Physics 121:
Velocity and Acceleration

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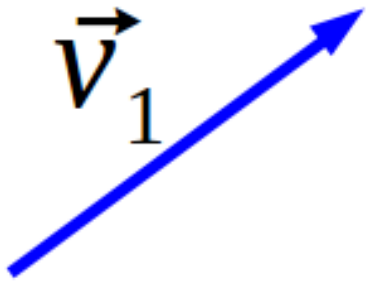
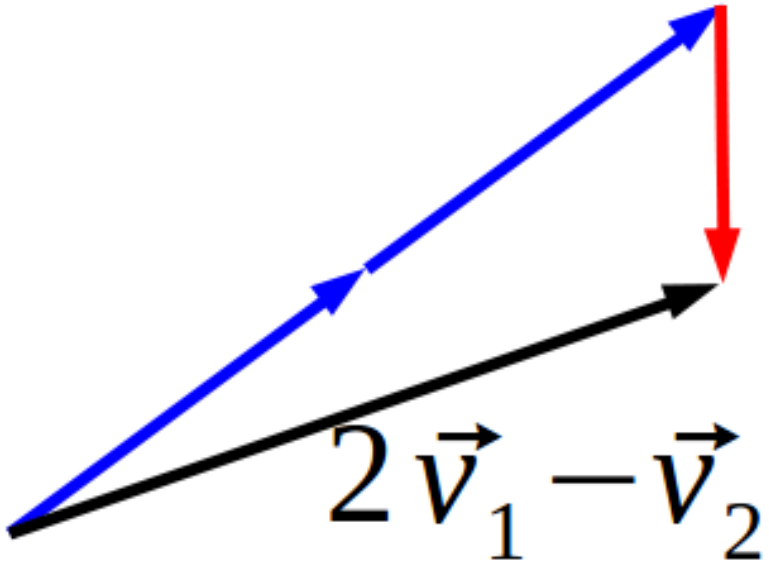
Mesa Community College

Quiz

Take vectors $\vec{v}_1$ and $\vec{v}_2$ and draw the vector $2\vec{v}_1 - \vec{v}_2$.



Quiz



Velocity

- You all know the story of the tortoise and the hare right?

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- Which one ran the fastest? In other words which one had the highest speed?

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  - The hare
- Which one had the highest average speed?
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Velocity

$$\text{average speed} = \frac{\text{distance traveled}}{\text{time interval spent traveling}} = \frac{d}{\Delta t}$$

- Group question race...

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- Group question race...
- If you drive 10 miles in 15 minutes what is your average speed in mph?

$$\text{average speed} = \frac{10 \text{ mi}}{1/4 \text{ hr}} = 40 \text{ mph}$$

Velocity

- What is the difference between speed and velocity?

Velocity

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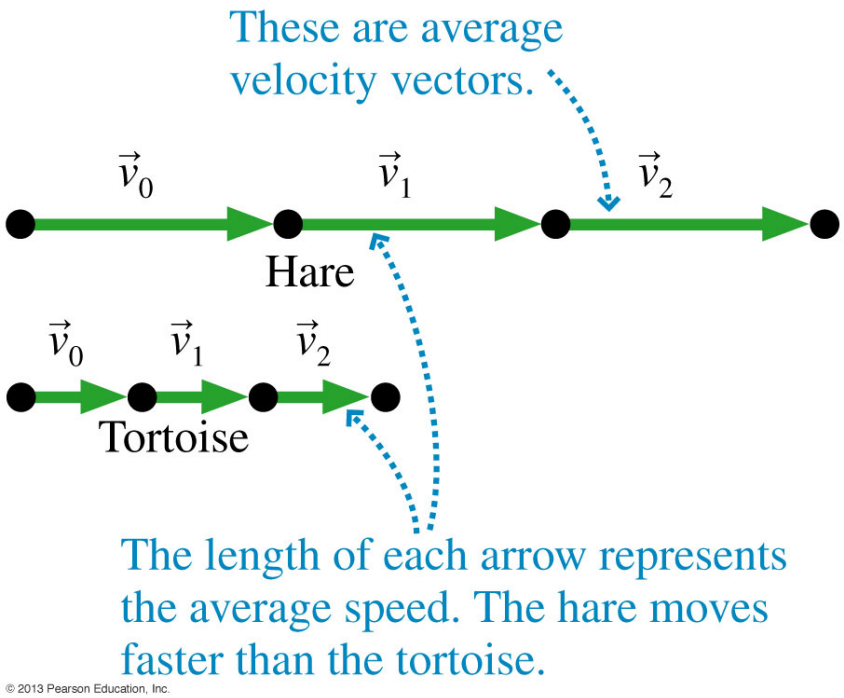
$$\vec{v}_{ave} = \frac{\Delta \vec{r}}{\Delta t} \tag{1}$$

- Notice that $\vec{v}_{ave}$ points in the same direction as $\vec{\Delta r}$, the direction of motion.

Velocity


These are average velocity vectors.
$\vec{v}_0$
$\vec{v}_1$
$\vec{v}_2$
Hare
$\vec{v}_0$
$\vec{v}_1$
$\vec{v}_2$
Tortoise
The length of each arrow represents the average speed. The hare moves faster than the tortoise.
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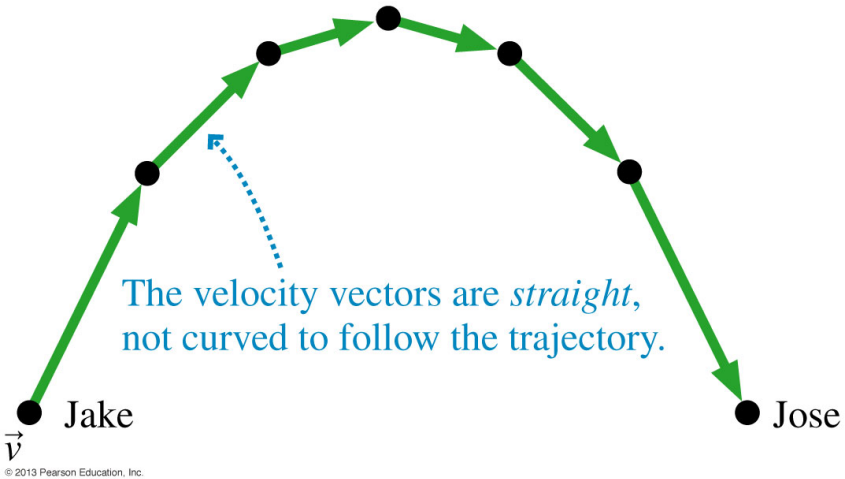
The velocity vectors are *straight*, not curved to follow the trajectory.
Jake
Jose
$\vec{v}$
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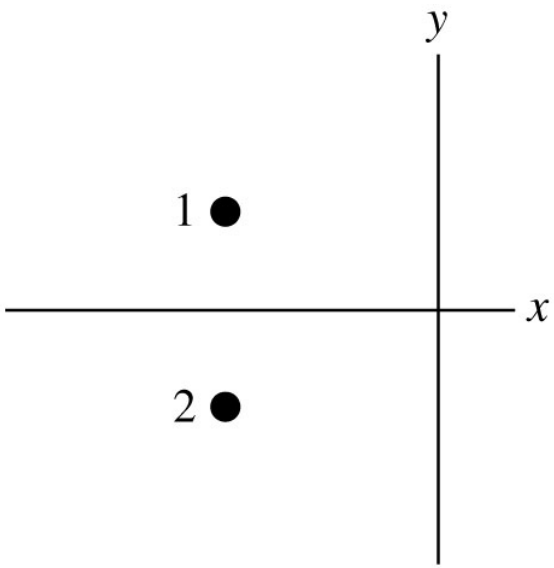
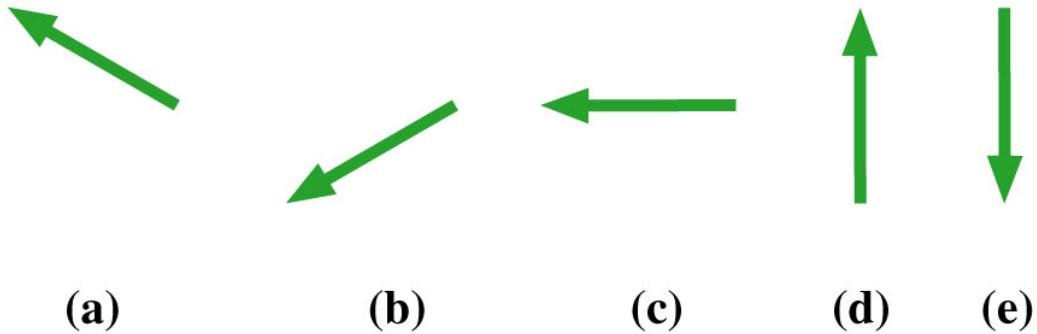
Quick Check

A particle moves from position 1 to position 2 during the interval Δt. Which vector shows the particle's average velocity?





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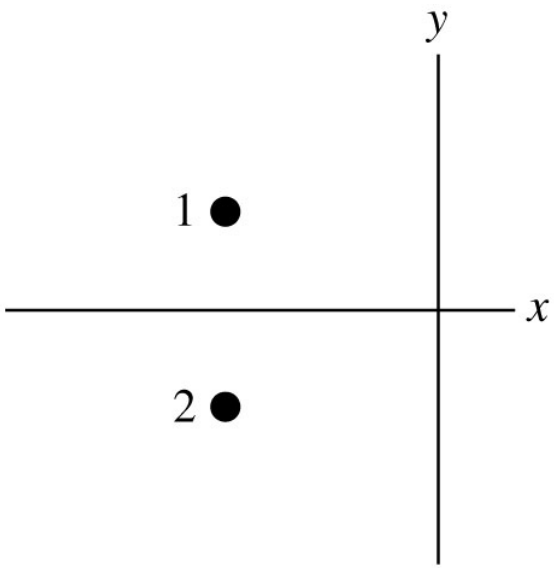
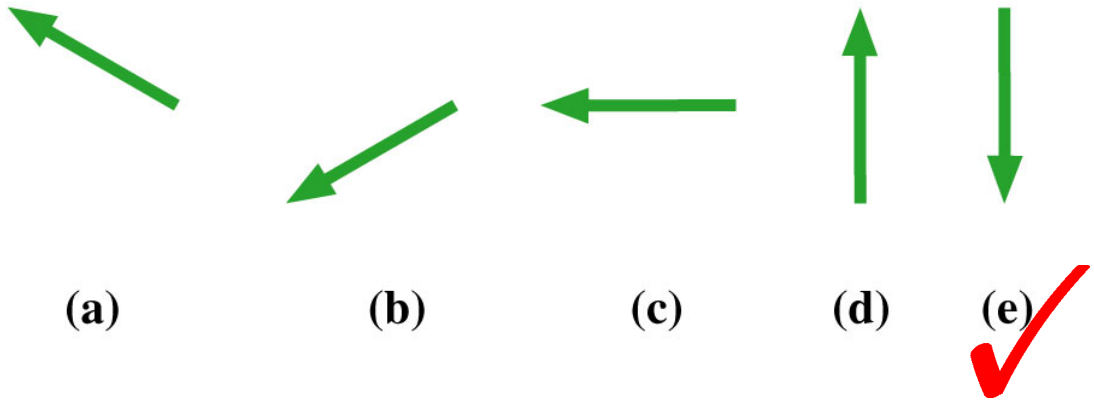
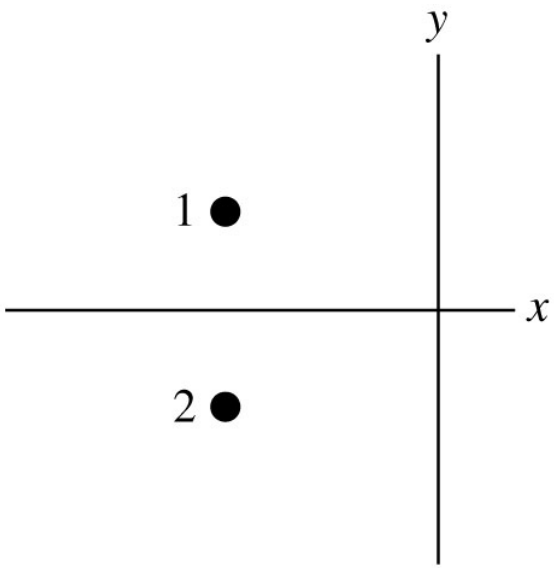
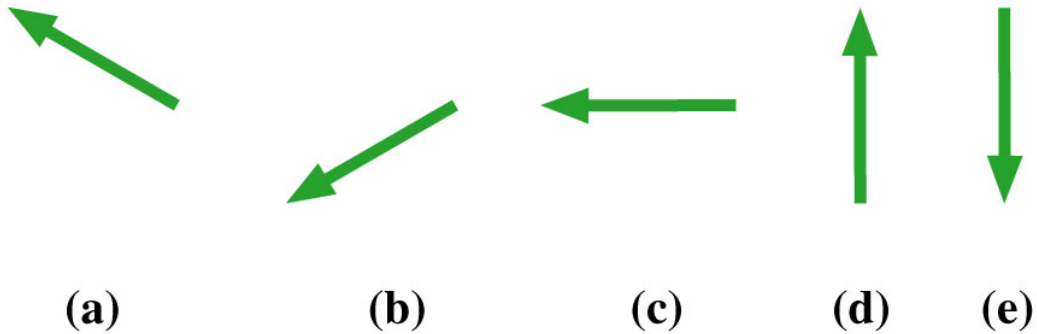




Quick Check

What if it follows some specific path (draw path on the board)?
Which vector shows the particle's average velocity?





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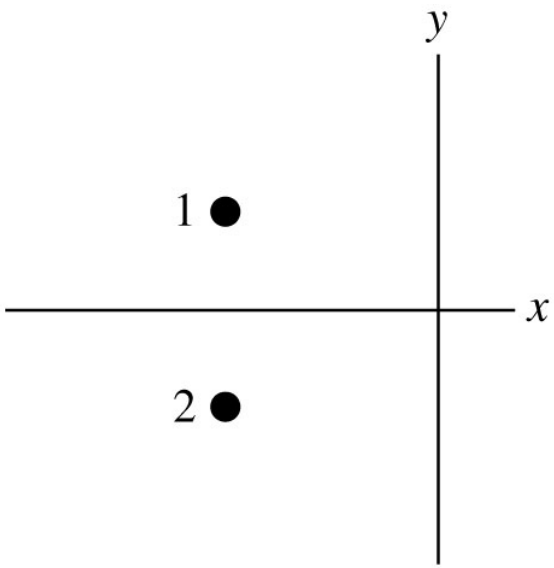

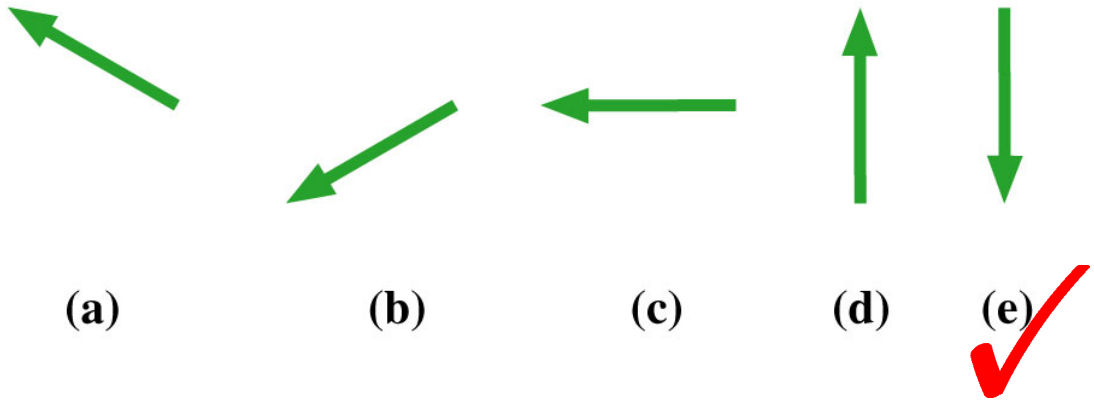

Linear Acceleration

- We defined velocity as the ratio $\Delta\vec{r}/\Delta t$, the rate of change of the position. To fully describe motion we also need the rate of change of velocity. We call this average acceleration.

$$\vec{a}_{ave} = \frac{\Delta\vec{v}}{\Delta t} \tag{2}$$

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- Acceleration is a little more abstract than velocity so here's an example from every day life.
  - Does anybody know how fast their vehicle can accelerate from 0 to 60 mph? My 2002 4 cylinder Ford Ranger can probably do it in about an hour... (only slightly exagerating). What then is the average acceleration of my truck in mi/hr^2?

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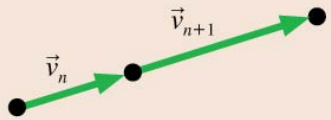
$$\vec{a}_{ave} = \frac{60 - 0 \text{ mi/hr}}{1 \text{ hr}} = 60 \text{ mi/hr}^2$$

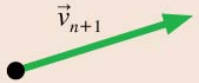
Linear Acceleration

TACTICS BOX 1.3 **Finding the acceleration vector**

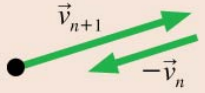
To find the acceleration as the velocity changes from $\vec{v}_n$ to $\vec{v}_{n+1}$, we must determine the *change* of velocity $\Delta\vec{v} = \vec{v}_{n+1} - \vec{v}_n$.



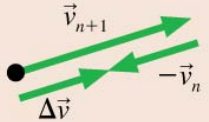
❶ Draw the velocity vector $\vec{v}_{n+1}$.



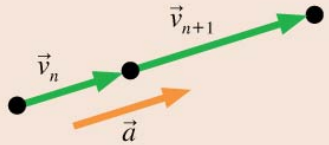
❷ Draw $-\vec{v}_n$ at the tip of $\vec{v}_{n+1}$.



❸ Draw $\Delta\vec{v} = \vec{v}_{n+1} - \vec{v}_n$
$= \vec{v}_{n+1} + (-\vec{v}_n)$
This is the direction of $\vec{a}$.



❹ Return to the original motion diagram. Draw a vector at the middle point in the direction of $\Delta\vec{v}$; label it $\vec{a}$. This is the average acceleration at the midpoint between $\vec{v}_n$ and $\vec{v}_{n+1}$.

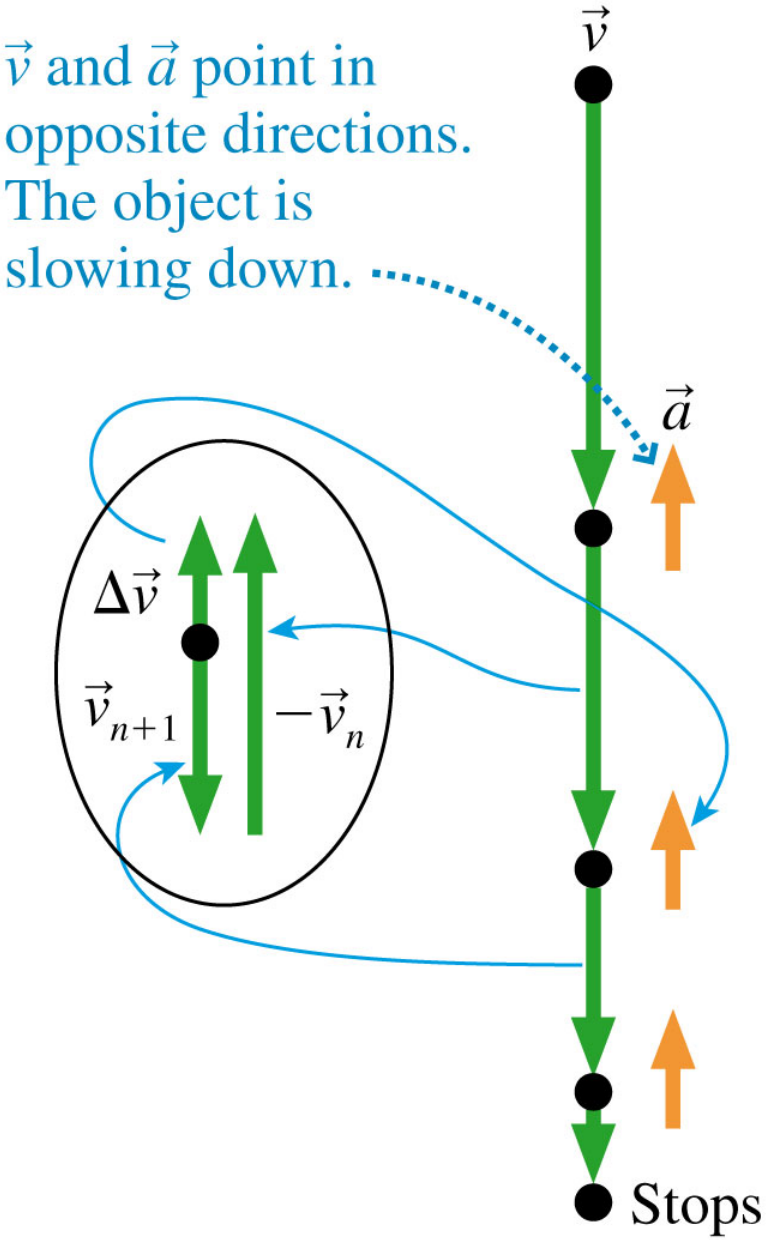


Exercises 21–24

Many Tactics Boxes will refer you to exercises in the *Student Workbook* where you can practice the new skill.

Note that the acceleration vector goes at the dot between the vectors, not under the vector.

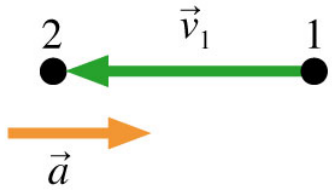
Linear Acceleration - Example

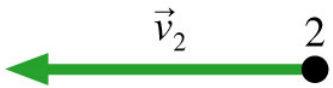


Motion diagram of a spaceship landing on Mars.

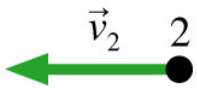
Quick Check

A particle undergoes acceleration $\vec{a}$ while moving from point 1 to point 2. Which of the choices shows the velocity vector $\vec{v}_2$ as the particle moves away from point 2?

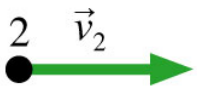




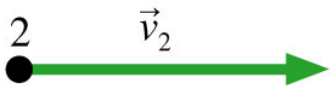
(a)



(b)



(c)



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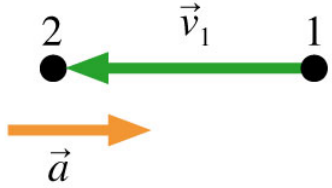
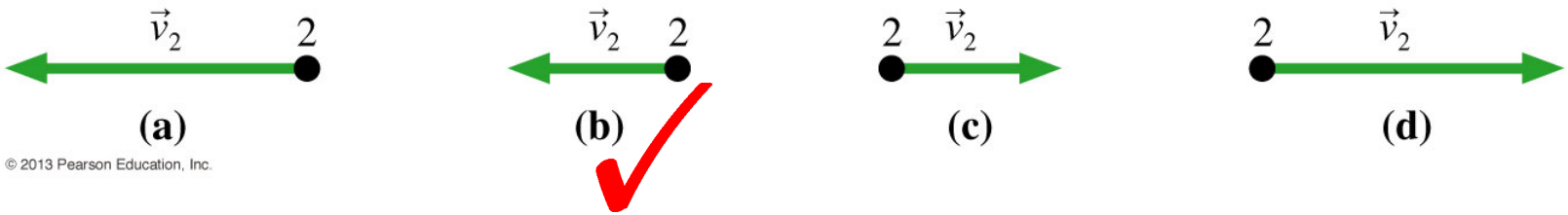
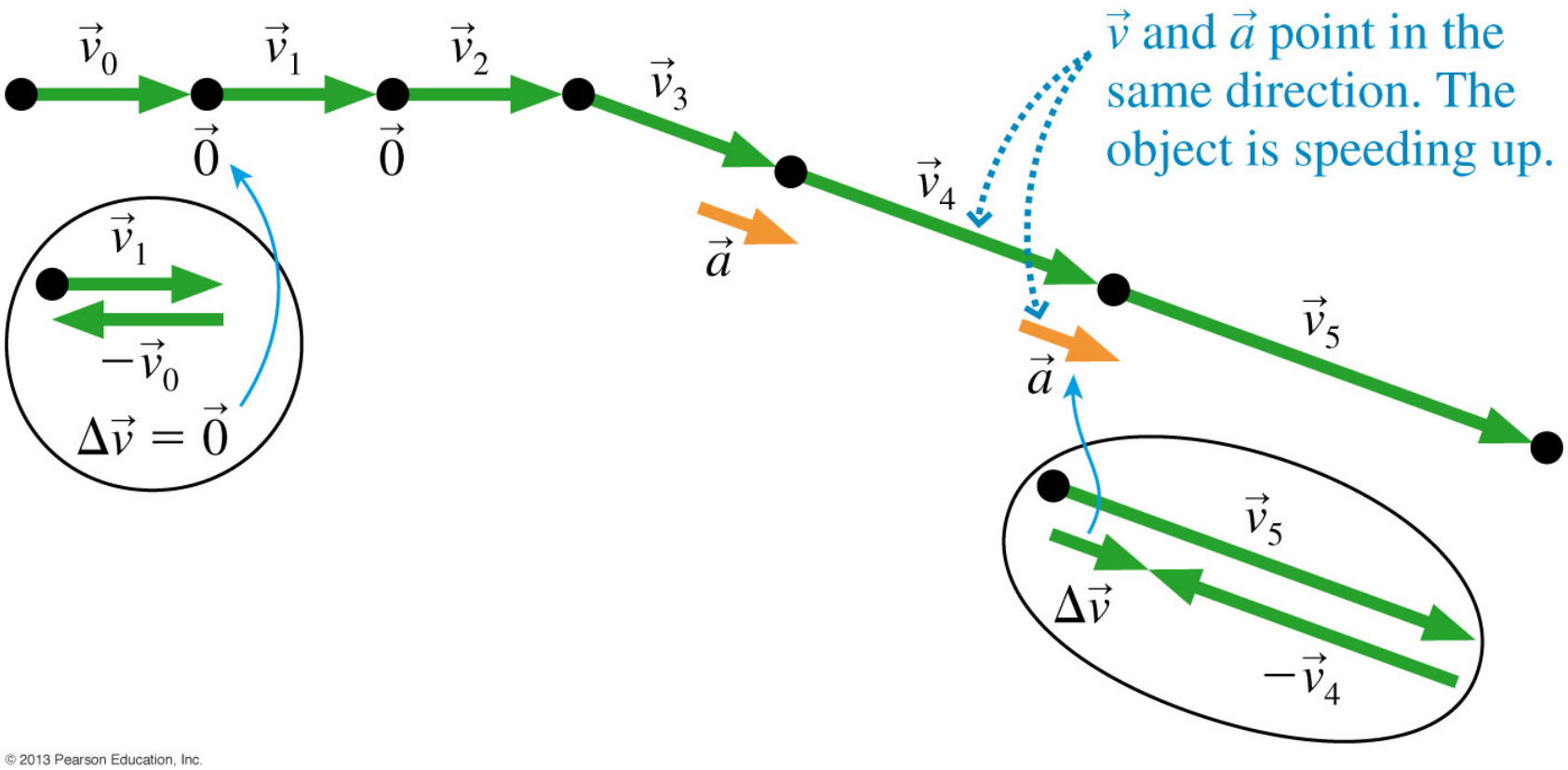




How did you solve it?

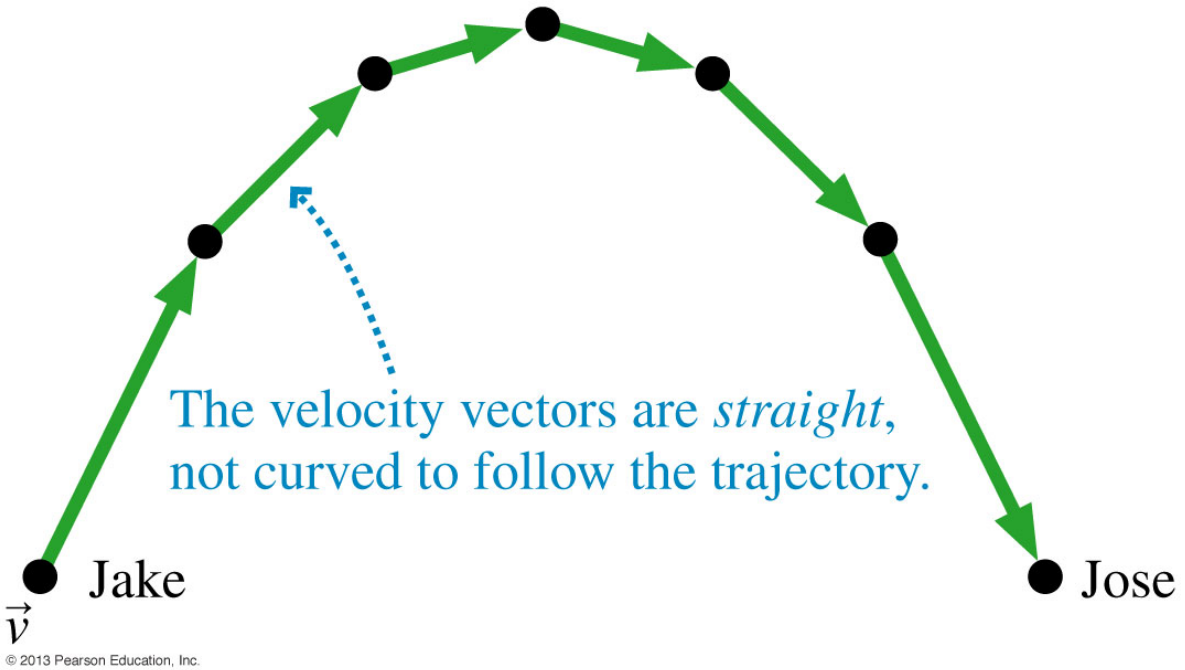
Linear Acceleration - Example



Motion diagram of skier.

Linear Acceleration

Build the acceleration vectors at each middle point and raise your hands when you see a pattern.



Linear Acceleration

- Imagine throwing a ball straight into the air. On the way up what direction is the velocity/acceleration? (write your answers on the white board)

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- What about at the peak, what is the direction of the velocity/acceleration?

Linear Acceleration

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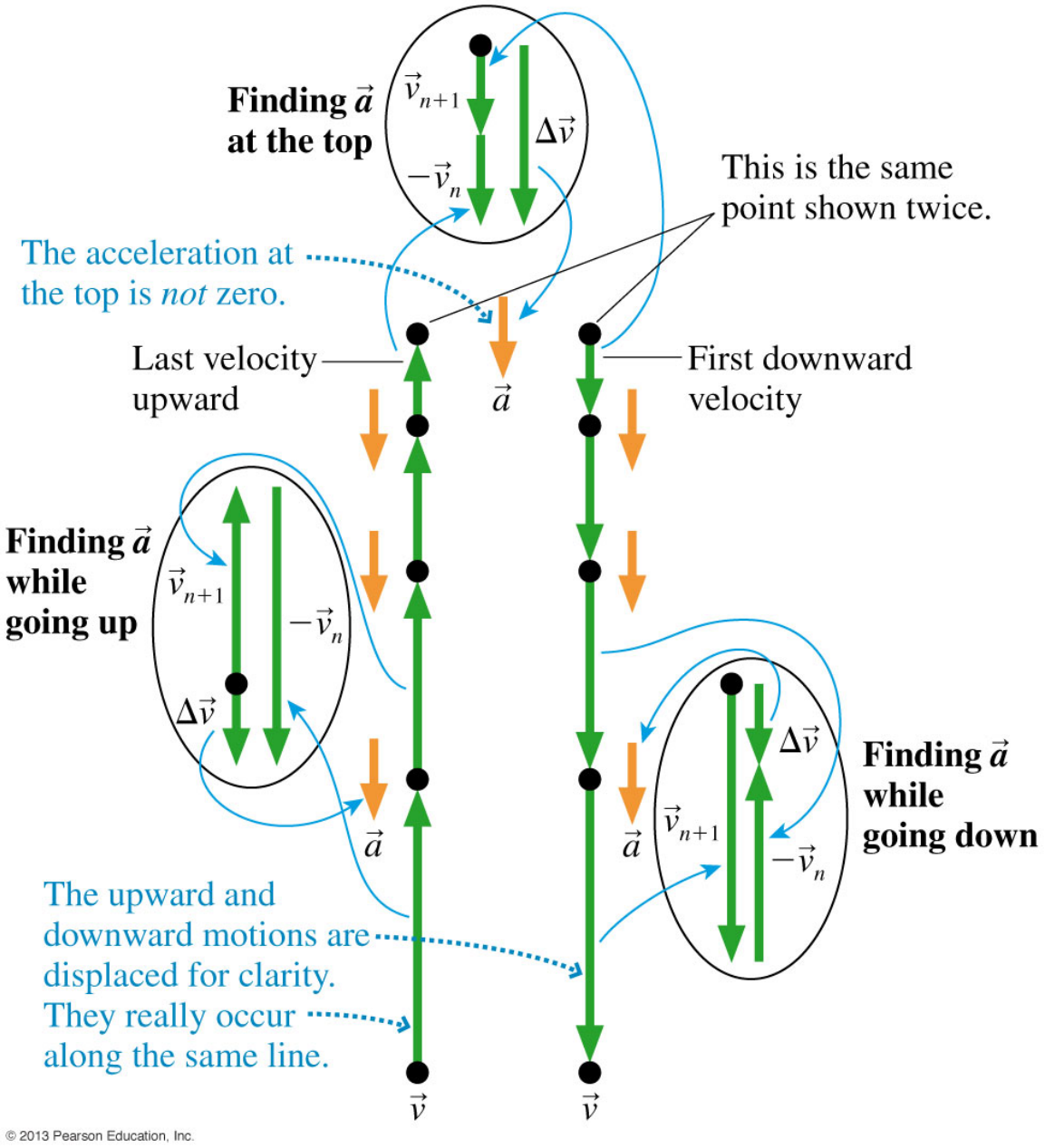
- What about the on way down, what is the direction of the velocity/acceleration?
- What about at the peak, what is the direction of the velocity/acceleration?
- Now draw the picture and figure it out for sure.

Linear Acceleration

You get the same result here, except that there was no horizontal motion to start with.



Question?

- I have one... Have any of you had the chance to look at the Mastering Physics tutorial HW yet?
- Do you have any questions about that?
- The first HW that is due next Thursday at 11:59pm is on mastering physics.