Relative Velocity and River Boat Problems

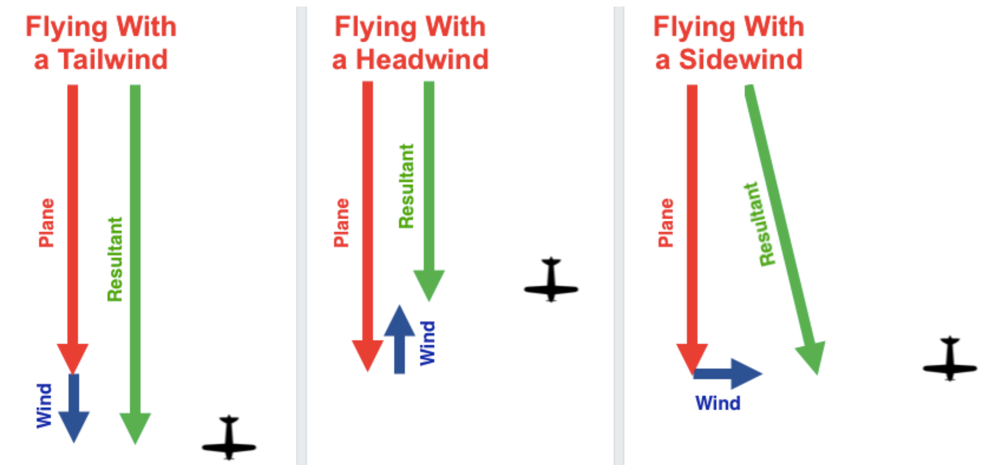
Lesson Notes

Relative Velocity

On occasion, an object will move within a medium that is moving with respect to an observer. On such occasions, an observer on the moving object will observe a different speed as an observer on a “stationary” reference frame. We would say that **the velocity of the object is relative to the observer**.

Headwinds, Tailwinds, Sidewinds - Example #1

Consider a small plane traveling with a velocity of 200 km/hr, south with respect to the air. The air is moving (wind) with a velocity of 50 km/hr with respect to an observer on the ground. Consider three wind directions:



250 km/hr with respect to observer on ground

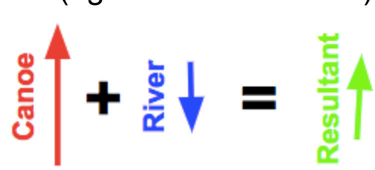
150 km/hr with respect to observer on ground

206 km/hr with respect to observer on ground

Canoeing Up the River vs. Down the River - Example #2

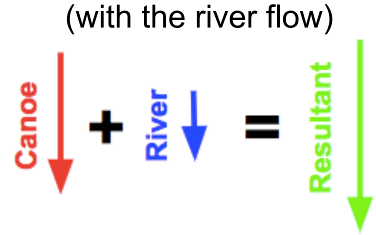
A canoe in a river moves 2 m/s with respect to the water. The river moves 1 m/s with respect to the shore. What is the speed of the canoe with respect to an observer on the shore if the canoe heads ...

... Up the River
(against the river flow)



Resultant v = 1 m/s, North

... Down the River
(with the river flow)



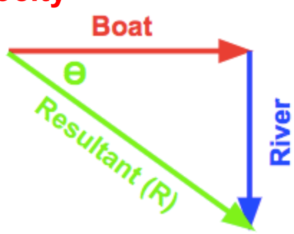
Resultant v = 3 m/s, South

Moving Across a River in the Presence of a Current - Example #3

A boat heads east across a 140-m wide river with a velocity of 4.0 m/s with respect to the water. The water moves 3.0 m/s, South with respect to the shore. Determine …

1. … the resultant velocity of the boat.
2. … the crossing time of the boat.
3. … the distance the boat travels down the river.

Resulant Velocity



Magnitude:

$R = \sqrt{(4.0)^2 + (3.0)^2} = 25.0\ m^2/s^2$

R = 5.0 m/s

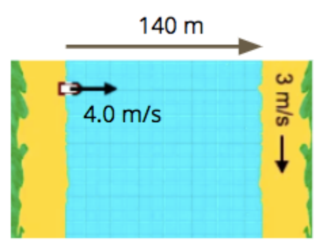
Direction:

$\Theta = \tan^{-1}(3.0 / 4.0) = 37°$

37° S of E or **323° CCW from East**

Crossing Time

- Use the distance-time-speed relationship (d=v•t) to determine the crossing time.
- Since the river width (140 m) is an east-to-west distance, use the east-to-west velocity (4.0 m/s) to solve for crossing time.

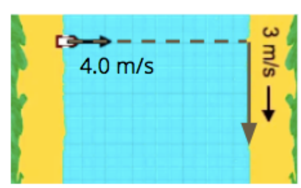


t = d/v = (140 m) / (4.0 m/s)

t = 35 s

Downstream Distance

- Use the distance-time-speed relationship (d=v•t) to determine the downstream distance.
- Since the downstream distance is a north-to-south distance, use the north-to-south velocity (3.0 m/s) to and the crossing time (35 s).



d=v•t = (3.0 m/s)•(35 s)

d = 105 m

Independence of Perpendicular Components of Motion

Riverboat problems demonstrate that **perpendicular components of motion are independent of each other.** A southward river velocity does not affect the time to cross the river. The time to head east is only affected by the eastward distance and the eastward velocity.