Relative Velocity

Example 1
A freight train pulling several flatcars is slowly passing a highway intersection at $10 \, km/h$. A hobo on one of the flatcars is walking toward the engine at $5 \, km/h$. What is the velocity of the hobo relative to an observer waiting in a truck stopped at the crossing?

Example 2
Suppose the hobo in Example 1 turns around and walks away from the engine at $5 \, km/h$. What is his velocity with respect to the observer then?

Example 3

A person who can row a boat at $5.0 \, km/h$ in still water tries to cross a river whose current moves at a rate of $3.0 \, km/h$. The boat is pointed straight across the river, but its progress includes a downstream motion die to the river current. (a) What is the velocity of the boat with respect to the shore? (b) If the river is $200 \, m$ wide, how far downstream does the boat land?

Example 4

A small airplane flies with an airspeed of $200 \, km/h$. A novice pilot wishing to fly from Columbia to Charlotte heads along a path that is due north. The wind is blowing from northwest to southeast at $28 \, km/h$. What is the resultant ground speed of the plane and what is the direction in which the plane actually travels?

Relative Velocity Worksheet

1. The pilot of a light plane heads due north at an air speed of $400\,km/h$. A wind is blowing from the west at $60\,km/h$.

   a) What is the plane's velocity with respect to the ground? ($405\,km/h\,[8.5°\ E\ of\ N]$)

   b) How far off course would the plane be after 2.5 h, if the pilot had hoped to travel due north but had forgotten to check the wind velocity? (150 $km\,[E]$)

2. A canoeist paddles north across a river at 3.0 *m/s*. (The canoe is always kept pointed at right angles to the river.) The river is flowing east at 4.0 *m/s* and is 100 *m* wide.

   a) What is the velocity of the canoe relative to the river bank? ($5.0\,m/s\,[53°\ E\ of\ N]$)

   b) Calculate the time required to cross the river. (33 *s*)

   c) How far downstream is the landing point from the starting point? (133 *m*)

3. A pilot wishes to make a flight of 300 km [NE] in 45 min. On checking with the meteorological office, she finds that there will be a wind of 80 km/h from the north for the entire flight. What heading and airspeed must she use for the flight?
   ($460\,km/h\,[52°\ N\ of\ E]$)

4. A boat traveling at 3.0 *m/s* through the water keeps its bow pointing north across a stream that flows west at 5.0 *m/s*. What is the resultant velocity of the boat with respect to the shore?
   ($5.8\,m/s\,[31°\ N\ of\ W]$)

5. A dog walks at 1.6 *m/s* on the deck of a boat that is traveling north at 7.6 *m/s* with respect to the water.

   a) What is the velocity of the dog with respect to the water if it walks towards the bow (the front of the boat)? ($9.2\,m/s\,[N]$)

   b) What is the velocity of the dog if it walks towards the stern (the back of the boat)?
   ($6.0\,m/s\,[N]$)

   c) What is the velocity of the dog with respect to the water if it walks towards the east rail, at right angles to the boat's keel? ($7.8\,m/s\,[12°\ E\ of\ N]$)

6. An airplane maintains a heading due west at an airspeed of 900 *km/h*. It is flying through a hurricane with winds of 300 *km/h*, from the northeast.

   a) In which direction is the plane moving relative to the ground? (11° S *of* W)

   b) What is the plane's ground speed? (1132 *km/h*)

   c) How long would it take the plane to fly from one city to another 500 *km* away, along the path in (a)? (0.44 *h*)

7. A 70 *m* wide river flows at 0.80 *m/s*. A girl swims across it at 1.4 *m/s* relative to the water.

   a) What is the least time she requires to cross the river? (50 *s*)

   b) How far downstream will she be when she lands on the opposite shore? (40 *m*)

   c) At what angle to the shore would she have to aim, in order to arrive at a point directly opposite the starting point? (55°)

   d) How long would the trip in part (c) take? (61 *s*)

8. A pilot maintains a heading due west with an air speed of 240 *km/h*. After flying for 30 *min*, he finds himself over a town that he knows is 150 *km* west and 40 *km* south of his starting point.

   a) What is the wind velocity, in magnitude and direction? (100 *km / h* $\left[37° \text{ W } of \text{ S}\right]$)

   b) What heading should he now maintain, with the same airspeed, to follow a course due west from the town? (19.6° *N of* W)

9. The navigator of an airplane plans a flight from one airport to another 1200 *km* away, in a direction 30° east of north. The weather office informs him of a prevailing wind from the west, of 80 *km/h*. The pilot wants to maintain an airspeed of 300 *km/h*.

   a) What heading should the navigator give the pilot? (17° *E of* N)

   b) How long will the flight take? (3.6 *h*)

   c) How much time did the wind save? (0.40 *h*)