

1. You are standing on train tracks, and a train is approaching you from the west (heading eastward) at 23.3 m/s. Inside the train, a boy is walking toward the back of the train at 0.6 m/s, relative to the train itself. What is the velocity of the boy, relative to you?
2. Two cars are at rest, bumper to bumper, facing the same direction. The front car begins driving forward at 15 m/s, while the back car begins driving backward (in reverse) at 10 m/s. Inside the front car, a child throws a pillow toward the back of the car with a speed of 4 m/s, relative to the car. What is the pillow's speed, relative to someone in the back car?
3. A motor boat travels down a river, with the current. The water is flowing at 6.2 m/s northward, and the boat is moving at 18.0 m/s relative to the water. How fast is the boat moving, relative to a person walking along the river bank, northward, at 1.0 m/s?
4. A woman is skydiving. After deploying her parachute, she falls toward the ground at a steady 8.5 m/s, relative to the ground. She looks up and sees a Coke bottle, which must have fallen from the airplane. It is falling downward, directly toward her, at 20.0 m/s, relative to the ground. (Note that both the woman and the Coke bottle are falling at their terminal velocities. Neither is accelerating.) What is the velocity of the woman, from the point of view of the Coke bottle?
5. A red car and a blue car are at two ends of the flight deck on a large aircraft carrier. Facing each other, the red car drives forward (northward) at 30 m/s while the blue car drives forward (southward) at 25 m/s. Both speeds are relative to the flight deck. Meanwhile, the entire carrier is moving northward at 40 m/s, relative to the water. What is the velocity of the red car, relative to the driver of the blue car?
6. A spaceship is heading toward Mars at 80,000,000 m/s, relative to Earth. A missile is shot from the front of the ship, toward Mars, at 12,000 m/s, relative to the ship. What is the velocity of the missile, relative to Earth?
7. Inside a particle accelerator, a proton is shot forward (say, eastward) at 85% of c , while a second proton is shot toward the first (westward) at 95% of c . What is the speed of one of these protons, relative to the other?
8. A spaceship is heading away from Earth at 120,000,000 m/s. From the ship, a missile is launched toward Earth (gasp!) at 20,000 m/s, relative to the ship. What is the velocity of the missile, relative to Earth?
9. A spaceship is heading away from the Earth at 78% of c . A lamp attached to the outside of the ship is then turned on, and a beam of light heads toward Earth. What is the speed of the light, relative to Earth? (Prove it mathematically.)
10. A river flows northward at 8.0 m/s. A boat crosses the river, from its west bank to its east bank. The boat travels at a constant 14.0 m/s, relative to the water. (a) What is the velocity of the boat, relative to a tree growing next to the river? (b) If the river is 40 m wide, how long does the boat take to cross? (Assume the boat does not slow down approaching the opposite bank.) **This problem is meant to be a challenge.*