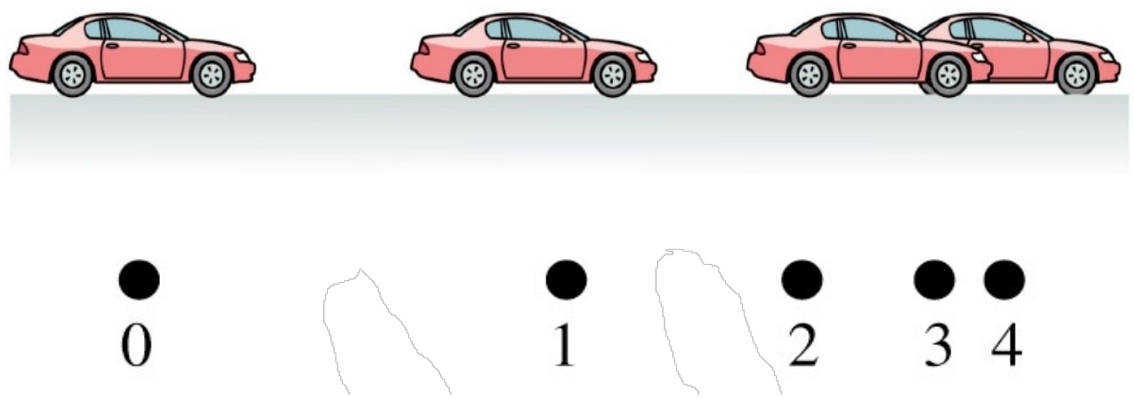
Motion Diagrams



Quiz

Three motion diagrams are shown. Which is a dust particle settling to the floor at constant speed, which is a ball dropped from the roof of a building, and which is a descending rocket slowing to make a soft landing on Mars?

A. (a) is dust, (b) is ball, (c) is rocket.
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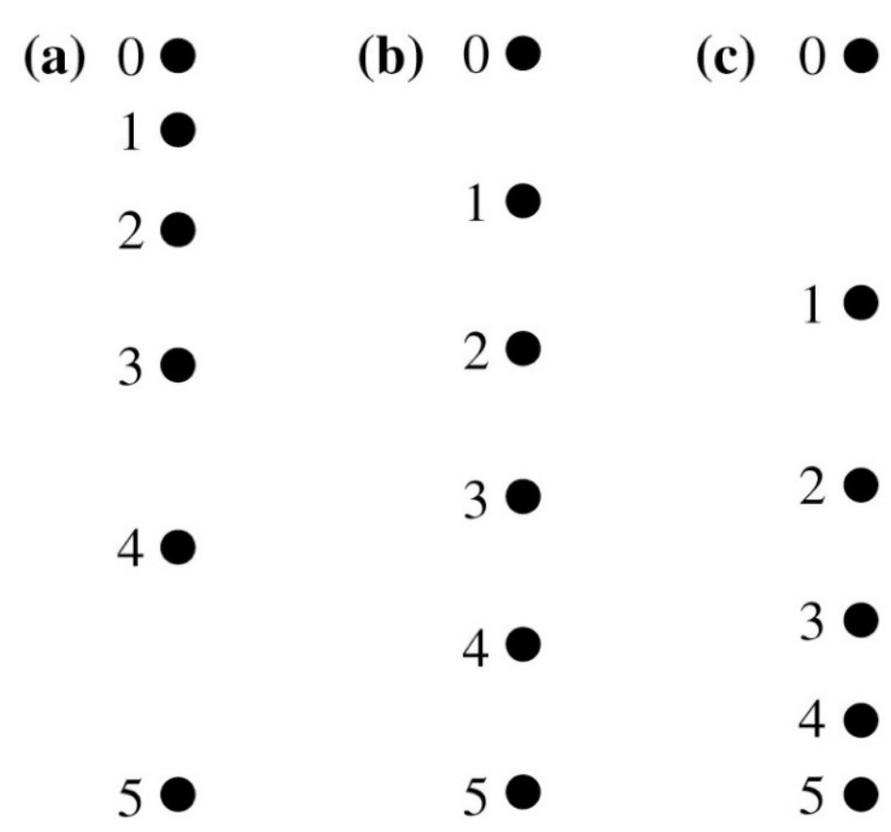

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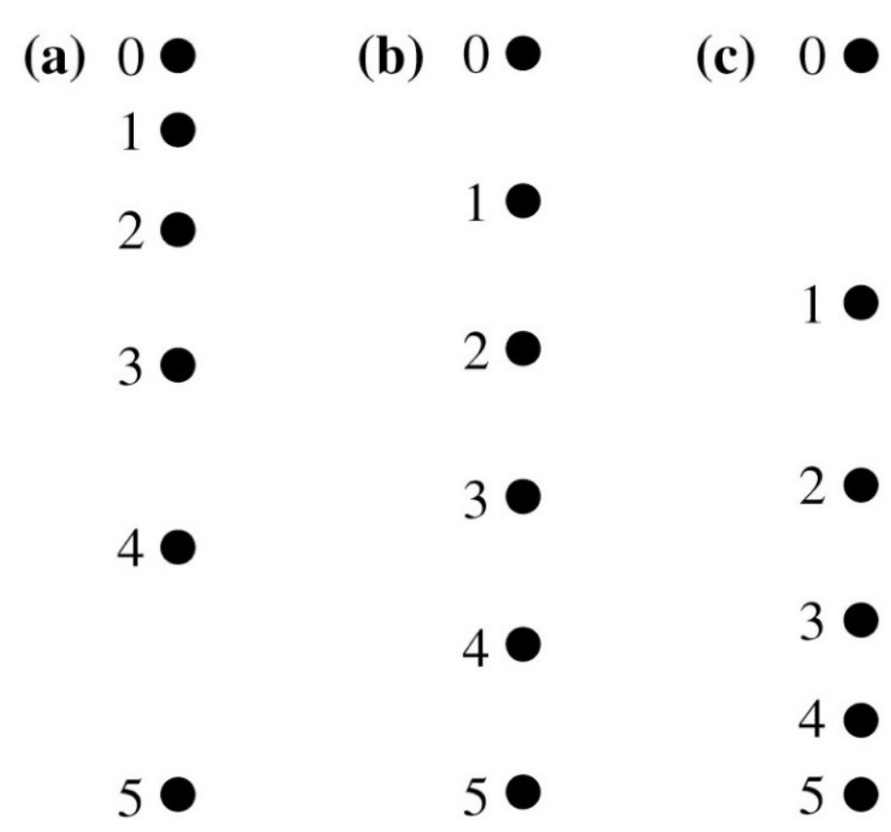


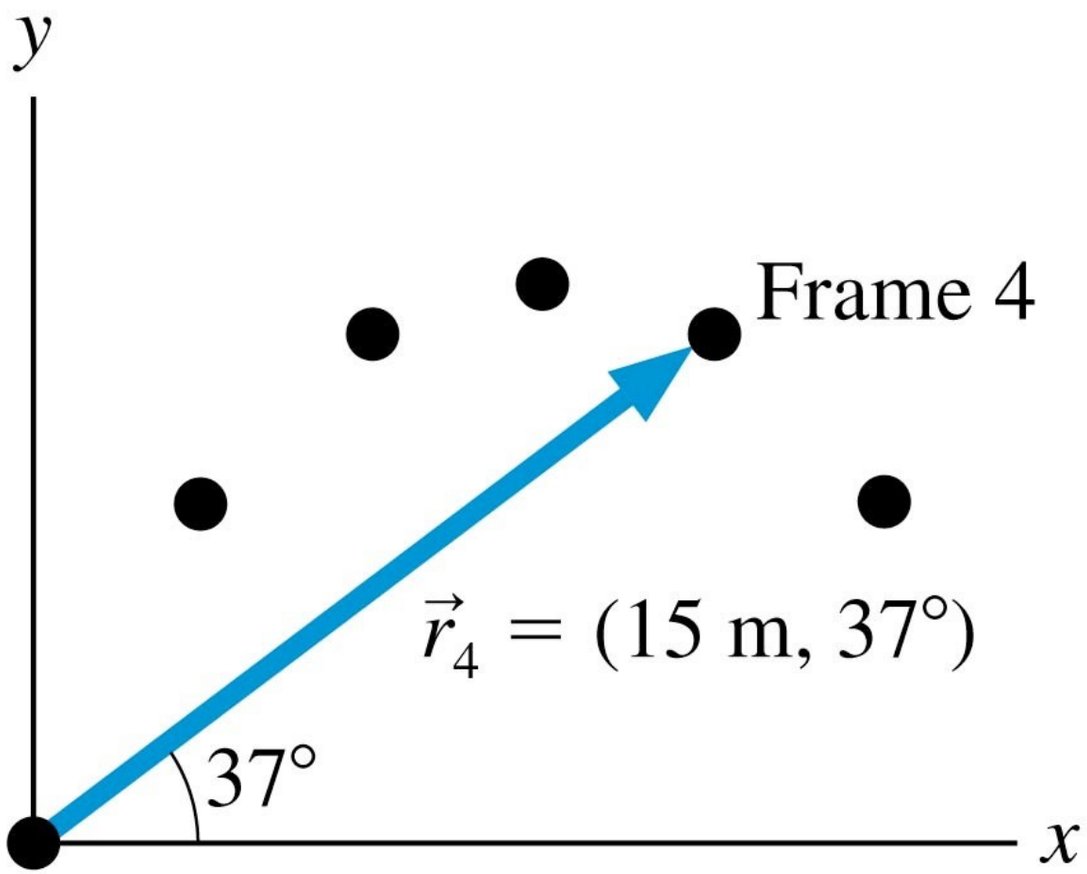
Position Vector

Vector

Magnitude and Direction

Scalar

Magnitude only



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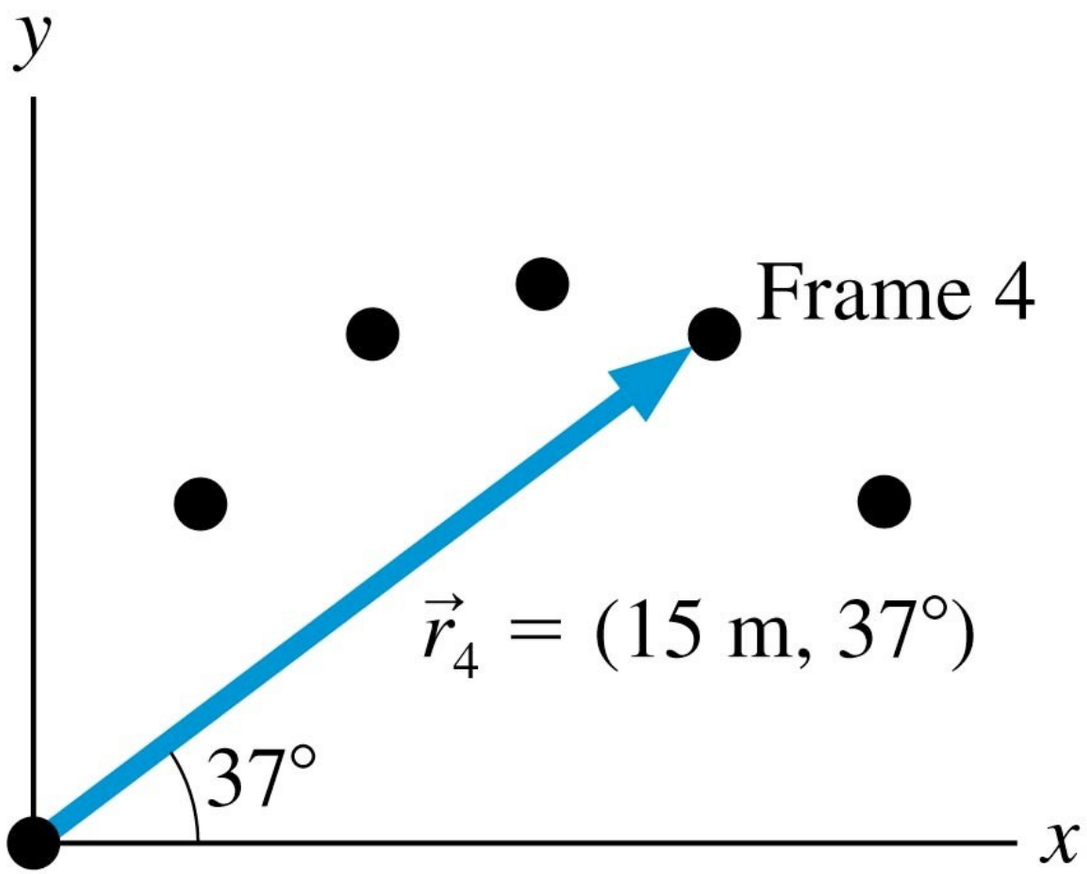


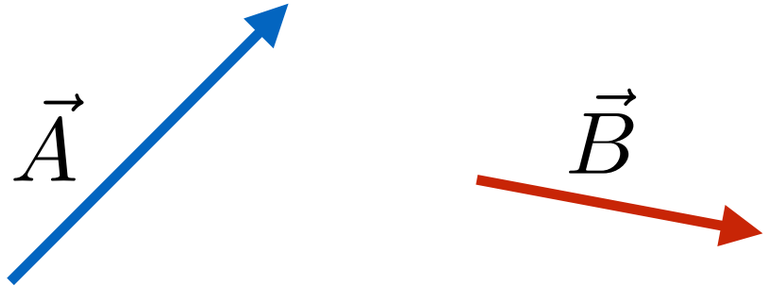
Mass

Volume

Length

Speed

Vector Addition



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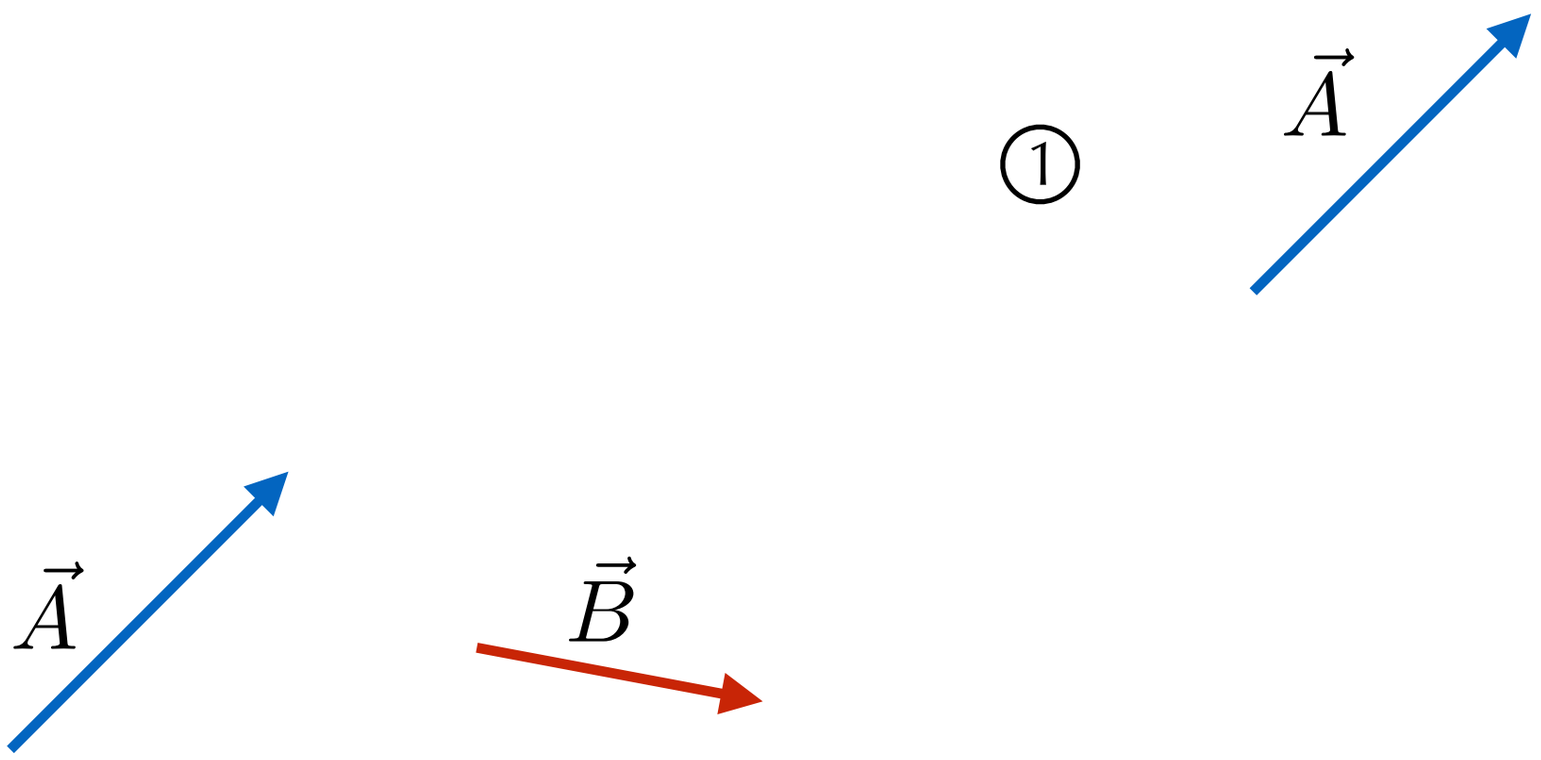

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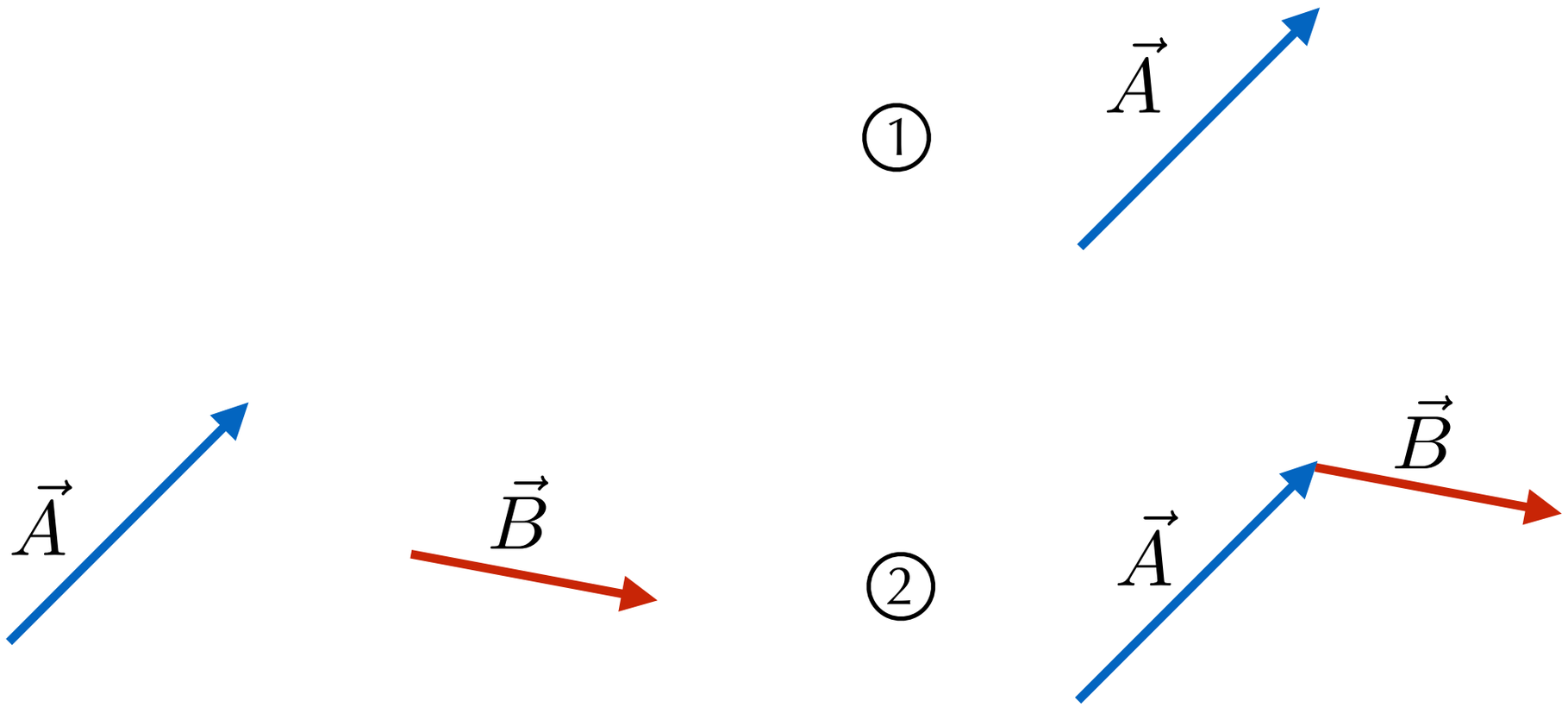

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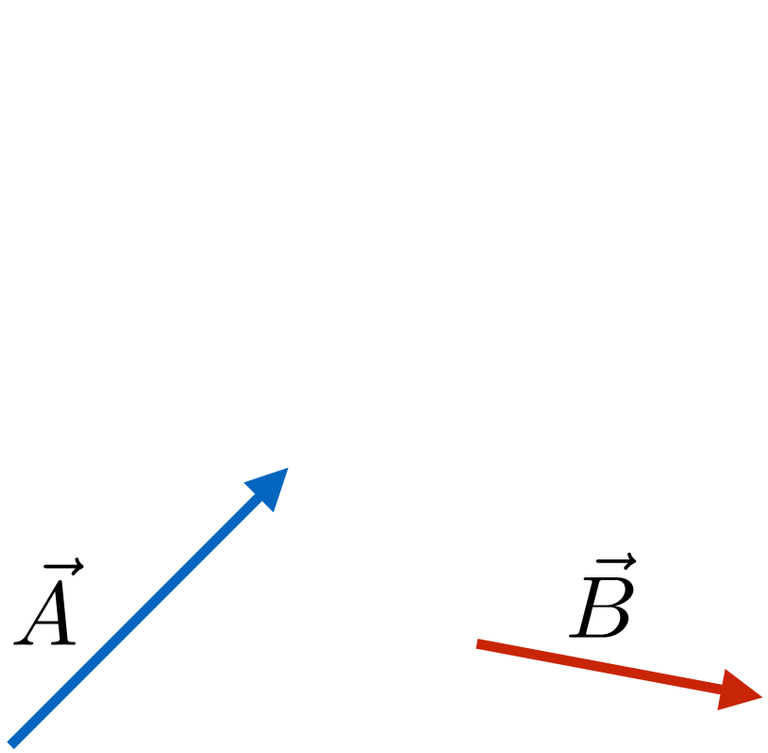
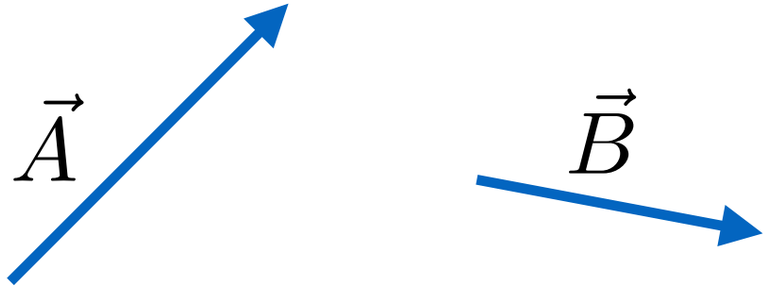


① $\vec{A}$

② $\vec{A}$ $\vec{B}$

③ $\vec{A}$ $\vec{B}$ $\vec{A}+\vec{B}$

Vector Subtraction



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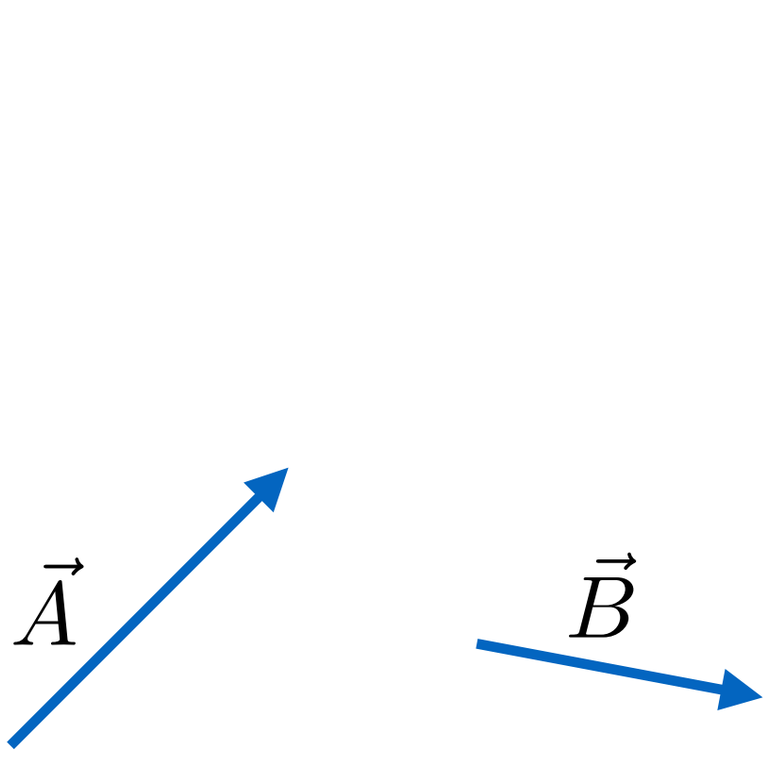

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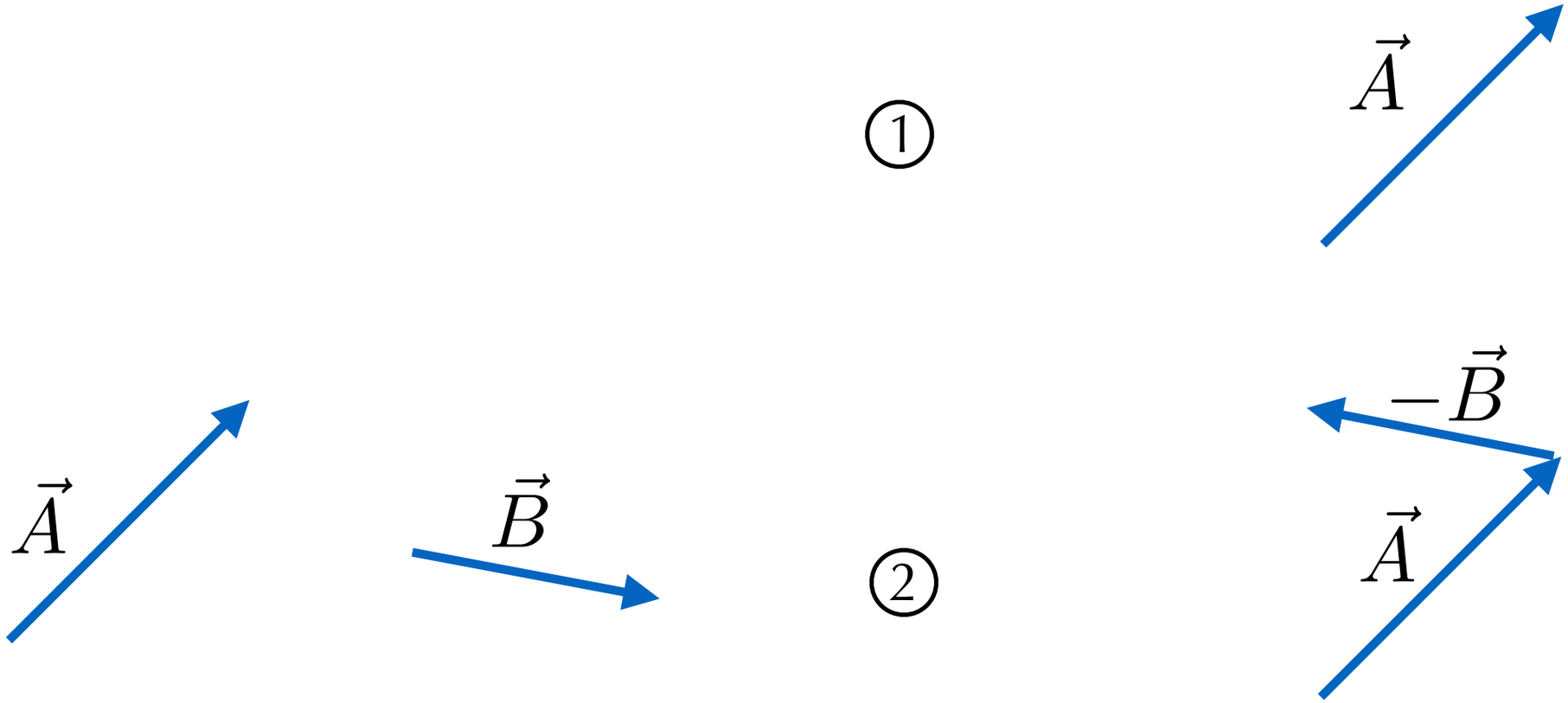

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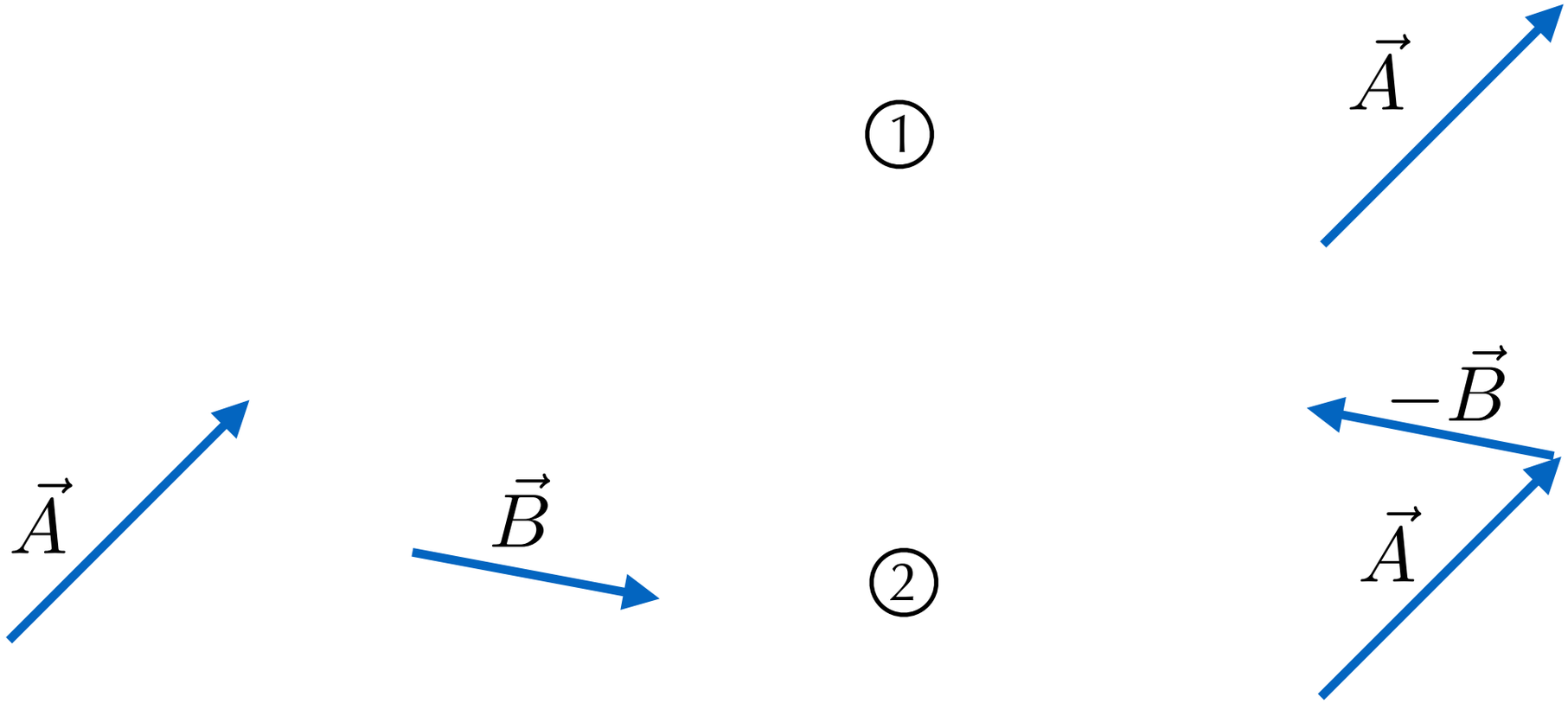
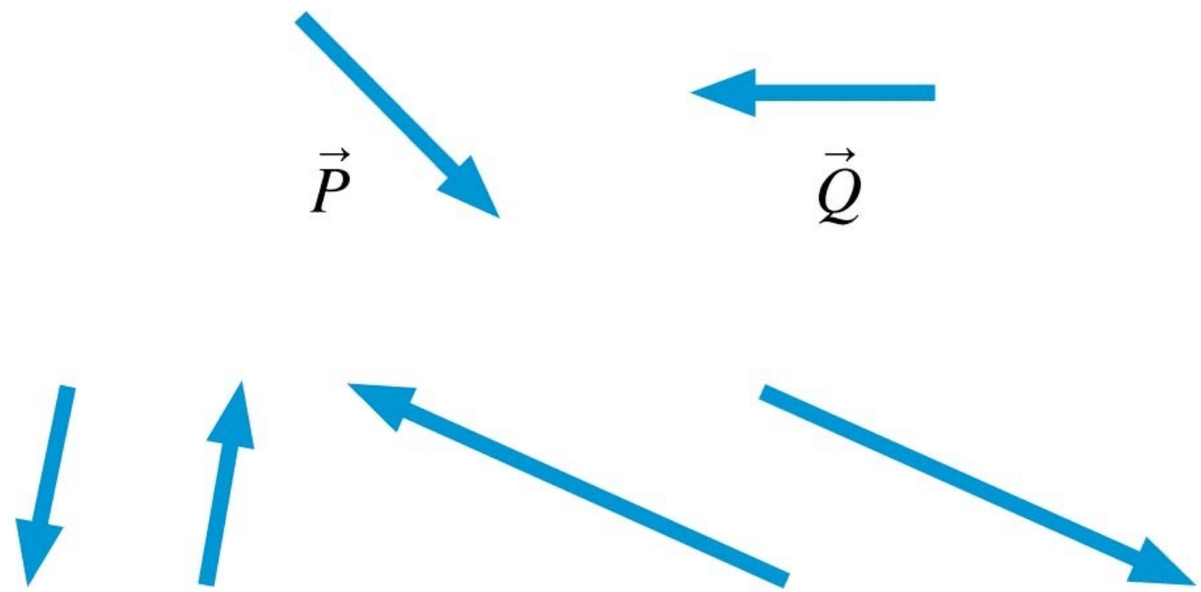


Quiz

Given the vectors $\vec{P}$ and $\vec{Q}$, what is $\vec{P} + \vec{Q}$



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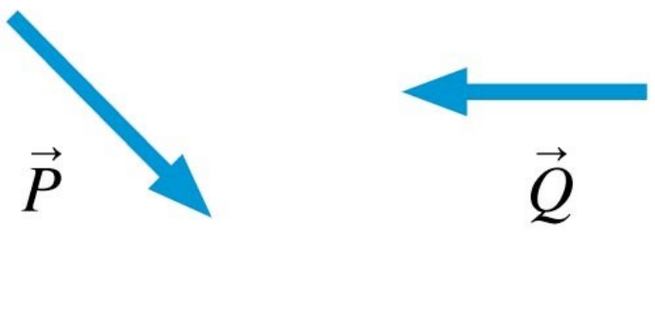

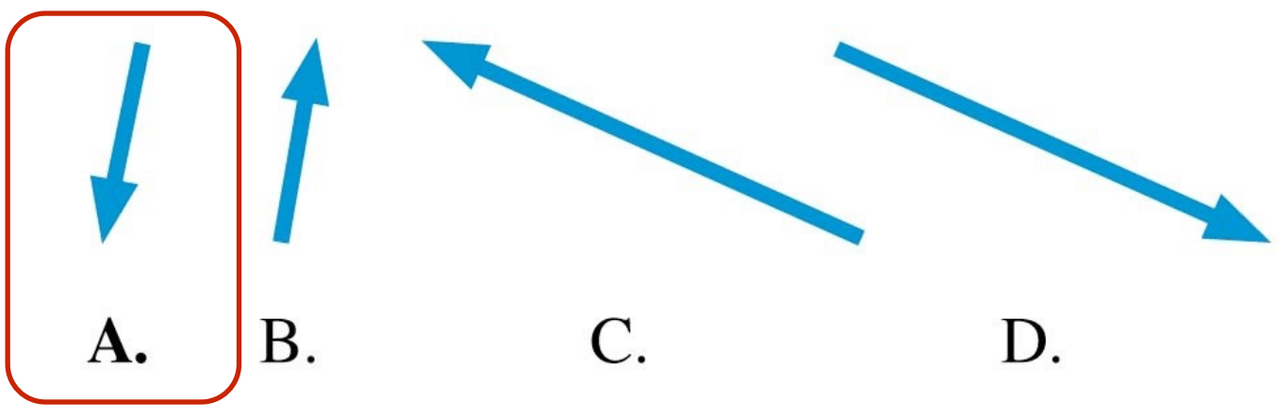

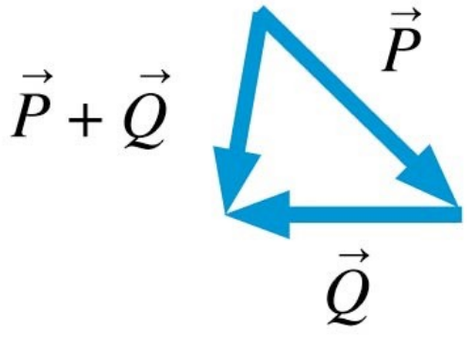

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A. B. C. D.

Quiz

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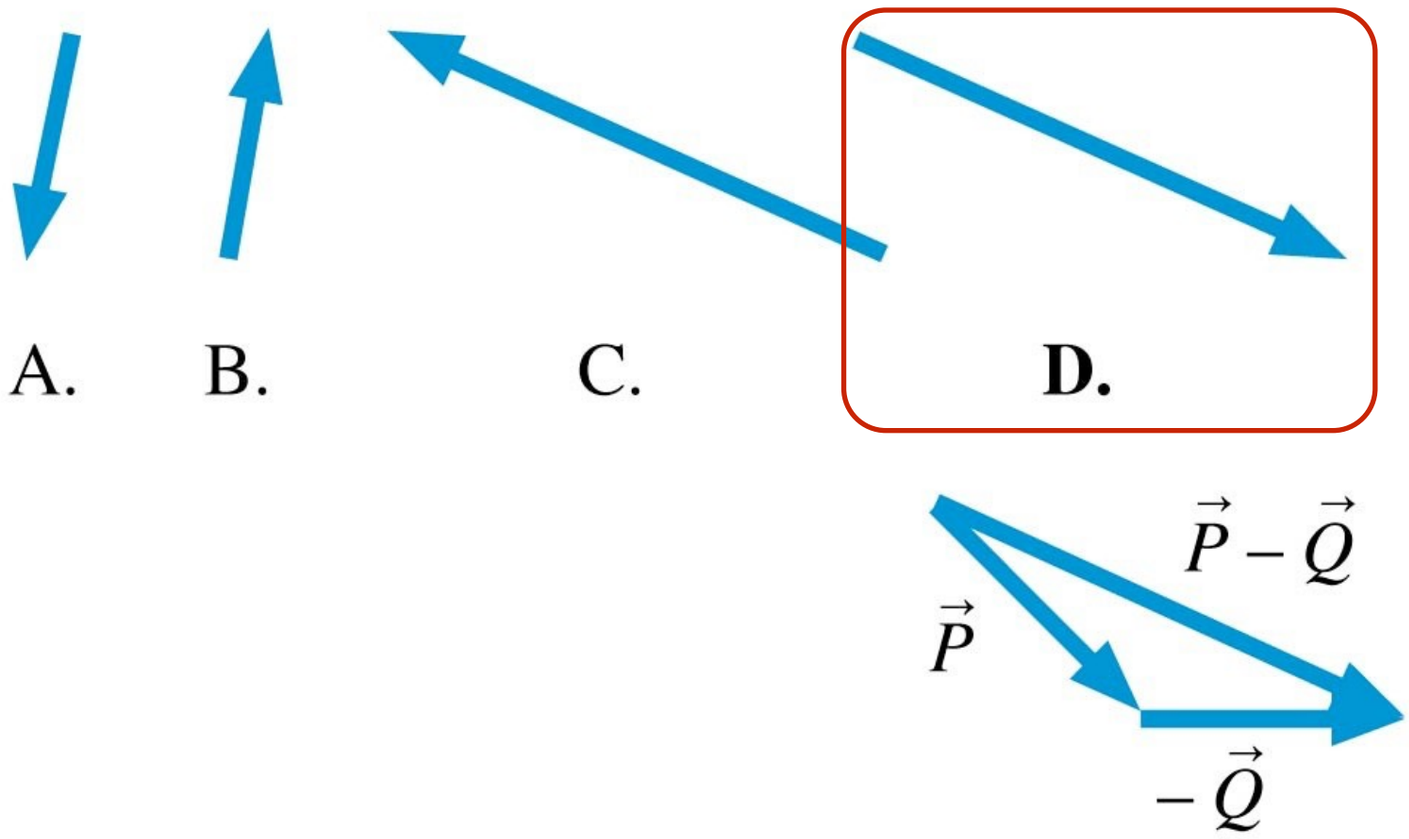
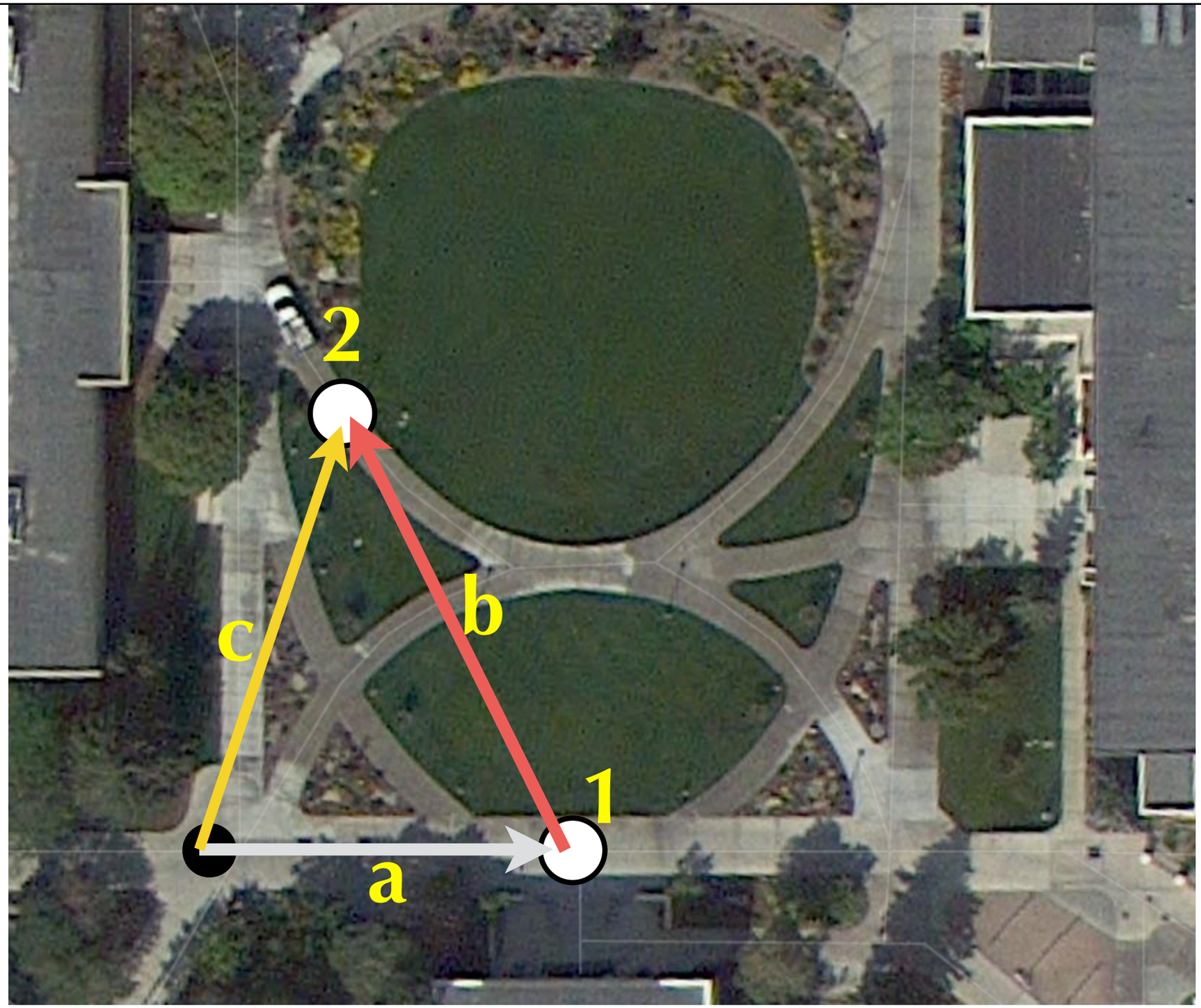


You are standing in front of the library pondering a scripture you read this morning when you realize you are late for physics class. Just before you get to the Romney building you stop and ask yourself, "I wonder how my position vector has changed."



Velocity vs. Speed

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Average speed

$$v_{\text{avg}} = \frac{\text{distance traveled}}{\text{time elapsed}}$$

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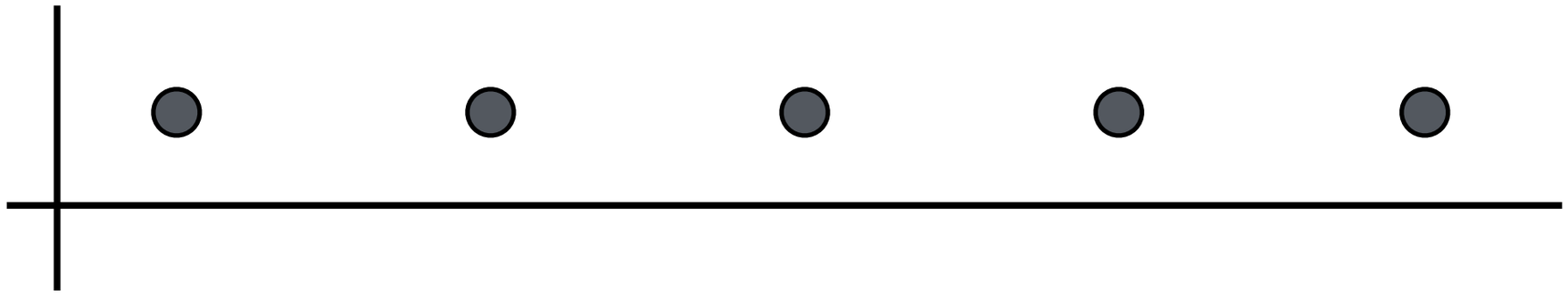
Motion Diagrams with Velocity Vectors

What are the displacement vectors here?



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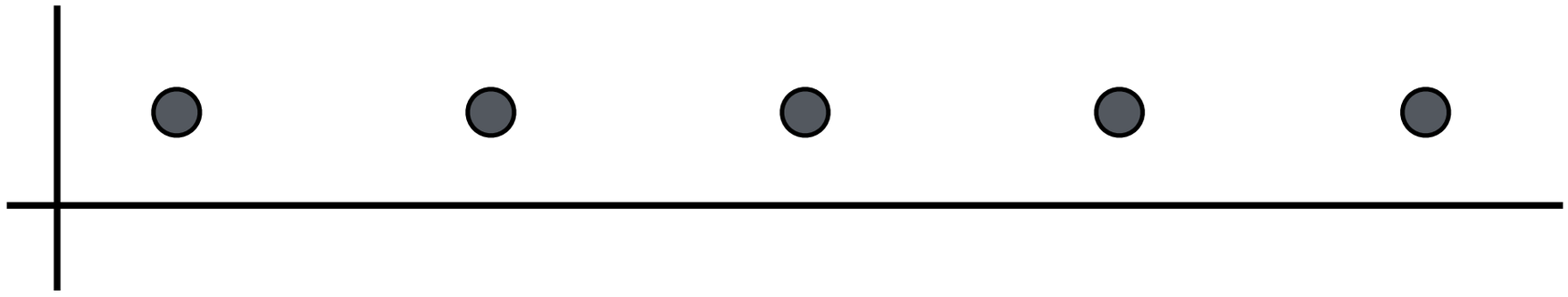

$$\vec{v}_{\text{avg}} = \frac{\Delta \vec{r}}{\Delta t}$$

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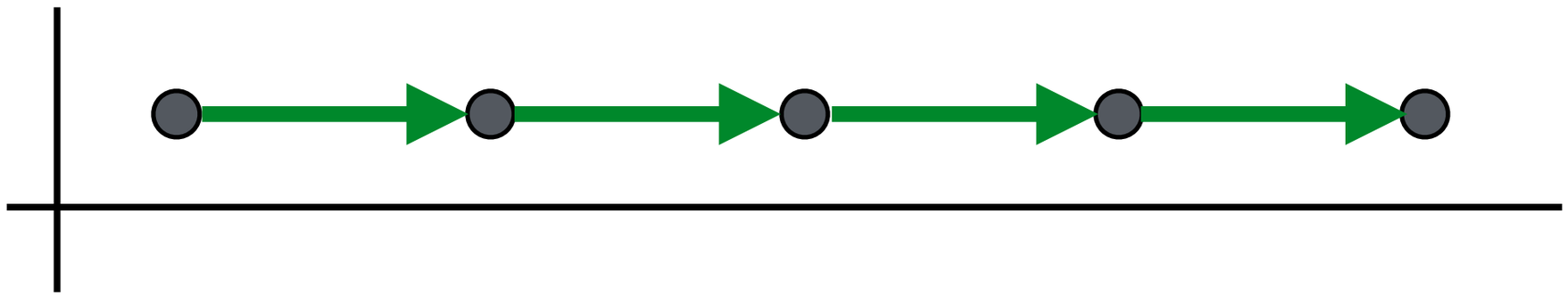

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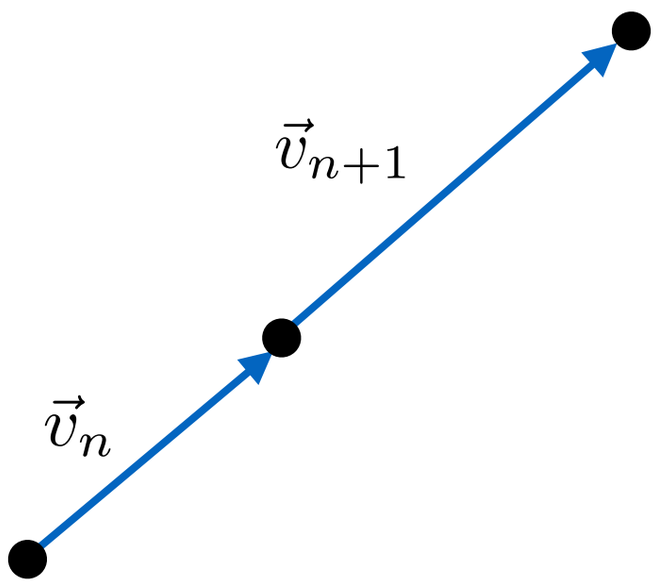
Finding the Acceleration Vector



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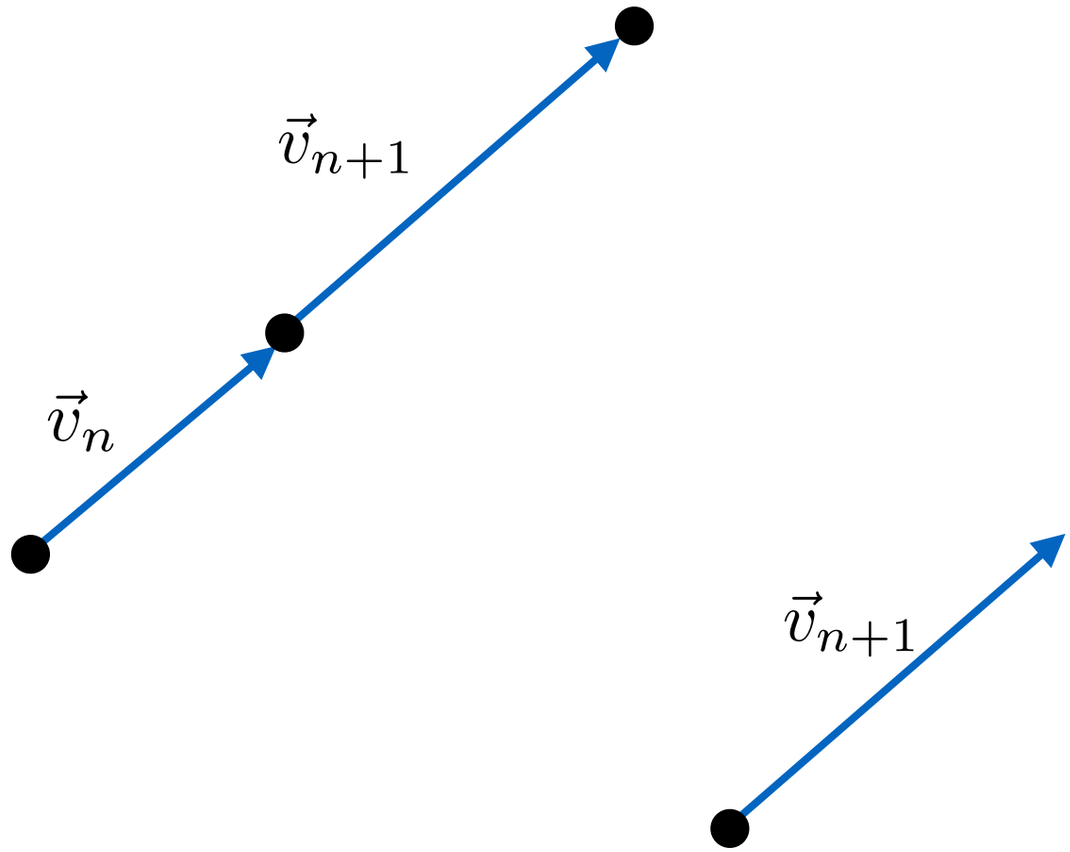

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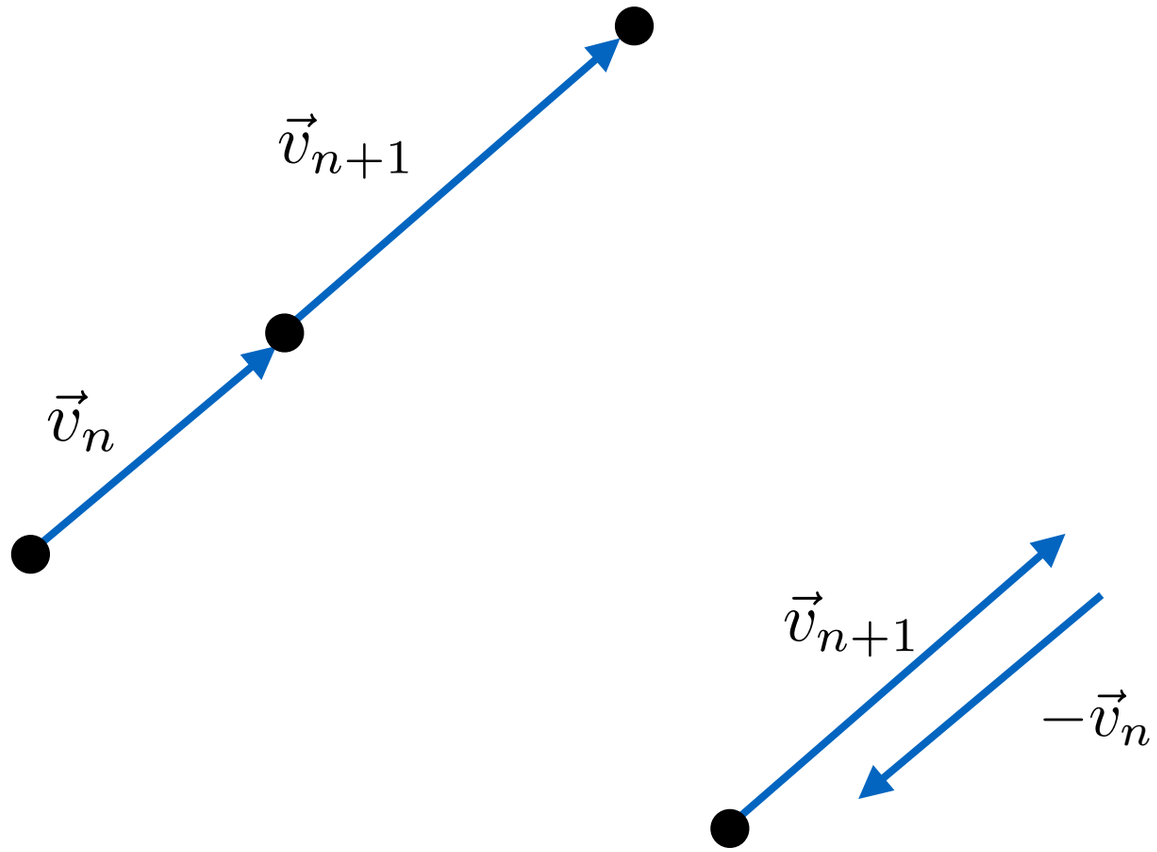

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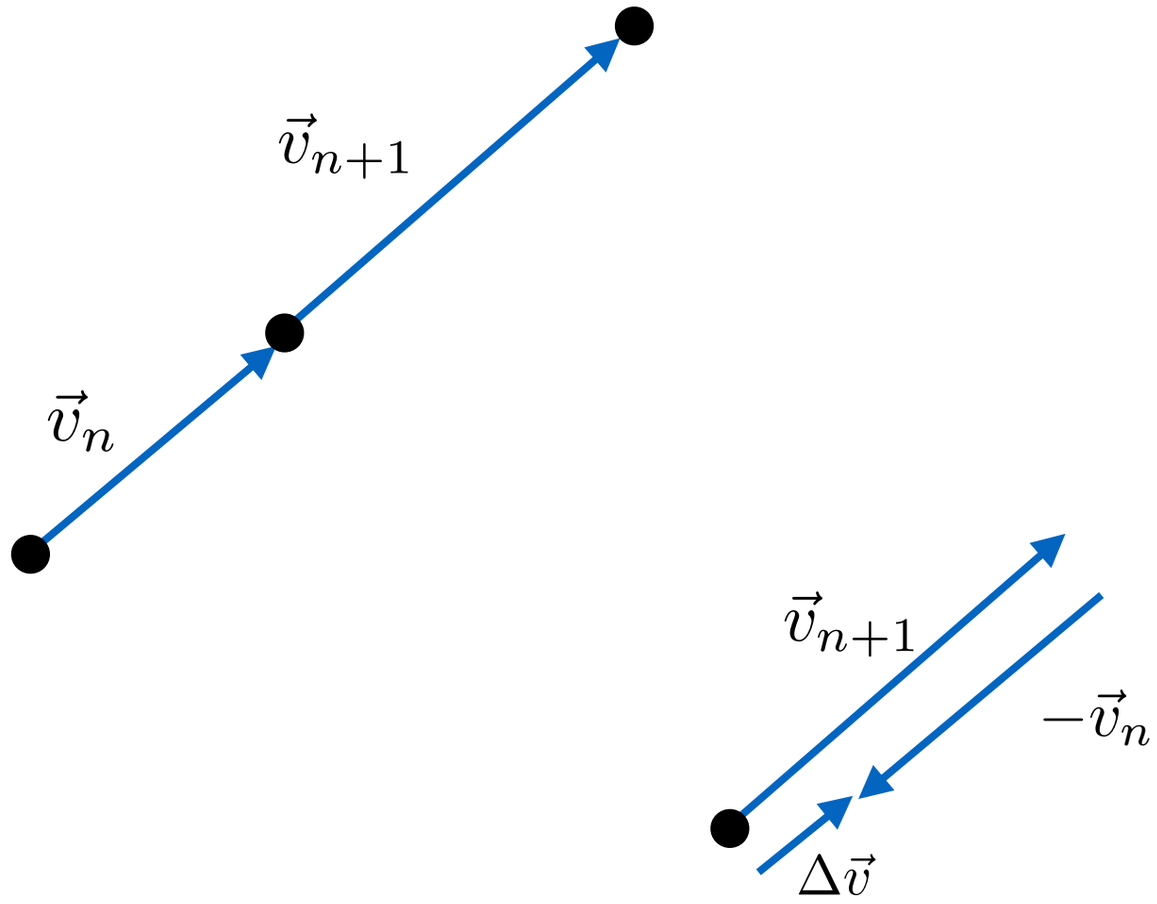

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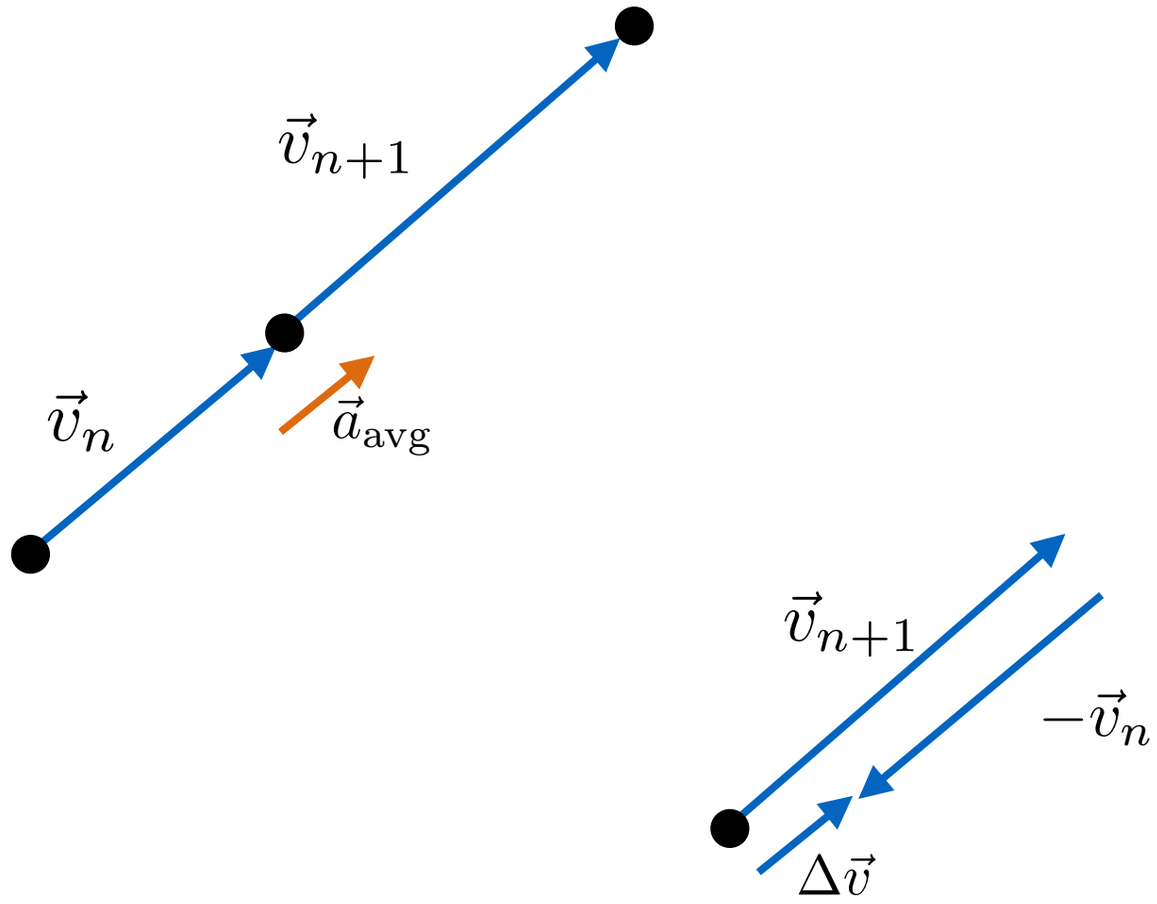

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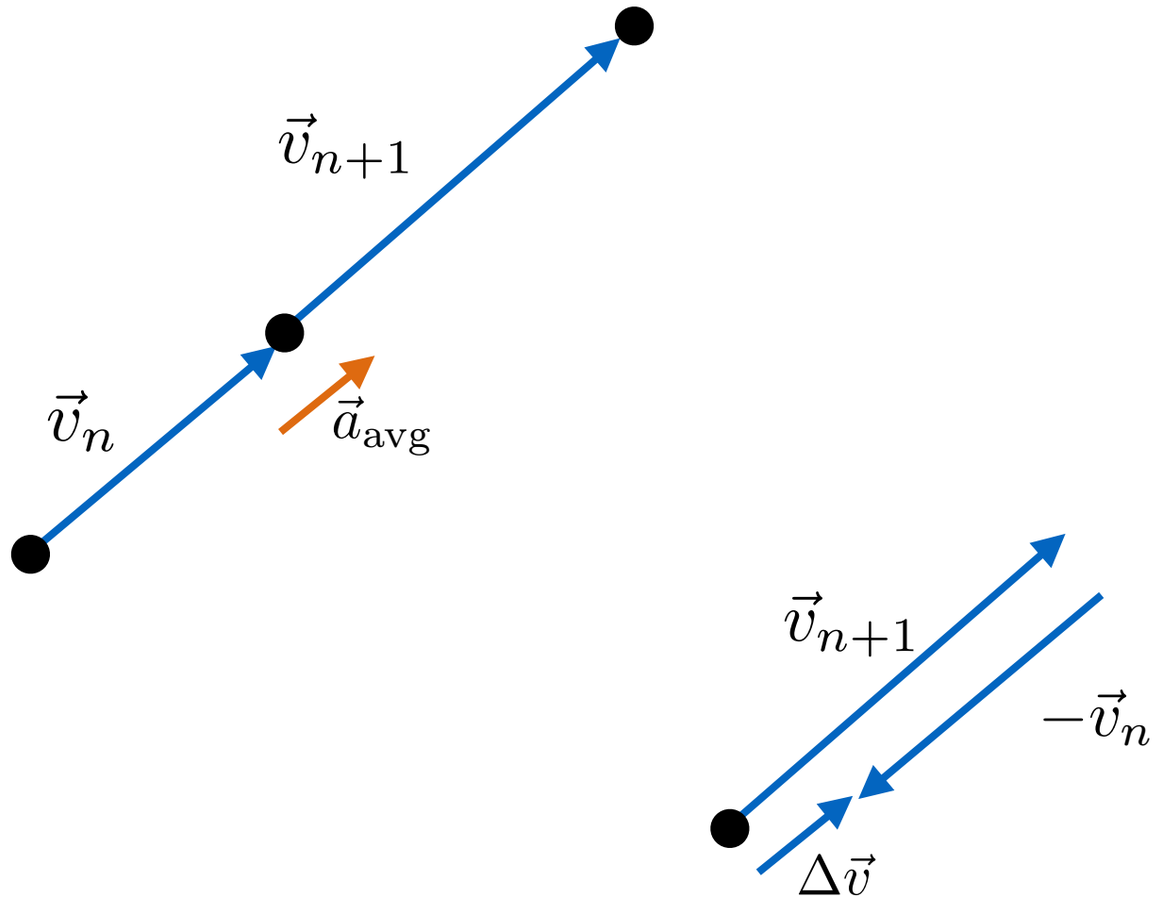
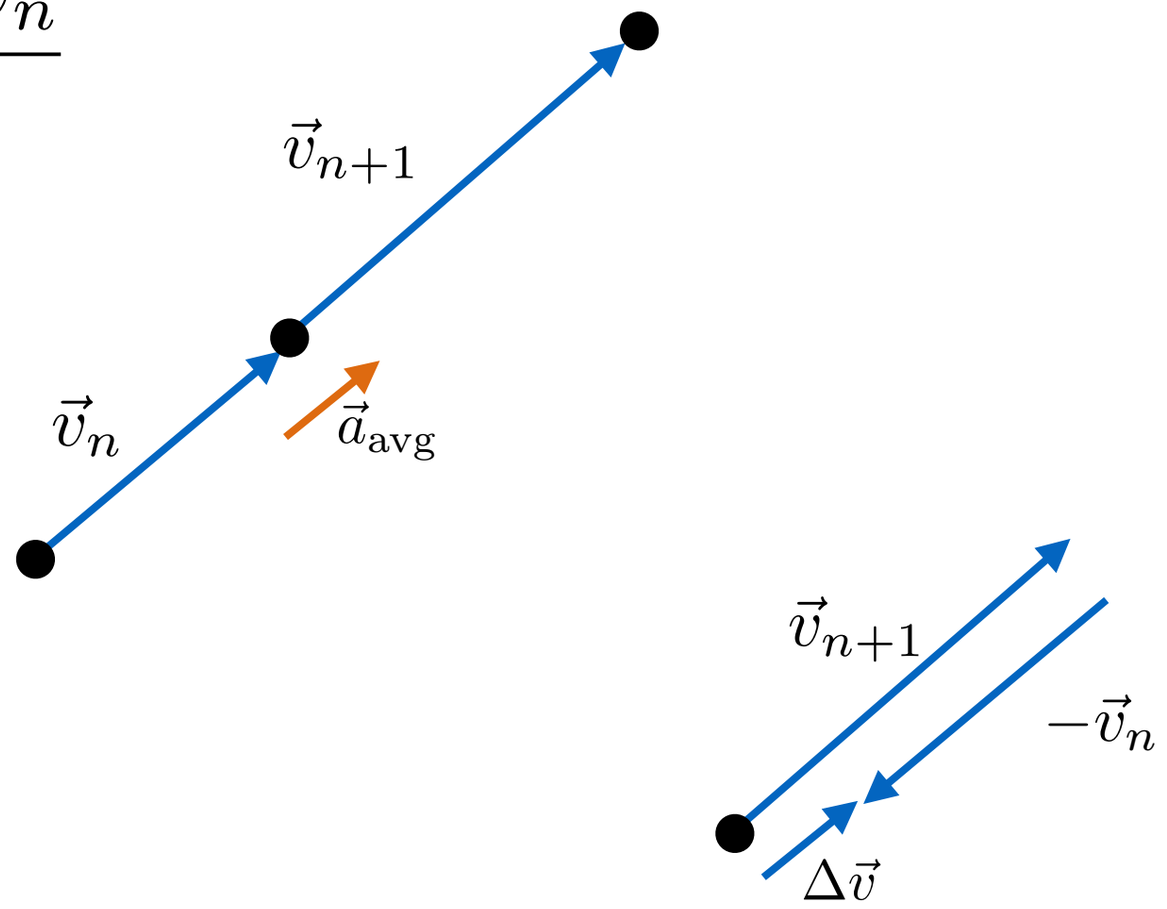


- Notice that the acceleration vectors goes beside the dots, not beside the velocity vectors.
- That is because each acceleration vector is the *difference* between *two* velocity vectors on either side of a dot.

Finding the Acceleration Vector

$$\vec{a}_{\text{avg}} = \frac{\Delta\vec{v}}{\Delta t} = \frac{\vec{v}_{n+1} - \vec{v}_n}{\Delta t}$$



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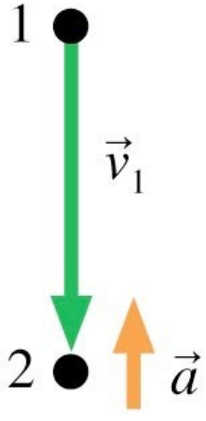
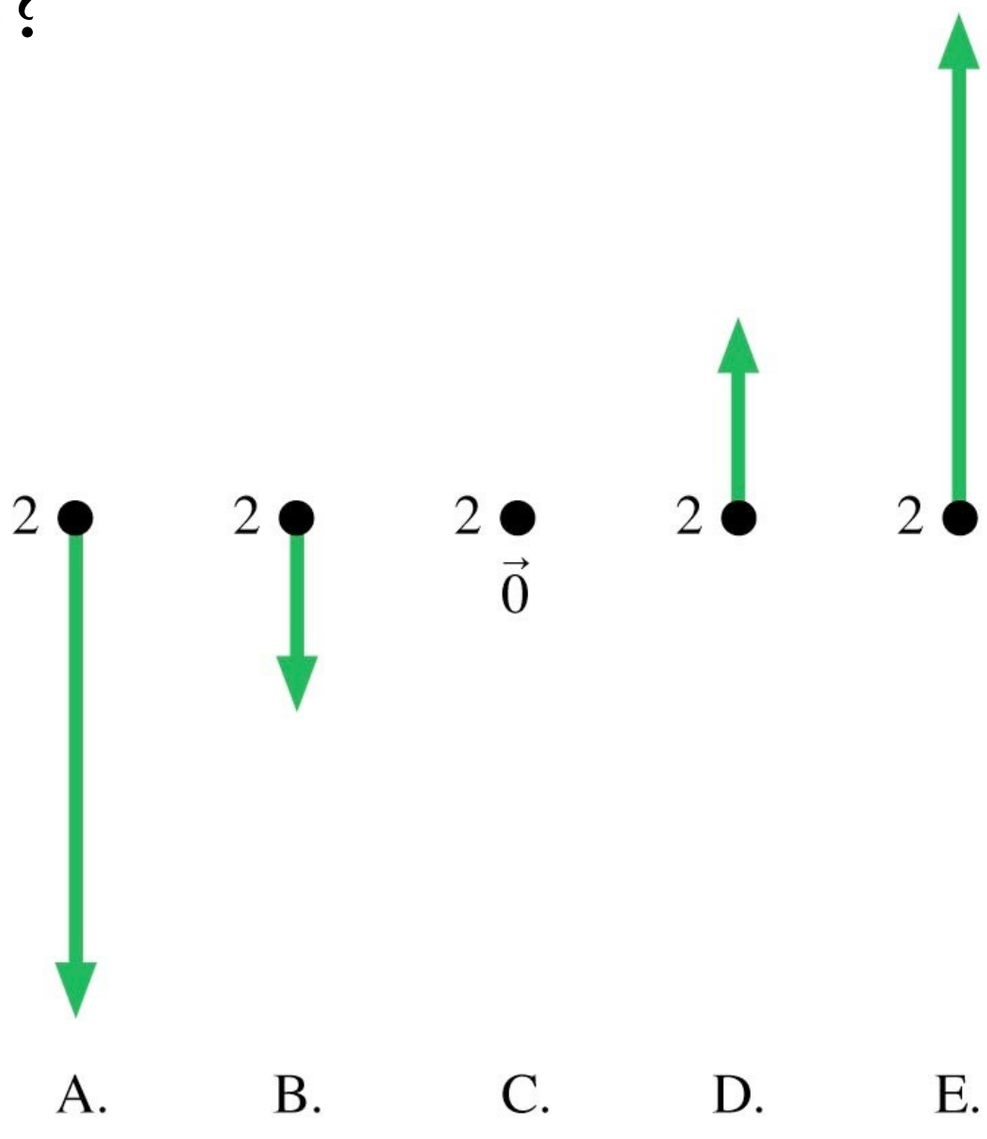
Quiz

A particle has velocity $\vec{v}_1$ as it accelerates from 1 to 2. What is its velocity vector $\vec{v}_2$ as it moves away from point 2 on its way to point 3?





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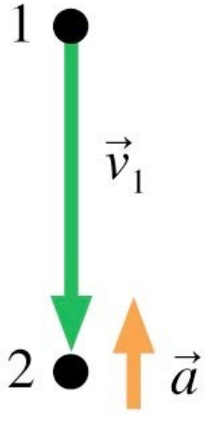

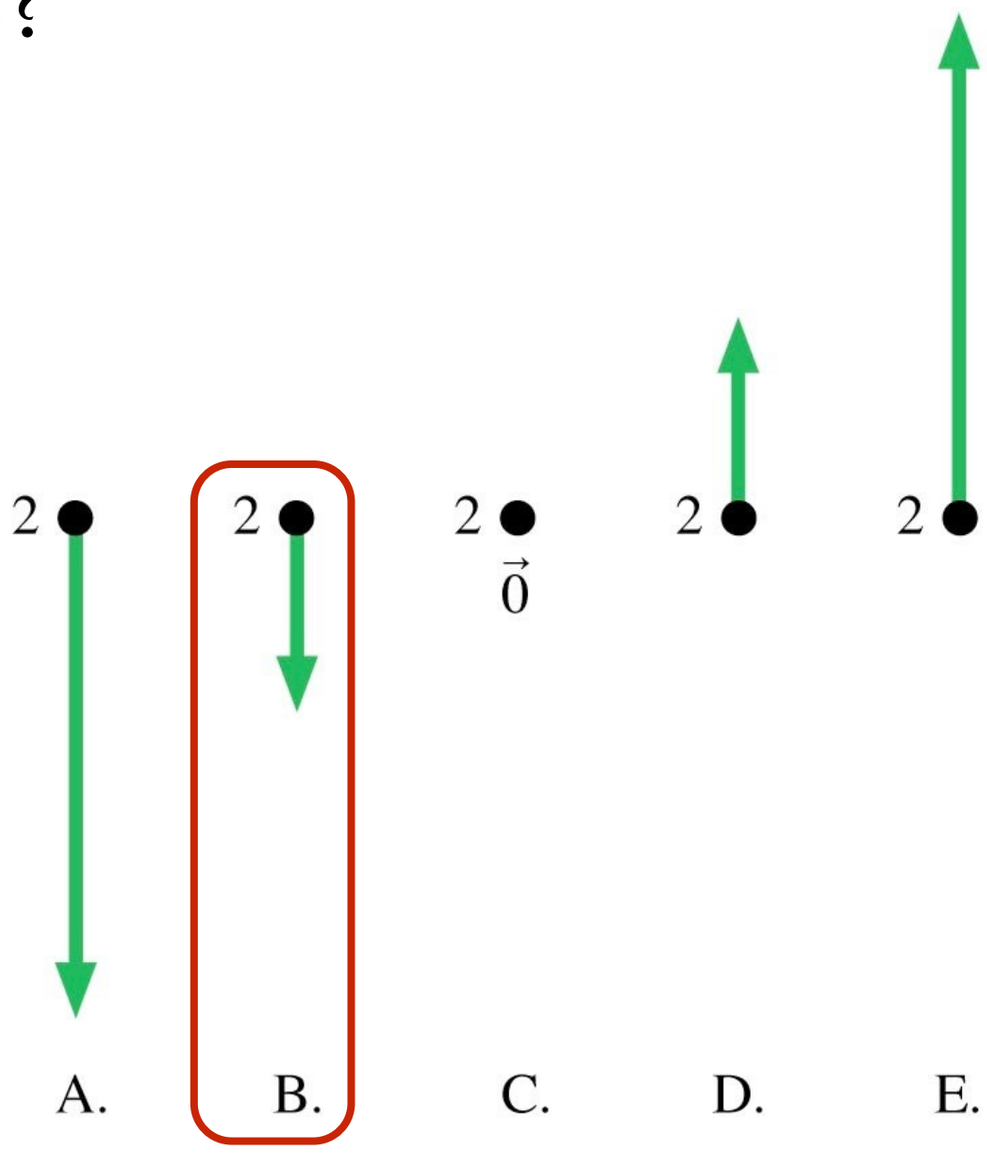

The Complete Motion Diagram

A complete motion diagram consists of:

a. The position of the object at each frame, represented as a dot.
b. Average velocity vectors connecting each dot in the motion diagram to the next dot. There is one velocity vector per two dots in the motion diagram. Label these vectors
c. Average acceleration vectors. There is one acceleration vector connecting two velocity vectors. The average acceleration vectors are placed at the location of the dots.

Example

A skier glides along a smooth, horizontal snow at constant speed, then speeds up going down a hill. Draw the skier's motion diagram

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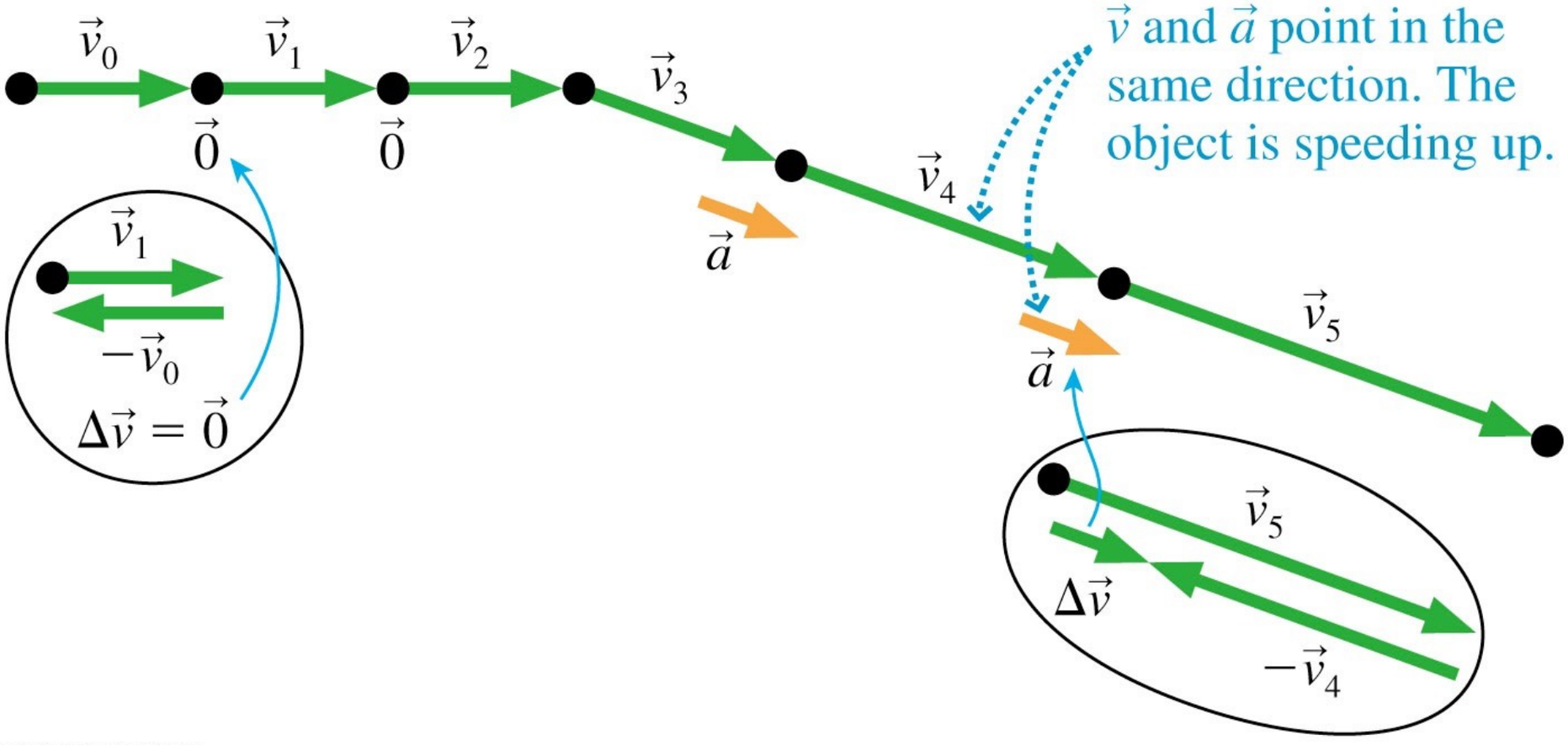
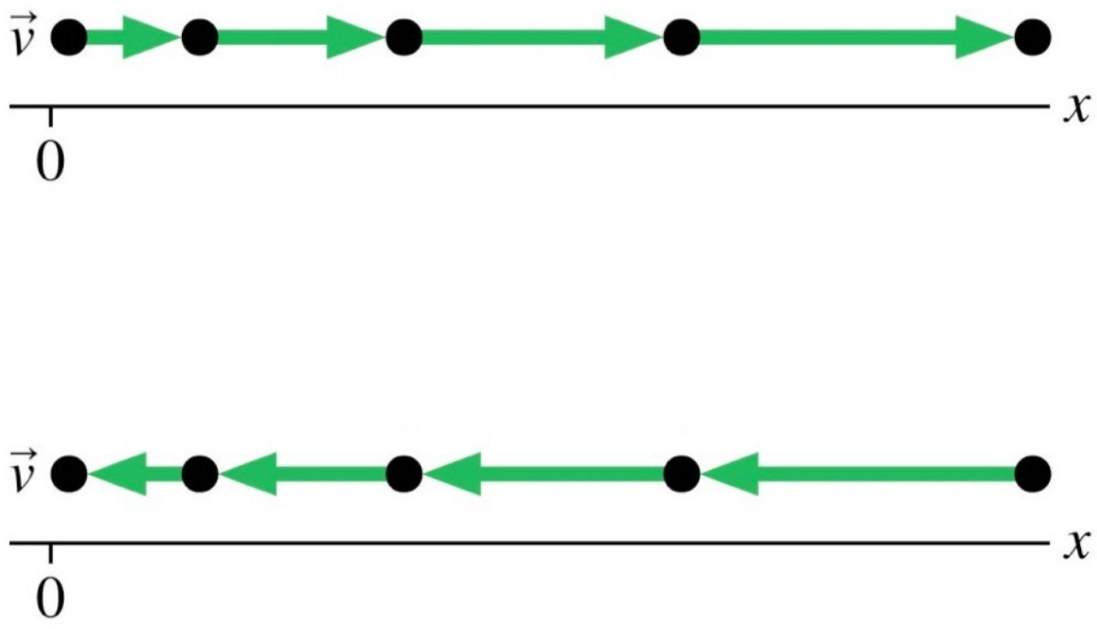


Speeding Up or Slowing Down

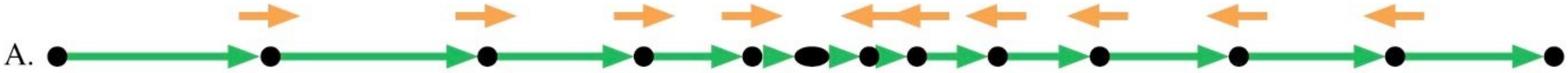
- Is the object speeding up or slowing down?
- What is the acceleration vector?



Quiz

A cyclist riding at 20 mph sees a stop sign and actually comes to a complete stop in 4 s. He then, in 6 s, returns to a speed of 15 mph. Which is his motion diagram?

A.



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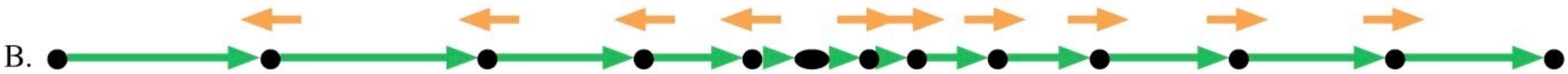
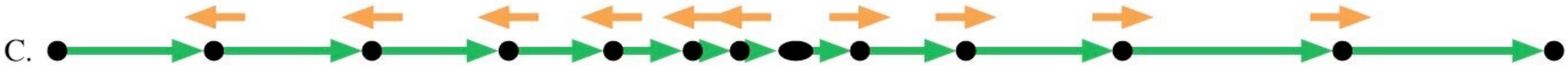
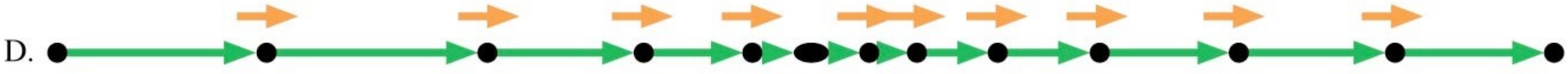


C.



D.



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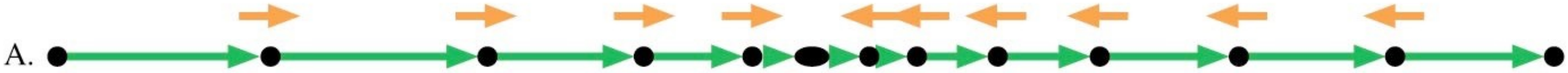

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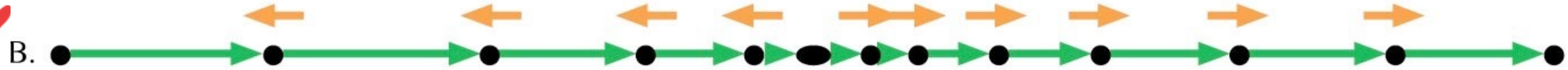

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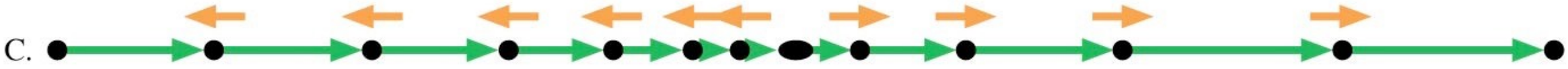

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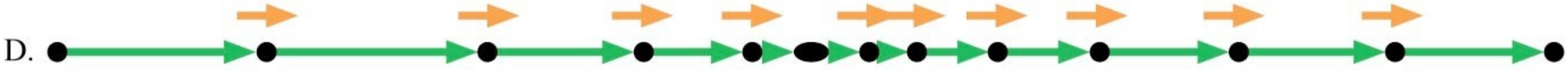

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A ball is tossed straight up in the air. At its very highest point, the ball's acceleration vector $\vec{a}$

a. Points up.

b. Is zero.

c. Points down.

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In fact, the acceleration vector points down as the ball rises, at the highest point, and as it falls.