**Relative Motion**

* **Independence of Vectors: Perpendicular vectors are independent of each other.**
* **A swimmer going East across a river flowing south has two independent velocities acting on her which do not affect each other.**
* **Ex. Boats/swimmers in rivers or planes with winds.**
* **If you are on a train moving at 60 km/h[W], you are moving at 0 relative to the train but moving at 60 km/h [W] relative to the ground.**
* **If you walked to the rear of the train at 10 km/h [E], you are moving at 10 km/h [E] relative to the train but moving at 50 km/h [W] relative to the ground.**
* **The swimmer has a velocity relative to the river that is quite different to her velocity relative to an observer on the shore.**
* **An airplane having a velocity of 1200 km/h [N] in a wind of 300 km/h [W] would appear to move diagonally to us on the ground. The plane may head North but is blown off course.**
* **The application of vectors in two dimensions to navigation of airplanes or boats as well as swimmers in a river requires the use of the chain rule.**
* **For the swimmer, the chain rule can be applied as follows; let “s” stand for swimmer, “g” for ground and “w” for water. The velocity of the swimmer relative to the ground is: svg**
* **The vector sum follows as:**

**svg = svw + wvg**

* **The pre-subscript denotes the object that is moving and the post-subscript denotes the frame of reference with respect to which the object is moving.**

**Examples**

1. **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 river flows at 3.0 km/h [E]. What is the swimmer’s velocity relative to the ground?**

**Step 1) State chain rule:**

**svg = svw + wvg**

**Step 2) Draw vector diagram as per chain rule:**

svw = 4.0 km/h

wvg = 3.0 km/h

svg

θ

**Step 3) Determine svg including direction:**

**svg2 = (3.0 km/h)2 + (4.0 km/h)2**

**svg = 5.0 km/h**

**θ = tan-1(3.0 km/h)/(4.0 km/h)**

**= 37o E of N**

1. **An airplane has a velocity of 240. km/h [E] relative to the air. An 80.0 km/h wind blows from the North. Calculate the velocity of the airplane relative to the ground.**

**pvg = avg + pva**

**{253 km/h [E18.4oS]}**

1. **A biologist’s speed is 4.50 m/s in still water. The nerd heads North across a river that moves at 2.0 m/s [E]. He is chased by Velociraptors. There will be carnage.**
2. **What is the velocity of the nerd relative to the shore?**
3. **How long does it take him to cross the 1000.m wide river?**
4. **How far downstream is the nerd when he reaches the opposite side? (More Velociraptors wait in hiding).**
5. **What heading might the nerd take to end up straight across from his starting point?**
6. **How long would the trip take if he heads as per question d)?**

**Answers: a) 4.9 m/s [N24oE] b) 222 s c) 4.4 x 102 m [E] d) [N26oW] e) 2.5 x 102 s**

1. **An airplane wants to fly due West. The airplanes velocity is 200. km/h relative to the air. A wind blows at 62 km/h to the North. Determine the heading the plane must take and the velocity of the plane relative to the ground.**

pvg

pva = 200 km/h

avg = 62 km/h

θ

**{pvg = 193 km/h, θ = 18.4o S of W}**