Relative Motion

$$_{p}\vec{V}_{g} = {}_{p}\vec{V}_{a} + {}_{a}\vec{V}_{g}$$

- $_{p}\vec{V}_{g}$: velocity of plane wrt ground (resultant)
- $_{p}\vec{V}_{a}$: velocity of plane wrt air
  - airspeed
  - heading
- $_{a}\vec{V}_{g}$: velocity of air wrt ground
  - wind speed
  - wind direction

SP1

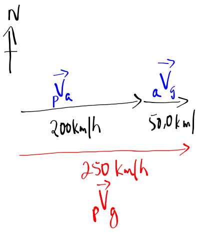
$_{p}V_{a} = 200 \text{ km/h}$

$_{a}\vec{V}_{g} = 50.0 \text{ km/h [E]}$

$_{p}\vec{V}_{g} = ??$

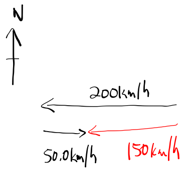
a) heading [E]
b) heading [W]
c) heading [N]
d) heading [N40°E]

a)



$$_{p}\vec{V}_{g} = {}_{p}\vec{V}_{a} + {}_{a}\vec{V}_{g}$$
$$_{p}\vec{V}_{g} = 200 \text{ km/h [E]} + 50 \text{ km/h [E]}$$
$$_{p}\vec{V}_{g} = 250 \text{ km/h [E]}$$

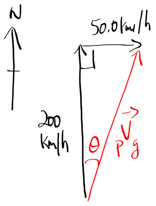
b)



$_{p}\vec{V}_{g} = 150 \text{ km/h [W]}$

$$_{p}\vec{V}_{g} = {}_{p}\vec{V}_{a} + {}_{a}\vec{V}_{g}$$
$$_{p}\vec{V}_{g} = 200 \text{ km/h [W]} + 50.0 \text{ km/h [E]}$$
$$_{p}\vec{V}_{g} = 150 \text{ km/h [W]}$$

c)



$$_{p}\vec{V}_{g} = {}_{p}\vec{V}_{a} + {}_{a}\vec{V}_{g}$$
$$_{p}\vec{V}_{g} = 200 \text{ km/h [N]} + 50.0 \text{ km/h [E]}$$

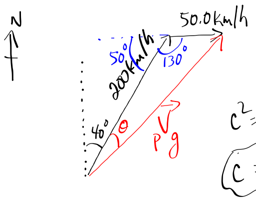
* must use a vector addition diagram since the vectors are 2D.

$$c^2 = a^2 + b^2$$
$$c^2 = 200^2 + 50.0^2$$
$$c = 206 \text{ km/h}$$

$$\tan\theta = \frac{50.0 \text{ km/h}}{200 \text{ km/h}}$$
$$\theta = 14.0°$$

$$_{p}\vec{V}_{g} = 206 \text{ km/h [N 14.0°E]}$$

d)



$$c^2 = a^2 + b^2 - 2ab\cos C$$
$$c^2 = 200^2 + 50^2 - 2(200)(50)\cos 130°$$
$$c = 235 \text{ km/h}$$

$$\frac{\sin A}{a} = \frac{\sin B}{b}$$

$$_{p}\vec{V}_{g} = {}_{p}\vec{V}_{a} + {}_{a}\vec{V}_{g}$$
$$_{p}\vec{V}_{g} = 200 \text{ km/h [N40°E]} + 50.0 \text{ km/h [E]}$$

* must use a vector addition diagram

$$\frac{\sin\theta}{500} = \frac{\sin 130}{235}$$
$$\sin\theta = \frac{50° \sin 130}{235}$$
$$\theta = 9.4°$$

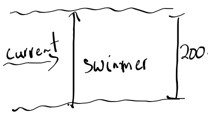
$$_{p}\vec{V}_{g} = 235 \text{ km/h [N49°E]}$$

SP2

$_{s}\vec{V}_{w} = 1.80\,m/s\ [N]$

$_{w}\vec{V}_{g} = 1.00\,m/s\ [E]$

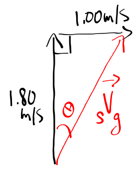
$_{s}\vec{V}_{g} = ??$



$_{s}\vec{V}_{g} = {}_{s}\vec{V}_{w} + {}_{w}\vec{V}_{g}$

$_{s}\vec{V}_{g} = 1.80\,m/s\ [N] + 1.00\,m/s\ [E]$?

* use a vector addition diagram.



a) $c^2 = a^2 + b^2$

$c^2 = (1.80)^2 + (1.00)^2$

$c = 2.06\,m/s$

$\tan\theta = \frac{1.00}{1.80}$

$\theta = 29.1°$

$_{s}\vec{V}_{g} = 2.06\,m/s\ [N\,29.1°\,E]$

b) $\vec{V}_{across} = \frac{\Delta\vec{d}_{across}}{\Delta t}$

* velocity and displacement directions MUST match

$\Delta t = \frac{\Delta\vec{d}_{across}}{\vec{V}_{across}}$

$\Delta t = \frac{200\,m}{1.80\,m/s}$

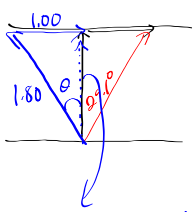
$\Delta t = 111\,s$

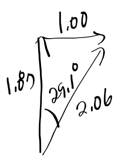
c) $\vec{V}_{downstream} = \frac{\Delta\vec{d}_{downstream}}{\Delta t}$

$\Delta\vec{d}_{down} = (1.00\,m/s\ [E])(111\,s)$

$\Delta\vec{d}_{down} = 111\,m\ [E]$

she will go 111 m downstream





this resultant will be less than 1.80 m/s so it will take longer to cross the river.

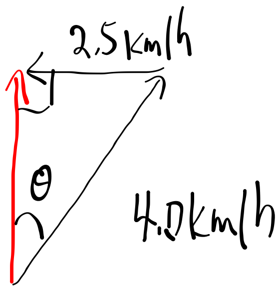
The time to cross the river is the same as if there were no current IF you are headed straight across (i.e. the current is

SP3

$_{s}\vec{V}_{w} = 4.0\,km/h$ [??]

$_{w}\vec{V}_{g} = 2.5\,km/h$ [W]

$_{s}\vec{V}_{g} = ??$ [N]



a) what heading?

b) how long to cross 2.0 km wide river

$$\sin\theta = \frac{2.5}{4.0}$$

$$\theta = 39^\circ$$

a) head [N39°E]

b) $c^2 = a^2 + b^2$

$(4.0)^2 = (2.5)^2 + b^2$

$b = 3.1\,km/h$

$$\vec{V}_{across} = \frac{\Delta \vec{d}_{across}}{\Delta t}$$

$$\Delta t = \frac{2.0\,km}{3.1\,km/h}$$

$\Delta t = 0.64\,h$

38 min