a place of mind

FACULTY OF EDUCATION

Department of
Curriculum and Pedagogy

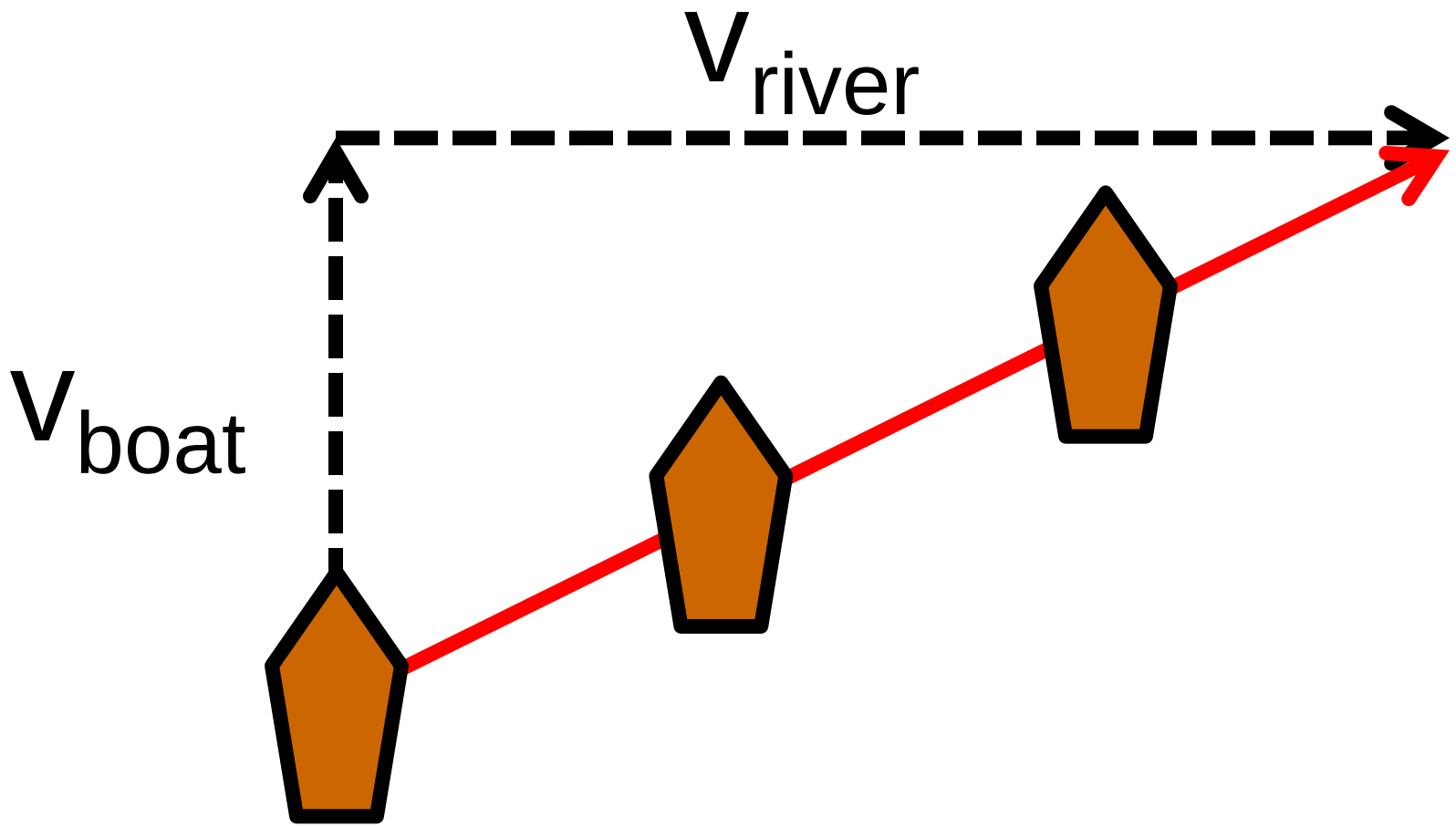
Physics

2-D Kinematics: Relative Velocity

Science and Mathematics Education Research Group

Supported by UBC Teaching and Learning Enhancement Fund 2012-2013

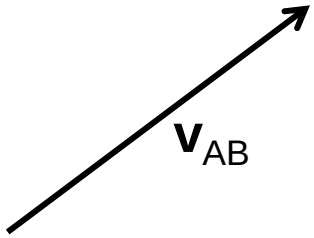
Relative Velocities



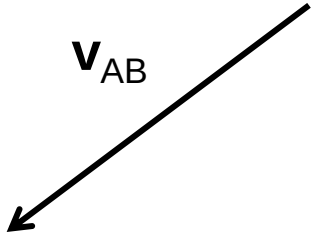
Relative Velocity I

Velocity A and Velocity B are shown below. What is the velocity of A with respect to B?

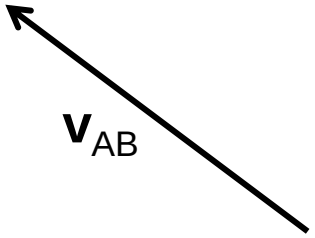
A.



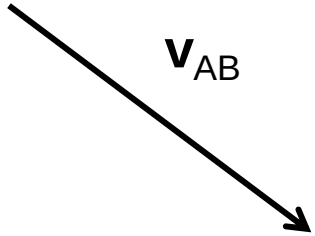
B.



C.



D.



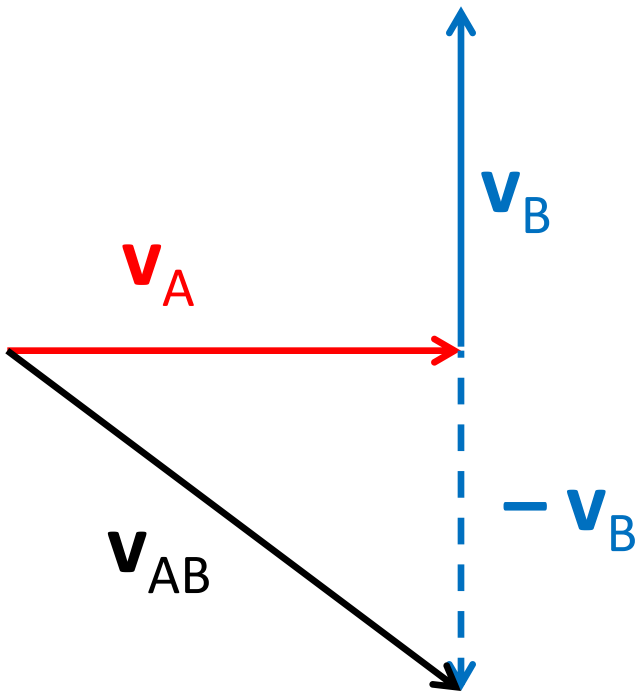
In all questions bold letters are used to represent vectors,

Solution

Answer: D

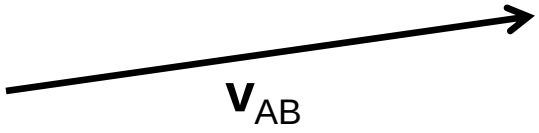
Justification: The velocity of A with respect to B ($\mathbf{v}_{AB}$) can be found by subtracting the two vectors:

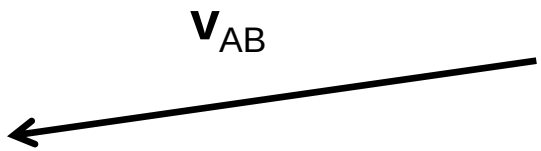
$$\mathbf{v}_{AB} = \mathbf{v}_A - \mathbf{v}_B$$

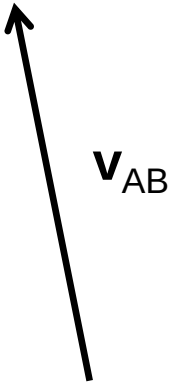


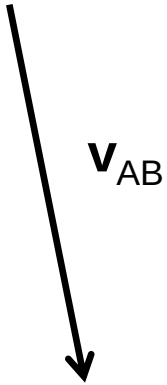
Relative Velocity II

Velocity A and velocity B are shown below. What is the velocity of A with respect to B?

A. 

B. 

C. 

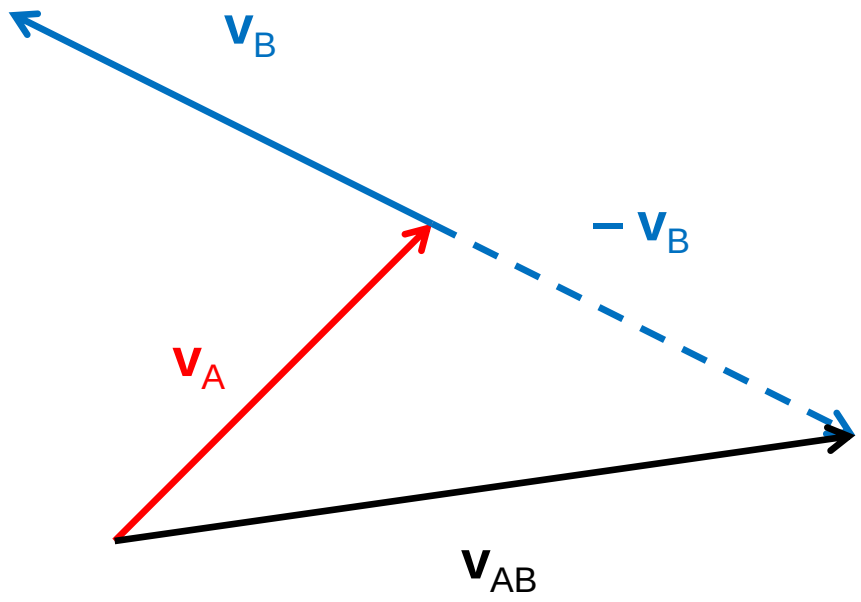
D. 

Solution

Answer: A

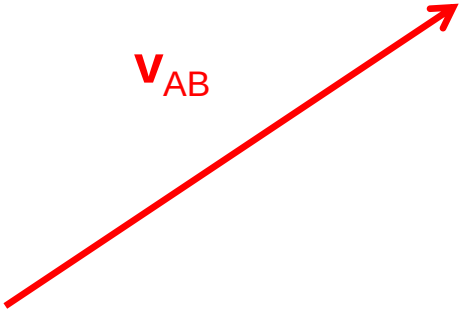
Justification: The velocity of A with respect to B ($\mathbf{v}_{BA}$) is given by:

$$\mathbf{v}_{AB} = \mathbf{v}_A - \mathbf{v}_B$$

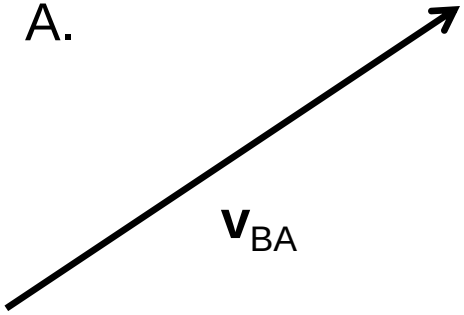


Relative Velocity III

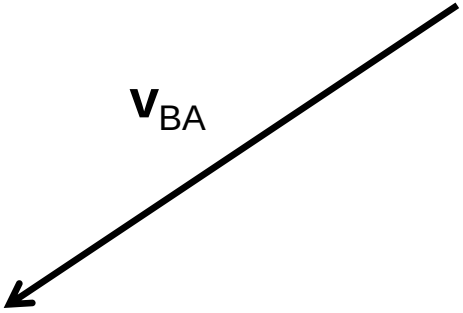
The velocity of A relative to B is shown below.
What is the velocity of B relative to A?



A.



B.



C. Either $\mathbf{V_A}$ or $\mathbf{V_B}$ needs to be known

D. Both $\mathbf{V_A}$ and $\mathbf{V_B}$ need to be known

Solution

Answer: B

Justification: The velocity of A with respect to B is:

$$\mathbf{v}_{AB} = \mathbf{v}_A - \mathbf{v}_B$$

The velocity of B with respect to A is:

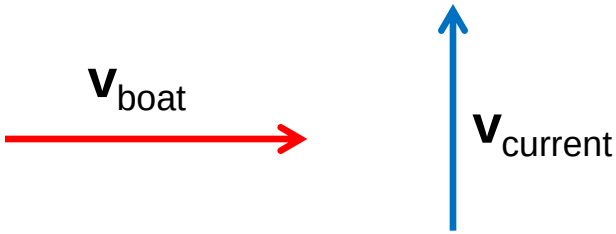
$$\mathbf{v}_{BA} = \mathbf{v}_B - \mathbf{v}_A$$

Notice that:

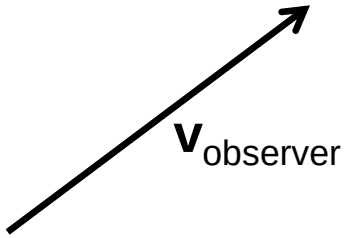
$$\mathbf{v}_{BA} = -(\mathbf{v}_A - \mathbf{v}_B) = -\mathbf{v}_{AB}$$

Relative Velocity IV

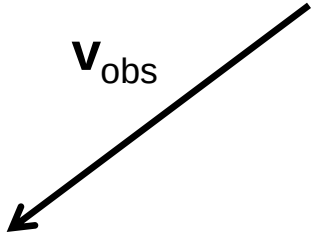
A boat moves with $\mathbf{v}_{boat}$. The current moves with $\mathbf{v}_{current}$. What is the velocity of the boat as seen by an overhead observer?



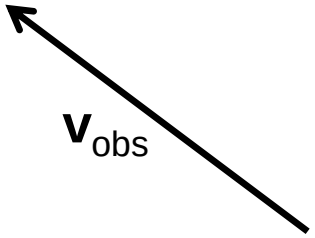
A.



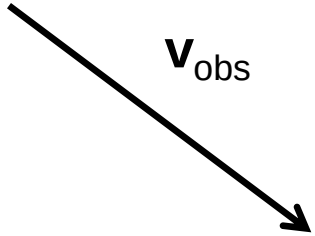
B.



C.



D.

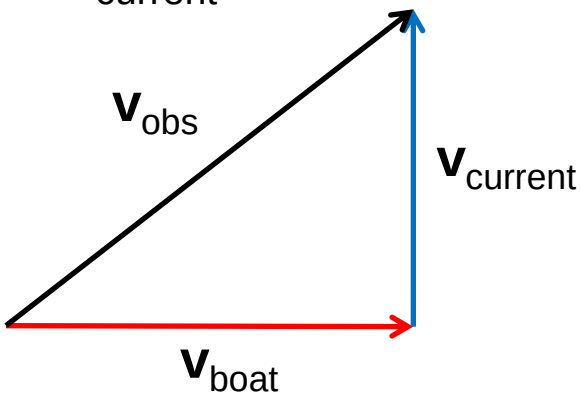


Solution

Answer: A

Justification: The velocity of A is affected by the force of the current. The boat travelling through a moving current has both a vertical component and horizontal component of velocity. The resulting velocity the boat travels is the sum of the two vectors:

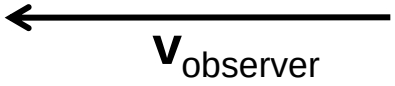
$$\mathbf{v}_{observer} = \mathbf{v}_{boat} + \mathbf{v}_{current}$$



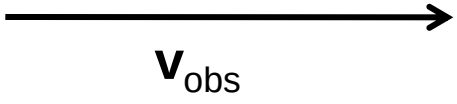
Relative Velocity V

A boat moves with $\mathbf{v}_{boat}$. The current moves with $\mathbf{v}_{current}$. What is the velocity of the boat as seen by an overhead observer?

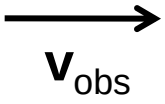
A.



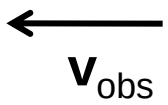
B.



C.



D.

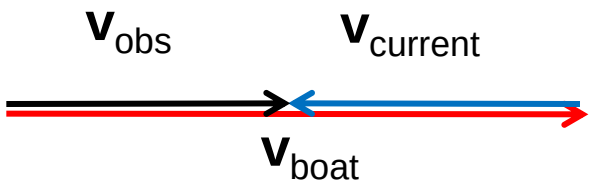


Solution

Answer: C

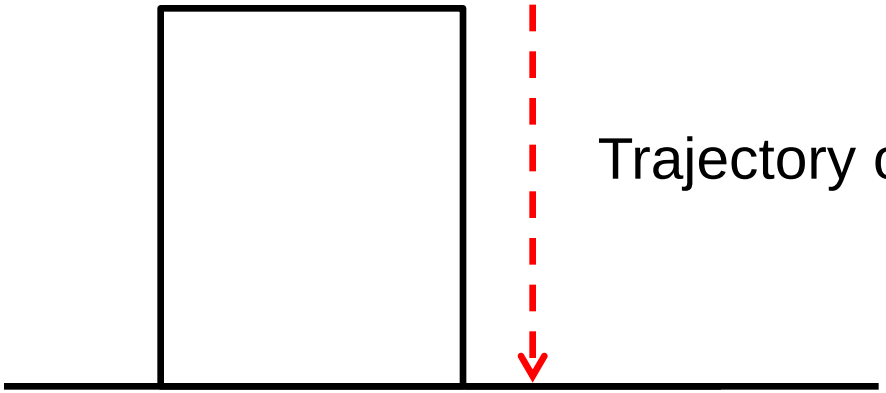
Justification: The velocity of A is affected by the force of the current. The current "pushes" the boat backwards at a rate of $\mathbf{v}_{current}$. Since the current is not stronger than the velocity of the boat, the boat will continue to travel forwards, but the observer will note a slower velocity than the driver of the boat.

$$\mathbf{v}_{observer} = \mathbf{v}_{boat} + \mathbf{v}_{curret}$$



Relative Velocity VI

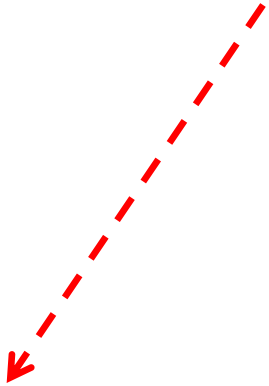
A ball is dropped from 4 m above the ground.



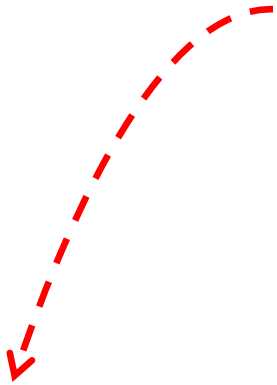
What is the trajectory of the ball as seen by an observer moving 3 m/s to the right?

A.

B.



C.



Solution

Answer: C

Justification: To a stationary observer, the ball drops with trajectory A.

To an observer moving 3 m/s [right], the ball will appear to be dropped with an initial velocity of 3 m/s [left].

Since the ball is affected by gravity, the vertical velocity of the ball is not constant, thus the ball follows the parabolic trajectory C as seen by the moving observer.