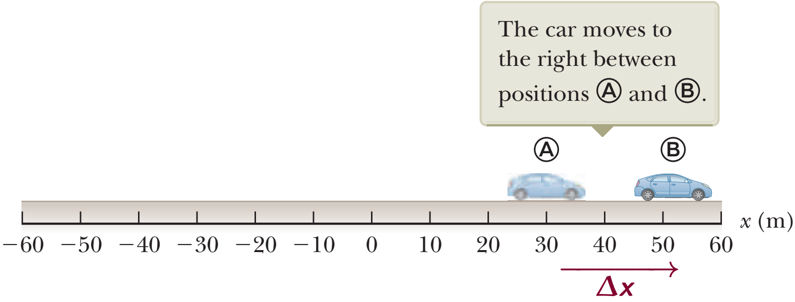
SI units: meters, m

Position, Displacement, Distance Example

The starting position of the car is $\mathbf{x}_i = 30$ m $\mathbf{i}$, the final position is $\mathbf{x}_f = 50$ m $\mathbf{i}$.

The distance the car travels is $d = 50 \text{ m} - 30 \text{ m} = 20$ m.



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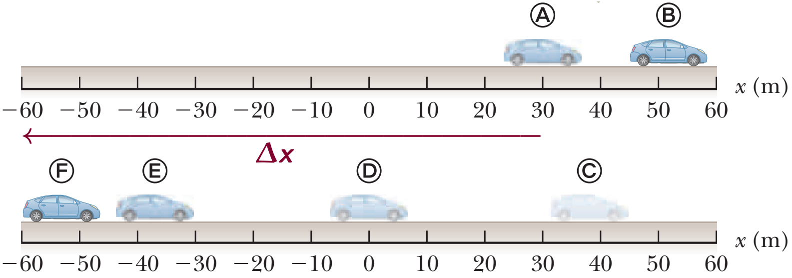
Position, Displacement, Distance Example

The starting position of the car is $\mathbf{x}_i = 30$ m $\mathbf{i}$, the final position is $\mathbf{x}_f = -60$ m $\mathbf{i}$.

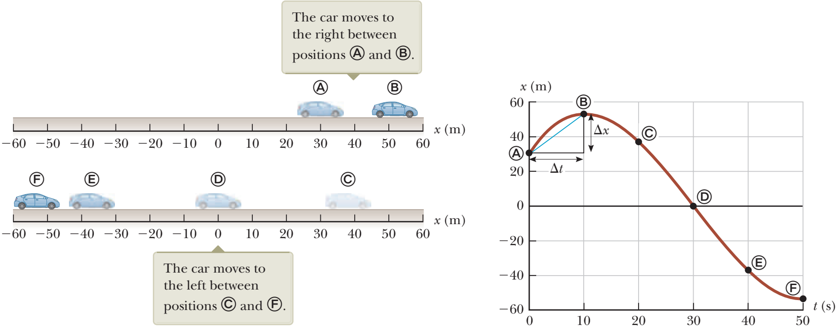
The distance the car travels is $d = 130$ m.



The displacement of the car is

$$
\begin{aligned}
\Delta \mathbf{x} &= \mathbf{x}_f - \mathbf{x}_i \\
&= (-60\mathbf{i}) - 30\mathbf{i} \text{ m} \\
&= -90 \text{ m } \mathbf{i}
\end{aligned}
$$

Position vs. Time Graphs



[1] Figures from Serway & Jewett

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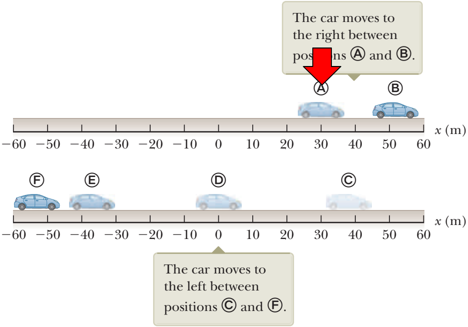

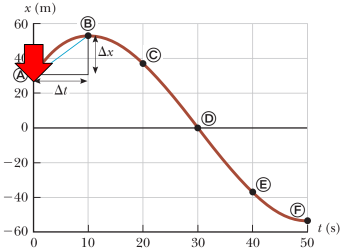

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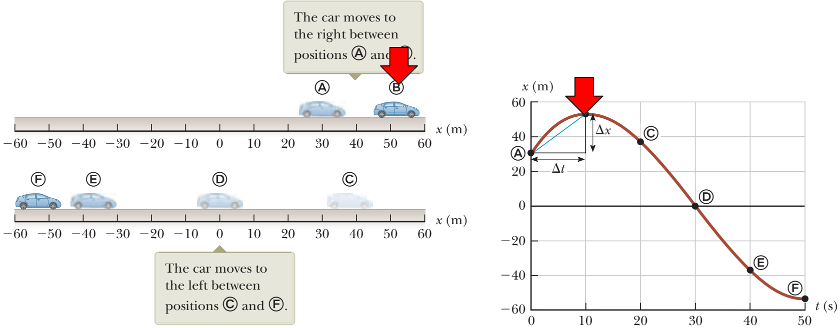

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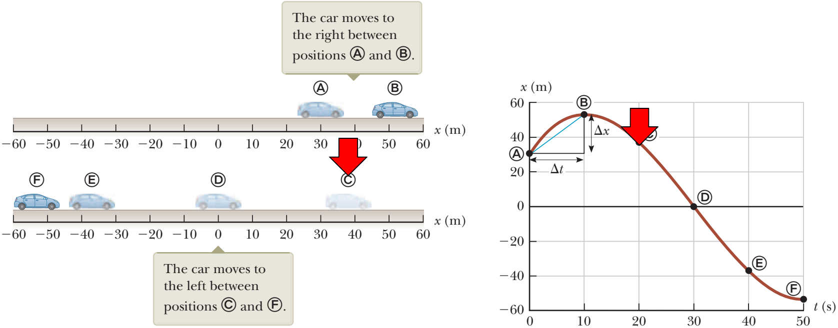

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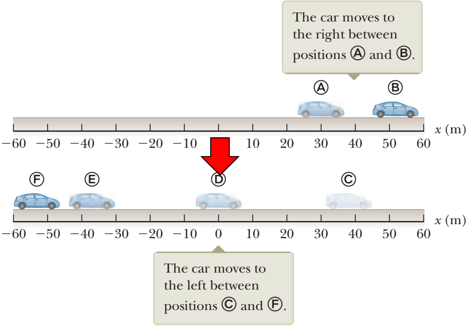

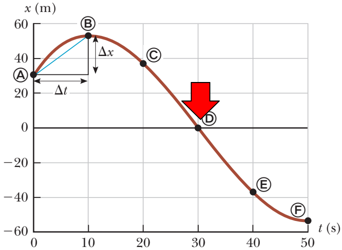

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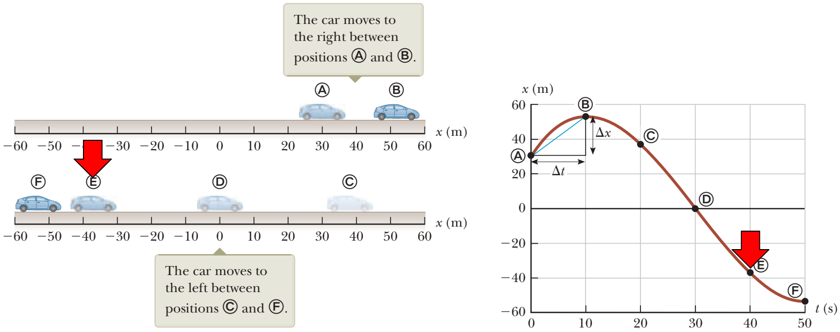

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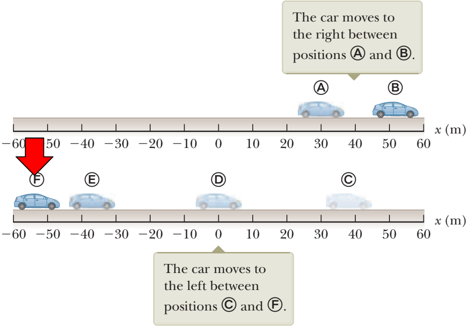

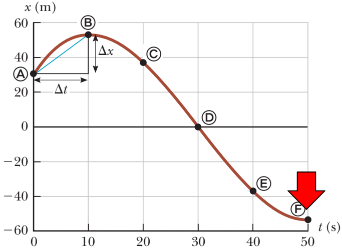

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Quantities

How position changes with time.

(instantaneous) velocity	$\mathbf{v} = \frac{\mathrm{d}\mathbf{x}}{\mathrm{dt}}$	speed and direction
average velocity	$\mathbf{v}_{\mathbf{avg}} = \frac{\boldsymbol{\Delta x}}{\Delta t}$	
instantaneous speed	v or $\lvert\mathbf{v}\rvert$	"speedometer speed"
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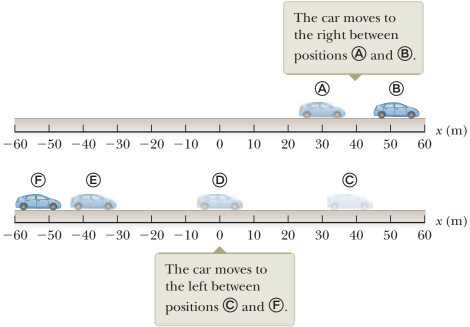
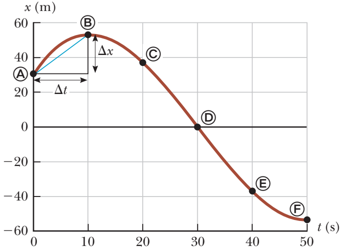
Can speed be negative?

Does average speed always equal average velocity?

Position vs. Time Graph (Revisited)





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

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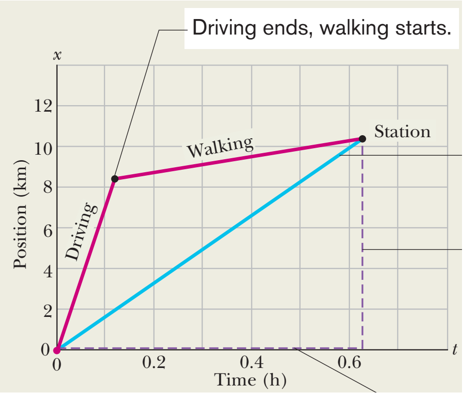
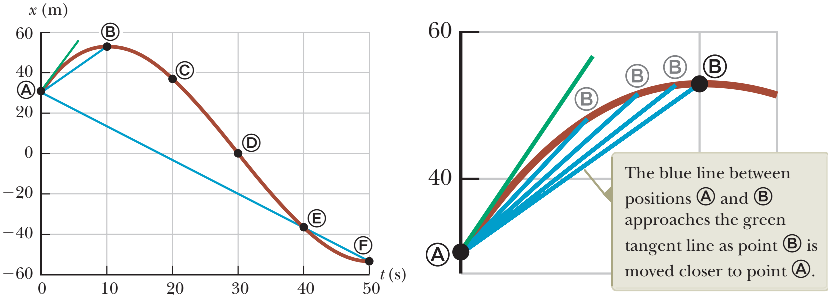
Average Velocity, Sample Problem 2.01

You drive a beat-up pickup truck along a straight road for 8.4 km at 70 km/h, at which point the truck runs out of gasoline and stops. Over the next 30 min, you walk another 2.0 km farther along the road to a gas station.



[1] Halliday, Resnick, Walker, 10th ed, page 17.

Instantaneous Velocity and Position-Time Graphs



$$\mathbf{v} = \lim_{\Delta t \to 0} \frac{\mathbf{x}(t+\Delta t) - \mathbf{x}(t)}{t + \Delta t - t} = \lim_{\Delta t \to 0} \frac{\Delta \mathbf{x}}{\Delta t} = \frac{d\mathbf{x}}{dt}$$

Summary

- kinematic quantities
- interpreting graphs of kinematic quantities

Quiz Start of class tomorrow (Thursday, Sept 27).

Homework

- Ch 2 Questions: 3; Problems: 1, 3, 7, 13
- Graphs: look at and understand figure 2-6, page 19.