PHYSICS

RELATIVE VELOCITIES IN 2-D

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Adding velocity vectors is exactly the same as adding displacement vectors. The idea is to reduce the vectors into ***TWO*** component vectors (one in the NS, one in the EW). After you have acquired your component vectors, you can use them to find the resultant velocity using Pythagorean Theorem and Primary Trig Ratios.

Ex: A swimmer jumps into a river and swims for the opposite shore. Her velocity relative to the water is 4.0 km/h [N] and the current is flowing 3.0 km/h [E]. What is the swimmers velocity relative to the ground?

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Ex: An airplane is travelling 250 km/h [S 25^{o} W] relative to the air. It experiences a wind of 50 km/h [E] relative to the ground. What is the velocity of the airplane relative to the ground?

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Ex: A plane with an airspeed of 150 km/h heads north. There is a wind of 80 km/h [E 30^{o} N]. Find the velocity of the plane relative to the ground.

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Ex: An archer attempts to shoot an arrow 120 km/h due west. There is a wind of 30 km/h [N 43^{o} W]. What is the velocity of the arrow relative to the ground?

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Ex: A cannon ball is fired at 200 km/h [N 31^{o} E] and experiences a wind 50 km/h [S 20^{o} E]. Find the resulting velocity.

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*Ex. A plane **wants** to fly due north. Its engines have the ability to fly 300 km/h and there is a wind of 50 km/h [N 30 E]. What direction does the plane have to fly to achieve its goal of flying due North?*

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Ex: A plane is flying at 100 km/h [S 25^{o} E] and experiences a 40 km/h west wind for the first half of the trip and a 50 km/h [N 40^{o} W] for the second half. What is the resultant velocity?

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Ex: A bullet moving at 400 km/h [S] is shot through a wind tunnel that has a wind of 200 km/h [N 40 W]. What is the resultant velocity?

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Ex: A boat is driving across the ocean at 80 km/h with a heading of [N 20^{o} W]. Throughout its journey it experiences a current of 30 km/h [N]. What is the resultant velocity?

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Ex: A boat wants to travel due south. Its motors are driving at a speed of 40 km/h and the 15 km/h current has a heading of [S 30^{o} E]. What direction must the boat travel to end up due south?

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HOMEWORK

Relative Velocity Worksheet

1. A swimmer has a velocity of 2 m/s directly across a river that is flowing at 4 m/s. What is the actual velocity of the swimmer and at what angle? Draw vectors and theta.

2. A plane is flying at 100 m/s due north with a cross wind (perpendicular to plane's velocity) of 20 m/s to the west. What is the planes actual velocity and angle from true north?

3. A sailboat is on a heading of due East at 5 m/s while crossing the Gulf Stream current, which is moving 4 m/s due North. What is the sailboats actual speed and heading?

4. A plane leaves Atlanta flying northeast at 100 m/s. Another plane leaves Atlanta flying southwest at 150 m/s. What is their velocity relative to each other?

5. A swimmers path appears to be going directly across a river at 1.5 m/s. The current is 2 m/s. How fast and at what angle must he be swimming?

6. A ship is heading 30º north of east at 10 m/s. The ocean currents there are flowing north a 1 m/s. A man walked across the ship at 1 m/s in a direction perpendicular to the ship (30º west of north). Draw all the velocity vectors. Add them using components. This is the velocity of the man relative to the earth.

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HOMEWORK

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 hope 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? (9.2 *m/ s* [*N*])
b. What is the velocity of the dog if it walks towards the stern? (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*)

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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* [37° W *of* S])
b. What heading should he now maintain, with the same airspeed, to follow a course due west from the town? ([19° *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*)