# Relative Motion Problems

$$\vec{V}_{pg} = \vec{V}_{pa} + \vec{V}_{ag}$$

- $\vec{V}_{pg}$: to an observer on the ground
- $\vec{V}_{pa}$: airspeed + heading
- $\vec{V}_{ag}$: wind speed + direction

## SP 1

$\vec{V}_{pa} = 200\ km/h\ [??]$

$\vec{V}_{ag} = 50.0\ km/h\ [E]$

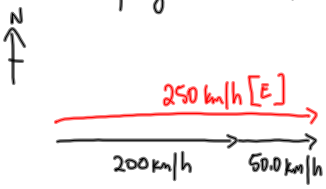
$\vec{V}_{pg} = ??$

$\vec{V}_{pg} = \vec{V}_{pa} + \vec{V}_{ag}$

a) $\vec{V}_{pg} = 200\ km/h\ [E] + 50.0\ km/h\ [E]$

$\vec{V}_{pg} = 250\ km/h\ [E]$

a) heading is [E]
b) [W]
c) [N]
d) [N 40° E]



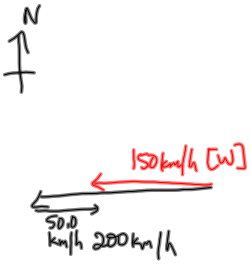

b) heading [W]:

$\vec{V}_{pg} = \vec{V}_{pa} + \vec{V}_{ag}$

$\vec{V}_{pg} = 200\ km/h\ [W] + 50.0\ km/h\ [E]$

$\vec{V}_{pg} = 200\ km/h\ [W] - 50.0\ km/h\ [W]$

$\vec{V}_{pg} = 150\ km/h\ [W]$

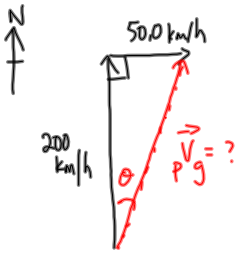



c) heading [N]:

$\vec{V}_{pg} = \vec{V}_{pa} + \vec{V}_{ag}$

$\vec{V}_{pg} = 200\ km/h\ [N] + 50.0\ km/h\ [E]$

not in same direction




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

$c^2 = 200^2 + 50.0^2$

$c \doteq 206\ km/h$

$\tan\theta = \frac{opp}{adj}$

$\tan\theta = \frac{50.0}{200}$

$\theta = \tan^{-1}\left(\frac{50.0}{200}\right)$

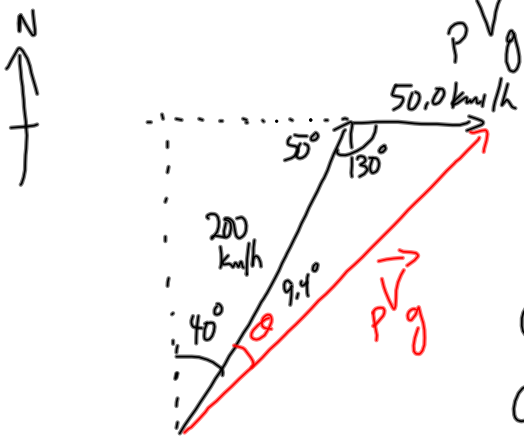
$\theta \doteq 14.0°$

The velocity of the plane with respect the ground is 206 km/h [N 14.0° E]

d) heading [N40°E]

$$\vec{V}_{pg} = \vec{V}_{pa} + \vec{V}_{ag}$$

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




Law of Cosines

$$c^2 = a^2 + b^2 - 2ab\cos C$$

$$c^2 = 200^2 + 50.0^2 - 2(200)(50.0)\cos 130°$$

$$c \doteq 235\text{ km/h}$$

Law of Sines

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

$$\frac{235}{\sin 130°} = \frac{50.0}{\sin\theta}$$

$$235\sin\theta = (50)(\sin 130°)$$

$$\sin\theta = \frac{(50)(\sin 130°)}{235}$$

$$\theta = \sin^{-1}\left(\frac{(50)(\sin 130°)}{235}\right)$$

$$\theta \doteq 9.4°$$

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

$40° + 9.4°$

2. $\vec{V}_{sw} = 1.80\ m/s\ [N]$

$\vec{V}_{wg} = 1.00\ m/s\ [E]$

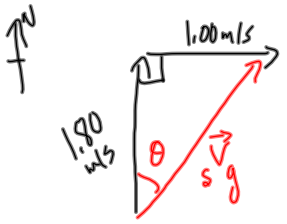
$\vec{V}_{sg} = ??$

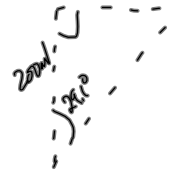
$\Delta\vec{d}_{across} = 200\ m\ [across]$

a) $\vec{V}_{sg} = ??$

b) $\Delta t = ?$

c) $\Delta\vec{d}_E = ??$




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

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

$c \doteq 2.05\ m/s$

$\vec{V}_{sg} = 2.05\ m/s$ $[N29.1°E]$

$\tan\theta = \frac{opp}{adj}$

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

$\theta = \tan^{-1}\left(\frac{1.00}{1.80}\right)$

$\theta \doteq 29.1°$

b) time to cross:

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

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

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

$\Delta t \doteq 111\ s$

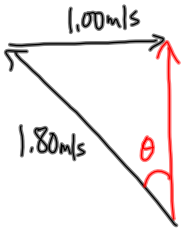
c) $\vec{V}_{downstream} = \frac{\Delta\vec{d}_{downstream}}{\Delta t}$

$\Delta\vec{d}_{down} = \vec{V}_{down}\,\Delta t$

$= (1.00\ m/s)(111\ s)$

$\doteq 111\ m$

What if you wanted to go straight across?




$\sin\theta = \frac{opp}{hyp}$

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

$\theta = \sin^{-1}\left(\frac{1.00}{1.80}\right)$

$\theta \doteq 33.7°$

head $[N33.7°W]$