Introduction to Mechanics
Kinematic Quantities

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Last time

- order of magnitude exercise
- introducing 1-D kinematics
- quantities of motion
    - position, displacement, and distance

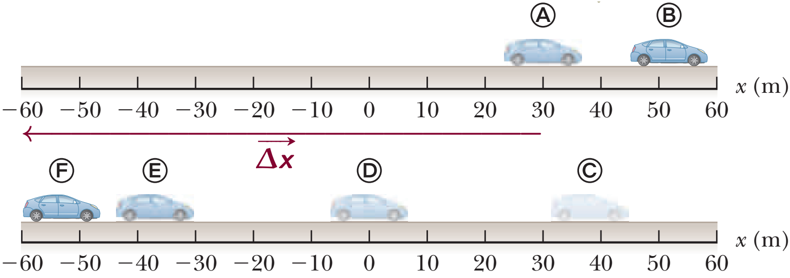
Overview

- quantities of motion
  - speed and velocity
  - acceleration

Example from yesterday

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

The distance the car travels is $d = \boxed{130\text{ m}}$.



The displacement of the car is

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

Speed

We need a measure how fast objects move.

$$\text{speed} = \frac{\text{distance}}{\text{time}}$$

If an object goes 100 m in 1 second, its speed is 100 m/s.

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Speed can change with time.

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Average speed is the average of the object's speed over a period of time:

$$\text{average speed} = \frac{\text{total distance traveled}}{\text{time interval}}$$

Velocity

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Is its velocity constant?

Velocity

How position changes with time.

Quantities

velocity	$\vec{\mathbf{v}}$ $\left(= \frac{\mathrm{d}\,\vec{\mathbf{x}}}{\mathrm{dt}}\right)$
average velocity	$\overrightarrow{\mathbf{v_{avg}}} = \frac{\overrightarrow{\Delta x}}{\Delta t}$
instantaneous speed	v or $\lvert\vec{\mathbf{v}}\rvert$
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Can speed be negative?

Units: meters per second, m/s

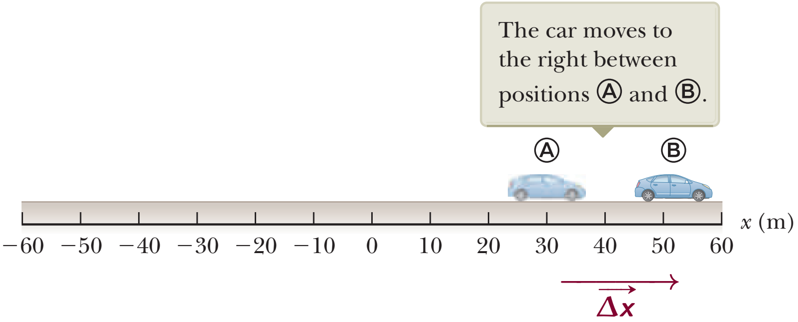
Average Velocity vs Average Speed Example

The displacement of the car is $\overrightarrow{\Delta x} = 20 \text{ m } \hat{\mathbf{i}}$.

The distance the car travels is $d = 20$ m.

The time for the car to move this far is **10 seconds**.

What is the average velocity of the car? What is the average speed of the car?



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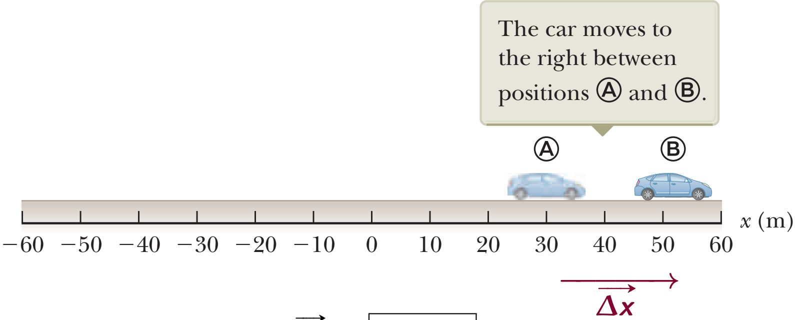

average velocity $\vec{\mathbf{v}}_{avg} = \dfrac{\overrightarrow{\Delta x}}{\Delta t} = \boxed{2 \text{ m/s } \hat{\mathbf{i}}}$

average speed $= \dfrac{d}{\Delta t} = \boxed{2 \text{ m/s}}$ (same magnitude in this case)

Average Velocity vs Average Speed Example

The displacement of the car is -90 m $\hat{\mathbf{i}}$.

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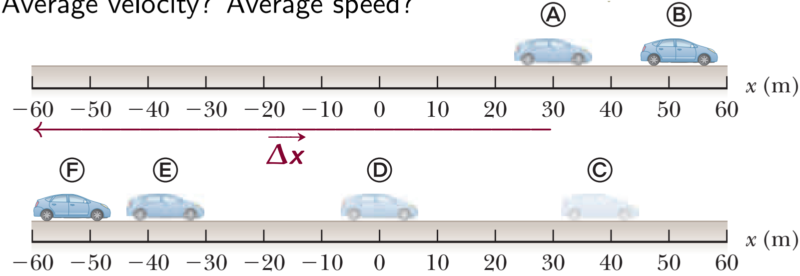
The time for the car to move A→F is **50 seconds**.

Average velocity? Average speed?



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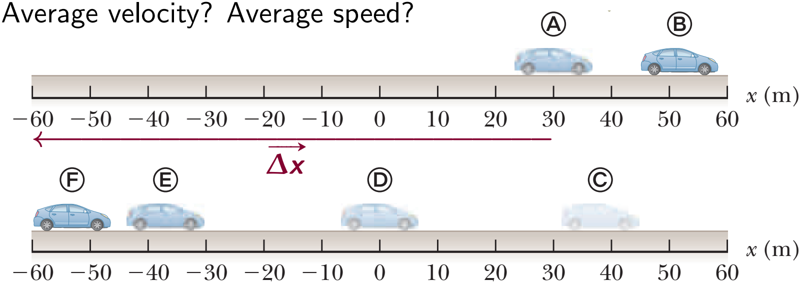

average velocity $\vec{\mathbf{v}}_{\text{avg}} = \frac{\overrightarrow{\Delta x}}{\Delta t} = \boxed{-1.8 \text{ m/s } \hat{\mathbf{i}}}$

average speed $= \frac{d}{\Delta t} = \boxed{2.6 \text{ m/s}}$ **Not the same!**

Question

Quick Quiz 2.1[1] Under which of the following conditions is the magnitude of the average velocity of a particle moving in one dimension smaller than the average speed over some time interval?

A A particle moves in the $+x$ direction without reversing.

B A particle moves in the $-x$ direction without reversing.

C A particle moves in the $+x$ direction and then reverses the direction of its motion.

D There are no conditions for which this is true.

[1] Serway & Jewett, page 24.

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Conceptual Question

1. If the average velocity of an object is zero in some time interval, what can you say about the displacement of the object for that interval?

[1] Serway & Jewett, page 50.

Acceleration

Speed and velocity can change with time.

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If an object is moving with constant speed in a circular path, is it accelerating?

Acceleration

Quantities

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average acceleration	$\overrightarrow{\mathbf{a}_{\mathbf{avg}}} = \frac{\overrightarrow{\Delta \boldsymbol{v}}}{\Delta t}$

Acceleration is also a vector quantity.

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If the acceleration vector is pointed in the **same** direction as the velocity vector (*ie.* both are positive or both negative), the particle's **speed is increasing**.

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If the acceleration vector is pointed in the **opposite** direction as the velocity vector (*ie.* one is positive the other is negative), the particle's **speed is decreasing**. (It is "decelerating".)

Summary

- introducing kinematics
- quantities of motion

Homework Walker Physics:

- Ch 2, onward from page 47. Conc. Ques: 1, 3, 9; Probs: 1, 3, 5, 7, 9, 13
- Ch 2, onward from page 47. Conc. Ques: 13; Probs: 35, 41