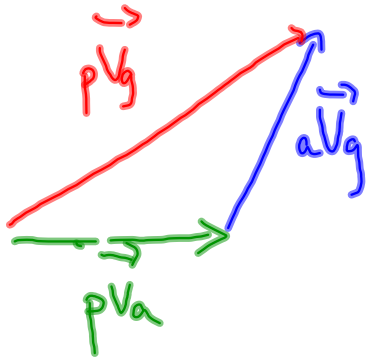
RELATIVE MOTION PROBLEMS

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

where $\vec{v}_{pg}$ is the velocity of the *plane* with respect to the *ground* ← relative to ground

$\vec{v}_{pa}$ is the velocity of the *plane* with respect to the *air* ← airspeed + heading

$\vec{v}_{ag}$ is the velocity of the *air* with respect to the *ground* ← wind speed + direction



Example 1

airspeed = 200km/h $|{}_p\vec{V}_a|$ ← magnitude of the vector

wind = 50km/h [E] ${}_a\vec{V}_g$

${}_p\vec{V}_g$ = ?

a) heading [E]

b) heading [W]

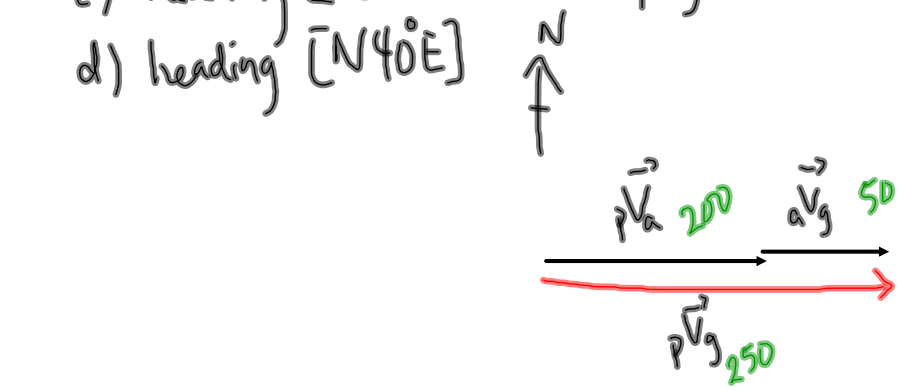
c) heading [N]

d) heading [N40°E]

a) ${}_p\vec{V}_g = {}_p\vec{V}_a + {}_a\vec{V}_g$

${}_p\vec{V}_g$ = 200km/h [E] + 50km/h [E]

${}_p\vec{V}_g$ = 250km/h [E]



The velocity of the plane with respect to the ground is 250km/h [E]

b) ${}_p\vec{V}_g = {}_p\vec{V}_a + {}_a\vec{V}_g$

${}_p\vec{V}_g$ = 200km/h [W] + 50km/h [E]

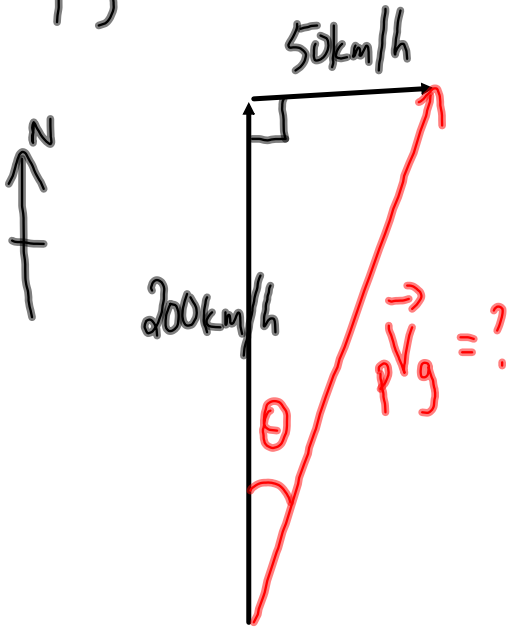
${}_p\vec{V}_g$ = 200km/h [W] − 50km/h [W]

${}_p\vec{V}_g$ = 150km/h [W]

The velocity of the plane with respect to the ground is 150 km/h [W]

c) $\vec{pV_g} = \vec{pV_a} + \vec{aV_g}$

$\vec{pV_g} = 200\text{km/h [N]} + 50\text{km/h [E]}$ ← a 2-dimensional problem



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

$c^2 = (200\text{ km/h})^2 + (50\text{km/h})^2$

$c = 206\text{ km/h}$ ↑ speed

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

$\tan\theta = \frac{50\text{ km/h}}{200\text{ km/h}}$

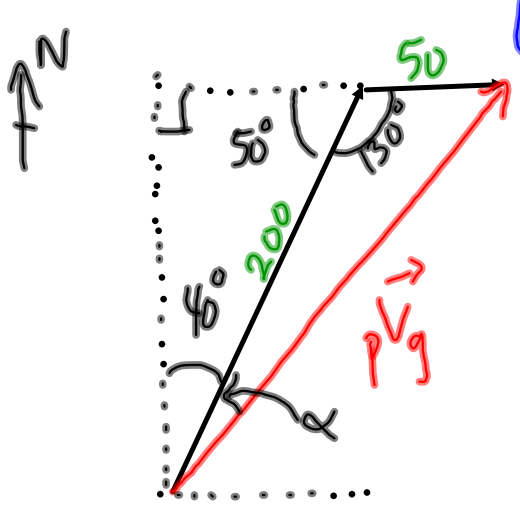
$\theta = \tan^{-1}\left(\frac{50\text{ km/h}}{200\text{ km/h}}\right)$

$\theta = 14°$ ← gives dir

The velocity of the plane with respect to the ground is 206km/h [N14°E]

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

$\vec{V}_{pg} = 200\,km/h\,[N40E] + 50\,km/h\,[E]$ ← 2-dimensional problem!!



LAW OF COSINES

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

$c^2 = (200\,km/h)^2 + (50\,km/h)^2 - 2(200\,km/h)(50\,km/h)\cos 130°$

$c \doteq 235\,km/h$

LAW OF SINES →

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

$\frac{50\,km/h}{\sin \alpha} = \frac{235\,km/h}{\sin 130°}$

$\sin \alpha = \frac{(50\,km/h)\sin 130°}{235\,km/h}$

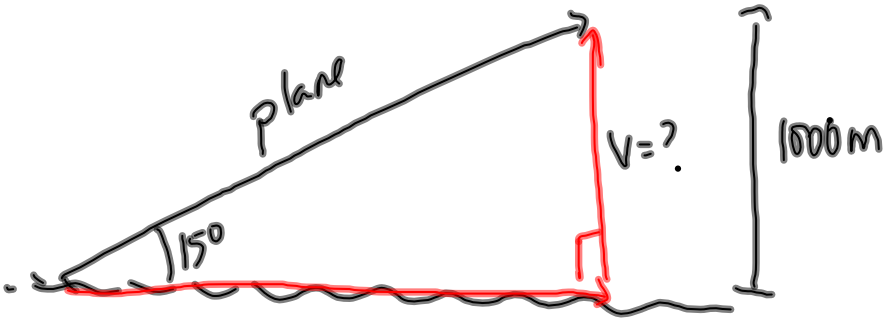
$\alpha \doteq 9.4°$

The velocity of the plane with respect to the ground is

$235\,km/h\,[N\,49°\,E]$

Components of Vectors (from HW)

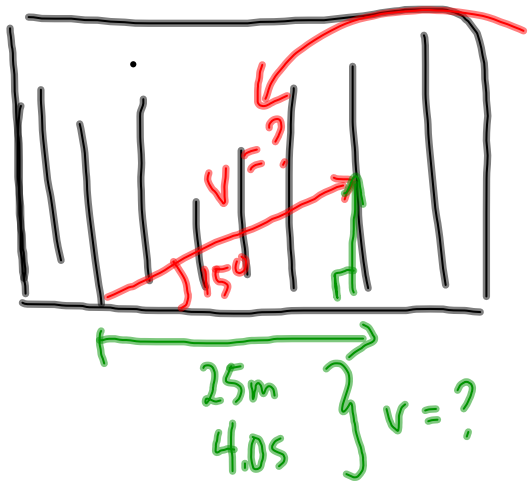
4.



shadow
200km/h

$\vec{V} = \frac{\Delta \vec{d}}{\Delta t}$ ← $\Delta \vec{d}$ and $\vec{V}$ MUST be in the same dir

5.



the velocity of the football player.